POST-IMPLEMENTATION EVALUATION OF ENTERPRISE RESOURCE PLANNING (ERP) SYSTEMS

ArunKumar Madapusi, B.E., M.B.A.

Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

May 2008

APPROVED:

Richard E. White, Major Professor
Lewis A. Taylor III, Committee Member
Grant E. Miles, Committee Member
Chang E. Koh, Committee Member
D. Krishna Sundar, Committee Member
Anat BarNir, Department Program Coordinator
Nancy Boyd-Lillie, Chair of the Department of Management
O. Finley Graves, Dean of the College of Business Administration
Sandra L. Terrell, Dean of the Robert B. Toulouse School of Graduate Studies

Madapusi, ArunKumar, Post-Implementation Evaluation of Enterprise Resource Planning (ERP) Systems. Doctor of Philosophy (Management), May 2008, 295 pp., 41 tables, 9 illustrations, references, 174 titles.

The purposes of this dissertation were to define enterprise resource planning (ERP) systems, assess the varying performance benefits flowing from different ERP system implementation statuses, and investigate the impact of critical success factors (CSFs) on the ERP system deployment process. A conceptual model was developed and a survey instrument constructed to gather data for testing the hypothesized model relationships. Data were collected through a cross-sectional field study of Indian production firms considered pioneers in understanding and implementing ERP systems. The sample data were drawn from a target population of 900 firms belonging to the Confederation of Indian Industry (CII). The production firms in the CII member directory represent a well-balanced mix of firms of different sizes, production processes, and industries.

The conceptual model was tested using factor analysis, multiple linear regression analysis and univariate Anova. The results indicate that the contributions of different ERP system modules vary with different measures of changes in performance and that a holistic ERP system contributes to performance changes. The results further indicate that the contributions of CSFs vary with different measures of changes in performance and that CSFs and the holistic ERP system influences the success achieved from deployments. Also, firms that emphasize CSFs throughout the ERP implementation process achieve greater performance benefits as compared to those that focus on CSFs during the initial ERP system deployment. Overall, the results of the study support the relationships hypothesized in the conceptual model.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

Introduction

Information management is a powerful driver of business performance and sustainable organizational growth. Increased globalization over the past decade has forced firms worldwide to face unprecedented levels of competition and operate in a dynamic business environment. Firms seek to manage such competitive pressures and environmental uncertainties by adopting best business practices, engaging in continuous design improvements, speeding up the product development cycle, ensuring manufacturing flexibility, streamlining sourcing arrangements, and managing myriad logistics channels. Firms are investing heavily in information technology (IT) systems to effectively integrate and coordinate these activities across their supply chains as well as shape the way they conduct business. In particular, more and more firms around the world are implementing packaged software called enterprise resource planning (ERP) systems.

The global ERP market has registered explosive growth over the past decade increasing from $1 billion in 1990 (Mabert, Soni, & Venkataramanan, 2000) to over $ 350 billion in 2004 (AMR Research, 2000; 2005; Gartner, 2003a; IDC, 2003; 2004). An overview of the global ERP market by Datamonitor (2005) indicates that North America accounted for the bulk of ERP system deployments (46%), Europe (28%), Asia-Pacific (20%), and South America (6%). A similar market share distribution pattern has been forecast till 2008.

The ERP market's high growth rates through much of the 1990s were mainly driven by the year 2000 (Y2K) issue. Most ERP system implementers were firms belonging to the developed countries from the North American, European, and the Asia-Pacific regions. The high incidence of ERP system implementations in the developed markets during the 1990s was facilitated by factors such as the presence of excellent infrastructure facilities, a strong economic base, supportive government policies, high IT maturity and computer culture, and process-oriented management (Huang & Palvia, 2001). The top five ERP system vendors (SAP, Oracle, PeopleSoft, Baan, JD Edwards) accounted for about 59% of the global ERP market in 1999 (AMR Research, 2005).

In the early 2000s there was a slump in the ERP market as the Y2K-compliant ERP system implementers in developed countries consolidated and leveraged their deployments to maximize ERP system benefits. This period was marked by market consolidation among ERP system vendors as they sought to improve their product lines by Web-enabling their products and introducing add-ons to extend the ERP system across the supply chain. Most major ERP system vendors also introduced ERP systems targeted at industry verticals and small and medium enterprises (SMEs).

In contrast to the stagnant growth rates in the developed ERP markets in the early 2000s, during this period there was increasing penetration of ERP systems in the underdeveloped ERP markets in countries such as Asia, Africa, Middle East, and South America. The building up of basic IT and complementary infrastructure to support IT related investments and global competitive pressures resulted in an increasing number of ERP system deployments in the emerging markets. Most firms in these markets are yet to consolidate and leverage their implementations to obtain the full potential benefits from their ERP system.

In the past few years there has been a recovery in the ERP market (14% in 2004 according to AMR Research, 2005) marked by expanding implementation scope among firms in the developed markets as well as new and expanded implementations in the developing markets. In 2004, the Asia-Pacific region posted the highest growth rate (19%), followed by the North

American region (16%), and the European region (12%). AMR Research (2005) indicates that consolidation among ERP system vendors during the 2000s has resulted in the top five vendors (SAP, Oracle, Sage, Microsoft, SSA Global/Baan), accounting for about 72% of the market in 2004. Their study further indicates that among the top five global ERP system vendors, SAP remains the market leader with a 40% market share, followed by Oracle with 22%, Sage with 5%, Microsoft with 3%, and SSA Global with 3%.

Though, there is a time lag in the adoption of ERP systems among firms in the developed and developing markets, ERP system implementations in these markets show remarkably similar trends. In both these markets, early ERP system deployments comprised mostly of module and sub-module implementation of module categories such as financials, logistics, and human resources that streamlined and integrated key functional areas (Hernandez, 1998; Meissner, 2000). Once these early ERP system implementations stabilized, firms in these markets then turned their attention to expanding their implementation scope by adding more value chain activities through deployment of modules such as supply chain management (SCM) and customer relationship management (CRM) (Davenport, 2000; Hayman, 2000).

Various studies indicate that 50% to 70% of all worldwide ERP system implementations, in both the developed and developing markets, face problems and fail to achieve their stated objectives (Buckhout, Frey, & Nemec Jr., 1999; Hong & Kim, 2001; Umble & Umble, 2002; De, 2004). Even firms that achieved technically successful implementations are unable to garner the expected benefits from their ERP system deployments. Studies show that the main reason attributed to this high incidence of problematic implementations, and the non-achievement of stated objectives by technically successful implementations, is due to firms failing to institute organizational changes by focusing on critical success factors (CSF) in parallel with the technical implementation of their ERP systems (Sadagopan, 1999; Scott & Vessey, 2000; Gowigati & Grenier, 2001; Kennerley & Neeley, 2001).

A synthesis of the above discussion indicates that ERP systems have evolved into ‘a necessity for doing business’ for firms in both the developed and developing markets. This rise in the popularity of ERP systems has generated interest in their underlying concepts, their components, the influence of their implementation status on differential performance benefits to the firm, and the impact of CSFs on system deployments. The next section of this chapter provides an overview of ERP systems. This is followed by a section which focuses on the lack of ERP system literature regarding implementation issues, benefits, models to guide ERP system implementing firms, and hence the need for research in this area. The final section provides an outline for this research study.

Understanding ERP

The first part of this section describes the evolution, characteristics, and various definitions of ERP systems. The later part of the section discusses ERP system modules, CSFs that facilitate ERP system deployments, and the benefits that accrue to successful implementers.

Evolution of ERP

Most research studies view the evolution of ERP systems from a manufacturing perspective. In the late 1950s and the early 1960s, automated reorder point (ROP) systems were used for scheduling production, ordering materials, and shipping products within an assigned plant area. During the mid-1960s, computerized materials requirements planning (MRP) systems began to replace ROP systems. These systems represented the first off-the-shelf business application systems available in the market. They supported the creation and maintenance of master data and bill of materials (BOM) across all products and parts in one or more plants.

BOM processors and forecasting algorithms along with computerized production reporting tools formed typical parts of the MRP system (Chung & Snyder, 2000; Klaus, Rosemann, & Gable, 2000; Rondeau & Litteral, 2001).

In the mid-1970s, manufacturing resources planning (MRP II) systems began to replace MRP systems. MRP II systems integrated materials as well as production capacity requirements in the calculation of overall production capabilities. In addition, advanced reporting capabilities enabled the efficient scheduling and monitoring the execution of production plans. The IT underlying MRP and MRP II systems focused primarily on automating transactions in order to increase the firm's operational efficiency (Chung & Snyder, 2000; Klaus et al., 2000; Rondeau & Litteral, 2001).

The MRP systems typically ran on mainframes, reflected centralized computing, involved limited interactions between users and the system, and had low levels of functional integration. The MRP II systems, in contrast, mainly used multi-user networks and ran on a variety of IT platforms. The late 1980s witnessed rapid advances in technology and MRP II systems were integrated with other systems such as computer integrated manufacturing (CIM), just-in-time (JIT), electronic data interchange (EDI), and manufacturing execution systems (Hsieh & Kleiner, 1992; Sillince & Sykes, 1993; Rondeau & Litteral, 2001).

In the early 1990s, ERP systems replaced MRP II systems. ERP systems extended MRP II system functionalities to include functions such as human resources, sales and distribution, and quality to create seamless, integrated information flows across the entire firm. ERP systems comprise of a suite of integrated products that use a common IT architecture and can be linked or de-linked and integrated with legacy and other application systems. These systems run on multi-user networks and allow the simultaneous aggregation, de-aggregation, and manipulation of real-time data across functions. ERP systems now form the IT backbone of firms and their functionalities have extended to include inter-firm integration facilitated by business applications such as electronic-commerce (E-Commerce), SCM, and CRM (Sadagopan, 1999; Chung & Snyder, 2000; Yen, Chou, & Chang, 2002).

Characteristics of ERP

ERP systems collect data through a single comprehensive database and make it available to modular applications that support all of a firm's value chain activities across functions, business units, and geographical areas. These systems have emerged as the de facto operating standards for firms and represent generic but multi-level configurable and customizable solutions that incorporate best practices which basically reflect a series of assumptions about how firms operate in general (Davenport, 1998; Klaus et al., 2000; Markus, Petrie, & Axline, 2000; Koch, 2001).

Researchers have identified a number of key features that characterize ERP systems (Chung & Snyder, 2000; Siriginidi, 2000; Yen et al., 2002; Al-Mashari, Al-Mudimigh, & Zairi, 2003). ERP systems share the same data definition across all modules through the use of a data dictionary. They facilitate the maintenance of a single set of data across all business processes and hence provide common data access to all users. The use of client-server technology, middleware, and the Internet enables ERP systems to be configured according to the dynamic business needs of firms. An open system network architecture allows any module of the ERP system to be linked or de-linked from the system without affecting other modules. ERP systems also contain repositories, which capture all semantics in business processes, business objects, and firm structures.

The discussion in the preceding paragraph highlights the underlying philosophy of ERP systems as the leveraging of IT to achieve capabilities for harnessing intra-firm and inter-firm resources. ERP systems achieve this by integrating intra-firm and inter-firm business activities through a combination of tools, technologies, integration mechanisms, and organization fit strategies (Davenport, 1998; Beretta, 2002). Integration helps in the coordination of business activities. ERP systems embed integration enabling technologies and adopt a process view of the firm. This enables the management of firm interdependencies, thereby enabling cross-functional information flows, language sharing, and cognitive integration among functional units (Harrold, 2001; Beretta, 2002).

Definitions of ERP

ERP has been defined by researchers and practitioners in different ways. The Gartner Group coined the term ERP in the early 1990s to describe a collection of applications that can be used to manage all of a firm’s business activities. Minahan (1998) defines ERP as a complex software system that ties together and automates the basic processes of a business. Al-Mashari and Zairi (2000) indicate that ERP represents an optimal enterprise-wide technology infrastructure. Researchers also refer to ERP systems as enterprise resource management (ERM) systems, enterprise systems (ES), and business systems respectively (Slater, 1999; Davenport, 1998; 2000). ERP systems are further described as applications that integrate functional areas and allow functions to share a common database and business analysis tools (Chen, 2001; Mabert, Soni, & Venkataramanan, 2001a).

In recent literature, the definition of ERP has undergone changes as ERP systems were extended to include inter-firm activities through integration of front-office and back-office business applications such as SCM and CRM. In the early 2000s, the Gartner Group coined the term enterprise resource planning II (ERP II) to refer to business strategies and a set of industry-domain-specific applications that build customer and shareholder value by enabling and optimizing enterprise and inter-enterprise collaborative operational and financial processes (Gartner, 2002). Gould (2002) states that the cross-enterprise integration enhancements such as process extensions, verticalization of functionalities, and IT architecture define ERP II. Weston Jr. (2003) indicates that the concept of ERP II extends beyond ERP to include technology planning and execution issues that support business processes and change management; and hardware, software, and technical issues. Researchers also refer to ERP II systems as ES's (Kawalek & Wood-Harper, 2002) and as electronic- ERP (e-ERP) systems (Ash & Burn, 2003).

ERP Defined

The discussion in the preceding paragraphs indicates that various terminologies and descriptions are used to define ERP systems. Though studies suggest that the definition and scope of ERP has changed over time, the phrase enterprise resources planning and its abbreviated term ERP has become the most common terminology used by researchers and practitioners to denote integrated business application packages. This research study also uses the phrase enterprise resource planning and its abbreviated term ERP to denote a broad and universal "umbrella" system, which includes all value chain business applications that are integrated into a firm's ERP-based information system (IS) infrastructure.

Modules of the ERP System

Early implementers deployed ERP system modules that addressed key intra-firm activities pertaining to the finance, logistics, and human resources functions. Typically firms deployed modules such as financial accounting, controlling, personnel administration, personnel development, general logistics, materials management, procurement, inventory control, production planning, and sales and distribution (Hernandez, 1998; Appelrath & Ritter, 2000). Each of these modules in turn comprised of numerous sub-modules that accessed a common database.

Firms chose to deploy modules in three ways. Firms implemented each of these modules and/or sub-modules on a stand-alone basis to address specific business activities. They deployed one or more modules and/or sub-modules as a partially integrated solution that addressed a group of business activities. Firms also chose to leverage the full integration potential of the ERP system by implementing all the modules and sub-modules to form a complete ERP system (Hernandez, 1998; Koch 2001; Poston & Grabski, 2001).

As firms stabilized their intra-firm deployments, they then extended their implementations with the addition of modules that addressed inter-firm activities across the supply chain. Typically firms deployed modules such as SCM, CRM, E-Commerce, product data management (PDM), and EDI (Ayers, 2001; Tyler, 2002; Yen et al., 2002). Each of these modules in turn comprises of numerous sub-modules that accessed the firm's common database.

Critical Success Factors for ERP System Implementation

Though, firms generally reported success in their ERP system deployments, there are many failures or near failures in implementing these systems (Buckhout et al., 1999; Hong & Kim, 2001; Umble & Umble, 2002). Firms faced difficulties in completing their implementations and achieving effective integration due to numerous technical, managerial, and organizational challenges. Most firms adopted a CSF-based implementation approach to overcome these difficulties.

Early CSF research identified individual CSFs and indicated that firms which focus on these factors will achieve implementation success (Davenport, 1998; Bingi, Maneesh, & Jayanth, 1999; Padmanabhan, 1999). Researchers later realized that these CSFs are interdependent and hence later CSF research focused on developing CSF frameworks to aid the ERP system implementation process (Al-Mashari & Zairi, 2000; Sousa & Collado, 2000). Realizing that different CSFs are important in different phases of the ERP project, recent literature prioritized and classified CSFs, according to the ERP life cycle implementation process (Kraemmergaard & Rose, 2002; Kumar, Maheshwari, & Kumar, 2003).

Changes in Performance due to ERP System Implementation

Firms collect, generate, and store huge quantities of data that are spread across divisions, functions, regions, and databases. Though invaluable, this fragmented data represents one of the main drags on business productivity and performance (Davenport, 1998). The early intra-firm ERP system deployments enabled firms to standardize, integrate, and streamline their data and process flows to provide seamless information for effective decision-making (Davenport, 1998; Mabert et al., 2001a). Firms leveraged this information output to effect efficiency improvements in functional areas such as inventory management, procurement, and order management (Mabert et al., 2000; Madhavan, 2000). Once their early intra-firm ERP system deployments stabilized, firms fine-tuned their systems and added modules to extend their ERP systems across the supply chain. Firms then leveraged their early efficiencies to obtain strategic benefits such as increased profitability, higher return on investment (ROI), and increased customer satisfaction (Johnson, 2000; Willis & Willis-Brown, 2002).

Systems Approach to ERP

Studies indicate that single module or sub-module implementations result in increased efficiency benefits accruing to firms (Klaus et al., 2000; Hitt, Wu, & Zhouo, 2002). Most ERP system studies, however, indicate that firms derive enhanced benefits by implementing all the modules of the ERP system (Johnson, 2000; Mabert et al., 2001a; Poston & Grabski, 2001). These studies also suggest that effective integration of modules over a number of years enhances business performance. Firms facilitate the implementation process by instituting continuous organizational changes in parallel with their technical implementations. The focus on managing both the ERP system implementation as well as the larger environment further helps firms maximize the benefits from their ERP systems. The above discussion suggests that firms which adopt a systemic view of their system implementations derive optimal performance benefits.

Need for Research

Due to the relative newness of the ERP field, rapid advances in ERP technologies, and the high incidences of implementation delays and failures, practitioner-oriented articles to a large extent dominate literature. Descriptive and case studies form the bulk of academic research with survey studies gaining prominence in the past four to five years. These studies, to a large extent, adopted a short-term focus by stressing the effective management of the ERP system implementation process. Only recently researchers have shifted their attention to the long-term analysis of specific operational and usage issues.

Overall, empirical work on ERP systems is limited. Several modules that form part of the ERP system have been identified, specific CSFs associated with effective implementations have been examined, and the early benefits that firms obtain from their ERP systems have been listed. Most of these studies, however, examined the above issues separately and systematic studies with scientific rigor are by and large absent. The absence of theory-driven ERP models in literature also provides a weak foundation for empirical work.

General Model of ERP System Implementation

This research study attempts to fill the literature gaps identified in the preceding paragraphs by evaluating the varying performance benefits flowing from different ERP system implementations as well as investigating the impact of CSFs on the ERP system deployment process. A perusal of the discussion earlier in this chapter indicated that ERP systems comprise of a number of modules. The systemic concept that underlies ERP systems suggests that increasing changes in performance accrue to firms as they implement more and more modules of the ERP system. Firms enhance their performance benefits by fine-tuning their ERP systems through effective integration of modules over a number of years. Studies further show that CSFs play a crucial role in facilitating ERP system deployments. A general model of ERP system implementation based on the above discussion and elaborated further in chapter 2 is given in Figure 1.

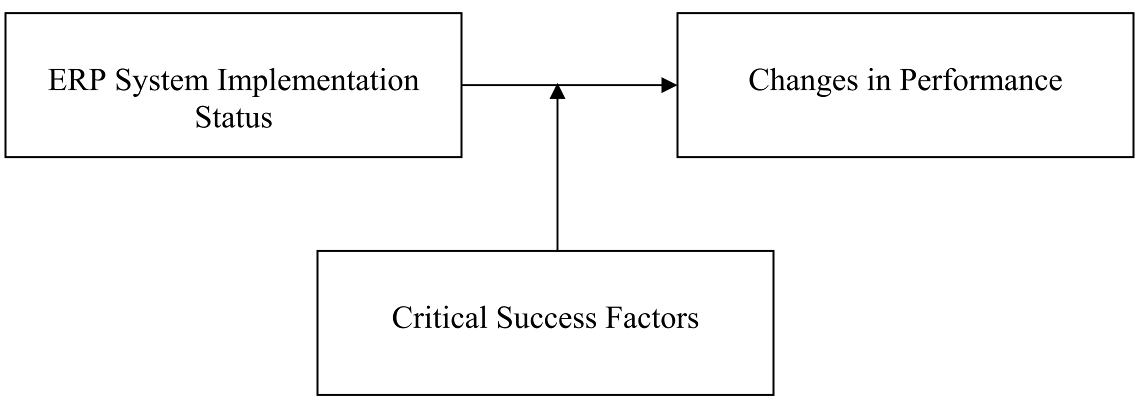


Figure 1. General Model of ERP System Implementation.

The model in the figure relates the ERP system implementation status to changes in performance with the moderation of this relationship by CSFs. The theoretical underpinnings of this model are based on the use of Galbraith's information processing theory (Galbraith, 1977;

Galbraith, Lawler III, & Associates, 1993; Mohrman, Galbraith, Lawler III, & Associates, 1998; Galbraith, Downey, & Kates, 2002) discussed later in chapter 2.

The plateauing of the ERP market in developed countries and rising competitive and global pressures has resulted in high ERP growth rates in the developing markets. An analysis of literature in chapter 2 indicates that most ERP system research is focused on developed countries and there is limited coverage of ERP issues in developing markets. Studies also show that the ERP markets in both the developed and the developing countries face similar problematic implementation issues. The paucity of theoretical ERP system research and the high rate of implementation delays in the developing countries suggest that field testing the ERP system implementation model in a developing country would be of immense benefit for researchers and practitioners in the ERP arena. The Indian ERP market, described later in chapter 3, represents a good market to test the ERP system implementation model. This research study is important as it builds and tests a globally applicable, literature-based, and theory-driven ERP system implementation model to enhance our understanding of ERP system concepts and associated implementation issues and benefits. This understanding would enable firms to optimally leverage their ERP systems and successfully face the increasing demands of globalization.

Research Questions

The first phase of this research study comprises of a literature review of ERP systems as well as other relevant systems studies. A synthesis of literature led to the identification of the various modules comprising the ERP system, the CSFs associated with ERP system implementations, and the changes in performance that accrue from ERP system deployments. Firms enhance their performance benefits with holistic ERP system deployment. Holistic ERP systems in this study refer to complete ERP system deployment and fine-tuning the system through effective module integration over a number of years. The relationship between each of the ERP modules and changes in performance are first examined. Then, the relationship between holistic ERP systems and changes in performance is investigated. Finally, the impact of CSFs on the above relationships is examined to obtain a better understanding of the ERP system concept. The following research questions are addressed in the first phase of this study:

(1) What are the modules that comprise an ERP system?
(2) Does a holistic ERP system provide changes in performance?
(3) What are the CSFs that impact ERP system implementations?
(4) What are the changes in performance that result from ERP system implementations?

The second phase of this research study involves the development of a literature-based and theory-driven ERP system implementation model with testable hypotheses. The modules, CSFs, and performance changes identified in the first phase of the study constitute the model variables. The model was tested through a cross-sectional survey of Indian firms that are representative of the Indian production industry. Data were collected through a survey instrument developed from literature. The data were analyzed through factor and regression analyses as well as univariate analysis of variance (ANOVA) to test the relationship between the relative contributions of ERP system modules and differential changes in firm performance as moderated by CSFs. The following research questions are addressed in the second phase of this research work:

(5) Does a relationship exist between the implementation status of the ERP system and changes in performance?
(6) Do CSFs influence the relationship between the implementation status of the ERP system and changes in performance?

Summary

This chapter provided an overview of the global ERP market, examined the concept of ERP systems, highlighted areas where there is a paucity of ERP system research, and formulated research questions to address the imbalances in these research areas in the context of this study's objectives. In the ensuing chapters, a literature-driven and theory-based ERP system implementation model to enhance our understanding of ERP systems is developed and operationalized. The model was tested through a survey study using a sample of production firms in India. Data collected from the survey were analyzed and evaluated to test the relationship between ERP system implementation status and changes in firm performance as moderated by CSFs.

The following outline is used to describe the research study: Chapter 1 gives an overall view of the purpose of the study. It describes and defines ERP systems and traces their evolution. The chapter further defines the research problem, derives research questions, and provides a foundation for the following chapters. Chapter 2 reviews literature pertinent to the identified research issues in this study. A synthesis of descriptive, case, and survey studies identifies the modules of the ERP system, the CSFs associated with ERP system implementations, and changes in firm performance resulting from ERP system deployments. Then the modules, CSFs, and the changes in performance are grouped into categories based on literature. Galbraith's (1973, 1977) information processing model is used as a theoretical framework for the research model of ERP system implementation suggesting linkages between the variables identified in the literature review. Hypotheses derived from the model are postulated.

Chapter 3 reports the methodology used to conduct this research study and includes issues concerning survey instrument development and data collection procedures. Chapter 4 presents the results of the analysis. Analysis includes factor analysis for summarization and data reduction, and multiple regression analyses and univariate ANOVA for testing the postulated hypotheses. Chapter 5 provides an overall summary of the findings of the study and discusses the implications of the findings. The chapter also discusses the limitations of this research study and suggests directions for future research.

This study contributes to the body of scientific knowledge by identifying the relationship between ERP system implementation status and changes in firm performance. CSFs associated with the facilitation of the ERP system implementation process and their impacts on the above relationship were identified. Academicians and practitioners can leverage the information presented in this research study to enhance their understanding of conceptual and system-oriented ERP system issues, optimize their ERP system implementations, and hence maximize the returns from their ERP systems.

CHAPTER 2

LITERATURE REVIEW

Introduction

There is a lot of interest and discussion in enterprise resource planning (ERP) systems over the past decade in the international arena. Firms belonging to the developed countries in North America, Europe, and Asia-Pacific dominated the ERP market throughout most of the 1990s. Most firms in these developed markets have stabilized and extended their ERP system and shifted their focus from implementation to effective system utilization and integration. During the late 1990s and the early 2000s, ERP vendors turned their attention to the developing countries in Asia, Africa, Middle East, and South America. The focus of most firms in these developing markets is on the successful implementation and obtainment of early benefits from their ERP system. This chapter, which represents a synthesis of ERP research and other relevant studies, addresses the six research questions of this study, derives a theory driven ERP system implementation model, and develops hypotheses for empirical testing.

The first part of this chapter consists of a timeline-based review of ERP system literature consisting of descriptive studies, case studies, survey studies, and modeling and simulation studies. Other relevant studies are also discussed to provide additional support to the findings obtained from the ERP system studies. This is followed by a discussion of ERP system research pertinent to the development of this study's survey instrument.

The second part of this chapter represents a synthesis of the literature discussed in the first part and identifies modules comprising the ERP system, the critical success factors (CSFs) associated with the implementation process, and the changes in performance due to the ERP system deployment. The systemic concept underlying ERP is also discussed to provide a conceptual understanding of these systems. An ERP system implementation model is then developed, which suggests a relationship exists between the implementation status of ERP systems and changes in performance as moderated by CSFs.

The third part of this chapter provides theoretical support for this research study. Galbraith's information processing theory is used as a theoretical framework to underpin the ERP system implementation model developed in the earlier part of the chapter. Two sets of testable hypotheses are then derived for empirical investigation from a synthesis of the discussion in the earlier sections of the chapter.

ERP Systems Research

This section provides a chronological review of ERP system and other relevant research consisting of descriptive, case, and survey studies. Cross-study comparison tables at the end of each of the different types of methodological studies discussed are developed to identify the modules that comprise the ERP system, the CSFs that facilitate the implementation process, and the changes in performance that accompany deployments. A discussion of relevant modeling and simulation studies lends support to the findings of the above mentioned cross-study comparison tables. A review of ERP system and other relevant research studies is also undertaken to develop the survey instrument used in this study.

Most of the early research on ERP systems is exploratory in nature with the "going live" of the system dominating literature. The ERP system market comprised largely of firms that had enterprise-wide legacy systems in place for decades and ensuring year 2000 (Y2K) survival was a major reason for their implementing ERP systems. Later ERP system research indicates that in the post-Y2K era firms started to add modules to their existing deployments in order to bring more and more of their intra-firm as well as key inter-firm processes and activities under the

ERP system. Firms focused on managing CSFs to facilitate their implementation process in an attempt to achieve quicker benefits. Recent ERP system research indicates that firms are fine-tuning their existing implementations and extending their ERP systems across the supply chain to include front-office and back-office activities. In addition, firms have started to focus on the effective utilization and integration of their ERP modules to derive synergistic benefits.

Due to the relative newness of the ERP field, research on ERP systems during the 1990s was mostly dominated by descriptive and case studies. In the past four to five years, researchers have started using survey methodologies to examine ERP system implementations. There is, however, still a paucity of rigorous empirical studies on ERP systems as most of these survey studies did not use validated survey instruments.

Descriptive Studies

Most early studies on ERP system implementations are descriptive in nature as firms struggled to understand the nature of ERP systems, and the best way to deploy these systems to realize potential benefits. Only recently have researchers started to address conceptual issues such as the operational and strategic use of these systems. Other relevant studies discussed in this section include material requirements planning (MRP), electronic data interchange (EDI), and integration of multiple systems deemed relevant to ERP system implementing firms.

The various descriptive studies in this section have been chosen for discussion based on their pertinence to this research study's objectives. These studies are representative of ERP descriptive literature and are described using a timeline-based approach. A cross-descriptive study comparison is undertaken at the end of this section to build support for a theory-driven ERP system implementation model.

ERP System Studies

Early descriptive literature discussed the initial issues confronting implementing firms such as the composition of the ERP system, the CSFs to ensure implementation success, and the early benefits that accrue to firms from their deployments. Typically these studies focused on implementation activities and there is minimal coverage of system integration and usage issues. This is due to the implementing firms' focus on ensuring Y2K compliance.

Studies indicate that firms generally deploy a few modules and sub-modules that automate key functional areas such as finance, human resources, and logistics (Hernandez, 1998; Raghuraman, 1999; Sastry, 1999). Hernandez (1998) suggests that firms implement modules such as financial accounting, controlling, enterprise controlling, investment management, treasury management, personnel administration, personnel development, general logistics, materials management, plant maintenance, production planning, project system, quality management, sales and distribution, business workflow, office, and archive link.

Miller (1999) and Sadagopan (1999) indicate that successful early implementers then deploy additional modules to bring key inter-firm business activities under the purview of the ERP system. Miller (1999) suggests that firms typically implement extension modules such as supply chain management (SCM), customer relationship management (CRM), electronic-commerce (E-Commerce), and advanced planner and optimizer/advanced planner and scheduler (APO/APS). Firms also Web-enable their implementations to facilitate greater integration of business activities across the supply chain.

Studies indicate that firms use CSFs to ensure success of their ERP system implementations (Karakanian, 1999; Kochan, 1999; Raghuraman, 1999; Sastry, 1999). Karakanian (1999) suggests that CSFs are an integral part of a firm's successful ERP system deployment strategy. Firms should plan their implementations so that all relevant CSFs, such as integration, implementation team, resources, visibility and profile, technical system details, user involvement, consultants, implementation schedules, training, learning, and post-implementation issues, are taken care of at the project initiation stage itself.

As firms extended their ERP systems, studies indicate that firms institute organizational changes in parallel with their technical deployments to achieve successful implementations (Bingi et al., 1999; Padmanabhan, 1999; Sweat, 1999). Bingi et al. (1999) emphasizes the importance of firms using a balanced mix of organizational and technical CSFs for ensuring successful ERP system implementations. The findings from their study suggests that firms focus on CSFs such as top management commitment, planning, alignment (reengineering firms' processes with those of the ERP system), consultants, skilled project team, implementation rollout strategy, employee buy-in, communication, cultural changes, data integrity, and training. The effective handling of CSFs confers competitive advantages to firms by enabling them to leverage the information from their ERP systems to streamline their operations, add to profit margins through efficiency gains, and increase customer satisfaction levels.

Caldwell (1998), Menezes (1999), and Rajani (1999) indicate that the benefits of fully functional ERP systems are realized 1 to 3 years after implementation. Caldwell (1998) suggests that firms suffer an initial 3 to 9 month productivity dip after the ERP system "goes live." This is overcome by redefining jobs, establishing new procedures, and fine-tuning the ERP system. The next stage, which lasts from 6 to 18 months, involves structural changes, process integration, and implementing extensions to the ERP system. The resulting streamlining of operations and effective system usage helps firms achieve quick return on investment (ROI) as well as reap efficiency benefits. The third stage, of 1 to 2 years duration, involves organizational transformation, where the synergies of people, process, and technology results in increased customer satisfaction and competitive advantages to firms.

Later descriptive literature is more general in nature in describing the components and configurations of ERP systems. Studies also focused on specifying CSFs that firms should emphasize to ensure implementation success. Faced with increasing time and budget overruns, most firms still focused on implementation issues and tended to follow a CSF-based approach to guide their deployments.

Studies indicate that ERP systems are comprised of integrated modules that support intra-firm and inter-firm business activities (Appelrath & Ritter, 2000; Boss Corporation, Crum, & Others, 2000; Meissner, 2000; Siriginidi, 2000). Appelrath and Ritter (2000) suggest that firms implement those ERP system modules, which ensure the availability of full system functionality for meeting all their business needs. The modules that firms implement are financial accounting, treasury, controlling, investment management, project system, enterprise controlling, sales and distribution, materials management, quality management, plant maintenance, production planning, logistics, personnel management, computer aided design (CAD) integration, computer aided test tool (CATT), open information warehouse (OIW), application link enabling (ALE), operation system platform, database platform, and front end services. Appelrath and Ritter further suggest that firms implement add-on modules to serve their specific business needs such as business information warehouse and APO/APS.

Ayers (2001), Chen (2001), and Shields (2001) indicate that firms expand the scope of their implementations by Web-enabling their ERP systems to facilitate self-service usage and link their supply chain activities so as to obtain increased performance benefits. Shields (2001) suggests that firms Web-enable their implementations when they implement extension modules such as SCM, CRM, EDI, B2B (business to business), B2C (business to consumer), data warehouses, and executive information systems (EIS). This is due to the growing realization among firms that full integrated system deployment across the supply chain and effective system usage would help garner synergistic benefits.

In an effort to ensure successful implementations, most firms did not pay adequate attention to managing organizational and people issues across the ERP implementation cycle (Comerford, 2000; Chen, 2001; Romeo, 2001; Weston Jr., 2001). Chen (2001) emphasizes effective management of all ERP system issues, from the pre-implementation to the post-implementation stages. He suggests that firms focus on issues such as assessing needs and choosing the right ERP system, aligning their business processes to the ERP system, and use CSFs such as top management support, implementation team, user support, culture changes, and continuous learning to facilitate the implementation process. He further suggests that firms which effectively use their ERP system can leverage information output and experience early efficiency gains. Firms can then consolidate their implementations to achieve enhanced benefits.

Instead of focusing on individual CSFs, studies indicate that firms developed unified CSF models to ensure smooth ERP system deployments (Al-Mashari & Zairi, 2000; Sousa & Collado, 2000; Nah et al., 2001). Sousa and Collado (2000) classify CSFs into four categories. The first one is organizational-strategic with CSFs like management support, organizational change management, project scope management, project team composition, business process engineering (BPR), user involvement, project champion, and trust between partners. The second category is organizational-tactical and comprises of CSFs such as dedicated staff and consultants, internal and external communication, formal project plan and schedules, training, preventive maintenance, effective use of consultants, and empowered decision makers. The third one describes technological-strategic CSFs like implementation strategy, minimal customization, and relevant ERP version. The last category includes technological-tactical CSFs such as software configuration and legacy system knowledge.

Recent literature focuses on firms implementing extensions to their ERP systems, which are referred to as enterprise resource planning II (ERP II) systems. Firms emphasized CSFs required for the maintenance and successful deployment of these complete ERP systems. Firms also sought to consolidate and build on the early benefits derived from their implementations.

Lall (2003) and Satyan (2003) indicate that firms emphasize appropriate CSFs for their holistic implementations as their focus shifted to operational and usage rather than deployment issues. Lall (2003) suggests that firms facilitate extended ERP system implementation by focusing on CSFs such as planning, project management (breaking the projects into smaller and manageable pieces), change management, training, implementation rollout strategy, alignment between business processes and the ERP system (through minimal customization), detailed documentation, use of a project champion to spearhead the project, a balanced implementation team, and the use of external consultants closely involved with the project at all stages.

Studies indicate that firms consolidate early benefits and leverage their CSFs to obtain increased benefits from their ERP systems (Adams, 2002; Drayer & Wight, 2002; Evgeniou, 2002; Al-Mashari et al., 2003). Evgeniou (2002) suggests that firms align their ERP systems to dynamic environments by balancing their standardization and integration needs to achieve flexibility and visibility of operations. This top management driven process results in early efficiencies and quick ROIs, and also confers competitive advantages to firms through increased availability of real-time information for local flexibility and global visibility.

Wyatt (2002), Dataquest (2003) and Satyan (2003) indicate that firms obtain synergistic benefits when they extend the ERP system across the supply chain to deploy a complete ERP system. Dataquest (2003) suggests that early ERP adopters expand their ERP systems by implementing modules such as SCM, CRM, and product data management (PDM). The extended ERP system enables firms to consolidate and enhance operational benefits such as consistency and reliability of data, a reduction in inventory and non-performing assets, streamlined transaction processing, operations-level reporting, and integrated financial information.

Other Relevant Studies

Various studies examined system implementations such as MRP, EDI, and hybrid application systems and the findings from these studies suggest that the issues discussed are pertinent to ERP implementing firms.

Miller and Sprague (1975) suggest that successful implementation of MRP systems depends on the existence of a good organizational support system, adequate employee skill-sets, and top management commitment. The successful MRP system implementers obtain benefits over a number of years such as increased information availability, expediting and de-expediting to ensure on-time deliveries, keeping inventories low, short-term materials management, long-term budgeting and reporting, and increased user satisfaction.

In another study, Gupta and Neel (1992) address EDI implementation issues. They analyze the organizational changes that result from EDI deployment. Their study’s findings suggest that the use of EDI has become a competitive necessity for firms as it has expanded beyond its traditional role in ordering and purchasing into areas such as just-in-time (JIT) inventory, transferring funds, and electronic authorizations. This in turn has triggered organizational changes that firms should effectively manage in order to benefit from EDI implementations. Firms have to retrain workers as demand for EDI skills go up, control methods have to be instituted as the use of EDI results in lack of paper audit trails, and increased information visibility along the supply chain requires paying attention to data integrity at the source.

Hsieh and Kleiner (1992) suggest that firms realize enhanced benefits by integrating multiple application systems. Their study examined the performance benefits of integrating MRP and JIT systems. The findings suggest that both MRP and JIT leverage information and emphasize the integration and the coordination of manufacturing and various interfacing activities. Further, MRP supports JIT and by linking these two together a firm can achieve zero inventories, which is the main objective of JIT.

Summary

A review of ERP system as well as other relevant studies discussed in this section suggests that most early ERP system implementers focused mainly on adopting the right ERP system, stressing CSFs to facilitate rapid implementation rollout strategies, and evaluating the early benefits derived from successful implementations. Firms stabilized and then extended their ERP systems to include more and more intra and inter-firm activities in order to enhance performance benefits. Firms also started fine-tuning their systems as they realized that synergistic benefits flow from complete system usage over a number of years. As many technically successful implementations did not garner expected benefits, firms sought to manage organizational issues in parallel with their technical implementations to derive desired performance benefits. This suggests that firms that successfully incorporate CSFs into their ERP implementation process will maximize their ERP system benefits.

Table 1 represents a cross-study comparison of ERP system modules described in the descriptive studies. As many of the studies limited their discussion to a few specific modules of the ERP system, the studies referenced in the table have been chosen for their wide coverage of the modules comprising the ERP system.

Table 1
A Cross-Study Comparison of ERP Modules Described in Descriptive Studies

Modules	Descriptive Studies													
	ERP Studies													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Summary
Financials	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc		GS
Controlling	Desc	Desc		Desc		Desc		Desc	Desc		Imp			GS
Materials Management	Desc	Desc	Desc	Desc		Desc	Desc	Desc	Desc		Desc	Desc		GS
Production Planning	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc		Desc	Desc		GS
Project System	Desc	Desc		Desc		Desc		Desc	Desc		Desc			GS
Sales and Distribution	Desc	Desc	Desc	Desc	Desc	Desc		Desc	Desc		Desc	Desc		GS
General Logistics	Desc	Desc		Imp	Imp	Desc	Desc	Desc	Desc		Desc	Desc		GS
Quality Management	Desc	Desc		Desc		Desc		Desc	Desc		Desc			GS
Human Resources	Desc	Desc			Desc	Desc	Desc	Desc	Desc		Desc	Desc		GS
Supply Chain Management		Desc		Desc	Imp					Desc	Desc	Desc	Desc	GS
Customer Relationship Management		Desc					Desc			Desc	Desc	Desc	Desc	LS
Plant Maintenance	Desc	Desc				Desc		Desc	Desc					LS
E-Commerce		Desc		Desc								Desc		LS
Advanced Planning Optimization/Advanced Planning Scheduling		Desc				Desc			Desc	Desc	Desc			LS
Management Information System				Desc					Desc					LS
Product Data Management		Desc								Desc			Desc	LS

Studies Referenced

(1) Hernandez (1998)
(2) Miller (1999)
(3) Raghuraman (1999)
(4) Sadagopan (1999)
(5) Sastry (1999)
(6) Appelrath and Ritter (2000)
(7) Boss Corporation et al. (2000)
(8) Meissner (2000)
(9) Siriginidi (2000)
(10) Ayers (2001)
(11) Chen (2001
(12) Shields (2001)
(13) Dataquest (2003)

Note

Desc = Described as a module of the ERP system.
Imp = Implied as a module of the ERP system (not directly described).
GS = Good support for inclusion as a module of the ERP system (module referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a module of the ERP system (module referenced in less than 50% of studies in the table).

Most of the research studies in this section describe the modules comprising the ERP systems provided by a cross-section of ERP system vendors. These studies, depending upon the ERP system vendor they focus on, use different terminologies and module descriptions to describe the ERP system. Hence, the studies presented in the table are synthesized to ensure consistency in the use of terminology and module descriptions in describing ERP systems. A few studies referenced in the table do not directly describe some of the ERP system modules but implicitly refer to them. The findings from such studies are denoted by the term 'Imp' in the table to refer to the implied reference made by researchers in describing these modules. The 16 modules considered to comprise the ERP system, described in a cross-study comparison of descriptive studies, are given in the table. The modules that are referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as modules of the ERP system. Also, the modules that are referenced in less than 50% of the studies are classified as having low support for their inclusion as modules of the ERP system.

It can be inferred from a perusal of the table and the studies described in this section that most early descriptive studies described modules that automated key business areas such as financials, materials management, production planning, and sales and distribution. Many of these firms also focused on sub-module implementations such as purchasing and inventory management (materials management module), investment management and treasury management (financials) and MRP (production planning module). In later and recent descriptive literature there is an increased, albeit limited, coverage of modules such as SCM and CRM that extend the ERP system to cover inter-firm activities. The studies discussed in this section also indicate that firms implement add-on modules such as APO/APS to support key business areas when extending their systems across the supply chain. There is not much exposure among firms, however, to add-on modules like PDM as these are relatively firm-specific and are deployed once firms stabilize their partial ERP system deployments.

Table 2 represents a cross-study comparison of CSFs considered crucial in facilitating the implementation of ERP systems. Most of the research studies in this section describe CSFs that are essential for achieving ERP system implementation success. Many of the studies in the table limit their discussion to a few specific CSFs. Hence, the studies referenced in the table have been chosen for their wide exposition of the CSFs essential for facilitating successful ERP system deployment. Also, most studies explicitly describe the CSFs that firms should focus on to ensure ERP system deployment success. A few studies referenced in the table, however, do not explicitly discuss some of the CSFs but imply that their management is crucial for implementation success. The findings from such studies are denoted by the term ‘Imp’ in the table to refer to the implied reference made by researchers in describing these CSFs.

The 14 CSFs considered essential for ensuring ERP system implementation success, described in a cross-study comparison of descriptive studies, are given in the table. The CSFs that are referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as CSFs in ERP system implementations. Also, the CSFs that are referenced in less than 50% of the studies are classified as having low support for their inclusion as CSFs in ERP system implementations. A review of the table and the studies discussed in this section reveals that most descriptive studies focused on CSFs emphasizing managerial issues such as top management support, planning, project management, and alignment. Some firms partially focus on certain CSFs like business case (planning), and steering committee (top management). Firms also stress CSFs that emphasize organizational issues like user support, training, learning, communication, user support, and organizational culture.

Table 2
A Cross-Study Comparison of CSFs Described in Descriptive Studies

Critical Success Factors	Descriptive Studies																
	ERP Studies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Summary
Top Management Support	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Imp	Desc	Desc	Desc	Desc		Desc			GS
Planning	Desc			Desc	Imp	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	GS
Project Management	Imp			Desc	Desc	Desc	Imp		Desc	Desc		Desc		Desc	Desc	Desc	GS
Alignment (BPR & Customization)	Desc	Desc		Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc			Desc	Imp	GS
Implementation Strategy	Desc	Desc	Desc	Imp	Imp		Desc	Desc		Desc		Imp	Desc			Desc	GS
Consultants	Desc	Desc			Desc		Desc	Desc	Desc	Desc		Imp	Desc		Desc		GS
Implementation Team	Desc	Desc	Desc	Imp	Imp				Desc	Desc	Desc	Desc	Desc		Desc		GS
Data Accuracy	Desc	Imp		Imp	Imp	Desc						Imp	Desc			Desc	GS
User Support	Imp	Desc	Desc	Desc	Desc	Imp	Desc	Desc		Desc	Desc	Imp		Imp	Imp	Imp	GS
Training	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc		Desc		Desc	Desc	Desc	Desc		GS
Learning	Imp	Desc	Desc		Imp			Desc	Desc		Desc		Desc		Imp		GS
Organizational Culture	Desc	Imp	Desc	Desc	Imp			Desc			Desc	Desc		Imp			GS
Communication	Desc	Desc		Imp	Desc		Desc	Desc		Desc	Imp	Desc		Desc			GS
National Culture	Desc							Imp									LS

Studies Referenced

(1) Bingi et al. (1999)
(2) Karakanian (1999)
(3) Kochan (1999)
(4) Padmanabhan (1999)
(5) Raghuraman (1999)
(6) Sastry (1999)
(7) Sweat (1999)
(8) Al-Mashari and Zairi (2000)
(9) Comerford (2000)
(10) Sousa and Collado (2000)
(11) Chen (2001)
(12) Nah et al. (2001)
(13) Romeo (2001)
(14) Weston Jr. (2001)
(15) Lall (2003)
(16) Satyan (2003)

Note

Desc = Described as a CSF in ERP system implementation.
Imp = Implied as a CSF in ERP system implementation (not directly described).
GS = Good support for inclusion as a CSF in ERP system implementation (CSF referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a CSF in ERP system implementation (CSF referenced in less than 50% of studies in the table).

The table indicates that there is good support for technical issues such as implementation strategy, implementation team, data accuracy, and consultants. The table further reveals that most studies do not address implementation challenges arising out of cross-border rollouts of the ERP system.

Table 3 represents a cross-study comparison of changes in performance that result from successful ERP system deployments. Most of the research studies in this section describe the changes in performance that are essential for achieving ERP system implementation success. As many of these studies limit their discussion to a few specific performance changes, the studies referenced in the table have been chosen for their wide coverage of the changes in performance experienced by firms that had successfully deployed ERP systems. Besides the changes in performance obtained from a review of ERP studies, changes in performance from other relevant studies deemed pertinent to ERP system implementing firms have also been included in the table. Also, most studies listed in the table explicitly describe the performance changes that firms obtain from their ERP system deployment. Many of these studies, however, do not explicitly discuss some of the performance changes but imply that these are benefits that firms obtain from their ERP systems. The findings from such studies are denoted by the term 'Imp' in the table to refer to the implied reference made by researchers in describing these performance changes.

The 11 performance measures for assessing ERP system implementation success, described in the cross-study comparison of descriptive studies, are given in the table. The performance measures referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as performance measures in ERP system implementations. Also, the performance measures referenced in less than 50% of the studies are classified as having low support for their inclusion as performance measures in ERP system implementations.

Table 3
A Cross-Study Comparison of Changes in Performance Described in Descriptive Studies

Performance	Descriptive Studies													
	ERP Studies										Other Relevant Studies			
	1	2	3	4	5	6	7	8	9	10	11	12	13	Summary
Information Availability	Desc	Desc	Desc	Imp	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	GS
Information Quality	Imp			Desc		Desc		Desc		Desc		Desc	Desc	GS
Standardization	Imp	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Imp	Desc		Imp		GS
Integration	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Desc	Imp	Imp	Desc	Desc	Desc	GS
Inventory Management	Desc	Desc		Imp	Desc		Desc	Imp	Desc	Desc	Desc	Desc	Desc	GS
On-time Delivery		Desc		Imp	Desc		Imp	Desc	Imp		Desc	Imp	Imp	GS
Profitability	Desc	Desc		Imp	Desc	Desc	Desc		Desc			Desc	Desc	GS
Return on Investment	Desc		Imp		Imp	Imp	Imp	Desc				Imp		GS
Customer Satisfaction	Desc	Desc		Imp	Desc		Imp	Imp	Imp			Imp	Desc	GS
Competitive Advantage	Desc	Desc			Desc		Imp	Desc				Desc	Imp	GS
User Satisfaction	Desc					Imp	Imp		Imp		Imp		Imp	LS

Studies Referenced

(1) Caldwell (1998)
(2) Bingi et al. (1999)
(3) Menezes (1999)
(4) Rajani (1999)
(5) Chen (2001)
(6) Adams (2002)
(7) Drayer and Wight (2002)
(8) Evgeniou (2002)
(9) Wyatt (2002)
(10) Dataquest (2003)
(11) Miller and Sprague (1975)
(12) Gupta and Neel (1992)
(13) Hseih and Kleiner (1992)

Note.

Desc = Described as a performance measure in ERP system implementation.
Imp = Implied as a performance measure in ERP system implementation (not directly described).
GS = Good support for inclusion as a performance measure in ERP system implementation (performance measure referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a performance measure in ERP system implementation (performance measure referenced in less than 50% of studies in the table).

Case Studies

From an analysis of the table as well as studies discussed in this section it can be inferred that most studies focused on informational benefits such as standardization and information availability. Firms consolidate these informational benefits and streamline their operations thus realizing transactional improvements in areas like inventory management and on-time delivery. The table as well as the studies discussed further show that firms obtained benefits such as customer satisfaction, profitability, and competitive advantage. Firms also obtained partial benefits throughout their implementation process like cost savings, personnel, and productivity, all of which can be classified under the profitability performance measure.

Most empirical work in the area of ERP systems is limited to case studies. Early and later case studies typically examine implementation issues to identify specific CSFs and also classify them into frameworks. Recent literature indicates that firms have shifted their focus from implementation issues to effective system usage and module integration in order to leverage the full potential benefits of their ERP systems. Other relevant studies discussed in this section include MRP, EDI, and integration of multiple application systems. These studies are relevant to ERP system implementing firms and pertinent in the context of this research study's objectives.

The analysis of case studies in this section is guided to the extent possible by Eisenhardt's (1989) study on theory building from case studies. The case studies in this section were largely selected based on their ERP system implementation focus and pertinence to the study's research questions. These studies are representative of ERP case study literature and are discussed using a time-based outline. A cross-case study comparison is undertaken at the end of this section to build support for a theory-driven ERP system implementation model.

ERP System Studies

Early case study literature identified and classified the CSFs for implementation success and listed early benefits by analyzing specific cases of firms that had deployed ERP systems. As firms realized that their implementations involved changes in organizational structures, processes, and work designs, they focused on CSFs that addressed these issues to obtain early benefits.

Davenport (1998) examines the strategic implications of deploying a complete ERP system. In a case study analysis of a multinational ERP system implementation, he indicates that a planned top management driven and user supported implementation strategy is crucial for ensuring technical and organizational changes as well as ERP system-business alignment. His study demonstrates that benefits from successful implementations include the standardization and integration of processes, increase in customer satisfaction and gaining of competitive advantage due to leveraging of real-time accurate information, and increase in profitability owing to savings in costs due to reduced levels of inventory, receivables, and labor.

Dataquest (1998) analyzes the implementation of an ERP system in a textile firm. The key CSFs for a successful deployment include project management, customization to suit industry and firm specific needs, continuous training programs, communication, change management programs, top management support, project steering committee, and external consultants. The firm used the real-time and accurate information available from the ERP system to strength its supply chain activities, improve customer order planning and execution, and standardize and integrate its business processes.

Cameron and Meyer (1998) investigate two ERP system deployments – one a failure and the other a success. Their study suggests that CSFs can make or break implementations; the key CSFs for successful deployment being planning, top management commitment, business process skills, information technology (IT) skills, project management, training, and change readiness. Holland and Light (1999) also use cross-study comparisons to identify CSFs for successful ERP system deployment. They develop a general CSF model comprised of two components. The first component – strategic factors – comprises of legacy systems, implementation strategy, customization, business vision, ERP strategy, top management support, project management, culture, communication, and planning. The second component – tactical factors – consists of client consultation, personnel, consultants, business process change and software configuration, business-ERP alignment, training, user support, client acceptance, monitoring and feedback, communication, and troubleshooting. Their study suggests that this CSF model helps firms successfully plan and implement their ERP system projects.

In another case study, Kharbanda (1999) indicates that people and processes are the main factors that ensure success or failure of ERP system projects. He suggests that CSFs such as planning, project management, user support, implementation team, consultants, and ERP system-business alignment are important in ensuring successful implementations. Further, firms obtain early benefits from their ERP systems like availability of real-time information, standardization of processes, rationalization of manpower, integration, transparent working, and faster decision-making.

Later case study literature largely examines implementation issues and operational and strategic usage issues that were earlier not accorded much importance. Various studies suggest that firms focused on classifying CSFs into ERP life cycle models to better manage their ERP system implementation process. As firms deployed ERP systems across their worldwide operations, culture and configurational issues gained increasing importance.

Madhavan (2000) examines the ERP system implementation in a multinational firm that implemented modules such as production planning, financials, sales and distribution, inventory control, quality management, payroll, logistics, and materials management. He suggests that successful deployments result in benefits such as information availability and quality, integration of processes, inventory management, on-time delivery, productivity, customer satisfaction, cost savings, accurate forecasts, and capacity utilization. In another case study, Kennerley and Neely

(2001) suggest that firms focus on effective change management programs to quickly reap the early benefits of implementations. They identify early benefits as improved efficiency and control, reduced inventories, cross-country capacity utilization, increased leverage on suppliers, and improved planning.

Markus, Axline, Petrie, and Tanis, C. (2000) and Parr and Shanks (2000a) indicate that firms emphasize different CSFs in different stages of their ERP system deployment process to obtain increased performance benefits. Markus et al. (2000), in a cross-country case study analysis of 16 firms, identify and classify CSFs into three phases of a four-phase ERP life cycle model – chartering, project, shakedown, and enhancement). The CSFs in the project phase are minimizing customization, planning for system integration, use of consultants, and coordinating between key players in the implementation team. In the shakedown phase, the CSFs include adopting a process approach to implementation, implementing according to project scope, providing end user training to obtain employee buy-in, ensuring testing is done before going live, undertaking BPR, and ensuring data quality. The CSFs in the enhancement phase consist of having performance metrics in place to evaluate improvements due to ERP implementation, developing human capital, and reducing integration problems by minimizing customization. The phased management of CSFs helps firms quickly consolidate operational benefits and increase their profitability and customer satisfaction levels.

Firms faced configuration and cultural compatibility problems when they expanded their ERP system implementations across their global operations (Soh, Kien, & Tay-Yap, 2000; Koch, 2001). In his case study analysis, Koch (2001) identifies the modules comprising the ERP system as finance (financial management, controlling, treasury, EIS, business information warehouse), logistics (materials management, production planning, plant maintenance, sales and distribution), and others (human resources, quality management, project system, workflow). He suggests that configurational alignment of the ERP system enhances standardization and integration, and impacts the firm's bottom-line. The first configurational step concerns the overall design of the system, which is a model of the overall firm. The second one involves the design of business activities such as finance and logistics. The third step consists of user profiles, parameters, business processes that are either default settings or customized. The last one concerns supplementary programming for extensions.

Recent case study literature continues to be dominated by implementation issues as firms focused on extending their ERP systems and classifying CSFs to ensure successful ERP system implementations. There is also evidence of growing consolidation of early ERP benefits as firms strived to fine-tune their existing systems and implement extensions.

Studies indicate that firms obtain enhanced performance benefits when they undertake continuous organizational changes as they implement more and more modules of the ERP system (Legare, 2002; Pasha, 2003; Teltumbde, Tripathy, & Sahu, 2002; Barker & Frolick, 2003). Teltumbde et al. (2002) analyze the ERP system implementation in an oil producing firm. The modules implemented in this firm are financials, controlling, materials management, quality management, production planning, sales and distribution, plant maintenance, project system, human resources, and taxation. They emphasize CSFs such as top management support, planning, alignment, project management, user support, consultants, implementation team, data integrity, implementation strategy, training, communication, learning, and culture as necessary in ensuring successful ERP system deployment. Their findings suggest that effective handling of these CSFs would enable firms to leverage information from the ERP system and quickly reap early benefits and increase their ROI.

Literature indicates that firms emphasize different CSFs in different stages of the ERP implementation process (Sarker & Lee, 2002; Kumar et al., 2003). Kumar et al. (2003) restrict their examination of the importance of CSFs to the project and the shakedown phases of the ERP deployment process. The CSFs identified in the project phase are the selection of a competent project manager and implementation partners, planning, implementation team composition, project management, training, configuration and alignment, testing and quality assurance, and organizational change. In the shakedown phase, the CSFs stressed are training ensure buy-in, minimal customization, adequate testing, data quality, increased communication of benefits, and planning for maintenance and post-implementation activities.

Nandhakumar, Rossi, and Talvinen, J. (2002) and Worthen (2002) indicate that firms should maintain focus on effectively managing their CSFs as they implement module extensions and rollout their ERP systems across global locations. Nandhakumar et al. (2002) analyze the experiences of a multinational firm that had extended and Web-enabled its ERP system to include supply chain partners and customers. The modules implemented by the firm are financials, maintenance, materials management, project system, sales and distribution, human resources, SCM, CRM, and E-Commerce. Their study's findings suggests that the firm viewed its implementation as an organizational cultural change management process, driven by top management, and facilitated by employee buy-in. Detailed planning and ongoing communication of project status underscored the firm's external consultant driven phased implementation effort. Their findings further suggest that the continued focus on organizational factors while extending their ERP system enabled the firm to leverage its standardized and integrated processes and increase its profitability.

Firms sought to consolidate early gains from their ERP systems by leveraging the knowledge gained from their partial global deployments while implementing module extensions (Ash & Burn, 2003; Sarkis & Sundarraj, 2003; Zhang, Lee, Huang, Zhang, & Huang, 2005). Sarkis and Sundarraj (2003), in their case study analysis of a global electronic-ERP (e-ERP) implementation rollout, stress the importance of effectively managing change management factors to leverage E-Commerce and open system capabilities and achieve implementation success. The firm used a three-phased rapid implementation technique comprising of start-up, project management, and going live. The going live phase in turn was comprised of stages such as prototype, implementation of major modules such as finance and procurement, switchover to the global planning system, and the implementation of other modules such as sales, logistics, and marketing. The key CSFs identified are strategic planning, alignment, top management support, user support, user satisfaction, training, cultural changes, implementation team skills, project champion, standardization and integration, external partners, and the use performance metrics. Their study's findings suggests that after an initial productivity dip, the ERP system stabilized to give early benefits like inventory reductions followed by financial benefits over the long-term.

Other Relevant Studies

Many research studies examined implementation related issues in MRP and EDI deploying firms as well as firms that integrated multiple systems such as JIT and SCM. These other system studies indicate the importance of firms instituting organizational changes by focusing on CSFs in parallel with their technical system implementations. The implementation process adopted, the CSFs stressed, and the changes in performance evaluated in these other relevant studies are pertinent to ERP implementing firms.

Harold (1997) examines the implementation of EDI and indicates that a formal planning process, which incorporates performance metrics, clear-cut goals, and project scope, is essential to the success of adoption of EDI by firms. His study's findings suggests that the benefits that flow from successful EDI implementations pertain mostly to the procurement area such as reduction in material costs, reduction in material cycle time, and supplier consolidation.

Anderson and Schroeder (1984) and Sheldon (1994) use case study analyses to suggest guidelines for MRP and manufacturing resource planning (MRP II) system deployments. Anderson and Schroeder (1984) suggest that firms focus on CSFs such as top management commitment, planning, project management, communication, training, and education for the end users to ensure implementation success. The benefits from successful implementations are data and information accuracy; improved inventories, lead times, deliveries, customer satisfaction; and improved ROI, and profits. Their study's findings suggest that synergistic benefits from MRP systems accrue to the firm when the full functionality of the system is implemented.

Summary

A synthesis of ERP system and other relevant studies discussed in this section reveals that firms initially implement a few modules that address their key business areas. When these partial implementations stabilize, firms implement additional modules and add-ons to extend their ERP systems to cover more and more intra and inter-organizational processes. Firms also constantly fine-tune their system usage over time. As firms consolidate and build on their early implementation successes they obtain synergistic benefits when they implement the complete or holistic ERP system. A review of the case studies discussed also suggests that firms enhance their implementation successes when they undertake organizational changes in tandem with their technical deployments. Thus, firms that are able to successfully leverage their CSFs over the ERP life cycle maximize the benefits that flow from their implementations.

Table 4 represents a cross-study comparison of ERP system modules identified in the case studies discussed above. As many of the studies limit their discussion to a few specific modules of the ERP system, the studies referenced in the table have been chosen mainly for their wide coverage of the modules comprising the ERP system.

Table 4
A Cross-Study Comparison of ERP Modules Referred to in Case Studies

Modules	Case Studies											
	ERP Studies											
	1	2	3	4	5	6	7	8	9	10	11	Summary
Financials	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl	GS
Controlling	Impl	Impl			Imp	Imp		Impl		Impl		GS
Plant Maintenance	Impl	Imp	Impl	Impl			Impl	Impl		Impl		GS
Materials Management	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl	Impl		Impl	GS
Production Planning	Impl	Impl		Impl	Imp	Impl		Impl		Impl		GS
Sales and Distribution	Impl	Impl	Impl	Impl	Imp	Impl	Impl	Impl	Impl	Impl	Impl	GS
Human Resources	Impl	Impl		Impl	Impl	Impl	Impl	Impl		Impl		GS
Supply Chain Management	Imp					Impl	Impl	Imp	Impl		Imp	GS
Project System				Impl		Impl	Impl	Impl		Impl		LS
General Logistics	Impl			Imp	Imp		Imp				Impl	LS
Quality Management	Impl	Impl		Impl				Impl		Impl		LS
Customer Relationship Management	Imp						Impl				Imp	LS
E-Commerce						Impl	Impl	Imp			Impl	LS
Advanced Planning Optimization/Advanced Planning Scheduling								Imp				LS

Studies Referenced

(1) Davenport (1998)
(2) Madhavan (2000)
(3) Parr and Shanks (2000a)
(4) Koch (2001)
(5) Barker and Frolick (2002)
(6) Legare (2002)
(7) Nandhakumar et al. (2002)
(8) Teltumbde et al. (2002)
(9) Worthen (2002)
(10) Pasha (2003)
(11) Sarkis and Sundarraj (2003)

Note

Impl = Implemented as a module of the ERP system.
Imp = Implied as a module of the ERP system (not directly identified).
GS = Good support for inclusion as a module of the ERP system (module referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a module of the ERP system (module referenced in less than 50% of studies in the table).

Most of the research studies in this section identify the modules comprising the ERP systems provided by a cross-section of ERP vendors. These studies, depending upon which ERP system vendor they focus on, use different terminologies and module descriptions to identify the ERP system. Hence, the studies presented in the table are synthesized to ensure consistency in the use of terminology and module descriptions in identifying ERP systems. A few studies referenced in the table do not directly identify some of the ERP system modules but implicitly refer to them. The findings from such studies are denoted by the term 'Imp' in the table to refer to the implied reference made by researchers in identifying these modules.

The 14 modules considered to comprise the ERP system, identified in a cross-study comparison of case studies, are given in the table. The modules that are referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as modules of the ERP system. Also, the modules that are referenced in less than 50% of the studies are classified as having low support for their inclusion as modules of the ERP system.

It can be inferred from a perusal of the table and studies discussed in this section that most firms implemented the following modules - financials, materials management, and sales and distribution - that automated key business areas of the firm. There is limited implementation of modules such as quality management, project system, and general logistics. Many of the case study firms also implemented sub-modules like order management and marketing (sales and distribution module), payroll (human resources module), and purchasing and inventory management (materials management module). The findings from the table further suggest that firms initially extend their ERP systems to cover their supply chain activities before considering customer-targeted activities.

Table 5 represents a cross-study comparison of CSFs considered essential for facilitating the implementation of ERP systems. The studies referenced in the table have been chosen for their wide coverage of the CSFs identified in specific case study firms.

Table 5
A Cross-Study Comparison of CSFs Referred to in Case Studies

Critical Success Factors	Case Studies																	
	ERP Studies															Other Relevant Studies		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Summary
Top Management Support	Iden	Iden	Iden	Iden		Imp	Iden	Imp	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Imp	GS
Planning	Iden		Iden	Iden	Iden	Iden	Iden	Imp	Iden	Iden		Iden	Iden	Iden		Iden	Iden	GS
Project Management	Iden	Iden	Imp	Iden	Iden	Imp	Iden		Iden	Imp	Imp	Iden	Iden	Iden	Iden	Imp		GS
Alignment (BPR & Customization)	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden		Iden	Iden	Iden	Iden			GS
Implementation Strategy	Iden		Iden	Iden	Imp	Iden	Iden		Iden	Iden	Iden	Iden	Imp	Iden				GS
Consultants	Iden	Iden		Iden	Iden	Iden	Iden	Imp	Iden	Iden		Iden	Iden	Iden				GS
Implementation Team	Iden		Iden	Iden	Iden	Iden	Iden	Imp	Iden	Iden	Iden	Iden	Iden	Iden				GS
Data Accuracy			Imp		Imp	Iden	Iden	Imp	Imp			Iden	Iden			Imp	Iden	GS
User Support	Iden	Imp	Iden	Iden	Iden	Iden	Imp	Imp	Iden	Iden		Iden	Iden	Iden	Iden	Imp		GS
Training	Iden	Iden		Iden		Iden	Imp	Iden	Imp	Imp		Iden	Iden	Iden	Iden	Iden	Iden	GS
Organizational Culture	Iden	Imp	Iden	Iden		Imp	Imp	Imp	Imp	Iden	Iden	Iden	Imp	Iden	Iden			GS
National Culture			Imp	Iden			Imp	Iden		Iden		Iden	Imp	Iden	Iden			GS
Communication	Iden	Iden		Iden		Imp	Imp	Imp	Iden	Iden	Iden	Iden	Iden	Imp		Iden	Iden	GS
Learning						Iden	Iden	Iden	Imp			Iden	Imp			Iden	Iden	LS

Studies Referenced

(1) Cameron and Meyer (1998)
(2) Dataquest (1998)
(3) Davenport (1998)
(4) Holland and Light (1999)
(5) Kharbanda (1999)
(6) Markus et al. (2000)
(7) Parr and Shanks (2000a)
(8) Soh et al. (2000)
(9) Legare (2002)
(10) Nandhakumar et al. (2002)
(11) Sarker and Lee (2002)
(12) Teltumbde et al. (2002)
(13) Kumar et al. (2003)
(14) Sarkis and Sundarraj (2003)
(15) Zhang et al. (2005)
(16) Anderson and Schroeder (1984)
(17) Sheldon (1994)

Note

Iden = Identified as a CSF in ERP system implementation.
Imp = Implied as a CSF in ERP system implementation (not directly identified).
GS = Good support for inclusion as a CSF in ERP system implementation (CSF referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a CSF in ERP system implementation (CSF referenced in less than 50% of studies in the table).

Most studies in the table explicitly identify the CSFs that firms focus on to ensure ERP system deployment success. A few studies referenced in the table do not explicitly identify some of the CSFs but imply that their management is essential for implementation success. The findings from such studies are denoted by the term ‘Imp’ in the table to refer to the implied reference made by researchers in identifying such CSFs. Besides the CSFs identified from ERP system studies, CSFs from other relevant studies deemed pertinent to ERP system implementing firms have also been included in the table.

The 14 CSFs considered essential for ensuring ERP implementation success identified in a cross-study comparison of case studies are given in the table. The CSFs that are referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as CSFs in ERP system implementation. Also, the CSFs that are referenced in less than 50% of the studies are classified as having low support for their inclusion as CSFs in ERP system implementation. A review of the table as well as studies discussed earlier in this section reveals that most firms accorded attention to managerial factors such as top management support, planning, and project management as well as organizational factors such as user support, communication, and organizational culture. The table further indicates that firms paid limited attention to factors such as learning.

Table 6 represents a cross-study comparison of changes in performance that result from the successful implementation of ERP systems. Many studies in this section discuss only a few performance changes identified among the case study firms. Hence, the studies referenced in the table have been chosen for their wide exposition of the changes in performance experienced by the chosen case study firms. Besides the changes in performance obtained from a review of ERP system studies, changes in performance from other relevant studies deemed pertinent to ERP system implementing firms have also been included in the table.

Table 6
A Cross-Study Comparison of Changes in Performance Referred to in Case Studies

Performance	Case Studies													
	ERP Studies											Other Relevant Studies		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Summary
Information Availability	Imp	Iden	Iden	Imp		Iden	Iden			Iden	Iden	Iden	Imp		GS
Information Quality	Iden	Iden	Imp	Iden		Iden	Iden				Iden	Imp	Iden		GS
Standardization	Iden	Iden	Iden	Imp	Iden	Imp	Iden	Iden	Iden	Iden	Iden	Iden	Imp		GS
Integration		Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	Imp	Imp	GS
Inventory Management		Iden		Iden	Iden	Iden	Iden		Imp	Iden	Iden	Iden	Iden	Imp	GS
On-Time Delivery	Imp	Iden	Imp				Imp		Imp		Imp	Iden	Iden	Imp	GS
Profitability		Iden	Iden	Iden	Iden		Iden	Iden	Iden	Iden	Iden	Iden	Iden	Iden	GS
Customer Satisfaction		Iden		Imp	Iden	Imp	Imp		Imp	Imp	Iden				GS
User Satisfaction					Imp	Iden	Iden				Imp	Iden	Imp	Imp	GS
Return on Investment							Iden			Iden		Iden	Iden	Iden	LS
Cycle Times		Iden		Imp	Iden						Iden	Iden		Iden	LS
Monitoring		Iden					Iden								LS
Capacity Utilization			Iden	Iden			Iden					Iden			LS
Competitive Advantage		Iden									Iden	Imp			LS

Studies Referenced

(1) Dataquest (1998)
(2) Davenport (1998)
(3) Kharbanda (1999)
(4) Madhavan (2000)
(5) Markus et al. (2000)
(6) Parr and Shanks (2000a)
(7) Kennerley and Neely (2001)
(8) Koch (2001)
(9) Nandhakumar et al. (2002)
(10) Teltumbde et al. (2002)
(11) Ash and Burn (2003)
(12) Sarkis and Sundarraj (2003)
(13) Anderson and Schroeder (1984)
(14) Harold (1997)

Note

Iden = Identified as a performance measure in ERP system implementation.
Imp = Implied as a performance measure in ERP system implementation (not directly identified).
GS = Good support for inclusion as a performance measure in ERP system implementation (performance measure referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a performance measure in ERP system implementation (performance measure referenced in less than 50% of studies in the table).

Most studies listed in the table explicitly identify a few of the performance changes that firms obtain from their ERP system deployment. Many of these studies, however, do not explicitly identify some of the performance changes but imply that these are benefits that firms obtain from their ERP systems. The findings from such studies are denoted by the term ‘Imp’ in the table to refer to the implied reference made by researchers in identifying these performance changes. The 14 performance measures considered necessary for measuring ERP implementation success identified in the cross-study comparison of case studies are given in the table. The performance measures that are referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as performance measures in ERP system implementation. Also, the performance measures that are referenced in less than 50% of the studies are classified as having low support for their inclusion as performance measures in ERP system implementation.

An analysis of the results in the table as well as the studies discussed in this section indicates that most case studies focused on visible benefits such as standardization, integration, and information availability. Some firms also indicate limited obtainment of benefits such as information visibility (information availability) and forecast accuracy (information quality). As these visible benefits result in the streamlining of operational areas, firms realize efficiency gains in inventory management, on-time delivery, and productivity.

It can be further inferred from the table that only few studies address benefits such as ROI, and profitability; though some firms report increases in cost savings, personnel and productivity that contribute to increases in profitability. The changes in performance obtained from other relevant studies pertaining to MRP and EDI system implementations suggest that these firms leveraged their early visible gains to attain long-term benefits.

Survey Studies

Survey studies on ERP system implementations generally indicate that firms accorded high priority to effectively managing their implementation process. Most firms used a CSF-based approach and carried out organizational changes in parallel with their technical implementations. As firms fine-tuned and expanded the scope of their implementations, they explored the use of various performance metrics to measure the benefits accruing from their ERP systems.

This section also examines other relevant studies that address the implementation of MRP, MRP II, JIT, EDI, and total quality management (TQM) systems. The findings from these studies suggest that they are relevant to ERP system implementers. The survey studies discussed in this section were largely selected based on their ERP system focus and pertinence to the study's research questions. These studies are representative of survey literature and follow a time-based outline. A cross-survey study comparison is undertaken at the end of this section to build support for a theory-driven ERP system implementation model.

ERP System Studies

Early survey research focused mainly on ERP system implementation issues. Various studies analyzed the implementation and usage experiences of firms. A number of researchers also investigated CSFs deemed important by firms in their implementation process as well as the benefits obtained from their ERP systems.

Mabert et al. (2000), Mabert et al. (2001a), and Mabert, Soni, and Venkataramanan (2001b) examine ERP system implementations among US manufacturing firms. Their studies suggest that significant performance benefits accrue to firms that focus on CSFs while deploying their ERP system. Mabert et al. (2000) collected data from 479 companies (response rate of 9.6% - 479/5000) using a validated instrument from respondents in managerial positions. Their findings suggest that the deployment time for ERP systems is about a year and is tied closely to the implementation methodology used and the amount of customization undertaken. The common modules implemented by firms were financial accounting, materials management, production planning, order entry, purchasing, financial control, distribution and logistics, asset management, quality management, personnel and human resources, maintenance, and research and development. A small number of firms also extend and Web-enable their ERP systems to cover supply chain partners as well as customers. Most firms leverage the information from their ERP systems to attain early benefits and hence realize quicker ROI and profits.

Various studies examined the performance impact of CSFs on ERP system deployments (Kanungo & Bagchi, 2000; Ross & Vitale, 2000; Besson & Rowe, 2001; Francalanci, 2001). Ross and Vitale (2000) demonstrate that CSFs are important throughout the ERP life cycle. They used interviews to gather data from15 firms using three respondent categories (top management, functional management, and the ERP system project manager). The common modules implemented were inventory management, sales, logistics, SCM, CRM, and EDI. Their study suggests that, in the design phase, firms plan the standardization of processes; either customization of the ERP system to their business processes or adaptation of their business processes to the ERP system. The main focus of firms in the implementation phase was training to manage the organizational changes introduced by the ERP system. Also, factors such as use of consultants, implementation team skills, and communication were accorded importance in this stage. The stabilization phase witnessed an initial productivity dip after implementation and typical remedial activities involved cleaning up data and parameters, providing additional training, and the removal of software bugs. Most firms in this stage were yet to see measurable gains from their ERP systems. Continuous improvement efforts and the extending of the ERP system through add-ons marked the final phase. In this phase, firms also obtained early benefits such as inventory reduction, increased inventory turnover, improved order fill rate, cutting down of logistics expenses, reduced headcount, reduced working capital, optimized transportation, and improved system reliability. In the transformation stage, firms leveraged their organizational visibility to achieve customer satisfaction and gain increased agility. A larger sample size and more rigorous data collection methods would have enhanced the validity of the study.

Studies indicate that most firms do not use a common yardstick for evaluating their ERP system implementation success (Bradford & Roberts, 2001; Poston & Grabski, 2001). In one of the few studies that empirically examined the impact of ERP systems on overall firm performance, Poston and Grabski (2001) gathered data from multiple archival sources from firms that had publicly disclosed their ERP system adoption for the years 1980 to 1997 (effective sample size of 50). The independent variables assessed were the firm’s selling, general, and administrative costs (SG&A), firm’s cost of goods sold (COGS), and the number of employees as a percentage of revenues. The dependent variable measured was firm performance (defined as the ratio of cost to revenues so as to capture both the cost-reduction and the revenue-enhancing effects of ERP systems on the firm). The control variables were firm size and industry.

The findings of the Poston and Grabski (2001) study suggest that there is no significant change in costs as a percentage of revenues until three years after the implementation of the ERP system and then a significant decrease in costs occurs only for COGS as a percentage of sales. No significant decreases were associated with the SG&A costs scaled by revenues nor was there any improvement in residual income (RI). A significant decrease in the number of employees as a percentage of revenues was noticed for the three years after the ERP system implementation. The main limitation of the study is the lack of long-term post-implementation data as the benefits of ERP are not apparent until three or more years after implementation.

Recent survey studies continue to be dominated by implementation issues. The focus of most studies is on identifying sets of CSFs as well as specific CSFs essential for ensuring ERP system deployment success. Many researchers used varied performance metrics to examine the benefits accruing to firms from their ERP systems.

Studies indicate that a focus on CSFs through the ERP system implementation process results in significant performance benefits (Gefen & Ridings, 2002; Stratman & Roth, 2002; Tarafdar & Roy, 2003). Tarafdar and Roy (2003) examine ERP system implementations among Indian firms. Data were gathered on 25 firms through a semi-structured questionnaire from top management personnel. Their findings suggest that 90% of the firms chose to implement a few modules. The common modules implemented were financial accounting and control, sales and distribution, production planning, materials management, and human resources management. The modules implemented in the initial phases by firms were those that supported their critical objectives as well as computerized functional areas. Most firms used a phase-stage approach with each phase divided into planning, implementation, and post-implementation sub-stages. The CSFs focused in the planning sub-stages were business case, top management, business characteristics, IT readiness, and project planning and management. Firms stress CSFs such as alignment, implementation strategy, organizational change management, and open and honest communication in the implementation sub-stage. The CSFs emphasized in the post-implementation stage were process changes, organizational benefits, training, and learning. Firms leveraged their early benefits to gain competitive advantage as well as increase their profitability. The validity of the study's findings would be enhanced if the survey instrument was validated.

Various studies examined the importance of focusing on sets of CSFs to facilitate the ERP system implementation process (Mabert, Soni, & Venkataramanan, 2003a; Mabert, Soni, & Venkataramanan, 2003b; Olhager & Selldin, 2003). Olhager and Selldin (2003) examine the status of ERP system implementations in Swedish manufacturing firms. Their study gathered data from 190 firms (response rate of 37.2% - 190/511; effective sample of 158) mainly from respondents in the operations area. The sample comprised of mainly SME make-to-stock firms, which were considered representative of the Swedish manufacturing industry. The common modules implemented by firms were financials, controlling, maintenance, materials management, production planning, sales and distribution, logistics, human resources, quality management, as well as Web-enabled extensions to include supply chain partners and customers. Firms focused on CSFs such as alignment and implementation strategy to facilitate the implementation process. The benefits that accrued to successful implementers were mainly improvements arising out of the availability of accurate information as well as the standardization and integration of processes. Most firms were also able to achieve increased ROI as well as register improvements in their profitability.

As a growing number of firms started using their ERP systems, their attention turned towards evaluating implementation benefits (Hawking & Stein, 2004; Gefen & Ragowsky, 2005). Hawking and Stein (2004) make a distinction between benefits that flow from partial ERP systems and complete ERP systems. Their study examines the expected and actual benefits of complete ERP systems and attempts to identify the barriers and challenges to the attainment of ERP benefits. Data were gathered from the members of the SAP Australia User Group through an email based electronic survey (response rate of 26% - 48/166). The data were then used to classify ERP system implementations as beginning (implementation less than 1 year - about 6% of firms), consolidating (implementations between 1 to 3 years - about 54% of firms), and mature (implementations greater than 3 years - about 40% of firms) with those in the mature category having implemented extension modules, such as SCM, CRM, knowledge management (KM), data warehousing (DW), APO/APS, B2C, and B2B.

Hawking and Stein (2004) suggest that the expected and actual benefits attained were financial close cycle reduction, order management improvements, cash management improvements, inventory reductions, transportation/logistics reductions, and revenue/profit increase. The expected and actual benefits yet to be attained were productivity improvements, procurement cost reductions, on-time delivery improvements, personnel reductions, IT cost reductions, and maintenance reductions. The main barriers to benefit realization were lack of discipline, lack of change management, inadequate training, poor reporting procedures, inadequate process engineering, misplaced benefit ownership, inadequate internal staff, poor prioritization of resources, poor software functionality, inadequate ongoing support, poor business performance, under performance of project team, poor application management, and mismanagement of upgrades. The main limitations of the study are concerns regarding the data collection process and instrument validation.

<u>Other Relevant Studies</u>

Many research studies examined implementation issues in firms implementing MRP, MRP II, IT; and the integration of two or more of these systems. The implementation experiences of these firms, the CSFs stressed by them, and the changes in performance resulting from their successful deployments are relevant to ERP system implementers.

Various studies examined the costs, benefits, and CSFs associated with implementing MRP and MRP II systems (Schroeder, Anderson, Tupy, & White, 1981; White, Anderson, Schroeder, & Tupy, 1982; Li, Chaudhry, Chaudhry, & Wang, 2001; Lau, Zhao, & Lai, 2002; Petroni, 2002). White et al. (1982) examine the relationship between MRP system implementation problems and the success or failure of MRP system deployments. Data were gathered from respondents in managerial positions in 679 companies (response rate of 40% - 679/1700; effective sample size of 422) that had implemented MRP systems. The independent variables assessed were company/environmental, and system features; the intervening variables were implementation process, problems with data accuracy, and problems with management support; and the dependent variables were improved performance, and user satisfaction.
The findings of the White et al. (1982) study suggest that the main factors that differentiate successful and unsuccessful implementations were data accuracy, computerization, use of outside expertise, management support, and implementation approach. Firms mostly faced problems in areas such as education of employees, top management support, communications, expertise, overcoming resistance, forecasting accuracy, and data accuracy. Firms realized operational and organizational benefits from successful implementations. Validation of the survey instrument would have added more validity to the study's findings.

In another study, Duchessi, Schaninger, Hobbs, and Pentak (1988) identify the factors that determine the successful implementation of MRP II systems. Data were gathered through a validated instrument from the top management personnel of 352 firms (response rate of 7% - 352/4770, effective sample size of 272) that had implemented MRP systems. The independent variables assessed were organizational/behavioral determinants, and manufacturing determinants. The dependent variables were manufacturing planning and control, manufacturing performance, and business/financial performance.

The findings of the Duchessi et al. (1988) study suggest that most firms had basic MRP II functionality installed. Successful implementers, however, implemented more complete MRP II functionality than less successful firms. Firms focused on key CSFs such as planning, control, data accuracy, education, implementation team, and software and hardware characteristics. Firms were aware that they could consolidate their early benefits and achieve greater performance with full system functionality implementation and long-term system usage. The main concern about the validity of the study's findings is the low survey response rate.

In one of the few rigorous instrument development studies, Mirani and Lederer (1998) use a two-stage survey to identify and operationalize the performance benefits that firms obtain from their IT system implementations. In the first stage, their study identified nine performance measures as well as items to measure these variables from a synthesis of IT and information systems (IS) literature. The nine performance measures identified are competitive advantage, alignment, customer relations, information access, information quality, information flexibility, communications efficiency, systems development efficiency, and business efficiency. In the second stage, data were gathered from a sample of 936 IS managers (response rate of 22% - 200/936). The data were analyzed using confirmatory factor analysis (CFA). Their findings suggest support for the nine performance measures identified. The findings further suggest that the instrument developed to capture data on the performance measures is a reliable and valid one. The main limitation of this study is that respondents were not drawn from diverse functional areas.

Summary

A review of ERP system and other relevant studies discussed in this section reveals that most firms accorded high priority to effectively managing the implementations of their partial as well as complete ERP systems. A few firms that deployed the holistic ERP system, however, focused on operational and usage rather than implementation issues to obtain synergistic benefits. Firms that accorded importance to instituting organizational changes along with their technical implementations achieved smoother implementations and also obtained quicker accrual of ERP system benefits.

Table 7 represents a cross-study comparison of ERP system modules assessed in the survey studies discussed. The survey studies referenced in the table have been chosen for their coverage of the modules comprising the ERP system. Most of the research studies in this section assess the modules comprising the ERP system provided by a cross-section of ERP system vendors. These studies, depending upon which ERP system vendor they focus on, use different terminologies and module descriptions to describe the ERP system. Hence, the studies presented in the table are synthesized to ensure consistency in the use of terminology and module descriptions in assessing ERP systems. A few studies referenced in the table do not directly assess some of the ERP system modules but implicitly refer to them. The findings from such studies are denoted by the term ‘Imp’ in the table to refer to the implied reference made by researchers in assessing these modules. The 16 modules comprising the ERP system, assessed in a cross-study comparison of survey studies, are given in the table. The modules referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as modules of the ERP system. Also, the modules referenced in less than 50% of the studies are classified as having low support for their inclusion as modules of the ERP system.

Table 7
A Cross-Study Comparison of ERP Modules Assessed in Survey Studies

Modules	Survey Studies											
	ERP Studies											
	1	2	3	4	5	6	7	8	9	10	11	Summary
Financials	A		A	A		A	A	A	A			GS
Controlling	A		Imp	A			A	A	A			GS
Materials Management	A	A	Imp	A	A		A	A	A		A	GS
Production Planning	A		A	A			A	A	A			GS
Sales and Distribution	A	A		A	A	Imp	A	A	A		A	GS
Inventory Management	A	A	Imp	A	A			A				GS
Supply Chain Management	A	A	Imp		A	Imp	A	A		A		GS
Customer Relationship Management	A	A	Imp	Imp		A	A	A		A	A	GS
E-Commerce	A		Imp		A	Imp	A	A		A		GS
Plant Maintenance	A			A				A				LS
General Logistics	A	A	A	A				A				LS
Quality Management	A		Imp	A				A				LS
Human Resources	A		A		A			A	A			LS
Advanced Planning Optimization/Advanced Planning Scheduling	A				A		A	A		A		LS
Electronic Data Interchange		A		A						A		LS
Knowledge Management	Imp		Imp		Imp			Imp		A		LS

Studies Referenced

(1) Mabert et al. (2000)
(2) Ross and Vitale (2000)
(3) Bradford and Roberts (2001)
(4) Francalanci (2001)
(5) Mabert et al. (2001a)
(6) Gefen and Ridings (2002)
(7) Mabert et al. (2003b)
(8) Olhager and Selldin (2003)
(9) Tarafdar and Roy (2003)
(10) Hawking and Stein (2004)
(11) Gefen and Ragowsky (2005)

Note

A = Assessed as a module of the ERP system.
Imp = Implied as a module of the ERP system (not directly assessed).
GS = Good support for inclusion as a module of the ERP system (module referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a module of the ERP system (module referenced in less than 50% of studies in the table).

It can be inferred from a perusal of the table as well as the studies discussed in this section that there is a paucity of rigorous empirical studies on ERP system implementations as compared to descriptive and case study literature. Most firms implemented modules such as financials, materials management, and sales and distribution, which automated a few of their key business activities. Some firms also undertook sub-module implementations such as manufacturing (part of production planning) and order entry (part of sales and distribution). The table's findings suggest that most firms Web-enabled extensions to include their suppliers and customers. This early integration of primary business activities results in quicker accrual of benefits to firms. The limited coverage of modules like human resources, quality management, and plant maintenance shows that firms stabilize their early module deployments as well as a few key extension module implementations and then bring these support activities under the purview of the ERP system.

Table 8 represents a cross-study comparison of CSFs considered necessary in ensuring the successful implementation of ERP systems. Most of the literature in this section assesses CSFs considered essential for facilitating ERP system deployments. Many of the studies limit their discussion to a few CSFs assessed among the surveyed firms. Hence, the survey studies in the table have been chosen for their wide coverage of the CSFs for the respondent firms. A few studies referenced in the table do not explicitly assess CSFs but implicitly refer to them as essential for implementation success. The findings from such studies are denoted by the term 'Imp' in the table to refer to the implied reference made by researchers in assessing the CSFs. Besides the CSFs synthesized from ERP system studies, CSFs from other relevant studies deemed relevant to ERP system implementing firms have also been included in the table. The 15 CSFs considered essential for ensuring ERP system deployment success assessed in a cross-study comparison of survey studies are given in the table.

Table 8
A Cross-Study Comparison of CSFs Assessed in Survey Studies

Critical Success Factors	Survey Studies																	
	ERP Studies											Other Relevant Studies						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Summary
Top Management Support	A		A	A	A	A	A			A	Imp	A	A	A	A	A	A	GS
Planning		A	A	A	A	A	A	A		A	Imp	Imp	Imp	A	A	A	A	GS
Project Management			Imp		Imp	A	Imp			A	Imp	Imp	Imp	A		Imp	Imp	GS
Alignment (BPR & Customization)		A	A	A	A	Imp	A	A	A	A	A	A	Imp	Imp	A		A	GS
Implementation Strategy			Imp	A			A	A	A	A	Imp	A	A	Imp	Imp			GS
Consultants		A	A	A		Imp		A	Imp	A		A	A			A		GS
Implementation Team	Imp	A	Imp	A	A	A	A	A	Imp	A	A	Imp	Imp	A		A	Imp	GS
Data Accuracy		A		A	A		A	Imp	Imp	Imp		A	A	A	A	A	A	GS
User Support	A	Imp	A		Imp	A	Imp			Imp	A		A	A		Imp	A	GS
Training	A	A		A	A	A	A	A	Imp	A	A		A	Imp	A	A	A	GS
Learning		Imp	A		Imp	A	A			A			A	A	A	A	A	GS
Organizational Culture		A	A		Imp	Imp	Imp			Imp	Imp			A	Imp		A	GS
Communication		A	Imp		A	Imp	A			A			A	Imp		A	Imp	GS
National Culture	Imp		A						Imp	Imp	Imp				A	A		LS
IT Readiness										A		A	A					LS

Studies Referenced

(1) Kanungo and Bagchi (2000)
(2) Ross and Vitale (2000)
(3) Besson and Rowe (2001)
(4) Mabert et al. (2001a)
(5) Mabert et al. (2001b)
(6) Stratman and Roth (2002)
(7) Mabert et al. (2003a)
(8) Mabert et al. (2003b)
(9) Olhager and Selldin (2003)
(10) Tarafdar and Roy (2003)
(11) Hawking and Stein (2004)
(12) Schroeder et al. (1981)
(13) White et al. (1982)
(14) Duchessi et al. (1988)
(15) Li et al. (2001)
(16) Lau et al. (2002)
(17) Petroni (2002)

Note

A = Assessed as a CSF in ERP system implementation.
Imp = Implied as a CSF in ERP system implementation (not directly assessed).
GS = Good support for inclusion as a CSF in ERP system implementation (CSF referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a CSF in ERP system implementation (CSF referenced in less than 50% of studies in the table).

The CSFs referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as CSFs in ERP system implementations. Also, the CSFs referenced in less than 50% of the studies are classified as having low support for their inclusion as CSFs in ERP system implementations. A review of the table as well as studies discussed in this section reveals that most firms judiciously managed their CSFs by emphasizing managerial and technical factors such as top management support, planning, alignment, implementation team, and data accuracy. There is limited focus on IT readiness or the impact of different national cultures on ERP system implementations. The findings from the table further suggest that in contrast to the ERP system implementers, firms that have implemented other application systems focused on most of the CSFs assessed in the survey studies. ERP system implementing firms can leverage the findings from these other system application studies to enhance their implementation success.

Table 9 represents a cross-study comparison of changes in performance resulting from the successful implementation of ERP systems. Most of the studies in this section assess the changes in performance that are essential for achieving ERP system implementation success. Many of these studies in the table limit their discussion to a few assessed performance changes in their study samples. Hence, the studies referenced in the table have been chosen for their wide coverage of the changes in performance in the surveyed firms. Besides the changes in performance obtained from a review of ERP system studies, changes in performance from other relevant studies deemed pertinent to ERP system implementing firms have also been included in the table.

Table 9
A Cross-Study Comparison of Changes in Performance Assessed in Survey Studies

Performance	Survey Studies																		
	ERP Studies										Other Relevant Studies								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Summary
Information Availability	A	A	A	A	A	A	A	A	A	A	Imp		A	A	A		A		GS
Information Quality	A	A		A	A		A	A	Imp	A			A	A	A		A		GS
Standardization	A	A	Imp	A	Imp	A	A	Imp	A	A									GS
Integration	A	A	Imp	A		A	A	A	A	A		A	A	A	Imp	Imp	A		GS
Inventory Management	A	A	A	A		Imp	A	A	A	A	Imp	A	A	A		A	A	A	GS
On-time Delivery	A	A	A	A		A	A	A	Imp	A	Imp	A	A	Imp		Imp			GS
Profitability	A	A	A	A	A	A	A	A	A	A	A	A	A	A	Imp	A	A	Imp	GS
Customer Satisfaction	Imp	A				A	A	Imp	Imp	Imp		A	A	A	A		Imp	A	GS
Competitive Advantage	Imp	Imp	Imp		A	Imp	A	Imp	A	Imp	A	A	A	A	A		A		GS
Return on Investment	A		A	Imp	A		A	A			Imp				Imp				LS
User Satisfaction		Imp							A			Imp	A	Imp					LS

Studies Referenced

(1) Mabert et al. (2000)
(2) Ross and Vitale (2000)
(3) Bradford and Roberts (2001)
(4) Mabert et al. (2001a)
(5) Poston and Grabski (2001)
(6) Stratman and Roth (2002)
(7) Mabert et al. (2003b)
(8) Olhager and Selldin (2003)
(9) Tarafdar and Roy (2003)
(10) Hawking and Stein (2004)
(11) Gefen and Ragowsky (2005)
(12) Schroeder et al. (1981)
(13) White et al. (1982)
(14) Duchessi et al. (1988)
(15) Mirani and Lederer (1998)
(16) Li et al. (2001)
(17) Lau et al. (2002)
(18) Petroni (2002)

Note

A = Assessed as a performance measure in ERP system implementation.
Imp = Implied as a performance measure in ERP system implementation (not directly assessed).
GS = Good support for inclusion as a performance measure in ERP system implementation (performance measure referenced in 50% or more of studies in the table).
LS = Low support for inclusion as a performance measure in ERP system implementation (performance measure referenced in less than 50% of studies in the table).

Most studies listed in the table explicitly assess a few of the performance changes that firms obtain from their ERP system deployment. Some of these studies, however, do not explicitly assess some of the performance changes but imply that these are benefits that firms obtain from their ERP systems. The findings from such studies are denoted by the term ‘Imp’ in the table to refer to the implied reference made by researchers in assessing these performance changes. The 11 performance measures considered necessary for measuring ERP system implementation success assessed in the cross-study comparison of survey studies are given in the table. The performance measures referenced in 50% or more of the studies presented in the table are classified as having good support for their inclusion as performance measures in ERP system implementations. Also, the performance measures referenced in less than 50% of the studies are classified as having low support for their inclusion as performance measures in ERP system implementations.

An analysis of the table as well as studies discussed in this section reveals that most of the surveyed firms used real-time accurate information from their ERP systems to obtain benefits such as improved inventory management, and on-time delivery. Firms then leveraged these benefits into financial improvements as evidenced by good support for the profitability measure. This shows that firms were able to consolidate their early financial gains arising out of cost savings, personnel, and productivity to increase their profitability. It can be inferred from the table as well as the studies discussed that firms were able to increase their customer satisfaction levels and derive competitive advantage. A similar trend is also evident from the findings of other system implementation studies. Many ERP system as well as other system implementers, however, were not able to increase their ROI. The limited support for user satisfaction suggest that firms have not effectively managed their organizational change management programs to ensure employee buy-in. ERP system, as well as other system implementation literature, states that greater benefits accrue to firms, which fine-tune their systems with effective feedback and usage by users.

Modeling & Simulation Studies

Many studies used modeling and simulation techniques to examine ERP system deployments. Early research focused on implementation issues; however, recent studies indicate that firms have shifted their attention to measuring the benefits that flow from their ERP systems. This section also examines other relevant studies that address the implementation of SCM and multiple systems that are pertinent to ERP system implementers. The various modeling and simulation studies, discussed in this section using a timeline approach, were chosen for the relevance of their findings to ERP system implementing firms.

ERP System Studies

Early studies stressed the effective management of the ERP system implementation process. Recent research indicates that firms are paying increasing attention to operational and usage issues as they seek to examine post-implementation activities and evaluate the impact of their ERP systems on performance.

Scheer and Habermann (2000), and Gulla and Brasethvik (2002) advocate the use of business process modeling to facilitate ERP system deployments. Gulla and Brasethvik (2002) suggest that user-tailored views of business models serve as simplified process-oriented user interfaces and can be used to communicate project status throughout the firm. Their study advocates information integration across the firms' transaction, workflow, and management tiers.

Various studies indicate that firms could use models and simulations to handle organizational change issues (Hendrickson, 2001; Ahituv, Neumann, & Zviran, 2002). Hendrickson (2001) suggests that firms should stress different CSFs in different stages of their implementation process to facilitate their ERP system implementations. Firms use models to create project roadmaps and training programs. Firms further use detailed and realistic scope statements based on business needs and prioritize module rollouts by mapping business processes to ERP system functionalities. These models help in identifying organizational deficiencies before they impact ERP system budgets by taking into account organizational, process, people, and technical issues.

Hitt et al. (2002) and Stensrud and Myrtveit (2002) measure the performance gains accruing to firms from their ERP system implementations. Hitt et al. (2002) examine the impact of ERP system projects on firm performance using data gathered from the license agreements of a specific ERP vendor in the US between the time periods 1986 to 1998. They then match this data with the Compustat and Computer Intelligence InfoCorp databases to obtain a sample that includes only publicly traded firms in the US (response rate of 16.93% - 4069/24037). The performance measures are financial (productivity, stock market valuation, firm performance) and IT (IT data usage). The control variables are industry, firm size, and time.

The findings from the Hitt et al. (2002) study suggest that ERP system adopters rank consistently higher in performance across a wide variety of measures as compared to non-adopters. Financial markets reward the adopters with high market valuations both during and after performance. Most of the gains occur during the implementation period and there is a slight decrease in performance and productivity immediately after the implementation is complete. Implementation of the ERP system leads to increased performance and increasing performance results when additional modules are installed.

Other Relevant Studies

Many research studies used modeling and simulation techniques to address implementation issues in SCM, and the integration of multiple application systems, such as MRP and Kanban, and MRP and JIT. The findings of these studies are pertinent to ERP system implementing firms.

Lee, So, and Tang (2000) and Yu, Yan, and Cheng (2001) indicate that ERP system implementing firms can learn from the experiences of supply chain implementers when they are implementing extensions to their ERP systems. Lee et al. (2000) use modeling techniques to quantify the benefits from information sharing between supply chain partners in a two-level supply chain. Their findings demonstrate that information sharing alone will benefit the manufacturer (in terms of cost and inventory reductions) while lead-time reduction will benefit primarily the retailer (in terms of cost and inventory reductions). Both, the manufacturer and the retailer would benefit when information sharing and lead-time reductions are implemented. The characteristics of the demand process and the replenishment lead time have a significant impact on the benefits of information sharing to the manufacturer. This is especially so when the lead time is long and the demand is highly variable and correlated with time.

Firms can leverage the experiences of multiple application system integrations when they implement back-office and front-office extensions to their ERP systems (Krajewski, King, Ritzman, & Wong, 1987; Miltenburg, 2002). Miltenburg (2002) uses modeling techniques to analyze the computational requirements of widely used algorithms for production planning problems in MRP and JIT. He examines production-planning problems such as aggregate production planning, master production schedule, final assembly schedule, and detailed material plans. The findings suggest that optimal plans for all four production problems require an exponential number of computations in the number of integer decision variables. When the MRP system is used, the number of integer decision variables in the material plan problem is too large to solve the integer linear programming problem, so an explosion heuristic is used. When the JIT system is used, the number of integer decision variables in the material plan problem is small enough so that the integer linear planning problem can be solved with a relaxation of the integer restrictions on decision variables in later periods. The ERP system should pass on the best material plan that MRP is able to develop to a manufacturing execution system where it is executed as best as possible. Compared to MRP, JIT does not have much difficulty with the material plan. Thus, the study indicates that the integration of both MRP and JIT systems results in improved performance as compared to the implementation of either of the systems separately.

Summary

A review of ERP system and other relevant studies discussed in this section suggests that implementation issues dominate modeling and simulation literature. Firms initially used models to refine BPR approaches and then shifted to using models and simulations for handling organizational change issues and implementation approaches. This is due to their growing realization that successful implementations involve the seamless alignment of people, process, and technology. A synthesis of recent studies shows that firms also use models to quantify the performance benefits that flow from their successful ERP implementations.

ERP system related modeling and simulation studies are few in number and limited in their research content, especially in the context of the objectives of this research study. Hence, these studies are mainly used to demonstrate additional support to the findings of the different methodological studies discussed earlier in this chapter. A cross-study comparison of CSFs from ERP system modeling and simulation studies discussed indicates strong support for the alignment CSF (Scheer & Habermann, 2000; Ahituv et al., 2002) and the training CSF (Scheer & Habermann, 2000; Hendrickson, 2001; Ahituv et al., 2002; Gulla & Brasethvik, 2002). A perusal of cross-study comparison of changes in performance from ERP system and other relevant studies indicates that two changes in performance, stressed by various modeling and simulation studies are increased productivity (Hitt et al., 2002; Stensrud & Myrtveit, 2002) and information sharing (Lee et al., 2000; Yu et al. 2001).

Instrument Development Studies

Due to the relative newness of the ERP field, research on ERP systems during the 1990s was dominated by descriptive and case studies. ERP studies using survey methodologies during this period were very few and it is over the past four to five years that the first empirical studies on ERP systems appeared. An analysis of ERP, as well as other system, survey studies indicates that most field studies did not use rigorously validated survey instruments that would be useful for instrument development in the context of this research study's objectives. ERP system studies, as well as other relevant studies, identified as pertinent to survey instrument development in this research study, are discussed below.

ERP System Studies

Though many ERP system studies measure variables that are relevant to this research study's objectives, only a few of these studies use reliable and validated instruments. The discussion below is limited to Stratman and Roth's (2002) study, which outlines the development of a rigorously validated instrument pertinent to the measurement of this research study's variables. Other ERP system studies that use non-validated measures and are used in the survey instrument development process in this study are also mentioned.

Stratman and Roth (2002) developed a survey instrument to measure ERP competence constructs. Their study adopted a two-stage approach for the development of a survey instrument to test the relationship between ERP competence constructs and business performance. In the first stage, precise definitions and measurement items for each construct along with reliability and validity indicators was established. In the second stage, further refinement and validation of the measures was done using survey data collected on the scales developed in stage one.

In the first stage, Stratman and Roth (2002) identified eight constructs from a synthesis of cross-disciplinary literature considered important for ERP system implementation success. The eight independent constructs are strategic IT planning, executive commitment, project management, IT skills, business process skills, ERP training, learning, and change readiness. The dependent construct is business performance. The identification of the constructs was followed by the generation of a pool of items for each construct drawn from literature as well as based on site visits and interviews with practitioners active in the ERP field. Then, a manual sorting technique was conducted iteratively using independent panels of four to five expert judges (17 judges in total) with experience in the ERP system implementation area. The pretest scale reliability and validity were assessed using the Perreault and Leigh statistic (a value greater than 0.65 is considered acceptable) and item placement ratios (a value greater than 0.70 is considered acceptable) respectively. All the scales met or exceeded the above two criteria.

In the second stage of their study, Stratman and Roth (2002) used Dillman's (1978) total design method (TDM) survey implementation approach to gather data from 85 manufacturing firms in North America (response rate of 13% - 85/623, effective sample of 79). The survey sample population was drawn from three sources: the client list from the top five ERP system vendor Websites, North American manufacturing firms from PC Weeks's 1999 top 100 innovative manufacturers and Industry Week's 1999 top 1000 manufacturers, and the mailing list of the Association for Operations Management. The sample comprised of firms of various sizes and in different industries. The respondents were asked to indicate their level of agreement for each of the construct items using 7-point Likert-type scales ranging from 1 = disagree and 7 = agree for the competence constructs, and from 1=worse and 7=better for the business performance construct. The reliability of the scales was assessed using Cronbach's alpha. The Cronbach's alphas for the 9 scales are 0.87 (strategic IT planning, executive commitment), 0.91 (project management), 0.92 (IT skills), 0.83 (business process skills, learning), 0.85 (ERP training), 0.84 (change readiness), and 0.94 (business performance).

Stratman and Roth (2002) used literature review and input from expert ERP practitioners to establish the content validity of their scales. CFA resulted in fit indices of 0.90 or greater for all the scales thus establishing the unidimensionality of the instrument. Convergent validity was established by comparing the manual sort and mailed surveys, as well as by examining the factor loadings of the items onto their respective latent constructs in the CFA measurement models. All factor loadings were in the anticipated direction and magnitude and were statistically significant at $p < 0.05$. Discriminant validity was assessed using a series of chi-square difference tests between the nested CFA models for all construct pairs. All of the chi-square differences were significant at $p < 0.001$. Pearson's correlations of the factor weighted items with Compustat metrics provided support for the criterion validity of the scale. The final measurement scales and items for the independent constructs and the dependent construct in the Stratman and Roth (2002) study were strategic IT planning (6 items), executive commitment (7 items), project management (8 items), IT skills (11 items), business process skills (9 items), ERP training (8 items), learning (8 items), change readiness (8 items), and business performance (16 items). The overall results indicate that the instrument developed to measure the ERP competence constructs is a reliable and valid one.

Besides Stratman and Roth (2002), there are many other ERP system studies that examine specific variables pertinent to this research study. Some of these other ERP system studies used for developing items to measure the variables in this study are implementation strategy (Mabert et al., 2000; 2003b), alignment (Hong & Kim, 2001), data accuracy (Vosburg & Kumar, 2001), organizational and national culture (Krumbholz & Maiden, 2001; Sia, Tang, Soh, & Boh, 2002), communication (Tarafdar & Roy, 2003), and top management, communication, consultants (Teltumbde et al., 2002), besides others.

Other Relevant Studies

A number of other relevant studies use validated instruments to measure variables that are relevant to this research study's objectives. The discussion below is, however, limited to White's (1990) study, which developed a rigorously validated instrument, and is deemed most pertinent to the measurement of some of this research study's variables. White (1990) developed a survey instrument to measure varying changes in performance due to different implementation statuses of JIT systems. The instrument was initially derived from literature and consisted of a total of 72 items. The instrument pre-test involved focus groups comprised of experts in the areas of survey methodologies and JIT literature. Then a field test was conducted with eight JIT practitioners to clarify and revise ambiguous questionnaire items. The questionnaire was further pre-tested by a panel of academicians and practitioners active in the JIT field and suggested revisions were made to finalize the questionnaire for mailing. The sample survey population consisted of members of the Association for Manufacturing Excellence (AME). The survey procedures followed Dillman's (1978) TDM method and consisted of two series of mailings to

2460 firms (response rate of 44.1% - 1165/2640). The sample was representative of firms from various industries and of different sizes. The respondents were middle and upper level managers knowledgeable about the firms' JIT implementation and had a broad perspective on overall firm activities.

Each of the 10 JIT techniques identified in the White (1990) study formed an item and data were obtained for each item using an ordinal scale with the following ranges: not implemented, implementation started within the last year, implementation started 1 to 3 years back, implementation started 3 to 5 years back, and implementation started more than 5 years back. Data were scored using the mid-point of the assessment scale: not implemented (0), implementation started within last year (0.5), implementation started 1-3 years ago (2), implementation started 3-5 years ago (4), and implementation started more than 5 years ago (6). The measures of implementation status for each of the JIT technique were then collectively used to develop a measure for the overall JIT system status. Ten measures of changes in performance and three influencing variables were also identified and 5-point Likert type scales were used to collect data on each of them. White's (1990) findings are pertinent as the scales used to measure the JIT implementation status are relevant to the measurement of the ERP system implementation status in this research study.

Summary

A synthesis of instrument development research discussed above reveals that there are not many studies that use rigorously validated instruments in ERP as well as other systems research that are pertinent to this research study. The discussion also briefly mentioned a few ERP system as well as other relevant studies that have used non-validated measures to evaluate variables of interest to this research study. The development of the measuring instrument discussed in chapter 3 includes items mainly drawn from the above validated instruments; however, a few of the items developed from non-validated questionnaires were used.

The first part of the chapter discussed so far comprised of a timeline-based review of ERP system and other relevant literature consisting of descriptive, case, survey, and modeling and simulation studies. A cross-study comparison at the end of each of the different types of methodological studies analyzed yielded tables that identified the modules that comprise the ERP system, the CSFs that facilitate the ERP implementation process, and the changes in performance that accompany ERP system deployments. Modeling and simulation studies also contribute to a better understanding of ERP systems. Due to a paucity of such relevant studies in the context of this research study's objectives, the findings from the modeling and simulation studies are only used to provide additional support to the findings of the other types of methodological studies.

A synthesis of studies in the first part of this chapter broadly suggests that with effective usage over time (long-term usage of the system spread over a number of years), and with the implementation of more and more modules of the ERP system (the more complete the system is) firms will obtain increased synergistic performance benefits. These studies further suggest that effective management of CSFs will maximize and quicken the accrual of ERP performance benefits to firms. The second part of this chapter that follows builds on the synthesis of the literature discussed in the first part to identify the modules comprising the ERP system, the CSFs associated with ERP system implementations, and the changes in performance due to ERP system deployments. The outcome of this part of the chapter is the development of an ERP system implementation model.

Modules of the ERP System

This part of the research study addresses the first of the six research questions identified in chapter 1: What are the modules that comprise an ERP system? Changes in the ERP field are dynamic as ERP system vendors offer a wide array of modules, generic as well as tailored, that address all sections of a firm's business and information domains (Davenport, 2000; Hayman, 2000; Markus, Tanis, & Fenema, 2000). In this section, the cross-study comparison of modules resulting out of a synthesis of the different types of methodological studies is given in table 10.

Table 10
Modules of the ERP System

Modules	Methodological Studies				
	Descriptive Studies	Case Studies	Survey Studies	ERP System Vendors	Summary
Financials	GS	GS	GS	GS	C
Controlling	GS	GS	GS	GS	C
Materials Management	GS	GS	GS	GS	C
Production Planning	GS	GS	GS	GS	C
Sales and Distribution	GS	GS	GS	GS	C
Supply Chain Management	GS	GS	GS	GS	C
General Logistics	GS	LS	LS	GS	M
Project System	GS	LS	NS	GS	M
Plant Maintenance	LS	GS	LS	GS	M
Quality Management	GS	LS	LS	GS	M
Human Resources	GS	GS	LS	GS	M
Customer Relationship Management	LS	LS	GS	GS	M
E-Commerce	LS	LS	GS	GS	M
APO/APS	LS	LS	LS	GS	M
Management Information System	LS	NS	NS	NS	L
Product Data Management	LS	NS	NS	GS	L
Electronic Data Interchange	NS	NS	LS	NS	L
Knowledge Management	NS	NS	LS	GS	L
Inventory Management	NS	NS	GS	NS	L

Note

GS = Good support for inclusion as a module of the ERP system (module referenced in 50% or more of studies in each of the different types of methodological study tables).
LS = Low support for inclusion as a module of the ERP system (module referenced in less than 50% of studies in each of the different types of methodological study tables).
NS = No support for inclusion as a module of the ERP system.
C = there is consensus of agreement among researchers and ERP system vendors for inclusion as a module of the ERP system.
M = there is majority agreement among researchers and ERP system vendors for inclusion as a module of the ERP system.
L = there is lack of agreement among researchers and ERP system vendors for inclusion as a module of the ERP system.

It can be inferred from the table that most firms implement a finite set of ERP system modules that comprise the ERP system. The table also compares this research-based set of ERP system modules to the modules comprising the ERP systems offered by major global ERP system vendors to establish face validity. These global vendors whose ERP system modules are chosen for comparison with those obtained from ERP system literature (SAP, Oracle/PeopleSoft, Sage, Microsoft, SSA Global/Baan) account for about 70% of the global ERP market (IDC, 2003; Gartner, 2003a; AMR Research, 2005).

An analysis of the major ERP system global vendor Websites reveals broad support for the research based set of modules comprising the ERP system (www.sap.com; www.oracle.com; www.ssaglobal.com; www.microsoft.com). Among the ERP system vendors there are, however, minor differences in the terminologies used, the functionalities available under the modules, and the module descriptions under different ERP system versions. SAP in its various R/3 product versions lists materials management as a separate module comprised of purchasing, warehouse management and other sub-modules. In its recent mySAP ERP Web-enabled version, SAP, however, classifies materials management and warehouse management under supply chain management, purchasing under supplier relationship management. SAP in its R/3 versions lists quality management as a separate module, but under its mySAP ERP version this is classified under product life cycle management. In another example, SAP and SSA Global refer to the module that addresses purchasing activities as supplier relationship management, whereas Oracle terms it the procurement module. Oracle refers to the module that takes care of project management activities as the project module, whereas Microsoft terms it the project management and accounting module.

The findings from the module comparison between research studies and ERP system vendors are indicated in Table 10 through a three-part summary classification. Those modules that have good support across research studies as well as among ERP system vendors suggest that there is a consensus agreement regarding their inclusion as modules that comprise the ERP system. Some modules have majority support (a mix of good support, low support, and no support) across research studies and ERP system vendors. Such modules are classified as having majority agreement for their inclusion as modules comprising the ERP system. Research studies and ERP system vendors that do not provide majority support for modules (i.e. have two or more no support) suggest a lack of agreement in considering such modules as being part of the ERP system.

A review of table 10 reveals consensual agreement regarding six modules, majority agreement for eight modules, and lack of agreement on five modules. The table indicates that the 14 modules, identified through consensual and majority agreement by researchers and ERP system vendors, comprise the ERP system. These 14 modules are financials, controlling, plant maintenance, materials management, production planning, project system, sales and distribution, general logistics, quality management, human resources management, SCM, CRM, E-Commerce, and APO/APS. The table also shows that there is a lack of agreement among researchers and ERP system vendors regarding five modules (management information systems (MIS), PDM, KM, EDI, Inventory Management). Hence, in this research study, these five modules are not considered to be part of the ERP system.

Research suggests that once firms stabilize their ERP systems, they implement additional modules such as KM and PDM (Miller, 1999; Ayers, 2001; Hawking and Stein, 2004). The KM module helps firms capture and leverage firm-wide business knowledge for effective decision-making. The PDM module helps firms bring innovative and profitable products to market more effectively. Modules such as KM and PDM represent the tapping and leveraging of information from extended ERP system functionalities. Hence, these are considered as modules that firms optionally implement to enhance their ERP system's performance. Firms that have well entrenched legacy EDI systems in place would integrate their EDI systems with their ERP systems. The advent of Web-enabled ERP systems and the increasing use of the Internet for B2B transactions, however, obviate the need for non-EDI users to implement a separate EDI module. The built-in enterprise controlling functions in the controlling module of most ERP systems also renders unnecessary the need for firms to deploy a separate MIS module. Research indicates that the inventory management module forms part of the materials management module and thus this is a redundant module to implement. The above discussion lends support to the earlier contention that, in the context of this research study, these five modules do not constitute a part of the finite set of modules comprising the ERP system.

The description and categorization of the 14 modules comprising the ERP system in this research study varies widely in literature depending upon the specific ERP system focused by researchers in their studies. This ambiguity is a result of the different descriptions and categorizations that ERP system vendors use to describe the modular structure of their ERP systems. Each of the 14 modules identified in table 10 as comprising the ERP system are discussed below in order to obtain clear generic module descriptions and hence resolve ambiguity in their descriptions in literature and practice. These discussions are based on a synthesis of ERP literature and major ERP global vendors' module descriptions (www.sap.com, www.oracle.com, www.ssaglobal.com; www.lawson.com; www.microsoft.com; www.sage.com; www.ramco.com; www.qad.com).

ERP Modules

Financials (FI)

The financials module constitutes the operational aspects of the general accounting and financial information for the firm (Hernandez, 1998; Appelrath & Ritter, 2000). This module meets global accounting standards and typically comprises of integrated multi-site and multi-currency financial solutions that allows for reconciliation of balance sheets, profit and loss statements, and cash flow figures over different corporate entities. Flexible components such as the general ledger, accounts receivable, accounts payable, asset management, treasury management, and investment management, automate and streamline key business transactions across a firm's supply chain. This module enables the firm to balance the needs of its various stakeholders by focusing on key areas throughout the supply chain such as financial and managerial reporting, strategic analysis and planning, corporate governance, and treasury and risk management (www.ssaglobal.com; www.sap.com).

Controlling (CO)

The controlling module represents a firm's cost structures and the factors that influence them. This module focuses on areas such as cost control, product costs, production costs, and profitability analysis (Hernandez, 1998; Appelrath & Ritter, 2000). Also, the module uses activity-based costing methods to track and aggregate work activities along different dimensions (function, process, and product). This enables management consolidation of reporting on profitability of investments and processes as well as related cost structures (Francalanci, 2001). This module also helps firms optimally monitor and control all performance relevant information in integrated supply chain environments with complete control over their profitability (www.sap.com).

Materials Management (MM)

The materials management module handles activities related to material acquisitions and their control. The key focus areas are purchasing, inventory, warehouse, and consumption based planning. This module enables centralized and decentralized order/contract management, offers vendor rating functionality to measure supplier performance and uses Web-enabled self-service facilities that allows employees to do their own purchasing with specified vendors (Francalanci, 2001; www.ssaglobal.com; www.oracle.com). The module further helps firms balance their inventory levels against customer demand and supplier requirements by providing visibility, monitoring, adjustment, and control capabilities. It also serves as an inventory-planning tool, and manages complex warehouse structures, storage areas, and transportation routes (Hernandez, 1998; Appelrath & Ritter, 2000; www.sssaglobal.com; www.sap.com).

Production Planning (PP)

This module addresses the core logistics functions of a firm and coordinates manufacturing and supply efforts on customer orders (www.ssaglobal.com). The module scope includes key areas such as the different phases, tasks, and methodologies used in production planning (types, material procurement, and time) and the production process itself. The typical components that form part of this module include MRP, capacity requirements planning (CRP), Kanban/JIT, master planning, assembly orders, production orders, service maintenance, sales and operations planning, and work order management (Hernandez, 1998; Appelrath & Ritter, 2000; Francalanci, 2001).

Sales and Distribution (SD)

This module is transaction-intensive and enables the management of all sales and distribution activities such as ordering, promotions, competition, marketing, sales leads, call tracking, planning, mail campaigns, and billing. It allows for the definition and control of pricing structures, transportation and shipping routes, and foreign trade. Firms also benefit by faster communications due to the incorporation of EDI and Web-enabled features in this module (Hernandez, 1998; Appelrath & Ritter, 2000; Francalanci, 2001; www.lawson.com).

Supply Chain Management (SCM)

This module extends the scope of ERP systems to include planning and execution capabilities to manage inter-firm supply chains operations. The module helps firms manage their back-offices' linear, sequential, as well as adaptive supply chains, by providing firms with planning and execution capabilities to manage internal operations as well as extended inter-firm operations. The key components include order processing, inventory control, inventory planning and forecasting, distribution requirements planning (DRP), MRP, purchasing audit, customer order management, supply chain manufacturing, and supply chain planning (Ayers, 2001; www.sap.com; www.oracle.com; www.microsoft.com).

General Logistics (LO)

This module typically contains tools and reports to analyze and manage status and forecasts in the supply chain. The various activities handled by the module are master data, variant configurations, engineering changes, engineering data control, environmental health and safety issues, logistics information systems, forecasts, advanced inventory management, transportation, and warehouse management (Hernandez, 1998; www.oracle.com).

Project System (PS)

This module helps firms handle all activities, resource planning, and budgeting of complex tasks (Hernandez, 1998). This module enables project leaders and members ensure that a project is realized within set deadlines, costs, and results; and to provide the necessary resources and financial funds (Appelrath & Ritter, 2000). Firms use this module to effectively manage their projects through their respective life cycles by forecasting costs and budgets with increased accuracy, planning, scheduling, procurement, production, site execution, tracking, and billing (www.microsoft.com; www.ssaglobal.com; www.oracle.com).

Plant Maintenance (PM)

This module takes care of the complex maintenance of plant systems and supports graphical representations, connection to geographic information systems, and detailed diagrams. The maintenance module focuses on areas such as planning of preventive maintenance, handling of operational and maintenance problems, equipments, costs, and purchase requisitions (Hernandez, 1998; Appelrath & Ritter, 2000). Recent additional functionality has extended this module to include complete lifecycle maintenance management that includes the productive deployment of people, materials, and assets across diverse areas such as projects, contracts, procurement, property, assets, and field service (www.oracle.com; www.microsoft.com).

Quality Management (QM)

The module handles tasks relating to quality planning, inspection and control, and compliance with international quality standards to ensure that firms employ a unified approach to total quality management throughout the entire product life cycle (Hernandez, 1998; www.sap.com). The key areas covered by the module are inspection, control, certification, notification, and tools (Francalanci, 2001; www.ramco.com). This module also takes care of quality control in various business activities throughout the firm such as procurement, production, financials, controlling, and marketing (Appelrath & Ritter, 2000).

Human Resources (HR)

This module includes all business processes required to efficiently manage a firm's human resources needs – from recruitment to post termination benefits. The areas typically focused are personnel, payroll, e-recruiting, time management, training, benefits, workforce deployment and analytics, and self-service delivery (www.ramco.com; www.lawson.com). The module and its associated processes incorporate practices that adhere to specific country regulatory requirements concerning employment, taxation, and benefits (Hernandez, 1998; www.sap.com).

Customer Relationship Management (CRM)

This module facilitates extension of the ERP system for automating and streamlining of front-office functions such as sales, marketing, collaborative order management, and customer service (Gefen and Ridings, 2002; www.oracle.com; www.ssaglobal.com). Recent functionality additions include real-time availability checks, contract management, billing management, fulfillment visibility, and order tracking besides facilitating marketing planning, campaign management, telemarketing, lead generation, and customer segmentation (www.sap.com; www.microsoft.com).

E-Commerce (E-Comm)

The widespread use of the Internet and the rise of business models such as B2B enabled ERP system vendors to leverage technology standards and Web technologies such as java, intranets, extranets and offer Web-enabled ERP systems and portals through which firms can access ERP processes and data from anywhere in the world (Sarkis & Sundarraj, 2003; www.microsoft.com). Recent functionality offerings in this module include telesales, mobile service, self-service to employees, customers, partners, collaborative-commerce (c-commerce), and electronic-market (e-market) exchanges (www.oracle.com; www.microsoft.com).

Advance Planner Optimizer/Advance Planner Scheduler (APO/APS)

This module extends ERP systems to enable handling of complex processes such as shelf-life considerations, alternate routing, intermediate storage accounting, changeover light matrixes, clean-down time considerations, and fixed capacity storage constraints. The key components of the module are demand consensus, demand forecasting, production and distribution planning, production scheduling, and strategic and tactical network optimizations (www.ramco.com; www.oracle.com).

Module Sub-systems

Various studies that examined global ERP vendor systems classified these 14 modules into module categories in different ways (Hernandez, 1998; Miller, 1999; www.sap.com; www.oracle.com). A synthesis of studies discussed earlier in this chapter and a perusal of the Websites of major global ERP system vendors, however, reveals that the 14 modules identified in table 10 as comprising the ERP system can be classified into two module sub-systems

Hernandez (1998) and Appelrath & Ritter (2000) classify modules as belonging to four module categories. The financials module category is comprised of modules such as financial accounting, controlling, enterprise controlling, investment management, and treasury management. The logistics one is comprised of modules like general logistics, materials management, inventory control, plant maintenance, production planning, project system, quality management, and sales and distribution. The human resources module category consists of modules such as personnel administration, personnel development, time management, and payroll accounting. The last one consists of cross-application modules like business workflow, office, archive-link, and document management.

Various studies support the findings of Hernandez's (1998) and Appelrath and Ritter's (2000) studies. The number of module categories, the terminologies used, and the modules classified under each of the module categories tend to vary across the studies. Miller (1999) classifies ERP system modules into module categories such as financials, logistics, human resources, and SCM. Similar to Miller's (1999) classification, Boss Corporation et al. (2000) also classify ERP system modules into the financials, human resources, and SCM categories. Their study, however, categorizes modules into one more module category termed as manufacturing applications.

A perusal of some of the major global ERP system vendor Websites indicates that they also differ in their module category classification, terminology usage, as well as the description of modules that fall under each category. SAP classifies modules under categories such as financials, human capital management, customer relationship management, supply chain management, product life cycle management, supplier relationship management, operations, and mobile business (www.sap.com). Oracle also similarly classifies its modules into categories such as financials, human resources, customer relationship management, supply chain management, and product life cycle management. Their module classification, however, also includes categories such as service, marketing and sales, procurement, order management, projects, manufacturing, maintenance, and corporate governance (www.oracle.com).

SSA Global/Baan and Microsoft lend support to SAP and Oracle's classifications with regard to financial management, human capital management, customer relationship management, supply chain management, and product life cycle management. SSA Global, however, has additional module categories termed E-Commerce, field service, online business service, enterprise planning, enterprise score carding, and enterprise business intelligence (www.ssaglobal.com), whereas Microsoft has additional module classifications such as manufacturing, analytics, and portals (www.microsoft.com).

The above discussion suggests that researchers and global ERP system vendors largely concur on classifying the ERP system modules into broad module categories. They, however, differ on the number of module categories, the terminology used in describing the module categories, and the classification of modules under each of the module categories. In this study, the findings from ERP research as well as global ERP vendor Websites, are synthesized to obtain two module categories: the first one pertains to modules that address intra-firm activities, and the second one to modules that cater to inter-firm activities. Firms initially implement the intra-firm module sub-system comprising of modules such as finance, logistics, and human resources. Then, after stabilizing their internal ERP system deployments, they implement the inter-firm module sub-system consisting of modules such as supply chain, e-commerce, and planning and optimization. This research study uses the term module sub-systems to refer to the two module categories in tune with the study's focus on the systemic concept underlying ERP systems that is elaborated in the next section. The two module sub-systems and the module classifications under each are briefly discussed below.

Intra-firm Module Sub-System

The modules that pertain to financial activities are the financials and the controlling modules. These two modules provide an overall picture of the firm's accounting and the controlling functions. They incorporate decision capabilities with drill down facilities that help decision-makers monitor key performance indicators at various organizational levels. The modules that pertain to logistics activities are plant maintenance, materials management, production planning, project management, sales and distribution, general logistics, and quality management. These seven modules manage all supply chain activities from procurement to billing and also provide extensive decision support capabilities. The human resources module provides support for all personnel management and development activities in the firm. Many of the human resources activities in firms are country-specific such as adherence to employment laws, meeting statutory reporting requirements, taxes, benefits, and payroll. Hence, this module is comprised of business processes that largely cater to country-specific requirements.

Inter-firm Module Sub-System

The inter-firm module sub-system comprises of modules such as SCM, CRM, E-Commerce, and APO/APS. These modules not only help firms extend their ERP system to incorporate back-office and front-office business activities but also provide functionalities to leverage supply chain information from the ERP system for better decision-making.

An overall review of the above discussions reveals that the two module sub-systems as well as each of the 14 modules identified as comprising the ERP system, when implemented by firms, will result in improved performance changes. A synthesis of descriptive, case, survey, and modeling and simulation studies indicates that incremental implementation of modules and their increased usage over time will result in increasing changes in performance. Firms will realize overall performance benefits with the implementation of a holistic ERP system.

ERP Systems Approach and Implementation Status

This section of the research study addresses the second of the six research questions identified in chapter 1: Does a holistic ERP system provide changes in performance? Most firms emphasize process over structure and use the coordinative and integrative capacity of information processing systems to handle the complexity, uncertainty, and interdependence that comes along with this shift (Galbraith, 1973). ERP systems are process-oriented information systems and firms are increasingly deploying these systems to handle the increased complexity, uncertainty, and interdependence of their intra-firm and inter-firm activities.

Galbraith (1973) suggests that the complexities, uncertainties, and interdependences that firms face spur information processing demands, which could be either managed by increasing or decreasing the information processing capacity of firms. He further suggests that firms can undertake structural modifications to their technical core as a means of adapting to the increased processing demands of information. The findings of the Galbraith (1973) study are relevant to ERP systems as these systems are process-oriented, constitute the integrated information processing backbone for firms, and are capable of processing all intra and inter-firm information needs necessary to dynamically manage change.

Various studies that examined the systemic concept underlying ERP systems indicate that firms that adopt a systemic approach to ERP system implementations can leverage complete system functionality for maximizing their benefits. Davenport (1998) and Beretta (2002) suggest that ERP systems are comprised of a single database that gathers and feeds data into modular applications that support all of a firm's business activities across functions, business units, and regions. The integration of various modular applications results in the seamless integration and availability of all information flowing through a firm thus resulting in effective decision-making. In another study, Hernandez (1998) examines the integration among the various modules that constitute the ERP system. He indicates that all the modules comprising the ERP system are linked with each other to enable firms to process business activities from initiation to completion. For example, modules such as general logistics, materials management, plant maintenance, sales and distribution, production planning, project system, and quality management, seamlessly integrate with most other modules of the ERP system – from the financial and controlling modules to the human resources module. In another example, he shows that the sales and distribution module is transaction-intensive and integrates with all other modules of the ERP system such as production and planning, materials management, financials, quality management, project system, and human resources.

Some researchers state that single module deployment by firms constitutes an ERP system implementation and that firms can improve their performance with such installations (Klaus et al., 2000; Hitt et al., 2002). Most ERP system studies, however, indicate that firms derive overall benefits by implementing the complete ERP system and fine-tuning the system for effective use over a number of years (Johnson, 2000; Mabert et al. 2000; 2001a; Poston & Grabski, 2001; Willis & Willis-Brown, 2002). This view is supported by other relevant system studies (Schroeder et al., 1981; White et al., 1982; Duchessi et al., 1988) as well as multiple application system studies (Hsieh & Kliener, 1992; Cua, McKone, & Schroeder, 2001).

Johnson (2000), Kennerley and Neely (2001), and Satyan (2003) examine issues regarding the implementation of ERP systems. Johnson (2000) suggests that the real benefits from ERP systems accrue to firms about two to five years from the start of the ERP system project and nearly a year after the system goes live. In another study, Poston and Grabski (2001) suggest that ERP system deployments are associated with a significant decrease in COGS/Revenues about 3 years after implementation as benefits accrue to firms with effective usage of the system over a number of years. They further suggest that higher levels of benefits accrue as more and more ERP modules and extensions are implemented and hence the 3-year time frame adopted in the study may not be a sufficiently long period to measure implementation results.

Al-Mashari et al. (2003) attempt to tie CSFs to implementation time and improved performance benefits. Their study's findings suggest that those firms which effectively manage their CSFs can shorten their implementation time and garner substantial early benefits from their ERP systems. Further, the benefits of ERP system deployment are maximized when CSFs are leveraged to facilitate the relationship between ERP system implementation and changes in business performance. The findings of other system studies are also pertinent to the systems concept underlying ERP systems. Schroeder et al. (1981), White et al. (1982), and Duchessi et al. (1988) in their survey studies on MRP and MRP II system implementations, demonstrate that the time since implementation significantly increases the chances of successful implementation. The findings from their studies suggest that the MRP system implementation process should be viewed as a continuous process and that enhanced benefits are likely to reward a long-term focus on CSFs.

Studies that examined the integration of multiple systems indicate that enhanced benefits accrue to successful implementers. Hsieh and Kleiner (1992) examine the benefits of integration of MRP and JIT systems. The findings reveal that both MRP and JIT emphasize the integration and the coordination of manufacturing and various interfacing activities though they differ in terms of how this is achieved. Though the JIT system approach is physical and the MRP system approach is informational, both emphasize vendor management and teamwork. MRP supports JIT and by linking these two together it is possible to achieve zero inventories.

A synthesis of studies discussed above as well as in the earlier section of this chapter indicates that a systemic concept underlies ERP systems. These systems are integrated modular systems. Firms that implement one or a few modules of an ERP system may derive benefits mainly restricted to the functional areas and business activities to which these modules are targeted. The more modules that firms implement, greater will be the benefits that they derive, owing to the integrated linkages among different modules that address cross-functional business needs. When all the modules of the ERP system are fully implemented, firms maximize their performance benefits. This is due to the linkages among all the modules of the ERP system, which results in the integration of all of a firm's front-office and back-office operations. Firms engage in a continuous process of fine-tuning their systems to better serve their business needs. The results of this ongoing process, arising from the effective use of the system, is spread over a number of years and results in further enhanced gains accruing to firms over the long-term.

Critical Success Factors for ERP System Implementation

This section addresses the third of the six research questions identified in chapter 1: What are the CSFs that impact ERP system implementations? Most ERP system literature over the past decade focused on implementation issues as "getting the system to run" dominated the deployment process. Recent studies indicate that firms have realized that ERP system implementations are never complete but represent long run, continual processes. To handle the organizational changes that accompany ongoing ERP system deployments, most firms adopted a CSF based approach.

Table 11 provides the summary details from each of the different types of methodological studies described in the first part of this chapter. The findings from the cross-study comparison of CSFs are indicated through a three-part summary classification. Those CSFs that have good support across research studies indicate a consensus agreement regarding their role as crucial factors in ERP system implementations. Some CSFs have majority support (a mix of good support and low support) across research studies and such CSFs are classified as having majority agreement for their inclusion as key factors for facilitating the implementation process. Research studies that do not provide majority support for modules (i.e. have two or more 'no support') indicate lack of agreement among researchers regarding the criticality of such factors in implementations.

Table 11
CSFs for ERP System Implementation

Critical Success Factors	Methodological Studies			
	Descriptive Studies	Case Studies	Survey Studies	Summary
Top Management Support	GS	GS	GS	C
Planning	GS	GS	GS	C
Project Management	GS	GS	GS	C
Alignment (BPR & Customization)	GS	GS	GS	C
Implementation Strategy	GS	GS	GS	C
Consultants	GS	GS	GS	C
Implementation Team	GS	GS	GS	C
Data Accuracy	GS	GS	GS	C
User Support	GS	GS	GS	C
Training	GS	GS	GS	C
Organizational Culture	GS	GS	GS	C
Communication	GS	GS	GS	C
National Culture	LS	GS	LS	M
Learning	GS	LS	GS	M
IT Readiness	NS	NS	LS	L

Note

GS = Good support for inclusion as a CSF in ERP system implementation (CSF referenced in 50% or more of studies in each of the different types of methodological study tables).
LS = Low support for inclusion as a CSF in ERP system implementation (CSF referenced in less than 50% of studies in each of the different types of methodological study tables).
NS = No support for inclusion as a CSF in ERP system implementation.
C = there is consensus of agreement among researchers for inclusion as a CSF in ERP system implementation.
M = there is majority agreement among researchers for inclusion as a CSF in ERP system implementation.
L = there is lack of agreement among researchers for inclusion as a CSF in ERP system implementation.
.

A perusal of the cross-study comparison of CSFs in the table reveals that there is a consensus agreement for 12 CSFs, majority agreement for 2 CSFs, and lack of agreement for 1 CSF. The 12 CSFs identified through consensual agreement by researchers are top management support, planning, project management, alignment, implementation strategy, consultants, implementation team, data accuracy, user support, training, organizational culture, and communication. A synthesis of research studies in the early part of this chapter suggests that most ERP system implementation problems arise from an imbalance in focus among CSFs. An exclusive focus on technical CSFs would result in technically successful ERP system implementations that would not meet business objectives. Management support and organizational change management CSFs, on the other hand, have almost nothing to do with technology and almost everything to do with people and process. Research studies indicate that successful ERP deployments result from a balanced focus on people, process, and technology issues. The 12 CSFs, identified by consensual agreement among researchers, represent a balanced mix of managerial, organizational and technical factors.

There are 2 CFS, learning and national culture, that are identified as having majority agreement among researchers. A synthesis of literature on national culture discussed in the earlier sections of this chapter suggests that national culture values are generic and diffuse. Hofstede, Neuijen, Ohayv, and Sanders (1990) indicate that national cultural values are feelings, which are often unconscious and cannot be observed but manifest themselves in organizational behavior. This fine distinction between national and organizational culture gives rise to measurement difficulties. The above, coupled with a paucity of studies that have examined cross-cultural ERP system rollouts, is the main reason why there is only majority agreement on the importance of national culture as a CSF in ERP system deployments.

The learning CSF pertains to the leveraging of knowledge from internal and external sources to better facilitate the implementation process as well as promoting the effective use of the full capabilities of the ERP system. Learning is a dynamic process that contributes to smoother deployments, continuous improvement in business processes, and the building up of ERP competencies within the firm. Most firms lay stress on this CSF after stabilization and effective usage of their ERP systems over time. Such types of ERP system implementations are few in number and this is the primary reason why there is only majority agreement for this CSF.

The table also reveals that there is lack of agreement for the IT readiness CSF. The IT readiness CSF refers to the extent of computerization of key organizational functions and the widespread use of computers within firms. ERP systems overhaul the way businesses are run and hence all ERP system implementers have to necessarily go through a learning curve to successfully implement and use ERP systems. This could be the reason why the IT readiness of firms is not crucial for successful ERP system implementations.

A synthesis of the above discussion suggests that there are 14 CSFs, identified by consensual and majority agreement, that are essential for facilitation of the ERP system implementation. The description of these 14 CSFs varies widely in literature as a result of the type of methodological study used by researchers in examining these CSFs. Hence, each of the 14 CSFs identified in table 11 as being key factors in ERP system implementations are discussed below in order to obtain clear generic CSF descriptions and hence resolve ambiguity in their descriptions among researchers.

Critical Success Factors

Top Management Support

Top management support refers to the ongoing championing of the ERP system project within the firm, allocating necessary resources for successful deployment, and ensuring that the implementation process focuses on achieving business goals (Stratman & Roth, 2002). Firms go through a major transformation process when implementing ERP systems as these systems radically shift the way they do business. Because of the profound business implications of implementing these systems, it is imperative that there is sustained top management direction and support to mediate between the imperatives of technology and business (Davenport, 1998). Top management needs to institute a steering committee that closely monitors the progress of the ERP system project to ensure that the implementation process progresses as per schedule and does not spin out of control (Bingi et al., 1999; Teltumbde et al., 2002).

Planning

Planning refers to the continuous, detailed, and adaptive planning of a successful ERP system deployment taking into account a firm's changing cross-functional requirements (Stratman & Roth, 2002). Firms that adopt a planning process that covers project justification, building a business case, scope, the right ERP system, implementation schedule, and resources, can achieve expected project success (Comerford, 2000; Chen 2001). Researchers such as Holland and Light (1999) further stress the importance of planning at various organizational levels early on in the implementation process and monitoring the highly structured plan to completion.

Project Management

Project management refers to the ongoing coordination, scheduling, and the monitoring of project management tasks and activities to ensure that the objectives of the ERP system implementation are achieved (Stratman & Roth, 2002). Excellent project management techniques with clearly defined scope, work plans, resource requirement plans, and milestones are essential to ERP system implementation success (Nah et al., 2001; Umble & Umble, 2002). Researchers such as Weston Jr. (2001) further suggest that a well-documented project management design, which covers the entire ERP life cycle, contributes to the success of complex implementations.

Alignment

Alignment refers to the match between the processes embedded in the ERP system and the firms' business processes. Firms reengineer their business processes to conform to the ERP system and/or customize the ERP system so that it conforms to their business requirements (Hong & Kim, 2001). Though an ERP implementation rollout may be technically successful, a business-ERP system mismatch may result in substantial losses or even failure. The alignment must ensure synergistic ERP configurations at the strategic and the tactical business levels as well as at the technical levels (Markus et al., 2000; Koch, 2001).

Implementation Strategy

Implementation strategy refers to the rollout of the ERP system modules across the firm (Mabert et al., 2000; 2003b). Researchers such as Teltumbde et al. (2002) suggest that the rollout strategy is one of the important factors that impact the success of the ERP system project. Early ERP system implementation strategies comprised of phased or big bang approaches in tune with the firms' narrow focus of rapidly going live with their initial system deployments (Karakanian, 1999; Johnson, 2000). As firms broadened their implementation scope, they realized that their implementation rollout strategies were influenced by various characteristics such as physical scope, BPR scope, technical scope, module rollout strategy, and resource allocation (Parr & Shanks, 2000b).

Consultants

Consultants play a vital role in facilitating and guiding ERP system implementations from project inception to system upgrades. As ERP system projects demand multiple product-specific, business, and inter-personal skills, most firms outsource these skills rather than invest resources in developing them internally (Bingi et al., 1999; Kumar et al., 2003). Consultants are an integral part of ERP system implementation teams and their involvement with the ERP project includes transfer of their ERP expertise to the firm (Sousa & Collado, 2000; Teltumbde et al., 2002).

Implementation Team

Implementation team members who display a well-balanced mix of technical and business skills play a vital role in ensuring the success of ERP system implementations (Stratman & Roth, 2002; Kumar et al., 2003). Lack of understanding of user needs and project needs, and the non-deployment of best IT and functional resources are major reasons for ERP system implementation failure (Bingi et al.,1999; Gefen & Ridings, 2002). The empowered implementation team holds responsibility for creating the overall schedule as well as the detailed project plans besides making sure that necessary resources are made available when required (Nah et al., 2001; Tarafdar & Roy, 2003).

Data Accuracy

Data accuracy refers to the integrity of data that is input into the ERP system as well as the output obtained from the ERP system (Vosburg & Kumar, 2001). Due to the integrated nature of the ERP system, a wrong data entry has a domino effect throughout the entire firm and results in users unwilling to migrate to the ERP system. Processes to ensure data entry should be in place before the implementation starts and extend throughout the ERP life cycle (Umble & Umble, 2002). Researchers such as Vosburg and Kumar (2001) and Xu, Nord, Brown, and Nord (2002) further suggest that all employees play an active ongoing role in the maintenance of data integrity in the ERP system. Employees should understand the concept of integrated data in a manner that is consistent throughout the firm and also use this data accordingly.

User Support

User support refers to the acceptance of the ERP system by all the employees of the firm. ERP system implementations are more about people rather than process or technology and involve major organizational structural and process changes. Firms have to initiate change management programs to overcome user resistance and ensure user support and commitment (Stratman & Roth, 2002; Umble & Umble, 2002). Researchers such as Kanungo and Bagchi (2000) suggest that user involvement, user participation, and hence user commitment are essential for quick acceptance of the ERP system thus leading to more effective system usage and hence speedy benefits realization.

Training

Training refers to the ongoing process of teaching all the employees of the firm to use the ERP system effectively. Training programs are more effective if they are closely tailored to the requirements of various user groups (Stratman & Roth, 2002). Also, ongoing training programs, targeted at various organizational levels, are critical for ensuring effective system usage over a number of years and hence realization of the system's full potential benefits (Teltumbde et al., 2002; Kumar et al., 2003; Mabert et al., 2003a).

Organizational Culture

Organizational culture refers to organizational practices that manifest themselves visibly among the firm's employees (Hofstede et al., 1990). Implementing ERP systems causes major organizational transformations in firms. Studies indicate that communication, degree of control, people involvement, and empowerment are some of the key change readiness factors that help firms effect a change in their organizational culture accompanying an ERP system deployment (Soh et al., 2000; Sia et al., 2002). Also, various studies (Madhavan, 2000; Teltumbde et al., 2002; Ash & Burn, 2003) suggest that changes in business processes, information transparency, employee attitudes regarding job role changes and downsizing are some of the issues that firms need to address to ensure organizational-ERP system fit.

Communication

Ongoing communication within the firm, between all organizational levels, throughout the ERP life cycle is crucial to ensuring implementation success. Researchers such as Al-Mashari et al. (2003) and Tarafdar and Roy (2003) suggest that constant, open, and honest communication with various stakeholders throughout the ERP system life cycle is essential for ERP system success. An open information policy in turn results in greater understanding of organizational needs and hence quicker acceptance and effective usage of the ERP system.

National Culture

National culture refers to the values embedded unconsciously in people that cannot be observed but are manifested in alternative behaviors (Hofstede, 1980; Hofstede et al., 1990). ERP systems provide generic off-the-shelf solutions that may result in implementation problems when they are deployed across different cultures. Studies also suggest that firms have to customize their ERP systems and take into account local business practices while implementing ERP systems (Krumbholz & Maiden, 2001; Davison, 2002; Sia et al., 2002; Sheau, Chae, & Yang, 2004).

Learning

Learning refers to the processes designed to identify effective and improved uses of the ERP system as well as keep abreast of current developments in the ERP arena (Stratman & Roth, 2002). Many researchers consider the ERP system implementation as an organizational learning experience (Scott & Vessey, 2000; Besson & Rowe, 2001). Besson and Rowe (2001) suggest that a structured learning-by-doing process in ERP system implementations builds desired skill-sets and spreads knowledge throughout the firm. Scott and Vessey (2000) indicate that firms facing problematic implementations can use a “learning from failure” strategy to facilitate deployments and hence allow users to exploit ERP system functionalities and obtain long-term sustainable benefits.

Aggregate CSF

Various studies examined ERP system implementations and classify CSFs into categories in different ways (Kraemmergaard & Rose, 2002; Sarker & Lee, 2002; Tarafdar & Roy, 2003). Kraemmergaard and Rose (2002) identify three CSFs – business, technical, and personal competence – each of which in turn is comprised of key factors such as business (organizational, strategic, business process, project management), technical (technology, ERP), and personal (human resource, leadership, communication).. They then classify these CSFs over different stages of the ERP implementation project. The CSFs in the chartering phase are strategic, technology, project management, and communication. In the project phase, the CSFs are project management, business process, leadership, ERP, communication, and human resource. The CSFs in the shakedown phase are ERP, human resource, leadership, and communication. In the onward and upward phase, the CSFs are business process, organizational, ERP, technology, human resource, leadership, and strategic.

Studies also accord equal importance to all CSFs throughout the ERP life cycle and classify CSFs into broad categories (Al-Mashari & Zairi, 2000; Sousa & Collado, 2000; Al-Mashari et al., 2003). Al-Mashari et al. (2003) develop a CSF taxonomy and classify CSFs into broad categories to facilitate ERP system implementations. In the setting-up category, the CSFs are management and leadership, and visioning and planning. The CSFs in the implementation grouping are ERP system selection, training and education, systems integration, communication, project management, systems testing, process management, legacy systems management, and cultural and structural changes. In the evaluation category, the CSFs are performance evaluation and management. The CSFs in the ERP success grouping are correspondence success, process success, interaction success, and expectation success.

The above discussion indicates that researchers largely concur on the need for classifying CSFs into categories. Two broad streams of research, however, have emerged. The first one classified and prioritized CSFs into categories based on the ERP life cycle; whereas the second one classified CSFs into categories but accorded equal importance to all CSFs throughout the ERP life cycle. A synthesis of the two broad research streams coupled with this study's objectives, however, reveals that all the 14 CSFs form a single category. Research, discussed in the earlier part of this chapter, indicates that ERP system implementations are ongoing processes. The above suggests that various modules in the same site or various sites, in the same business unit or across different business units of a firm, within a country or across different countries, would be under different implementation statuses at any given point in time. Also, firms could be engaged in upgrading and fine-tuning any of their above deployments at any point in time thus resulting in a continuously changing implementation status. Thus, firms typically will focus on all the 14 CSFs, identified in Table 11, throughout the ERP implementation life cycle.

The 14 CSFs represent a well represented mix of managerial, technical, and organizational factors. Managerial activities pertaining to the ERP implementation process are represented by CSFs such as top management support, planning, project management, and alignment. The implementation of an ERP system radically transforms the way business is conducted throughout the firm. CSFs such as top management support, adequate planning, and good project management facilitate effective change management and hence are key to ensuring successful deployments. ERP systems are generic business solutions that reflect a series of assumptions based on a synthesis of best practices on how firms should operate. Hence, ERP system fit with business processes is essential for achieving anticipated deployment benefits.

CSFs such as user support, training, learning, communication, organizational culture, and national culture support a firm's various organizational activities. Research suggests that ERP systems have more to do with organizational change rather than technology per se. User participation and user involvement, bolstered by open and honest communication as well as ongoing training and learning initiatives foster user commitment. A culture-ERP system fit helps firms effectively leverage the full capabilities of the ERP system to obtain sustained long-term benefits.

Technical activities pertaining to ERP deployment are represented by CSFs such as implementation strategy, consultants, implementation team, and data accuracy. Studies suggest that a well-planned implementation strategy, driven by competent consultants and a skilled implementation team, would facilitate smooth system roll-out, and hence ensure quick attainment of potential ERP system benefits. Data integrity can mar or facilitate ERP system success. As ERP systems afford single-point data capture, data inaccuracies can have disastrous effects on effective decision-making.

A review of the above discussion reveals that effective management of the aggregate CSF, which represents a complete application of CSFs, will maximize the benefits that firms obtain from their ERP systems. A synthesis of descriptive, case, survey, and modeling and simulation studies suggests that effective management of CSFs also shortens the ERP deployment cycle, results in rapid implementation of the complete ERP system, and quickens the accrual of performance benefits to firms. The parallel and effective management of the 14 CSFs, along with the technical implementation of the ERP system, thus impacts positively on the relationship between ERP implementation system status and changes in performance.

Changes in Performance due to ERP System Implementation

This section addresses the fourth of the six research questions: What are the changes in performance that result from ERP system implementations? A synthesis of research studies in the earlier part of this chapter indicates that firms can significantly improve their business performance with ERP system implementations. Researchers also generally concur that effective management of CSFs shortens the time required for the maximization of benefits from ERP systems.

Table 12 provides the summary details from each of the different types of methodological studies described in the first part of this chapter. The findings from the cross-study comparison of performance changes are indicated through a three-part summary classification. Those performance changes that have good support across research studies indicate consensus agreement regarding their role as key benefits in ERP system implementations. Some performance changes have majority support (a mix of good support and low support) across research studies and are hence classified as having majority agreement for their inclusion as important benefits accruing to firms from their ERP systems. Research studies that do not provide majority support for performance changes (i.e. have two or more no support) indicate lack of agreement among researchers in considering these as ERP system benefits.

A perusal of the cross-study comparison of performance changes in the table suggests that there is a consensus agreement for seven performance changes, majority agreement for three performance changes, and lack of agreement for three performance changes. The seven performance changes identified through consensual agreement by researchers are information availability, information quality, standardization, inventory management, on-time delivery, profitability, and customer satisfaction. Analysis of these seven performance changes indicate that these benefits represent a well-balanced mix of informational, transactional, and organizational improvements that accrue to firms from successful ERP system deployments. The implementation of ERP system modules, however, by default results in integration of business activities across the firm. The implementation of the complete ERP system results in integration of both intra and inter-firm business activities. As ERP systems are integrative by nature, they directly and indirectly influence all of a firm's performance measures. Hence, as integration is a characteristic of the ERP system package, it is not considered part of the benefits resulting from the deployment of the ERP system.

Table 12
Changes in Performance Due to ERP System Implementation

Performance	Methodological Studies			
	Descriptive Studies	Case Studies	Survey Studies	Summary
Information Availability	GS	GS	GS	C
Information Quality	GS	GS	GS	C
Standardization	GS	GS	GS	C
Inventory Management	GS	GS	GS	C
On-time Delivery	GS	GS	GS	C
Profitability	GS	GS	GS	C
Customer Satisfaction	GS	GS	GS	C
Return on Investment	GS	LS	LS	M
User Satisfaction	LS	GS	LS	M
Competitive Advantage	GS	LS	GS	M
Capacity Utilization	NS	LS	NS	L
Monitoring	NS	LS	NS	L
Cycle Times	NS	LS	NS	L

Note

GS = Good support for inclusion as a performance measure in ERP system implementation (performance measure referenced in 50% or more of studies in each of the different types of methodological study tables).
LS = Low support for inclusion as a performance measure in ERP system implementation (performance measure referenced in less than 50% of studies in each of the different types of methodological study tables).
NS = No support for inclusion as a performance measure in ERP system implementation.
C = there is consensus of agreement among researchers for inclusion as a performance measure in ERP system implementation.
M = there is majority agreement among researchers for inclusion as a performance measure in ERP system implementation.
L = there is lack of agreement among researchers for inclusion as a performance measure in ERP system implementation.

Successful implementers use high quality information from their ERP systems for speedy and effective decision-making. The ERP system captures data at a single entry point and then makes it available throughout the firm after stringent data quality checks. The standardization of business processes are benefits that result from the deployment of the process-oriented ERP system. The streamlining of operational areas results in firms deriving transactional benefits such as improved inventory management and on-time delivery. Organizational benefits accrue from the cost savings that result from an increase in efficiencies. These cost savings are then passed to the customer in the form of high quality and effective services at lowered prices and hence results in increased customer satisfaction.

User satisfaction, ROI, and competitive advantage are three performance changes that are identified as having majority agreement among researchers. Studies indicate that firms consolidate, extend, and continually fine-tune their ERP systems to enhance the accrual of benefits from their implementations. This ongoing process is based to a large extent on user feedback and occurs over a number of years of effective system usage. Also, firms that deploy complete ERP system functionality will increase the ROI from their implementations. The consolidation of short-term benefits and the leveraging of long-term benefits will result in sustained competitive advantage to successful implementers. The above suggests that user satisfaction, ROI, and competitive advantage accrue to firms in the long run over a number of years. The majority agreement among researchers on these three performance changes is due to the paucity of long run benefits evaluation studies. These in turn are due to the fact that there are not many complete ERP system implementations that have been in effective use for a number of years.

The table further indicates that there are three performance changes characterized by lack of agreement among the different types of methodological studies. These three changes in performance are capacity utilization, monitoring, and cycle times. Studies discussed earlier in this chapter suggest that the 10 consensual and majority agreement performance changes discussed in the preceding paragraphs subsume performance changes resulting from capacity utilization and cycle times. The real-time insight into production planning enables firms to optimally use their production capacity by steering inventory stocks across sites thus leading to improved inventory management and on-time delivery. Reduction in cycle times arise as a result of increased information visibility into functional activities and is hence reflected in early benefits to the firm such as higher inventory turnover and on-time delivery. The integrated nature of the ERP system improves the monitoring capacity of the firm. ERP systems are highly configurable with regard to user profiles, parameters, and business processes. This in turns renders the monitoring of performance changes highly firm-specific. This is the reason for the lack of agreement among researchers with regard to monitoring being a key performance change measure.

It can be inferred from a synthesis of the above discussion that the 10 performance changes, identified by consensual and majority agreement, are essential for evaluating the benefits that flow from ERP system implementations. The description of these 10 performance changes varies widely in literature as a result of different interpretations by researchers examining ERP system implementations among firms across a cross-section of industries. Hence, each of the 10 performance changes identified in table 12 as being key performance changes in ERP system deployments are discussed below in order to obtain clear generic performance change descriptions and hence resolve ambiguity in their descriptions among researchers.

Performance Measures

Information Availability

Information availability refers to the changes in the availability of integrated real-time information from the ERP system. Firms leverage the information flowing through the seamless integration of the various modules of the ERP system to obtain greater insights into supply chain activities thus resulting in better decision-making (Davenport, 1998; Mabert et al., 2000; Adams, 2002; Mabert et al., 2003b).

Information Quality

Information quality refers to the changes in the availability of consistent and reliable information from the ERP system. The ERP system captures data at a single point and this data is then made available across the firm. Stringent data entry checks from streamlined operational areas and automated transactions ensure that data integrity is maintained thus ensuring high quality output from the ERP system (Dataquest, 1998; Rajani, 1999; Mabert et al., 2000; 2003b).

Standardization

Standardization refers to the streamlining and rationalization of business processes as well as information flowing through the firm. ERP systems impose discipline and consistency on the business processes of the firm. This results in uniform ERP system information outputs available across the firm (Dataquest, 1998; Menezes, 1999; Mabert et al., 2001a).

Inventory Management

Inventory management refers to changes in the inventory management processes that lead to sizeable reductions in inventory holdings, increased inventory turnover, and better control over inventories. Various studies indicate that ERP system implementers can gain sizable inventory reduction and increased inventory turnover benefits by standardizing their inventory management processes and improving performance to industry benchmark levels (Madhavan, 2000; Drayer & Wight, 2002; Mabert et al., 2003b).

On-time Delivery

On-time delivery refers to changes in the order management/order cycle that result from successful ERP system implementations. Improvements in on-time delivery facilitate on-time delivery of products/services to customers. These benefits are enhanced when the ERP system is put to effective use over a number of years (Mabert et al., 2003b; Hawking & Stein, 2004).

Profitability

Profitability refers to changes in profits that accrue to firms from their ERP systems. Firms obtain early cost savings as a result of streamlining of operational areas such as inventory, receivables, distribution as well as reduced information cost across the firm's supply chain (Davenport, 1998; Madhavan, 2000). As the system is put to effective use, firms obtain increased productivity levels for their various resources such as labor and capital (Hitt et al., 2002; Hawking & Stein, 2004). This in turn leads to rationalization of manpower (Davenport, 1998; Poston & Grabski, 2001). Firms obtain sustained profitability increases over the long run (greater than 3 years after implementation) with effective use of full system functionality (Poston & Grabski, 2001; Hawking & Stein, 2004).

Customer Satisfaction

Customer satisfaction refers to the changes in satisfaction levels experienced by the customers of ERP system implementers. Various studies indicate that firms increase their customer satisfaction by meeting parameters such as improved quality, shorter delivery times, quicker customer response, and expanded customer base. This in turn creates a self-propagating structure through deepening customer links with several layers of customers (Davenport, 1998; Ash & Burn, 2003; Watanabe & Hobo, 2003).

<u>Return on Investment (ROI)</u>

ROI refers to changes in the returns (technical as well as business) that firms obtain from their ERP system implementations. Most firms closely monitor and obtain increased ROIs at different unit of analysis levels (division, function, module) from their ERP systems. Successful implementers plan their implementation strategies so as to obtain faster and early ROIs from their ERP systems. This in turn enables them to sustain and increase stakeholder commitment to their ERP projects (Bradford & Roberts, 2001; Evgeniou, 2002; Satyan, 2002).

<u>User Satisfaction</u>

User satisfaction refers to the satisfaction levels resulting from the use of the ERP system. . Researchers such as Caldwell (1998), Kanunga and Bagchi (2000), and Tarafdar and Roy (2003) indicate that user participation, user involvement, and user commitment are the key to increased user satisfaction. This in turn leads to more effective usage of the implemented ERP system and thus results in greater implementation benefits.

<u>Competitive Advantage</u>

Competitive advantage refers to the ability of the firm to meet competitive challenges and enhance its market position. Firms can take advantage of the thousands of different configurations available in the ERP system and strategically plan and implement their ERP systems so as to obtain seamless ERP system-business alignment. This alignment in turn enables firms to leverage the full functionality of their ERP systems across the supply chain and enhance their competitive positions vis-à-vis their competitors (Caldwell, 1998; Davenport, 1998; Tarafdar & Roy, 2002).

Overall Performance

Various studies examined ERP as well as other system deployments classify performance measures into various categories in different ways. Researchers classify performance changes into categories based on a timeline accrual of benefits (Rajani, 1999; Satyan, 2002). Rajani (1999) classifies changes in performance due to ERP systems into 3 time-based categories. In the short-term, firms streamline their operational areas, automate transactions, and ensure data integrity. The next level of benefits occurs over the medium term. Firms use data from their ERP system for meaningful analysis and planning for major resources such as material, capacity, and manpower. At this stage, the firm realizes benefits in terms of reduced working capital, better financial forecasts, reduced cycle time for order fulfillment, and improved coordination between processes. The real benefit of ERP systems accrues to firms in the long-term when they are in a position to apply best business practices by integrating ERP system extensions and other application systems and enhance their competitive advantage.

Studies also classify performance measures into broad performance categories (Mirani & Lederer, 1998; Al-Mashari et al., 2003). Al-Mashari et al. (2003) classifies changes in performance measures due to ERP system implementations into five categories. The operational category concerns improvements in functional areas leading to cost reductions, cycle time reductions, and productivity improvements. Benefits such as better resource management, improved decision-making and planning, and performance improvements fall into the managerial grouping. Strategic benefits help firms to innovate, build cost leadership, generate product differentiation, and build external links in the supply chain. The firm's IT infrastructure benefits through IT cost reductions and increased IT capacity. Organizational benefits such as business learning and successful organizational changes also accrue to firms.

The above discussion indicates that researchers largely concur on the need for classifying performance changes into performance categories. Two broad streams of research, however, have emerged. The first one uses a time-based approach to classify and evaluate performance changes arising from ERP system deployments. The second approach classifies and evaluates benefits using broad performance change categories. ERP system implementations are ongoing processes. In consonance with their expanding implementation scope, firms continuously fine-tune their systems over time to maximize the benefits from their implementations. This suggests that differential benefits accrue to firms due to the different implementation statuses of the ERP system and thus at any point in time firms would be using all the 10 performance measures identified in Table 12 to evaluate their deployments. Hence, in the context of this research study's objectives, it is appropriate to consider changes in performance as one overall category comprising of all the 10 performance measures. These represent a well balanced mix of informational, transactional, and organizational performance elements as described below.

Changes in informational performance measures include information availability, information quality, and standardization. ERP systems force firms to adopt a process approach to their business activities. This coupled with data captured through a comprehensive database enables firms to obtain standardization benefits. The availability of accurate information output from the ERP system enhances user decision-making capabilities. Firms evaluate improvements in their transactional activities with the help of performance measures such as inventory management, and on-time delivery. Firms leverage the informational benefits from their ERP systems to streamline and improve the efficiency of their operational areas. This results in improvement in business activities such as improved inventory management, and on-time delivery of products and/or services. Organizational performance change measures include profitability, ROI, user satisfaction, customer satisfaction, and competitive advantage. The transactional cost savings combined with effective usage of the complete ERP system over the long run increases ROI as well as firm profitability. These cost savings as well as high quality service, when passed onto customers', results in increased customer satisfaction levels. The above performance improvements when sustained and enhanced over the long run through effective leveraging of the ERP system capabilities provide competitive advantages to firms.

A review of the above discussions indicates that all the 10 performance items are differentially impacted depending upon the ERP implementation status of firms. Early benefits from partial implementations give way to overall benefits as more number of modules and extensions comprising the module sub-systems are implemented. The fine-tuning and effective usage of the ERP system over a number of years further enhances the overall performance benefits obtained by firms.

Model of ERP System Implementation

A synthesis of literature in the preceding sections of this chapter that addressed the first four research questions posed in chapter 1 resulted in the identification of two ERP module sub-systems consisting of 14 modules that comprise the ERP system. Also, one overall change in performance comprising of 10 performance changes resulting from holistic ERP system deployments was identified. Further, all 14 CSFs were found to facilitate ERP system implementations.

An analysis of literature further indicates that a systemic concept underlies ERP systems and that a complete ERP system deployment results in overall benefits accruing to firms. The ERP system and its relationships to changes in performance as moderated by CSFs are shown below in figure 2.

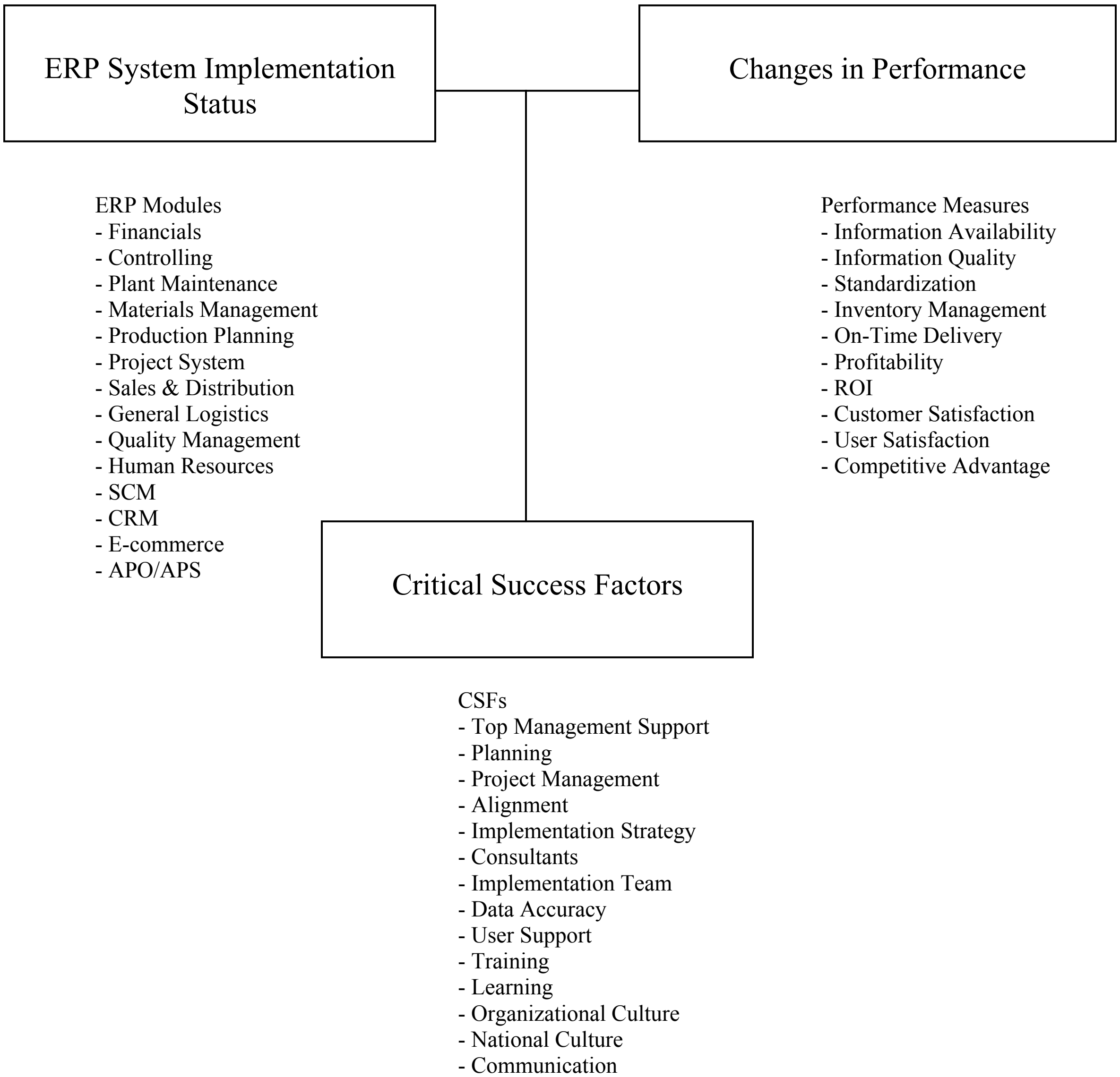


Figure 2. Model of ERP System Implementation.

The ERP system implementation model in the figure and the studies discussed earlier in this chapter suggest that incremental implementation of ERP system modules results in increasing changes in performance with the firms obtaining full synergistic benefits with a complete ERP system deployment. The fine-tuning and effective use of the ERP system over a number of years further enhances the benefits from ERP systems. CSFs further moderate the relationship between ERP implementation status and changes in performance.

Theoretical Model

An overall review of literature on ERP systems discussed in the earlier sections of this chapter indicates that there is a lack of theoretical development in ERP systems research. This section of the study establishes the theoretical perspective that underlies the ERP system implementation model developed in the previous section.

Galbraith's Model

The theoretical framework for investigating the relationships between the implementation status of ERP systems and changes in performance as moderated by CSFs is developed from Galbraith's information processing theory (Galbraith, 1973; Galbraith et al., 1993; Galbraith et al., 2002; Mohrman et al., 1998). Galbraith's earlier research (1973; 1974; 1977) uses a contingency theory-based, open-rational system approach to argue that performance is enhanced when there is a fit between the information processing requirements and capacities of firms. In his later research (Galbraith et al., 1993; Galbraith, 1994; 2000; 2002; Galbraith et al., 2002), Galbraith incorporates the open-natural system approach also by emphasizing that the management of organizational, management, and technical factors maximizes performance benefits. Galbraith's model of organizational design is given in figure 3.

Galbraith (1973; 1974; 1977) bases his information processing theory on the limited ability of organizations to process information. The basic proposition that underlies the information processing theory is that the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution to achieve a given level of performance. Galbraith defines uncertainty as the difference between the amount of information required to perform a task and the amount of information already possessed by the organization. Thus, there is a relationship between the amount of uncertainty faced by organizations and the amount of information processing done in organizations.

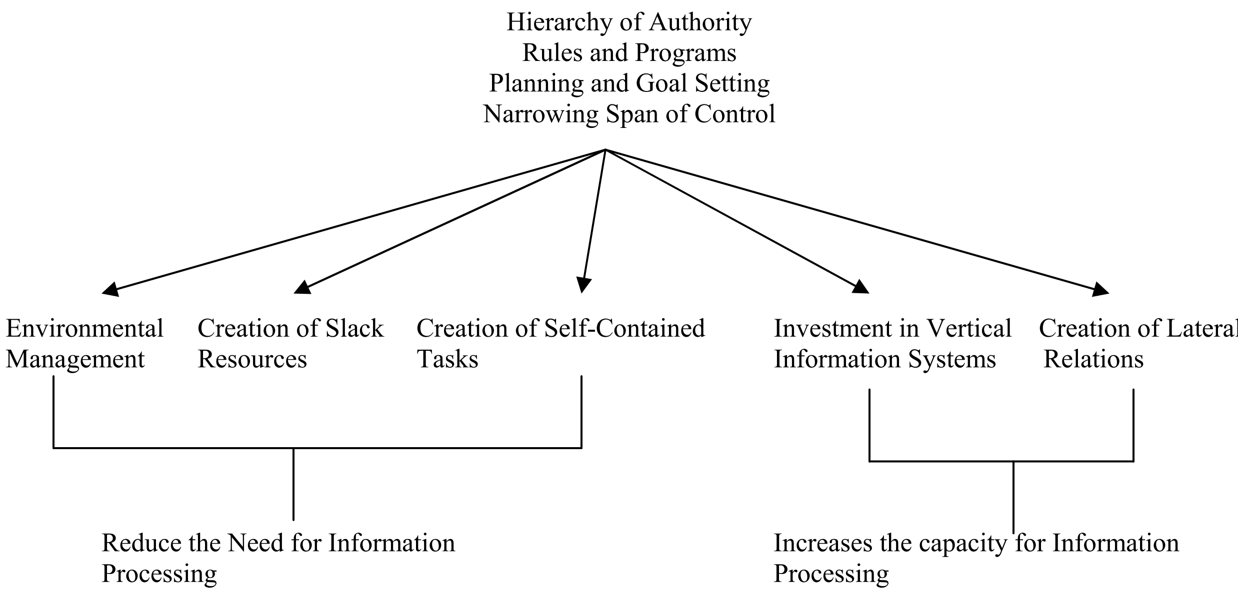


Figure 3. Galbraith's Model of Organizational Design. Adapted from Galbraith, J.R. (1977). *Organization Design*. Addison-Wesley Publishing Company Inc: Philippines.

Galbraith (1973; 1974; 1977) uses a mechanistic approach to explain his information processing approach as business environments were relatively stable in the 1970s. In his later works (Galbraith et al., 1993; Galbraith, 1994; 2000; Mohrman et al., 1998; Galbraith et al., 2002), however, Galbraith incorporates a social system approach to handle greater complexities that are characteristic of the dynamic business environments of the 2000s.

Galbraith (1977) suggests that firms can use four mechanisms to increase coordination among interdependent organizational tasks. The hierarchy of authority mechanism suggests that hierarchies preserve legitimacy by identifying clear lines of authority and by economizing on information processing capacity. The rules and programs mechanism are employed in addition to the hierarchy and their overall effect is to move routine and repetitive decisions to the lower levels of the organization. The planning and goal setting mechanism suggests that as the use of rules and programs increases discretion at lower organizational levels, organizations face potential behavior control challenges. To handle these behavior control challenges, organizations institute planning processes to set goals, and this goal setting increases coordination between interdependent tasks and at the same time allows local discretion. The narrowing span of control mechanism indicates that a decrease in span of control in the hierarchy of authority increases the capacity to process more information.

The ability of organizations to utilize these four coordination mechanisms depends on the combination of the frequency of exceptions and the capacity of the hierarchy to handle them. As the task uncertainty increases, the number of exceptions increases until the hierarchy is overloaded (Galbraith, 1977). Galbraith suggests that firms can handle this in either of two general ways; they can act to reduce the amount of information that is processed, or they can increase the capacity to process information.

Galbraith (1977) elaborates further on the different ways that firms can either reduce or increase the capacity of information processed to handle increasing amounts of task uncertainty. He suggests that there are three ways in which firms can act to reduce the amount of information that is processed. Firms can modify their environment by trying to reduce uncertainty about critical events. Firms can create slack resources by reducing the number of exceptions by reducing their levels of performance. Firms can also create self-contained tasks by changing the way tasks are decomposed into sub-tasks. Alternately, he suggests that firms can increase their capacity to process information in two ways. Firms can invest in vertical information systems that allow them to process information without overloading hierarchical channels. Firms can also create lateral relations through decentralizing decisions, which involves moving the level of decision-making to where the information exists.

Analysis of the above discussion indicates that the first mode (reducing the amount of information that is processed) decreases overloads on the hierarchy by reducing the number of exceptions that occur by lowering performance levels and hence the amount of information that needs to be processed. In contrast, the second mode (increasing the capacity to process information) takes the level of information as given and attempts to acquire and process the requisite information during task execution. Galbraith’s (1977) findings indicate that the overall effect of both these modes is to reduce the number of cases referred upward into the organization through hierarchal channels.

Theoretical Framework for ERP System Implementation

Galbraith’s (1973; 1974; 1977) information processing model broadly addresses the different ways in which firms can reduce uncertainty and improve their performance. His studies outline the role of IS as one of the options available to firms to increase their capacity to process large amounts of information while reducing the number of exceptions that overload the hierarchy. Galbraith’s later studies (Galbraith et al., 1993; Galbraith, 1994; 2000; 2002; Mohrman et al., 1998; Galbraith et al., 2002), however, acknowledge the pervasive role played by IS in both reducing the need for information processing as well as increasing the capacity of firms to process information. These later research studies also highlight the importance of managing CSFs in IS implementations.

The discussion in the following paragraphs ties the ERP system implementation model developed in the previous section to Galbraith’s theoretical framework. A perusal of the ERP system implementation model suggests that four of Galbraith’s five approaches to managing uncertainty are relevant to this study. These four approaches span both the broad approaches to managing uncertainty – reducing as well as increasing the capacity to process information. These four approaches are environmental management, creation of self-contained tasks, investment in vertical information systems, and creation of lateral relations. The use of the slack resources approach is not consistent with ERP system implementations and is also discussed below.

Reducing the Need for Information Processing

The creation of slack resources as an approach to reducing the need for information processing is not consistent with the implementation and usage of ERP systems. Slack resources indicate that the firm does not have the information processing capacity to deal with coordination requirements of interdependence and instead creates additional resources by reducing performance standards (Galbraith, 1973; 1974; 1977). The creation of these additional resources takes the form of increased delivery time, accumulation of inventory, lower productivity levels due to under-utilized resources, increase in personnel, increased machine time and incurring of higher costs.

The implementation of ERP systems obviates the need for firms to augment their resources in order to deal with the information processing needs associated with the increased coordination requirements for managing interdependencies. This is because ERP systems standardize and integrate enterprise-wide business processes resulting in the automation of transactions and the availability of accurate information for decision-making. For example, the implementation of the financial modules and the logistics modules results in quick financial close cycles and streamlined operational areas respectively. This results in transactional benefits such as improved inventory management and improved on-time delivery, and organizational level benefits such as operational costs savings that translate into increased profitability. The proper planning of the ERP system deployment, the ensuring of ERP system-business alignment by internal and external stakeholders, and enforcing data integrity procedures facilitates the above process. The implementation of extension modules such as SCM and CRM further increases real-time information availability and visibility across the supply chain and hence increase a firm's coordination capacities across inter-firm activities. This translates into increased transactional benefits such as decrease in costs and better utilization of resources as well as organizational level benefits such as increased customer satisfaction. The effective use of the ERP system by ensuring end-user support through established communication channels and training programs, and continuous top management monitoring enhances the performance benefits obtained from these complete ERP systems.

Galbraith (1973; 1974; 1977) indicates that firms can create self-contained tasks as another approach to reducing their information processing needs. This approach shifts the basis of authority structure from one based on input to one based on output. The creation of self-contained units around projects, products, processes, customers, or purchases eliminates the use of shared resources, reduces division of labor, and results in the point of decision moving closer to the source of information (Mohrman et al., 1998). Higher costs result due to a reduction in skills specialization and division of labor. The benefits, however, outweigh the costs and include greater local discretion, and ensuring ERP system-business fit by tailoring of systems and procedures to firm-specific needs.

ERP systems can support the use of self-contained tasks by configuring employees' decision-making responsibility levels according to organizational requirements. For example, firms that implement human resource modules and logistics modules, such as materials management, can use self-service features to provide greater discretion to employees' at all organizational levels to handle activities such as benefits entitlements and purchases. This is facilitated by firms paying adequate attention to factors such as national and organizational culture characteristics, changes in job design, communication, training, and learning programs (Mohrman et al., 1998; Galbraith, 2002). Also, the availability of enterprise-wide information from a single database requires employees to develop multi-tasking capabilities. These multi-skilled employees in turn contribute to a reduction in the costs associated with the division of labor and lack of specialization that are traditionally associated with the adoption of the self-contained tasks approach. Firms benefit by improved inventory management, increased user satisfaction, increased cost savings through improved productivity and hence higher profitability.

ERP systems can also be configured to a firm's specific world-wide requirements such as products, regions, and customers. This configurational flexibility enables the firm to match its ERP system configuration to its varying requirements of self-containment and hence decentralization. For example, under conditions of moderately diverse and moderately unpredictable tasks, firms may centralize their configurations so that modules such as financials, materials management, and human resources management are concentrated at the corporate headquarters; while logistics modules, such as sales and distribution, plant maintenance, and production planning, are distributed to their local locations. Under conditions of diversity and uncertainty, firms may decentralize their configurations so that only their financials modules are concentrated at the corporate headquarters, while distributing logistics, human resources, and extension modules to local locations. Firms may also strive to strike a balance between the demands of centralization and decentralization by adopting a hybrid configuration that falls in-between the two approaches outlined above. These flexible configurational options help firms maintain ERP system-business alignment.

Firms can also reduce their information processing needs by changing their environment, reducing uncertainty, and managing their dependence on others so that their present structure and processes are adequate. Firms can handle the uncertainty of their task environments by changing any or all of its constituent elements – strategy, technology, and location (Galbraith, 1977). Galbraith's study further suggests that firms can use independent mechanisms such as competitive response, public relations response and voluntarism as well as cooperative mechanisms such as implicit cooperation, contracting, co-opting, and coalescing to relate to their environment. The choice of mechanisms adopted depends largely on organizational requirements for balancing autonomy and flexibility needs, with the exchange of commitments to reduce uncertainty through cooperation and coordination.

ERP systems help firms balance their contrasting needs of autonomy and flexibility with cooperation and coordination through configuration of the system at four levels. These four levels are the overall design of the enterprise, design of business activities – user profiles, parameters, business processes, and customization through supplementary programming (Koch, 2001). The configuration flexibility of ERP systems enables firms to change any or all of its constituent elements such as strategy, technology, and location. For example, firms can configure their systems using financials, logistics, and human resource modules to handle their centralization, decentralization, and hybrid organizational needs across customers, regions and products.

Besides leveraging the autonomy and flexibility benefits that flow from intra-firm configurations, firms can also handle the complexity and the uncertainty of their task environments by implementing common supply chain processes across their front-office and back-office operations. Mohrman et al. (1998), Galbraith (2000; 2002), and Galbraith et al.

(2002) term such firms that build coordination and cooperation into their inter-firm value chains as using a front-back hybrid organizational arrangement. Their studies indicate that the use of enterprise systems, which encompasses separate applications such as e-procurement, e-human resources management, ERP, CRM, and SCM results in the seamless integration and management of critical events such as for example a disruption in the availability of supplies or uncertain and fluctuating customer demand.

The facilitation of the above configurations requires firms to focus on factors like fine-tuning ERP system-business alignment, continued user support, training and learning programs, and efficient project management. The efficacy of the above factors involves ongoing top management support and planning to confront and convert the conflict that may result from national and organizational culture characteristics of the supply chain partners into communication and coordination (Mohrman et al., 1998; Galbraith, 2000). Firms' benefit by increased streamlined transactions resulting from standardized and integrated processes and hence enhanced intra-firm performance. The increased information visibility across the supply chain results not only in increased transactional benefits but also in organizational and intra-organizational benefits thus increasing revenues and providing competitive advantages to all the supply chain partners.

Increasing the Capacity for Information Processing

In contrast to the approaches discussed above which help firms manage uncertainty by reducing their information processing needs, Galbraith (1973; 1974; 1977) indicates that firms can invest in vertical information systems to increase the capacity of existing channels of communication, create new channels, and introduce new decision mechanisms. These result in an increase in the capacity of firms to make use of information acquired during task execution without overloading the hierarchical channels as fewer exceptions would be referred up the hierarchy. Their studies further indicate that firms should consider four variables or dimensions while using vertical information systems to increase their information processing capacity to handle uncertainties. These are decision frequency or timing, scope of the database, degree of formalization, and the decision mechanism. Galbraith's later works (Galbraith et al., 1993; Galbraith, 1994; 2000; 2002; Mohrman et al., 1998; Galbraith et al., 2002) incorporate CSFs to illustrate each of the four dimensions suggested by his earlier studies.

The first dimension, decision frequency or timing, refers to the length of time between decisions. The length of time between decisions is dichotomized into periodic and continuous information flows. This timing or frequency dimensions affects the number of decisions that are referred upwards in the hierarchy. Galbraith (1977) suggests that as uncertainty increases frequent changes in plans need to be made as the interval between plans grows shorter and leads to fewer exceptions. ERP systems fall under the continuous information flow end of the decision frequency and timing dichotomy as they make available a continuous stream of intra and inter-firm real-time information for decision-making. The implementation of financials, logistics, human resource modules as well as extensions such as SCM and CRM result in increased information availability and visibility across the supply chain. Firms that pay attention to factors like accuracy of their data, and alignment between their ERP system and business processes, would benefit from increased transactional efficiencies as well as increased revenues and customer satisfaction due to quick information leveraging for effective decision-making.

The second dimension, the scope of the database, is dichotomized into two types - local and global. Local databases provide information for decision-making pertaining only to their immediate location whereas global databases provide access to information across locations. The choice of an appropriate database scope is determined by the interdependence between locations or subunits. The greater the interdependence between subunits, the greater the need for a global database (Galbraith, 1977). ERP systems use a single, integrated, and comprehensive database to consolidate enterprise-wide data and provide local and global information for effective decision-making. The databases of these systems can be configured according to firm-specific strategies as local or global, and users granted access according to roles that are parameter configurable (Markus et al., 2000; Clemmons & Simon, 2001; Koch, 2001). The efficacy of decisions taken with the information available at decision points, using global or local databases, depends on the management of appropriate managerial and organizational factors. As firms are affected by cognitive as well as goal factors by the use of either local or global databases, they should pay adequate attention to factors such as proper planning with top management input and support; user support through training, learning, communication programs, national and organizational culture characteristics. The resulting leveraging of the informational flow benefits translates into operational and financial improvements.

The third dimension refers to the degree of formality of the collection and reporting processes. The formalization of categories for collecting and reporting permits the transmission of standard information through expanded communication channels. Galbraith (1977) suggests that firms are, however, limited in their ability to standardize qualitative information and hence non-formal channels may be required to handle such type of information. ERP systems result in standardization and integration of business processes throughout the firm. For example, the implementation of financial modules ensures that the same type of accounting and controlling information is available throughout the firm. Further, the automation of transactions results in the ERP systems handling all routine and predictable events. These systems can also be configured to capture data on unique and non-routine events and raise exceptions up the hierarchy for problem solving. Firms needs to plan the categorization of events as routine and non-routine with top management input so that they can leverage such information to make quick decisions and obtain enhanced performance benefits.

The fourth dimension refers to the capacity of the decision mechanism to process information and select alternatives. Galbraith (1977) ties the capacity of the decision mechanism to decision frequency or timing and the scope of the database. He suggests that firms can choose from four prototype IS based on these two dimensions as well as cost. These are local-periodic, local-continuous, global-periodic, and global-continuous. ERP systems continually collect information and make it available for decision-making as needed. Also, these systems can be configured to capture information on local or global databases depending upon the specific needs of the firm. Thus, ERP systems can fall into two categories – local-continuous or global-continuous – based upon organizational requirements. Galbraith (2002) and Galbraith et al. (2002) suggest that ERP systems are process driven and global-real time information systems that are based on complete workflows with people given responsibility for whole processes. They suggest that successful deployments would, however, require firms stressing factors such as national and organizational characteristics and continued top management driven user support. Firms leverage the continuous real-time information from their ERP systems to achieve operational efficiencies and accrue organizational benefits.

Besides investing in vertical information systems, Galbraith (1973; 1977; 2002) and Galbraith et al. (2002) also suggest the creation of lateral relations to handle uncertainty by increasing the information processing capacity of the firm. This in turn reduces the number of decisions being referred up the hierarchy. Their studies show that lateral relations accomplish this by increasing discretion at the lower organizational levels of the firm thereby moving the level of decision-making to where the information exists rather than bringing the information up to the points of decision-making. The studies also suggest that coordination through lateral processes has become increasingly important with the current trend towards network and process-oriented organizational designs.

ERP systems facilitate the formation of lateral relations through their inherent process-oriented and modular structures that are configurable according to varied firm requirements. These integrated systems allow coordination of all partner firms along the value chain by removing space and time barriers to communication. Galbraith (2000) suggests that modular and component-oriented information systems, with embedded best practices in them, have replaced traditional managerial roles of communication and coordination. His other studies (Galbraith, 1994; 2002) suggest that firms use e-coordination to link processes to coordination needs through use of technologies such as integrated databases, email, groupware, teams, and intranets. This is supported by current ERP market trends wherein firms have transformed their ERP systems into Web-enabled systems that incorporate the above coordination mechanisms to provide standardized and integrated intra and inter-firm information availability and visibility for effective decision-making.

The creation of lateral processes, which involves links between the financial, logistics, human resources, and extension modules, is influenced and facilitated by people and change management issues. Galbraith (1993; 1994; 2000; 2002) and Galbraith et al. (2002) suggest that people and change management practices are essential for creating a congenial climate for the development and maintenance of lateral relations. Their studies also show that the move towards lateral relations is driven by top management and includes management development and training programs, action learning, use of teams and groups, use of change champions and outside consultants to ensure change readiness and deployment of change management programs, and the use of reward systems to increase user support. Firms' benefit by increased integration of activities, user satisfaction, and increased profitability.

It can be inferred from a synthesis of the discussion in this section that Galbraith's information processing approach serves as an appropriate framework to evaluate ERP system implementations. Each of the four approaches to handle uncertainty that is relevant to the implementation of ERP systems has been presented above. Firms can choose one or a combination of the four approaches depending upon their implementation strategies. Firms should ensure that irrespective of their chosen approach(s), there should be a match between their task information requirements and their capacity to process information.

Hypotheses

This section addresses the last two research questions of this study. They are: Does a relationship exist between the implementation status of the ERP system and changes in performance? Do CSFs influence the relationship between the implementation status of the ERP system and changes in performance? This research study, from a synthesis of literature, and supported by theoretical frameworks, suggests that the implementation status of ERP systems contributes to changes in performance. Firms derive synergistic benefits from complete ERP system deployments and further enhance their performance benefits through usage of the system over a number of years. This research model further suggests that CSFs play a critical role in moderating the relationship between ERP system implementation status and changes in performance.

ERP System Implementation Status and Changes in Performance

The association between ERP system implementation status and changes in performance was discussed earlier in this chapter. The discussion below reiterates the key points discussed in the earlier sections. Various studies suggest that firms that have implemented one module or a few modules are considered to have implemented ERP systems. These studies further suggest that benefits accrue to firms as a result of effective usage of a single ERP system module or a few ERP system modules (Klaus et al., 2000; Bradford & Roberts, 2001; Hitt et al., 2002; Gefen & Ragowsky, 2005). Most ERP system research, however, supported by other relevant studies, indicate that firms can leverage their ERP systems and enhance their business performance with complete ERP system deployment as well as through effective system use over a number of years (Schroeder et al., 1981; Duchessi et al., 1988; White, 1990; Johnson, 2000; Mabert et al., 2001a; Poston & Grabski, 2001; Willis & Willis-Brown, 2002). Galbraith's various studies (Galbraith, 1973; 1974; 1977; 1994; 2000; 2002; Galbraith et al., 1993; Mohrman et al., 1998; Galbraith et al., 2002) on managing uncertainty, using an information processing approach, also underscore the systemic concepts that underlie ERP systems.

Galbraith's (1973; 1974; 1977) studies suggest IS as one of the options that firms can use to meet their information requirements. Galbraith's (1994; 2002) and Galbraith et al's (2002) later studies acknowledge the pervasive influence of IS and suggest that appropriate IS's could be leveraged to adopt any or a combination of approaches to handle uncertainty. Using this latter approach, this research study discussed the use of four of Galbraith's (1977) five approaches to reducing uncertainty. It can be inferred from a synthesis of these discussions that ERP systems can be used to manage uncertainty. Firms implement those ERP modules that they believe will contribute to changes in performance. Accordingly, the first linkage in the ERP system implementation model suggests that a relationship exists between ERP system implementation status and changes in firm performance.

Galbraith et al. (1993) and Galbraith (2000; 2002) suggest that firms should integrate their front-office and back-office operations through IS extensions in order to derive enhanced performance benefits. Mohrman et al. (1998) also suggest that the implementation of modular systems and their integration over time will result in enhanced performance benefits accruing to firms. The findings of these studies, in the context of this research study's objectives, suggest that firms can derive synergistic benefits from the complete deployment of their ERP systems. Also, the implementation and the usage of these ERP systems over time would further result in enhanced performance benefits accruing to firms. The first linkage in the ERP system model is investigated by testing the first set of hypotheses – 1a and 1b – in this research study.

H1a: The implementation status of individual ERP system modules contributes to changes in performance.
H1b: The implementation status of a holistic ERP system contributes to changes in performance.

Influencers of ERP System Implementation Success

A number of variables have been identified as influencers of the relationship between ERP system implementation status and changes in performance. The impact of these variables on the ERP system implementation status and changes in performance has been discussed earlier in this chapter. The discussion below seeks to emphasize key points addressed in the earlier sections. A synthesis of ERP system research, supported by other relevant studies, indicates that firms that effectively manage their CSFs can successfully implement their ERP systems. Also, a CSF based approach enables firms to effectively integrate all the modules of the ERP system and effectively use the ERP system over a number of years. This results in enhanced performance benefits accruing to firms from their ERP systems (Duchessi et al., 1988; Holland & Light, 1999;

Ang, Sum, & Yeo, 2000; Al-Mashari & Zairi, 2000; 2003; Markus et al., 2000; Parr & Shanks, 2000a). Galbraith's various studies (Galbraith, 1993; 1994; 2002; Mohrman et al., 1998; Galbraith et al., 2002) also suggest that the technical implementation of IS in organizations should be accompanied in parallel by appropriate people and organizational changes.

Galbraith et al. (1993) suggest that firms focus on factors such as top management, planning, employee involvement, training, project management, and change management to achieve IS implementation success. Mohrman et al. (1998) support the findings of the Galbraith et al. (1993) study by suggesting that firms should also focus on managing external relationships with partners so that IS could be successfully deployed across the supply chain. Their study suggests that firms should also focus on factors such as communication, learning, national and organizational culture changes in order to achieve IS implementation success. Galbraith et al. (2002) provides further support by suggesting that firms leverage technologies such as e-coordination to manage the factors that are critical to IS deployment success. The findings of these studies, in the context of this research study's objectives, suggest that CSFs influence the relationship between ERP system implementation status and changes in firm performance. This second linkage in the ERP system implementation model is investigated by testing the second set of hypotheses – 2a and 2b – in this research study.

H2a: CSFs moderate the relationship between the implementation status of individual ERP system modules and changes in performance.
H2b: CSFs moderate the relationship between the implementation status of a holistic ERP system and changes in performance.

Summary

ERP systems have received increasing worldwide attention in the past decade. These systems transform the way firms do businesses and their implementation has become a business necessity. Issues such as their implementation, key factors for successful deployment, and benefits that accrue to firms have become increasingly important. A synthesis of research studies in this chapter identified 14 modules grouped into two module sub-systems that comprise the ERP system, 14 CSFs grouped into one aggregate CSF that impacts the implementation process, and 10 changes in performance grouped into one overall performance category. These studies overall support the research idea that the systemic implementation of ERP systems results in improved performance changes for firms, albeit necessary attention being paid to managing CSFs. An ERP system implementation model was then developed to represent the relationship between ERP system implementation status and changes in performance taking into account the moderating influence of CSFs on this relationship. Galbraith's information processing approach, based on a synthesis of open-rational and open-natural theories, provided the theoretical underpinnings for the ERP system implementation model. Two sets of hypotheses were then postulated for empirical testing. In chapter 3, the methodology used for examining the relationships suggested in the ERP system implementation model is discussed.

CHAPTER 3

RESEARCH METHODLOGY

Introduction

This research was a cross-sectional field study that involved the use of survey methodology to obtain data from firms across a variety of production environments. A model was developed in Chapter 2 to include key variables and their relationships in the implementation of enterprise resource planning (ERP) systems. A questionnaire was developed to collect data from Indian production firms for testing these relationships. The survey was implemented using a mixed-mode method wherein postal mail procedures were mixed with email delivery. Choices of multivariate techniques for analyzing the data include factor and regression analyses as well as univariate analysis of variance (ANOVA). An overview of this study's research methodology is shown in Figure 4.

Measuring Instrument

This section first addresses the questionnaire development process and construction method. Then, the items and scales used to measure the variables and the relationships in the ERP system implementation model are described. This is followed by a discussion on the structure of the questions used to gather data on the respondent and business unit characteristics. The last part of the section describes the reliability and validity of the survey instrument.

Questionnaire Development

The data collection instrument was primarily developed from a synthesis of ERP system as well as other relevant research considered pertinent to this study's objectives. The questionnaire development involved a four-step process as detailed in the following paragraphs.

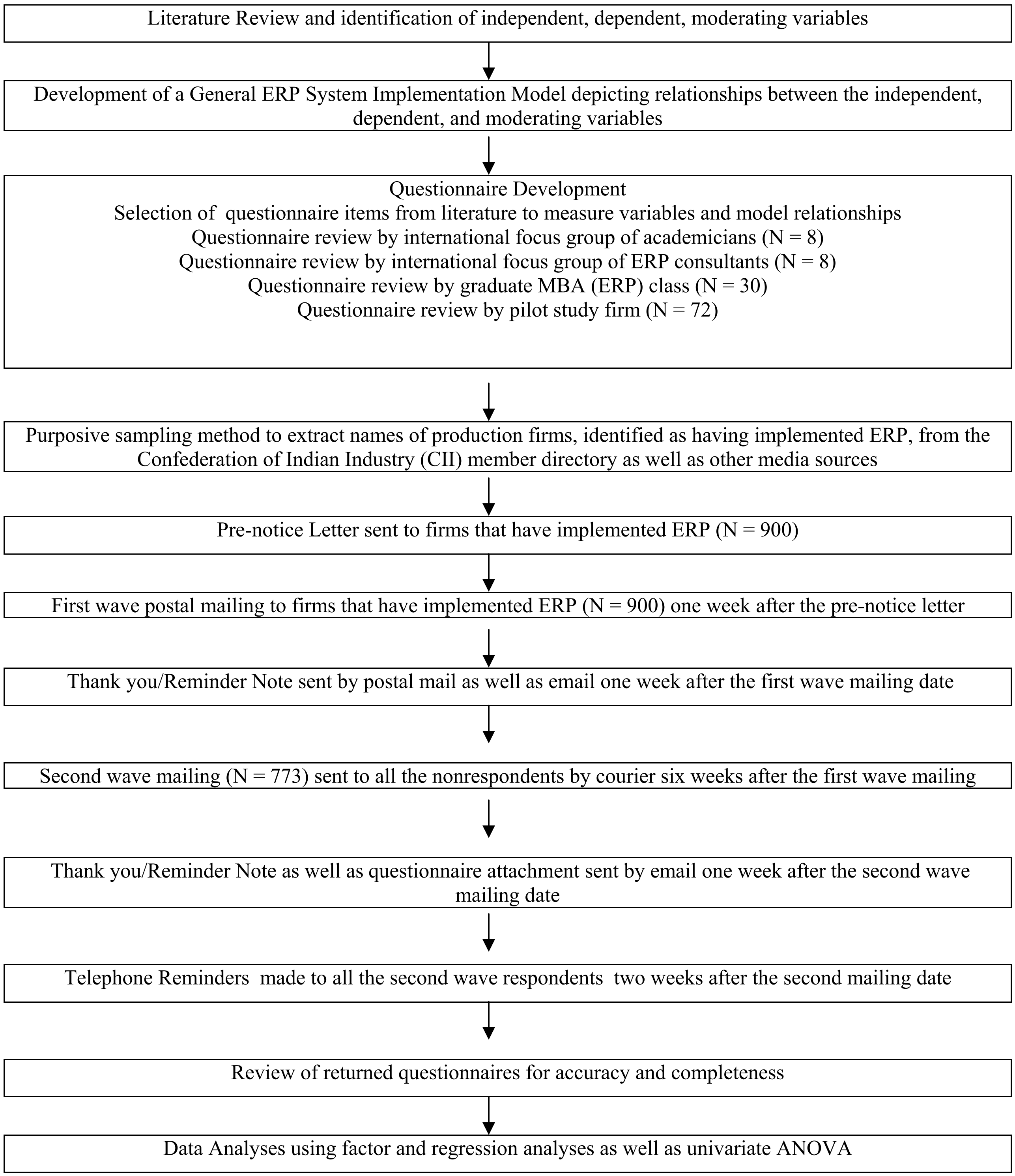


Figure 4. Research Methodology to Test the Relationships Between ERP System Implementation Status, Changes in Performance, and CSFs.

First, the questionnaire was submitted to an international focus group consisting of eight academicians (four each in the United States (US) and India) acknowledged as experts in the areas of survey methodologies and ERP system research. The inputs from the focus group of academicians led to the addition and deletion as well as the restructuring of certain items in the questionnaire. Follow-up discussions with four of these academicians helped in further clarification of certain ambiguous questionnaire items. The questionnaire was then submitted for review to an international focus group of eight consultants (two in the US, one in Australia, one in the United Kingdom (UK), four in India) with diverse functional backgrounds and extensive techno-functional experience in information technology (IT) and more specifically in ERP consulting (average consulting experience of over 10 years). Modifications and changes were made to specific questionnaire items as a result of inputs from this focus group. Follow-up calls to gain additional information were made to four of these consultants, which helped streamline the structure and layout of the questionnaire.

The questionnaire was then administered to a graduate MBA (ERP) class at the Indian Institute of Management Bangalore (IIMB) in India. The majority of the respondents possessed an engineering background and had worked with ERP systems in course projects involving industry-academia interactions. Twenty nine out of thirty students responded to the survey. Most changes to the questionnaire, as a result of inputs from this class, related to the layout of the questionnaire and the specific wordings of various items. Follow-up interviews with two of the respondents helped to further simplify the construction of certain questionnaire items.

The final step in the questionnaire development process involved conducting a pilot study in a public sector Indian mining firm, Orissa Mining Corporation (OMC), which had implemented a 100 user license ERP system. OMC is India’s largest mining firm with a 2004-05 sales turnover of $165 million and operational profit of $99 million (www.orissamining.com). The ERP project manager for this firm was the contact person for administering the questionnaire to the 100 ERP system users in the firm. Seventy two responses were received and two responses containing missing data were discarded (effective response rate of 70/100). The pilot study respondents had an average work experience of twenty years and a majority of them worked in managerial positions in diverse areas such as finance and engineering. The inputs from these ERP system users resulted in more modification and restructuring of a few questionnaire items.

Feedback from the respondent groups was incorporated at each step of the four-step questionnaire development process that allowed for an incremental and comprehensive development of the survey instrument. Follow-up calls and interviews, with a cross-section of the respondents at various steps in the questionnaire development process, indicated that most respondents were knowledgeable about ERP systems and were in a position to understand the impact of the ERP system on firm performance as well as the interplay of critical success factors (CSFs) that influences the implementation process.

Questionnaire Construction

Dillman’s (1978; 2000) time design method (TDM) and tailored design methods for constructing the questionnaire were followed to the extent possible. No changes were made to the questionnaire design to ensure that equivalent data were obtained across the mixed-mode survey methods used in this study. The questionnaire was printed on five 8 ½” x 11” sheets back to back. The questionnaire comprised of twenty questions and took about thirty minutes of the respondents’ time to complete. Most questionnaire items focused on obtaining information on the key variables and relationships in the ERP system implementation model. A few items were also included in the questionnaire to gather demographic information. The terminology used in the construction of the items was altered where relevant to refer to a “business unit” in order to be consistent with this study’s unit of analysis. The items and scales used to measure the variables and their relationships are discussed in the following paragraphs.

Operational Definitions

Independent Variables

In this study, the 14 modules identified as comprising the ERP system are financials, controlling, plant maintenance, materials management, production planning, project management, sales and distribution, general logistics, quality management, human resources, supply chain management (SCM), customer relationship management (CRM), electronic-commerce (E-Commerce), and advanced planner optimizer/advanced planner scheduler (APO/APS). These variables were developed from literature; however, the scales used to gather data on each of the modules in this study were drawn from the White (1990) and the Berry (1996) studies. Minor changes were made to the White (1990) and Berry (1996) scales to allow for sharper delineation in the measurement of the implementation statuses of the modules. Each of the 14 ERP system modules in this study formed an item to collect information on the implementation status of the ERP system (see Appendix 2). The data for these items were obtained using an ordinal scale consisting of the following ranges of implementation status: not implemented (NI), implementation started within the last year (0 to < 1 year), implementation started 1 or more but less than 3 years ago (1 to < 3 years), implementation started 3 or more but less than 5 years ago (3 to < 5), and implementation started 5 or more years ago (5+). Though Mabert et al. (2001a) and Kumar et al. (2003) and suggest longer time frames for examining ERP system deployments, most ERP studies suggest a five year implementation period for completion of holistic ERP system implementations as well as accrual of synergistic benefits. Hence, the five year time frame has been used in this research study.

Dependent Variables

A 7-point Likert type scale was used to collect information on the benefits associated with the implementation of ERP systems (see Appendix 2). The 10 changes in performance measures identified are inventory management, information quality, on-time delivery, standardization, profitability, return on investment (ROI), information availability, user satisfaction, customer satisfaction, and competitive advantage. The use of 7-point Likert type scales ranging from 1=disagree to 7=agree in this study was based upon its widespread usage among researchers such as Mirani and Lederer (1998), Mabert et al. (2000, 2001b, 2003a, 2003b) and Stratman and Roth (2002) to measure changes in performance resulting from ERP/IT system implementations.

Moderating Variables

Information was collected through 7-point Likert type scales on 14 CSFs identified in literature as having an influence on the relationship between ERP implementation status and changes in performance (see Appendix 2). The 14 CSFs identified are top management support, planning, user support, project management, training, learning, implementation strategy, alignment, consultants, implementation team, data accuracy, communication, organization culture, and national culture. Many researchers such as Mabert et al. (2000, 2001b, 2003a, 2003b) and Stratman and Roth (2002) have used 7-point Likert type scales, ranging from 1=disagree to 7=agree, to measure factors that impact the ERP system implementation process. The items used to measure each of the 14 CSFs were drawn from a synthesis of ERP and other relevant research studies. Minor changes were made to some of the items to reflect this research study's objectives. Consistent use has been made of terminologies in this study such as items "drawn" from studies referring to items (modified or not modified) taken from validated instruments and items "developed" from studies to items that have been written based on the findings of researchers. The items used to measure the CSFs are discussed in the following paragraphs.

Top Management Support

In this study, top management support refers to the ongoing championing of the ERP system project within the business unit, allocating necessary resources for successful ERP system deployment, and ensuring that the implementation process focuses on achieving business goals. The first five items (15-1a to 15-1e) were drawn from Stratman and Roth (2002) to measure the role of top management executives in the ERP system implementation process. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) study was 0.88.

Minor changes were made to some of the items in this scale. For example, the term "executives" in the Stratman and Roth (2002) questionnaire was replaced by "top management" in items 15-1a and 15-1c. This was to ensure that these items reflect the consistent terminology top management used in this research study. The sixth item (15-1f) was developed from the Teltumbde et al. (2002) study. Their study suggests that a steering committee composed of top management people from different functional areas should monitor the ERP system implementation progress against the project schedule. Consequently, their findings were incorporated as an item in this study.

Planning

Planning refers to the continuous planning of ERP system implementations in tandem with a business unit's changing cross-functional requirements. Four items (15-2a to 15-2d) were drawn from the Stratman and Roth (2002) instrument to measure the role of planning in the ERP system implementation process. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) study was 0.87. Minor changes were made to some of the items in this scale to ensure their relevance as well as their consistency in the use of terminologies in this research study. For example, the term "IT" in all the four items in the Stratman and Roth (2002) study was replaced by "ERP" in this study.

User Support

In this study, user support refers to the acceptance of the ERP system by all the employees of the business unit. The business unit has to institute change readiness programs to overcome employee resistance to changes induced by the ERP system deployment. The first four items (15-3a to 15-3d) used by Stratman and Roth (2002) to measure strategies for overcoming employee resistance and increasing user support were used in this study to measure user support. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) study was 0.85. Minor changes were made to some of the items to ensure consistency in the use of terminologies in this research study. For example, in item 15-3a, the term "ERP entity" in the Stratman and Roth (2002) study was replaced by "ERP defined business processes" in this research study. The fifth item (15-3e) was developed from the Kanungo and Bagchi (2000) study. Kanungo and Bagchi found that user participation and involvement were critical for ensuring user support for successful ERP system deployments. Their findings were incorporated as an item in this study to assess the extent to which user participation and involvement foster user support and hence acceptance of the ERP system.

Project Management

Project management refers to the ongoing coordination, scheduling, and the monitoring of project management tasks and activities to ensure that the objectives of the ERP system implementation are achieved. The first four items to measure project management (15-4a to 15-4d) were drawn from the Stratman and Roth (2002) study. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) was 0.91. The fifth item (15-4e) was developed from the Weston Jr. (2001) study. Weston Jr. (2001) found that maintaining documentation throughout the ERP life cycle is essential for effective project management. Hence, his findings were incorporated as an item in this study to assess the ERP documentation management process in the business unit.

Training

In this study, training refers to the ongoing process of teaching all the employees of the business unit to use the ERP system effectively. In this study, five items (15-5a to 15-5e) were drawn from the Stratman and Roth (2002) study to measure the impact of training on the ERP system implementation process. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) study was 0.86. Minor changes were made to item 15-5e. The phrase "on an ongoing basis" was added to the item in this study to reflect the continual need for review of the business unit's ERP training processes.

Learning

Learning refers to the processes designed by the business unit to identify effective as well as improved uses of the ERP system and also keep abreast of current developments in the ERP arena. Four items (15-6a to 15-6d) used to measure learning were drawn from the Stratman and

Roth (2002) study. The Cronbach's alpha of the scale used in the Stratman and Roth (2002) was 0.85.

Implementation Strategy

In this study, implementation strategy refers to the rollout of the ERP system modules across the business unit. Four items (15-7a to 15-7d) were developed from the Mabert et al. (2000; 2003a; 2003b) studies. Mabert et al. (2000; 2003a; 2003b) found that the choice of the firms' rollout strategies had a major impact on the success of ERP system implementations. Consequently, their findings were incorporated as items in this study to assess the impact of the business units' rollout strategies on the ERP system implementation process.

Alignment

Alignment refers to the match between the processes embedded in the ERP system and the business processes of the business unit. Firms reengineer their business processes to conform to the ERP system and/or customize the ERP system so that it conforms to their business requirements. Five items (15-8a to 15-8e) were developed from the Hong and Kim (2001) study to measure alignment between the ERP system and the business unit processes. Hong and Kim (2001) found that organizational fit, ERP adaptation, and process adaptation influenced the success of ERP system implementations. Their findings were incorporated as items to assess the impact of ERP system-business alignment on successful ERP system deployments.

Consultants

In this study, consultants refer to the vital role played by external consultants in facilitating and guiding ERP system implementations from project inception to system upgrades. The first two items (15-9a and 15-9b) were developed from the Sousa and Collado (2000) study. Sousa and Collado (2000) suggest that consultants should be integrated into the firms' ERP project implementation teams and that their ongoing involvement with the ERP project should involve transfer of their ERP expertise to the firm. These findings were incorporated as items 15-9a and 15-9b to measure whether the business unit phases out the role of consultants after ensuring the transfer of their expertise to internal team members.

The third item (15-9c) was developed from the Teltumbde et al. (2002) study. Teltumbde et al. (2002) suggest that external consultants help in streamlining the ERP implementation process and hence enable quicker deployment of the ERP system. Consequently their findings were incorporated as an item in this study. The fourth item (15-9d) was developed from the Bingi et al. (1999) study. Bingi et al (1999) suggest that turnover among consultants during the ERP project may impact the implementation process. Hence, their findings were incorporated as an item to measure disruptions in the ERP system implementation process due to change of consultants.

Implementation Team

Implementation team members who display a well-balanced mix of technical and business skills play a vital role in ensuring the success of ERP system implementations. The first item (15-10a) was developed from two items in the Stratman and Roth (2002) study to measure the technical ability of the implementation team. The next two items (15-10b, 15-10c) were also drawn from the Stratman and Roth (2002) study and measure the ability of the implementation team in interacting closely with business managers, particularly when realigning the ERP system with changing business processes. The Cronbach's alpha for the scale used in the Stratman and Roth (2002) study was 0.86. Minor changes were made to these items. For example, the term "IT staff" in both the items in the Stratman and Roth (2002) study was replaced by "implementation team" in this study. These changes were made to ensure consistency in the use of terminologies in this study.

The fourth item (15-10d) was developed from the Gefen and Ridings (2002) study. Gefen and Ridings (2002) found that different degrees of actual responsiveness in different sites during CRM implementation result in significant differences in the users' favorable assessment of the correctness and approval of the CRM deployment. Consequently, their findings were incorporated as an item in this study to measure whether responsiveness of the implementation team members to end-user needs leads to successful ERP system implementations.

Data Accuracy

In this study, data accuracy refers to the integrity of data that is input into the ERP system as well as the output obtained from the ERP system. The four items (15-11a to 15-11d) to measure this variable were developed from the Vosburg and Kumar (2001) study. Vosburg and Kumar found that lack of data quality adversely affected business decisions and that ensuring data quality at the pre-implementation stage itself was critical for maintaining data integrity in ERP systems. Hence, their findings were incorporated as items to assess the need for maintaining data accuracy from the time that it is input or transferred from legacy systems into the ERP system to the business impact of the use of quality data output from the ERP system.

Communication

Ongoing communication between all business unit levels throughout the ERP system life cycle is crucial to ensuring ERP system implementation success. Two items (15-12a, 15-12c) were developed mainly from the Tarafdar and Roy (2003) study with additional support from the Teltumbde et al. (2002) study. Tarafdar and Roy (2003) found that open and honest communication and feedback facilitates the ERP system implementation process and also ensures quicker acceptance of the ERP system by the end-users. Consequently, their findings were incorporated as items to measure the effects of open and honest communication processes on ERP system implementation and acceptance. Item 15-12b was developed from the Gulla and Brasethvik (2002) study. Gulla and Brasethvik (2002) suggest that processes that facilitate ongoing communication are a key element for ensuring the success of ERP system deployments. Their findings were incorporated as an item in this study to measure the importance of continual communication on ERP project status throughout the implementation life cycle.

Organizational Culture

In this study, organizational culture refers to organizational practices that manifest themselves visibly in business unit members. Hofstede et al. (1990) identified six dimensions of organizational culture (process-oriented vs. results-oriented, employee-oriented vs. job-oriented, parochial vs. professional, open system vs. closed system, loose control vs. tight control, and normative vs. pragmative). These six organizational culture dimensions of Hofstede et al. (1990) were measured in this study using items from ERP system as well as Hofstede et al.'s study (15-13a to 15-13f).

Three items (15-13a, 15-13c, 15-13d) were drawn from the Sia et al. (2002) study. The Cronbach's alpha for the scale used in the Sia et al. (2002) study was 0.88. The first item (15-13a) measures the organizational culture dimension that refer to the communication climate within a business unit (open versus closed). In this item, the phrase "coworkers from other departments to access the information system" in the Sia et al. (2002) study was replaced with "coworkers to access the ERP system" in this study to maintain consistent use of terminology. The third item (15-13c) measures the organizational culture dimension that opposes a concern with means to a concern with goals (process versus results-oriented). The Cronbach's alpha for the scale used in the Sia et al. (2002) study was 0.74. The fourth item (15-13d) measures the organizational culture dimension that refers to the degree of control within a business unit (tight versus loose control). In this item, the phrase “very complete and comprehensive information” in the Sia et al. (2002) study was replaced by the phrase “tight control” in this study to ensure relevant use of terminology.

The second item (15-13b) was developed from the Krumbholz and Maiden (2001) study and measures the organizational culture dimension that contrasts concern for people with concern for getting the work done (employee versus job-oriented). This item was modified to include the term “using the installed ERP system” in order to ensure its relevance to this study’s objectives. The last two items (15-13e, 15-13f) were developed from the Hofstede et al. (1990) study. The fifth item (15e-13e) refers to the customer orientation of the business unit and measures the pragmatic versus the normative nature of the business unit. The last item (15-13f) measures whether employees identify themselves more with the business unit or with their jobs (parochial versus professional).

National Culture

In this study, national culture refers to the values embedded unconsciously in people and that cannot be observed but are manifested in alternative behaviors. Hofstede et al. (1990) identified five dimensions of national culture (power distance, uncertainty avoidance, individualism/ collectivism, masculinity/femininity, long-term orientation). These five national culture dimensions of Hofstede et al. (1990) were measured in this study using items from ERP system as well as Hofstede et al.’s studies (15-14a to 15-14e).

The first two items (15-14a, 15-14b) were drawn from the Sia et al. (2002) study. The Cronbach’s alpha for the scale used in the Sia et al. (2002) was 0.74. The first item (15-14a) concerns power distance (high or low) and measures whether the ERP system facilitates the business unit supervision of employees. The second item (15-14b) addresses uncertainty avoidance (high or low) and measures whether the business unit uses the ERP system to provide more autonomy to its employees or enforces strict adherence to formal and standardized rules and procedures. Both these items were modified to include the phrase "the ERP system" in order to ensure consistent use of terminologies in this study.

Two items (15-14c, 15-14e) were developed from the Hofstede et al. (1990) study. The third item (15-14c) focuses on individualism/collectivism (high/low) and measures whether the ERP system resulted in job role changes that fostered individual or teamwork. The fifth item (15-14e) concerns masculinity/femininity (high or low) and measures whether business unit employees are comfortable with the increased workload that accompanies the ERP system deployment. The fourth item (15-14d) refers to the orientation towards time (long-term orientation) and was developed from the Krumbholz and Maiden (2001) study and measures whether the business unit focuses on the obtainment of short-term or long-term results from the ERP system.

Other Questionnaire Items

Three questions were used to gather data pertaining to the business unit's ERP system implementation. Questions 10, 12, and 14 in the survey instrument were developed from the Mabert et al. (2000; 2003b; 2001b; 2003a) studies. Items in question 10 gathered information on the type of ERP system implemented by the firm: single vendor, best of breed (BoB), and totally in-house developed. Items in question 12 gathered information on the sub-modules that were implemented under each of the 14 ERP system modules. Question 14 provided an overall measure of the success of the business unit's ERP system implementation. The first two items in

Question 16 were drawn from the Stratman and Roth (2002) study and measured respectively the intra-firm and inter-firm integration resulting from the implementation of the ERP system. The third and fourth items were developed to measure the increase in integration resulting from implementation of additional modules and system usage over time respectively.

Thirteen close-ended questions with ordered choices (items 1 to 9 and 17 to 20) were included in the survey instrument to gather data on the characteristics of the business unit as well as the profile of the respondents. Items in questions 1 to 9 gathered demographic information pertaining to the size of the business unit, type of business (manufacturing and/or service, make-to-stock and/or make-to-order), type of business unit (unionized and/or non-unionized, private and/or public sector, multinational and/or Indian origin), membership of professional associations, the type of production flow used in the business unit (project, job shop, batch, repetitive, flow), and the industry in which the business unit operates. Questions 17 to 20 gathered information on respondents pertaining to their overall work experience, work experience with the business unit, position in the business unit, current area of work, and educational level.

Reliability

The internal consistency method was used to evaluate the reliability of the survey instrument. Internal consistency measures the ability to replicate this study (Flynn, Schroeder, & Sakakibara, 1990; Kerlinger & Lee, 2000). Internal consistency was assessed using Cronbach's alpha (Cronbach, 1951), which is the correlation coefficient of each item with each other item (Nunnally, 1978). Using the SPSS 12.0 program, an internal consistency analysis was performed separately for each of the items. Nunnally's (1978) method was used to evaluate the assignment of items to scales. The item-score to scale-score correlations were used to determine if an item belonged to the scale as assigned, belonged to some other scale, or whether it should be eliminated. The results of the reliability analyses are discussed in chapter 4.

Validity

Three different types of validity are generally used to investigate the extent to which a survey instrument measures what it intends to measure: content validity, construct validity, and criterion-related validity (Nunnally & Bernstein, 1994; Flynn et al., 1990; Kerlinger & Lee, 2000). Content validity was assessed in this study using the 2 methods enunciated by Nunnally and Bernstein (1994) and Flynn et al. (1990): a representative collection of items and sensible methods of test construction. An extended literature search and a synthesis of research with an emphasis on recurring concepts, discussed in chapter 2, confirm that a representative collection of items was used. The earlier discussion in this chapter – using to the extent possible the TDM and the tailored design methods of Dillman (1978; 2000) – demonstrates that sensible methods of survey instrument construction were used.

Construct validity measures whether a scale measures the theoretical construct that it was designed to measure (Flynn et al., 1990; Kerlinger & Lee, 2000). In this study, factor analysis was used to establish construct validity. A principal components factor analysis was conducted on each scale to verify whether all the items loaded onto their respective factors. The results of this factor analysis and the results of the item-to-scale analysis, which indicates that the items were properly assigned to each of the theoretical constructs, are discussed in chapter 4. Criterion-related validity concerns the extent to which a survey instrument is related to a relevant criterion variable (Flynn et al., 1990; Huck, 2000). In this study, the criterion-related validity was evaluated by examining the multiple correlation coefficients computed for the 14 modules comprising the ERP system and each of the 10 measures of business unit performance. The analysis of the results discussed in chapter 4 indicates that the implementation status of the ERP system was positively correlated with each of the 10 performance measures thus demonstrating criterion-related validity.

Data Collection

This section provides details on the target population and the survey implementation procedures used in this research study.

Target Population

The global ERP market has registered high growth rates over the past decade. Though, the market witnessed a post-Y2K slump during the late 1990s and the early 2000s; it has since recovered in the past few years to post double-digit growth rates. Mabert et al. (2003b) indicate that over 30,000 firms worldwide have implemented ERP systems and the vast majority of these deployments have taken place in the period between the mid-1990s and 2000. Most of these implementations were concentrated in the developed countries and the bulk of ERP system research focuses on deployments in these developed markets.

The saturation of the deployment of ERP systems in the developed countries resulted in increasing penetration rates of ERP system implementations from the late 1990s in other markets comprised of developing countries such as India. The Indian ERP market was valued at $2.6 million in new license revenues in 1995-96 (De, 2004) and faced languishing growth rates through much of the mid-to-late 1990s. From the early 2000s, however, the Indian ERP market is on a high growth trajectory, clocking compounded annual growth rates of more than 17% over the past four to five years (new license revenues for 2006 estimated at $173 million by IDC India, 2003).

Similar to the trend among ERP system implementers in the developed countries, however, there is a high incidence of problematic and delayed implementations among Indian firms. This is despite global ERP system vendors (SAP itself accounted for about 54% of the Indian ERP market in 2004) and consultants dominating the Indian ERP market and using proven implementation methodologies to implement ERP systems. De (2004) indicates that the average cost overrun among Indian ERP system implementers is 178 %, the average schedule overrun is 230% percent of original expectations, and the average decline in functional improvements is 59%. His study further indicates that 90% of ERP system deployments in India are problematic implementations.

Most Indian ERP system research remains descriptive in nature or is confined to case analysis of ERP system deployments in individual firms. Due to the relative newness of the Indian ERP market, there are very few rigorous empirical studies that have systematically examined ERP system implementations. Thus, India, which has evolved into a high growth ERP market, represents an excellent target market for this research study. As ERP systems have evolved from materials requirements planning (MRP) and manufacturing resource planning (MRP II) systems, research indicates that most ERP system implementations worldwide have occurred initially in production firms. This suggests that production firms would account for most of the ERP system implementations in India. Studies such as Dataquest (2004) indicate that 90% of all large firms in India (with turnover greater than $100 million) have implemented ERP systems. Gartner (2003b) estimates the ERP penetration levels in the Indian manufacturing industry to be about 37%, with this sector alone accounting for about 10% of total IT spending in India for the year 2003-04 (a 40% increase over the previous year). These findings from the

Dataquest (2004) and the Gartner (2003b) studies lend further support to the identification of production firms as the sample population for this study.

To obtain data on the implementation of ERP systems, the Confederation of Indian Industry (CII) member directory was identified as the population for this study. The CII is India's premier business association with a direct membership of about 5,995 firms, and indirect membership of over 90,000 firms from around 336 national and regional sectoral associations. About 2,937 production firms represented in the CII can be considered as leaders in the use of IT systems such as ERP and hence serve as the sampled population for this research study. The production firms are from diverse industries such as machinery and equipment, metals, electrical and electronic machinery and equipment, chemicals, rubber and plastics, automotive, computer and telecommunications, apparel and textiles, paper, and oil and gas (www.ciionline.org). Also, the CII member directory indicates that these production firms represent a well-balanced mix of firms with different types of manufacturing processes, belonging to the private and the public sectors, being of national and multinational origin, comprising of large as well as SMEs, and hence can be considered as representative of India's production industry.

The CII, founded in 1885, is a non-governmental, not-for-profit, industry-led, and industry-managed organization. The stated vision of the CII is to identify and strengthen the role of Indian industry in the economic development of the country while working towards its globalization and integration into the world economy. The CII functions as a facilitator and works closely with the government as well as industry on policy issues, enhancing efficiency, competitiveness, and expanding business opportunities. The CII organizes business conferences, economic summits, trade fairs, and workshops, in partnership with local and world organizations, in India and abroad, to facilitate assimilation of global practices in Indian firms and to disseminate information on global opportunities to Indian as well as foreign firms. The CII has about fifty seven offices in India, seven overseas offices, and has institutional partnerships with two hundred and forty counter-part organizations in one hundred and one countries, thus serving as a reference point for the Indian industry as well as the international business community (www.ciionline.org). Hence, as India's apex business organization, the CII member directory represents an excellent choice for this study's target population.

Design

The research design used was survey methodology. The research issues considered in this study can be investigated through controlled non-experimental inquiry only. This is because the variables in this study are non-manipulable and also random respondent assignment is not possible. Since the implementation of ERP systems has already occurred in the sampled firms, this research study infers ex post-facto. The survey questionnaire captures a wide range of data through the assessment of respondents' perceptions. The data gathered are quantitatively analyzed in chapter 4 and the study's findings are interpreted and generalized in chapter 5.

Sampling Method

A purposive sampling method was used to extract the names of firms from the list of 2,937 production firms forming part of the CII member directory. Many ERP system-implementing firms may not be direct members of the CII but could belong to one or more of the CII-affiliated associations. Also, some recent CII members may not have been updated in the CII's mailing list. Hence, besides the CII member directory, about 240 production firms, identified as having implemented ERP systems from major ERP vendor Websites as well as academic and practitioner/trade journals, also formed part of the sample. The main inclusion criterion was that the sample firms should be predominantly engaged in production activities and should belong to the CII and/or any of its affiliated associations.

Telephone calls were made to all the 3,177 firms (2,937 production firms from the CII member directory and 240 production firms from a variety of media sources) to ascertain whether the firm had implemented an ERP system, whether the firm was willing to participate in the survey, and who would be the best person in the firm to send the survey instrument to and their contact details. This approach resulted in the selection of the names of 900 firms from the target population. Besides the 900 firms, 20 holding company ERP divisions, who requested a copy of all survey material sent to their respective corporate groups' business units', were identified.

Survey Procedures

The survey procedures for this study were developed from Dillman's (1978; 2000) TDM and tailored design methods and were followed to the extent possible. Research studies, such as that of Chandra and Sastry (1998; 2002), that used survey methodologies suggest that the concept of mail surveys in India is in its infancy compared to the developed countries and hence the responses to mail surveys are extremely poor (with a 8 to 9% response rate being considered the norm). In situations where mail surveys may not garner adequate response rates, Dillman (2000) suggests that mixed-mode surveys can be implemented to compensate for the situational weaknesses in the mail survey method. Researchers may tailor their survey implementations to specific situations by using different modes to reach respondents besides mail surveys (telephone, emails, Web surveys, interviews, and fax). A cross-section of the respondents (N = 90; about 10% of the target population of production firms) chosen at random indicated that a majority of them preferred postal mail and courier, and to a lesser extent email delivery procedures. Accordingly, this research study uses a mixed mode survey consisting of postal mail, courier, and email delivery mechanisms.

Based on Dillman's (1978; 2000) TDM and tailored design methods, one week before the first mailing date, a one page pre-notice letter was sent to all the 900 firms by postal mail (see Appendix 1). The pre-notice letter gave a brief introduction to the research study and requested the respondents' participation in the survey. The first wave survey mailing consisted of a personalized cover letter, a general instructions page, the questionnaire, a definitions page for the 14 ERP modules, and a pre-stamped reply envelope (see Appendix 2). The cover letter described the purpose of the study and explained why participation in this study was useful and important to the respondents. The letter also mentioned that the questionnaire has been reviewed and approved by the University of North Texas's (UNT's) Institutional Review Board (IRB). The letter further contained assurances that respondents will remain anonymous, explained that only aggregate data will be reported, and offered a summary of the study's results.

One week after the first wave mailing date, a thank you/reminder note was sent to all the 900 firms by postal as well as email (see Appendix 3). Dillman (2000) suggests that the use of this follow-up contact, which supplements as well as contrasts with the initial mailing mode, would not only increase coverage but also encourage response quality. About 70 firms sent email replies and/or called indicating non-receipt of the questionnaire as well as the pre-notice letter. Replacement questionnaires were couriered to all the 70 firms (five of the firms had requested that the questionnaire be sent by email and the same was accordingly done). The courier delivery procedure was chosen due to the vagaries of the Indian postal system as the contact details for all the 70 firms were verified to be correct but the postal mailings did not reach the respondents. Seventeen questionnaires were returned undelivered with the reason cited by the postal department being that the respondents' were not available. It was ascertained through follow-up calls that these 17 respondents had left their respective firms and the contact details of their replacements were obtained. Replacement questionnaires were then couriered to these 17 firms. 127 responses were received from the first wave mailing (response rate of 14.11% -127/900). Out of the 127 responses, 122 were received by postal mail and 5 were received by email.

Following Dillman's (1978; 2000) survey procedures, six weeks after the initial mailing date, a second mailing with a new personalized cover letter (see Appendix 4), a replacement general instructions page, questionnaire, and definitions page for the 14 ERP modules, and a pre-stamped reply envelope was couriered to the non-respondents. This new personalized cover letter stressed the important contribution of each completed questionnaire to the overall survey results and solicited the non-respondents' cooperation in completing and returning the questionnaire. The letter also included a note requesting the members to discard this mailing if they had already completed and returned the questionnaire from the first mailing.

One week after the second mailing date, a thank you/reminder note (see Appendix 5) along with the replacement questionnaire, general instructions page, and the definitions page for the 14 ERP modules was emailed to all the non-respondents of the first wave. The email delivery procedure was adopted as an alternate to the courier delivery approach to forestall the possibility of non-delivery of the couriered second wave questionnaires due to the vagaries of the Indian postal system (the courier firm chosen is part of the Indian postal system; selection of this courier firm was influenced by cost considerations). In addition, Dillman (2000) suggests that the use of alternative questionnaire delivery methods can lead to substantial increases in response rates. In the emailed thank you note/reminder note, the respondents were requested to complete and return either the couriered or the emailed questionnaire.

A final contact, designed to contrast with the previous contacts, was made by telephone two weeks after the second mailing to non-respondents. Dillman (2000) suggests that this final special contact improves overall response to surveys. During these telephone call contacts, 43 respondents confirmed that they had completed and mailed back the questionnaires. These 43 responses, however, were not received. When a request was made to these 43 respondents to resend a copy of their completed questionnaires, most of them mentioned that they did not have a copy of their completed and mailed questionnaires. As most of these respondents were reluctant to complete another questionnaire mailing, these 43 responses were considered lost in transit. The second wave mailing generated a return of an additional 104 responses. Out of the 104 responses, 88 were received via postal mail and 16 by email. Of the surveys mailed in the two waves, a total of 231 responses were returned for a response rate of 25.67% (210 by postal mail and 21 by email). Once a satisfactory response rate was obtained all additional mailings/contacts were discontinued.

Nonresponse Bias

Many business units in the sample surveyed were not publicly traded firms and hence not much public information is available to distinguish respondents from and non-respondents and thereby assess the extent of non-response bias. In an attempt to assess non-response bias, however, follow-up calls were made to a random sample of non-respondents (N = 34; about 5% of the nonrespondents) to determine why they did not participate in the survey. The most common reason given by the non-respondents was that they did not have the time to complete the survey questionnaire.

Sample

After completion of the two-wave mixed-mode survey, each returned questionnaire was initially reviewed to analyze the response to the questionnaire item that assessed whether the responding business units were members of the CII or any of the CII affiliated associations. All the responses obtained were from members of the CII or CII affiliated associations and hence were considered part of the sample. Then, each of the returned questionnaires was then reviewed to identify any omissions, ambiguities, and irregularities committed by the respondents while completing the survey so as to arrive at the effective sample to be used for analysis. Out of the 231 completed questionnaires received, 12 respondents mentioned they were yet to go live with their ERP systems and their responses were discarded. Three questionnaires had most of the data on the key model variables missing and these were also discarded. The data from the remaining 216 completed questionnaires were then input into the SPSS 12.0 program and the information verified to ensure accuracy.

A review of the dataset indicated that out of the 216 responses, 111 had varied amounts of missing data for the independent, moderating, and the dependent variables. Emails were sent to all the 111 respondents requesting them to provide information on the missing data in their questionnaire responses. Most of the missing data pertained to question 11 on the implementation status of the each ERP module in the respondent's business unit. Forty nine responses were received by email with the missing data details completed. Telephone calls were made to the remaining 62 respondents and information with regard to the missing data was obtained. The most common answer received from respondents was that they had completed question 11 with respect to only those ERP modules that had been implemented in their business unit; the assumption being that those ERP modules that were not marked on the questionnaire have not been implemented. A further perusal of the questionnaires revealed that 43 responses had varying amounts of missing data on the demographic variables in the questionnaire. Telephone calls were made to these 43 respondents to obtain information on the missing data. The accuracy of the demographic information obtained was verified by comparing the information obtained through the questionnaire against the information provided on the Websites of a random selection of firms (N = 22; about 10% of the sample size). The final dataset consisted of 216 firms (effective response rate of 24% - 216/900).

The 216 responses were then evaluated based on the business unit's level of manufacturing activities. This is because this study focuses on production firms as they represent the early users of ERP systems and account for most of the ERP system implementations in India. In the questionnaire, respondents indicated the percentage of their business unit's sales that comes from manufacturing activities and the percentage that comes from service activities. A frequency distribution based on the percentage of the business unit's sales generated from manufacturing is shown in figure 5.

A review of the data shown in figure 5 reveals that business units with 70% or more of their sales coming from manufacturing activities is a logical cut-off point to categorize business units as a majority of sales coming from manufacturing activities. This approach resulted in the omission of an additional 13 responses that represent primarily service firms. Only business units that realized 70% or more of their sales from manufacturing activities were included in the sample and thus the final dataset for analysis comprised of 203 responses.

To aid in understanding the basic characteristics of the underlying data and relationships, the data were graphically examined through construction of a histogram and a stem and leaf diagram. The nature of the relationships between the key study variables were next examined

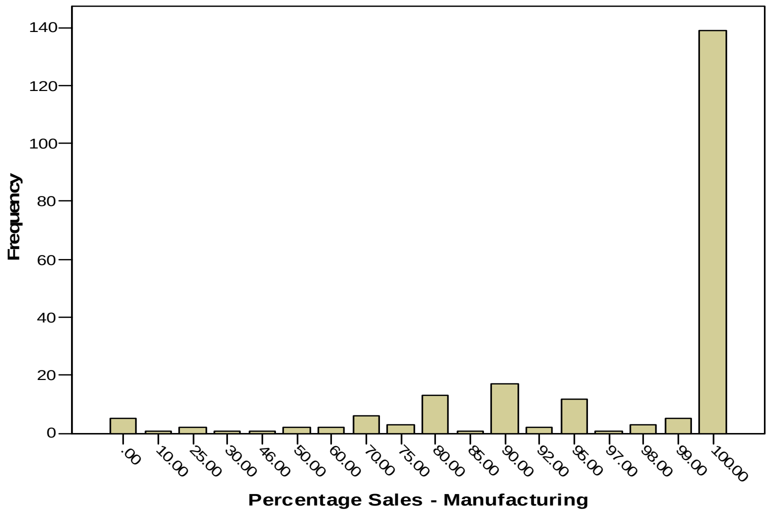


Figure 5. Frequency Distribution Based on Percentage of Sales Generated From Manufacturing.

through scatter plot and box plot diagrams. To assess the ability of the data to meet the statistical assumptions underlying multivariate techniques, the data were tested for normality, homoscedasticity, linearity, and the absence of correlations in prediction errors. The testing of these assumptions and their results are discussed in detail in chapter 4.

Power Analysis

Seventy two responses were obtained from the pilot study conducted at OMC (response rate of 72% - 72/100). Out of the 72 responses, two had most of the data on the key model variables missing and were discarded. The data from the remaining 70 responses were entered into the SPSS 12.0 program and then reviewed to identify any omissions, ambiguities, and irregularities committed by the respondents while completing the survey. Mean responses were substituted for the missing data. The data were assessed for linearity of the phenomena measured, constant variance of the error terms, independence of the error terms, and normality of the error term distribution. It was ascertained that there were no major violations of any of the statistical assumptions underlying multivariate techniques. Summated scales were constructed for the implementation status of the ERP system (five modules implemented at OMC) and the 10 performance measures. The SPSS 12.0 program was used to obtain the internal consistency of the two summated scales: Cronbach's Alpha for the ERP implementation status scale was .814 and that for the performance scale was .767.

A test of whether the holistic implementation status of OMC's ERP system would result in synergistic changes in performance was conducted by running standard multiple linear regression analyses. The results indicate that the model fit was significant at the .10 level (F = 3.899). The correlation coefficient obtained was .235 and the coefficient of determination R^2 .055. The regression coefficient (-.235), however, indicates a negative relationship between the ERP system's implementation status and firm performance. This negative association is due the fact that the pilot study was conducted within a year after the firm had gone live with its ERP system. ERP researchers such as Caldwell (1998) and Sarkis and Sundarraj (2003) indicate that most ERP firms experience a dip in firm performance the first year of going live; once the system stabilizes, firm performance picks up in the subsequent years.

Power analysis of the pilot study data using the proc power program in SAS 9.1.2 reveals that with an alpha level of .05 and an effect size of .235 {between small (0.10) to medium (0.30) effect size as per Cohen & Cohen, 1975} the power of the test was .504. Extrapolating the above power calculations, the power to sample size graph in the proc power program in SAS 9.1.2 indicates that at an alpha level of .05 and an effect size of .235 to achieve a desired power level of .80, the sample size required is around 160 (to achieve a desired power level of .90 the sample size required is 200). Also, researchers such as Hair, Anderson, Tatham, and Black (1998) suggest that a sample size equivalent to 15 times the number of independent variables (the minimum being 5 times the number of independent variables) is excellent for the type of analysis used in this study. Using this approach to determine the minimum sample size, a meaningful sample size is 210 (14 x 15) for a study with 14 independent variables. The number of responses received from the mailings broadly satisfies both the approaches to determine the required sample size.

Common Method Bias

Podsakoff and Organ (1986) attribute common method bias due to the same source bias that results when information is gathered using self-reports. The recommendations of Podsakoff and Organ (1986) for avoidance of common method bias problems were followed to the extent possible. This involved the use of scale re-ordering wherein the design of the questionnaire was altered so that the items used to measure the implementation status of ERP systems were placed before the items used to measure the changes in performance. Other steps involved the use of a purposive sampling technique to improve the representativeness of the sample and the adoption of a multi-mode survey method to increase the survey response rate.

Problems associated with the common method bias, however, cannot all be addressed before survey administration. Hence, post-hoc techniques were also used to assess the possible effects of common method variance (Podsakoff & Organ, 1986). Accordingly, Harmon's one-factor test was used to assess whether common method bias is a problem in this study. Seven factors with Eigen values greater than one were extracted from all the measures in this study and in total accounted for 63.34% of the total variance. The first factor accounted for 30.11% of the variance. Since a single factor did not emerge from the factor analysis and one factor did not account for most of the variance, this indicates that the results of the study are not due to common method bias.

Summary

This chapter examined in detail the rigorous design methodology used in this study. The development, modification, and validation of the survey instrument have been extensively discussed in this chapter. The target population, the survey implementation process, and the sample selection procedure have been described. The process of cleaning the data and testing for common method bias were also discussed. The analysis of results is presented in the next chapter.

CHAPTER 4

ANALYSIS OF RESULTS

Introduction

The results of the statistical procedures used to test the hypotheses are discussed in this chapter. First, data pertaining to the demographic profile for the business units as well as the respondents' characteristics are presented. Then, the results of the factor and regression analyses as well as univariate analysis of variance (ANOVA) are discussed.

Sample

The effective sample for this study consists of 203 production firms which derive more than 70% of their revenue from manufacturing activities. In this section of the chapter, the characteristics of the sampled business units are first discussed followed by a brief overview of the profile of the survey respondents.

Business Unit Characteristics

The survey questionnaire gathered demographic data pertaining to the size of the business unit, the extent of union involvement, firm type and origin, industry type, and the type of enterprise resource planning (ERP) system implemented. The data pertaining to the business unit characteristics are shown in Table 13. The first part of Table 13 indicates that the sample is a good representation of the Indian production sector comprising of firms of different sizes. The size of the business units were assessed in terms of both the number of employees as well as the annual sales turnover. The number of employees over 1,000 is the category most frequently represented and accounts for 41.4% of the sample (N = 84). This, together with the number of employees in the 500 to 999 category, represents 66% of the sample (N = 134). The number of employees in the two categories 0 to 99 and 100 to 249 have the lowest frequencies (N = 4 and N = 25 respectively) and account for 14.3% of the sample.

Table 13
Frequency Distribution for Business Units' Characteristics

Characteristics	Frequency	Percent
Number of Employees		
0-99	4	2.0
100-249	25	12.3
250-499	40	19.7
500-999	50	24.6
Over 1000	84	41.4
Annual Rupee Sales		
Greater than 5 crores but less than 100 crores	57	28.1
Greater than 100 crores but less than 250 crores	32	15.8
Greater than 250 crores but less than 500 crores	35	17.2
Greater than 500 crores but less than 1000 crores	29	14.3
Greater than 1000 crores	50	24.6
Union Status		
Unionized	45	22.2
Non-Unionized	47	23.2
Both	111	54.7
Sector		
Private	167	82.3
Public	32	15.8
Joint	4	2.0
Origin		
Multinational	40	19.7
Indian	157	77.3
Joint	6	3.0

The second part of Table 13 provides information regarding annual sales. The category with the highest frequency consists of 57 business units with annual sales between Rs. 5 and 100 crores and represents 28.1% of the sample. The category with the second highest frequency (N = 50) reported sales greater than Rs. 1,000 crores and forms 24.6% of the sample. The remaining firms in the sample (N = 96) are more or less evenly distributed across the three annual sales categories ranging from greater than Rs.100 crores to less than Rs. 1000 crores. More than half the firms in the sample (N = 111) have a mix of both unionized and non-unionized environments and represent 54.7% of the sample. The third part of Table 13 indicates that firms constituting the remaining part of the sample (N = 92) are more or less evenly distributed between unionized (22.2%) and non-unionized (23.2%) environments.

The fourth part of Table 13 indicates that a majority of firms (N = 167) belong to the private sector and represent 82.3% of the sample. Thirty two public sector firms responded to the survey and form 15.8% of the sample. Joint sector firms (N = 4) account for 2% of the sample. The last part of Table 13 indicates that a majority of firms (N = 157) are of Indian origin and comprise 77.3% of the sample. Multinational firms of foreign origin (N = 40) represent 19.7% of the sample while joint ventures (N = 6) constitute 6% of the sample.

The frequency distribution for business units by production type is presented in Table 14. Make-to-order was the primary production system used by firms in the sample. The mean percentage of products produced with a make-to-order system was 61.79%; 38.18% of the products were produced with a make-to-stock system. The sample data indicates that most firms employed a mix of different production processes; however, many firms also employed only one production process. Firms using the repetitive production process (26.37%) formed the largest mean percentage of the sample. Firms were more or less evenly distributed between the batch process (mean percentage of 21.97%) and the project process (mean percentage of 20.01%) types. The flow process type had a mean percentage of 17.74% and the job shop type 13.91%.

Table 14
Means Distribution for Business Units' by Production Type

Industries	Mean
Make-to-Order	61.79
Make-to-Stock	38.18
Production Flow Type	
Project	20.01
Job Shop	13.91
Batch	21.97
Repetitive	26.37
Flow	17.74

A wide variety of industries are represented in the sample. Table 15 shows the frequency distribution for business units by industry type. The majority of industries (67%) fall into one of 10 major industry groups. Business units in the automotive industry (N = 44) are the most frequently represented group accounting for 21.7% of the sample. The next most frequently represented group is machinery and equipment (N = 20) representing 9.9% of the sample.

Table 15
Frequency Distribution for Business Units' by Industries Represented

Industries	Frequency	Percent
Automotive	44	21.7
Machinery and Equipment	20	9.9
Basic Metal/Coal/Lignite/Uranium/Thorium/Others	13	6.4
Electronic/Telecommunication Equipment	11	5.4
Apparel and Textiles	11	5.4
Food Products & Beverages	11	5.4
Coke/Crude/Petroleum/Natural Gas/Others	9	4.4
Fabricated Metal Products	7	3.4
Rubber/Plastic Products	5	2.5
Paper and Paper Products	5	2.5
Others	67	33.0

Table 16 provides the frequency distribution for firms by the type of ERP system implemented. The table indicates that the majority of the firms (N = 132) implemented a single vendor ERP system representing 65% of the sample. SAP (N = 60) is the dominant ERP system implemented by 29.6% of the sampled firms. This is followed by Oracle/PeopleSoft (N = 21) accounting for 10.3% of the sample, SSA Global/Baan and Microsoft (N = 9 each) representing 4.4% of the sample each, and Ramco (N = 8) forming 3.9% of the sample. The other major ERP vendors are QAD and ESS (N = 5 each), representing 5.0% of the sample. A small number of firms (N = 14) have implemented two or more (BoB) ERP systems accounting for 6.9% of the sample. In-house developed ERP systems (N = 57) represent the second most dominant ERP system implemented among the sampled firms accounting for 28.1% of the sample.

Table 16
Frequency Distribution for Business Units' by Type of ERP System Implemented

Type of ERP System Implemented	Frequency	Percent
Single Vendor ERP System		
SAP	60	29.6
Oracle/PeopleSoft	21	10.3
SSA Global/Baan	9	4.4
Microsoft	9	4.4
Ramco	8	3.9
QAD	5	2.5
ESS	5	2.5
Others	15	7.4
Best of Breed ERP System		
SAP & Oracle/PeopleSoft	2	1.0
SAP & SSA Global/Ban	2	1.0
Others	10	4.9
In-House Developed ERP System		
In-House Developed ERP	57	28.1

Respondent Characteristics

The respondents' characteristics are given in Table 17. The respondents to the survey provided both their total number of years of work experience as well as years of work experience in the present firm. For ease of presentation, however, as shown in the first two parts of the table, responses were grouped into one of three categories: less than 5 years, 5 to 10 years, and over 10 years. The first part of Table 17 shows the frequencies for the respondents' total number of years of work experience. The majority of the respondents (N = 187) possess more than 10 years of work experience accounting for 92.1% of the sample. The second part of Table 17 shows the frequencies for the number of years the respondents have been with the present firm. The most frequently reported category is that of respondents with more than 10 years of work experience (N = 115) accounting for 56.7% of the sample. The next highest category is respondents with less than 5 years of experience (N = 60) forming 29.5% of the sample. Twenty eight respondents have been with the same firm between 5 to 10 years and account for 13.8% of the sample.

The third part of table 17 depicts information provided by respondents with respect to their current position in the firm. About half the respondents (N = 103) belong to the top management category and constitute 50.7% of the sample. The next highest category of respondents (N = 81) is middle management and represents 39.9% of the sample. Lower management (N = 8) and team leaders (N = 7) account for 3.9% and 3.4% of the sample respectively. The fourth part of table 17 presents information pertaining to the respondents' current area of work. A majority of the respondents (N = 175) work in the information technology/information systems (IT/IS) area and represent 86.2% of the sample. Finance (N = 15) is the next highest work area reported and accounts for 7.4% of the sample.

Table 17
Respondents' Characteristics

Total Experience	Frequency	Percent
Less than 5 years	6	3.0
5 to 10 years	10	4.9
Over 10 years	187	92.1

Experience with Present Organization	Frequency	Percent
Less than 5 years	60	29.5
5 to 10 years	28	13.8
Over 10 years	115	56.7

Current Position	Frequency	Percent
Top Management	103	50.7
Middle Management	81	39.9
Lower Management	8	3.9
Team Leaders	7	3.4
Others	4	2.0

Current Work Area	Frequency	Percent
Finance	15	7.4
Production	2	1.0
Marketing	4	2.0
Information Technology/Systems	175	86.2
Others	7	3.4

Level of Education	Frequency	Percent
Bachelor's degree	78	38.4
Master's degree	120	59.1
Doctorate	3	1.5
Others	2	1.0

The fourth part of the table further indicates that the other two occupational areas reported are marketing (N = 4) and production (N = 2) accounting for 2% and 1% of the sample respectively. The last part of Table 17 contains information pertaining to the respondents' highest level of education completed. A majority of the respondents (N = 120) posses a master's degree and account for 59.1% of the sample. Seventy eight respondents have completed their bachelor's degree and represent 38.4% of the sample. Three respondents have reported completion of a doctoral degree and constitute 1.5% of the sample.

Descriptive Statistics for Variables

In this section of the chapter, the descriptive statistics for the key variables in the study are discussed. The means and standard deviations associated with each scale used to measure the implementation status of ERP systems, the changes in performance attributed to the ERP system, and the critical success factors (CSFs) facilitating ERP system deployment are shown in Tables 18, 19, and 20 respectively. The means and standard deviations for the modules comprising the ERP system as well as the number of business units that have implemented each of these modules along with their percentages are shown in Table 18.

The measures of implementation status were assigned values based on the midpoint of the scale ranges. The midpoint scores assigned were 0 = not implemented, .5 = implemented 0 to 1 years, 2 = implemented 1 to 3 years, 4 = implemented 3 to 5 years, and 6 = implemented more than 5 years. The ERP module with the highest extent of usage was materials management (N = 197, Mean = 3.66, SD = 2.11) followed closely by the financials (N = 189, Mean = 3.61, SD = 2.25) and the sales and distribution (N = 182, Mean = 3.40, SD = 2.28) modules. The lowest extent of usage was reported for the customer relationship (CRM) module (N = 40, Mean = .38, SD = .99); the advanced planner optimizer/advanced planner scheduler (APO/APS) module (N =

42, Mean = .42, SD = 1.22) and the electronic-ecommerce (E-commerce) module (N = 45, Mean = .45, SD = 1.27) also had low usage rates.

Table 18
Mean Values of Implementation Status of ERP Modules

ERP Module	Means	SD	Number of business units with module implemented	Percent of business units with module implemented
Materials Management	3.66	2.11	197	97.0
Financials	3.61	2.25	189	93.1
Sales & Distribution	3.40	2.28	182	89.7
Production Planning	2.96	2.40	163	80.3
Quality Management	2.24	2.40	134	66.0
Controlling	2.23	2.44	125	61.6
General Logistics	1.84	2.38	100	49.3
Human Resources	1.72	2.12	117	57.6
Plant Maintenance	1.55	2.20	95	46.8
SCM	1.02	1.89	62	30.5
Project System	.92	1.81	63	31.0
E-commerce	.45	1.27	34	16.7
APO/APS	.42	1.22	34	16.7
CRM	.38	.99	40	19.7

The means and standard deviations for the changes in performance measures attributable to the ERP system implementation are presented in Table 19. The changes in performance measures were recorded on a Likert type scale ranging from 1 = disagree to 7 = agree. The maximum benefit derived by firms from implementing ERP systems was an increase in information availability (Mean = 6.35, SD = .99). This was closely followed by increases in information quality (Mean = 6.24, SD = .94) and standardization (Mean = 6.05, SD = 1.07). The performance measure that registered the least improvement is increase in competitive advantage (Mean = 5.15, SD = 1.52).

Table 19
Mean Values of Changes in Performance

Performance	Means	SD
Information Availability	6.35	.99
Information Quality	6.24	.94
Standardization	6.05	1.07
Inventory Management	5.97	1.12
On-Time Delivery	5.91	1.09
User Satisfaction	5.83	1.20
Profitability	5.43	1.41
Return on Investment	5.43	1.41
Customer Satisfaction	5.38	1.39
Competitive Advantage	5.15	1.52

The means and standard deviations for the CSFs critical for the successful implementation of the ERP system are presented in Table 20. The impact of CSFs were recorded on a Likert type scale ranging from 1 = disagree to 7 = agree. The role of communication in facilitating the ERP system implementation is rated the highest (Mean = 6.42, SD = .80). This is closely followed by data accuracy (Mean = 6.18, SD = .91) and implementation team support (Mean = 6.09, SD = 1.02). Respondents rated the national culture CSF (Mean = 4.94, SD = 1.09) the lowest among all CSFs facilitating ERP system deployments.

Factor Analysis

To create scales for each of the CSFs the data were first examined to check their suitability for conducting factor analysis. The data were then subject to factor analysis and the results are discussed in this section of the chapter. Visual inspection of the correlation matrix for the CSFs revealed that most correlations were greater than 0.30 and the correlations in the anti-image correlation matrix were small. The measures of sampling adequacy ranged from .60 (mediocre) to 0.91 (meritorious) and the Bartlett's tests of sphericity was significant. Hence, the data is appropriate for conducting factor analysis.

Table 20
Mean Values of CSFs

CSFs	Means	SD
Communication	6.42	.80
Data Accuracy	6.18	.91
Implementation Team	6.09	1.02
Project Management	5.85	1.27
Top Management Support	5.81	1.26
Alignment	5.80	1.12
Training	5.64	1.39
User Support	5.59	1.18
Planning	5.56	1.32
Consultants	5.42	1.36
Organizational Culture	5.20	1.17
Learning	5.10	1.28
National Culture	4.94	1.09

As mentioned in chapter 3, the implementation strategy CSF pertaining to the rollout of the ERP system was measured by four items (15-7a to 15-7d) developed from the Mabert et al. (2000; 2003a; 2003b) studies. Analysis of the sample data revealed inconsistencies in the respondents' responses to these 4 items measuring the implementation strategy CSF. A perusal of the 4 items as well as follow-up calls to 21 randomly chosen respondents (10% of the sample) indicated that respondents' were confused by the ambiguous wordings of these 4 items as they could choose to answer one or more of these items depending on their choice of implementation rollout. Hence, the implementation strategy CSF was dropped from further analysis.

The data for each of the remaining 13 CSFs were factor analyzed. The results of the factor analysis are shown in Table 21. An examination of the factor loadings indicates that all the items belonging to 9 of the 13 CSFs (top management support, planning, user support, project management, training, learning, alignment, implementation team, communication) had factor loadings exceeding .70 and accounted for more than 50% of the variance. The items belonging to the other 4 CSFs (consultants, data accuracy, organizational culture, national culture) had factor loadings ranging from a low of .462 to a high of .871.

Table 21
13 CSF Component Analysis Factor Matrix

CSFs	Items (Factor Loadings)					
Top Management Support	15-1a (.875)	15-1b (.853)	15-1c (.813)	15-1d (.878)	15-1e (.855)	15-1f (.796)
Planning	15-2a (.834)	15-2b (.843)	15-2c (.851)	15-2d (.872)		
User Support	15-3a (.809)	15-3b (.843)	15-3c (.736)	15-3d (.775)	15-3e (.843)	
Project Management	15-4a (.881)	15-4b (.858)	15-4c (.862)	15-4d (.864)	15-4e (.889)	
Training	15-5a (.892)	15-5b (.886)	15-5c (.884)	15-5d (.888)	15-5e (.885)	
Learning	15-6a (.792)	15-6b (.833)	15-6c (.850)	15-6d (.702)		
Alignment	15-8a (.889)	15-8b (.903)	15-8c (.854)			
Consultants	15-9a (.691)	15-9b (.842)	15-9c (.749)			
Implementation Team	15-10a (.847)	15-10b (.890)	15-10c (.923)	15-10d (.821)		
Data Accuracy	15-11a (.757)	15-11b (.871)	15-11c (.768)	15-11d (.498)		
Communication	15-12a (.839)	15-12b (.925)	15-12c (.867)			
Organizational Culture	15-13a (.657)	15-13c (.653)	15-13d (.830)	15-13e (.786)	15-13f (.708)	
National Culture	15-14a (.663)	15-14b (.706)	15-14c (.745)	15-14d (.644)	15-14e (.462)	

The latent root criterion as well as the scree test criterion indicates that each of 10 CSFs (top management support, planning, user support, project management, training, learning, implementation team, data accuracy, communication, national culture) loaded onto a single factor. Two factors were extracted from each of the 3 CSFs – alignment, consultants, and organizational culture. Factor analysis of the items belonging to the alignment CSF indicates that items 15-8a, 15-8b, 15-8c form a factor and the items 15-8d, 15-8e form another factor. Item 15-8d assesses whether “significant time and effort is required to customize the ERP system to our business practices”. Item 15-8e assesses whether “significant time and effort is required to re-engineer our business practices to conform to the ERP system”. These two items – 15-8d, 15-8e – were removed from the alignment CSF scale due to the possibility of confounding between the time element in these two items and the time element measured through the module implementation status scale. Hence, the alignment CSF scale consists of three items - 15-8a, 15-8b, and 15-8c.

The results of the factor analysis for the consultants CSF indicates that items 15-9a, 15-9b, 15-9c form a factor and 15-9d forms another factor. As item 15-9d “external consultants were changed during the course of the ERP project” emerged as a single item factor, this item was removed from the consultants CSF scale. Hence, the consultants CSF scale consists of three items – 15-9a, 15-9b, 15-9c. Items 15-13a, 15-13c, 15-13d, 15-13e, 15-13f belonging to the organizational culture CSF emerged as one factor and item 15-13b formed another factor. As item 15-13b “the management is only interested in employees getting work done using the installed ERP system rather than addressing their concerns” was extracted as a single item factor, it was removed from the organizational culture CSF scale. Hence, the organizational culture CSF scale consists of 5 items – 15-13a, 15-13c, 15-13d, 15-13e, 15-13f.

A summary of items omitted from the scales and the number of items retained is presented in Table 22. Internal consistency analysis using the SPSS 12.0 program was conducted for each of the 13 CSFs and their Cronbach's Alpha is also presented in the table. The results presented in the table indicate that the Cronbach's Alpha increased for five of the 13 CSFs when compared to literature. Items for six of the 13 CSFs were drawn from multiple studies and this precludes a direct comparison of their Cronbach's Alpha values with those drawn from literature. A detailed discussion of the above is given in Chapter 5.

Table 22
Summary of Items Omitted from the 13 CSF Scales & Cronbach's Alpha

CSFs	Original Number of Items	Number of Items Omitted	Final Number of Items	Cronbach's Alpha	Cronbach's Alpha (Literature)
Top Management Support	6	0	6	.916	.88 (7 items)
Planning	4	0	4	.869	.87 (6 items)
User Support	5	0	5	.858	.85 (8 items)
Project Management	5	0	5	.916	.91 (8 items)
Training	5	0	5	.931	.86 (8 items)
Learning	4	0	4	.805	.85 (8 items)
Implementation Strategy	4	4	0	_	_
Alignment	5	2	3	.853	_
Consultants	4	1	3	.633	_
Implementation Team	4	0	4	.892	.93 (11 items)
Data Accuracy	4	0	4	.680	_
Communication	3	0	3	.848	_
Organizational Culture	6	1	5	.775	_
National Culture	5	0	5	.648	_
Total	64	8	56		

An examination of the reliability analysis results for each of the 13 CSF scales indicates that removal of items with low factor loadings did not result in any significant improvement of scale reliabilities and hence no items were deleted based on this criterion. The reliability coefficients of the alignment, consultants, and the organizational culture CSFs before deletion of items were .642, .493, and .703 respectively.

Regression Analysis

The data were first examined to check their suitability for conducting multiple regression analyses. A test on whether demographic data influences the relationships hypothesized in this research study was conducted. The data were then subject to regression analyses and univariate ANOVA and the results are discussed in this section of the chapter.

Regression Assumptions

Research studies indicate that most empirical ERP system studies use multiple regression analyses to analyze data (Francalanci, 2001; Hong & Kim, 2001; Gefen & Ridings, 2002; Mabert et al., 2003a; Gefen & Ragowsky, 2005). The findings from these studies suggest that the type of regression analyses used depends on the way in which the moderator changes the effect of the independent variables on the dependent variables (linear, quadratic, or step). In this research study, multiple linear regression analysis was chosen to test the ERP system implementation model. This regression technique was chosen based on the a priori assumption that the effect of the independent variables on the dependent variables changes linearly with respect to the moderators.

Hair et al. (1998) indicate that problems due to multicollinearity need to be addressed when correlations between the independent variables exceed 0.90. A perusal of the correlation matrix between the independent variables in this study revealed that the correlations ranged from .111 to .858, which is well below the Hair et al's recommended criteria of 0.90. Lewis-Beck (1980) and Hair et al. (1998) indicate that multiple variable collinearities can also be examined by regressing each independent variable on all the other independent variables. The regression of each independent variable on all the other independent variables resulted in a R^2 ranging from .210 to .818 showing some intercorrelation exists but none exceeded the threshold value of 0.90. Further, the variance inflation factor (VIF) values were also examined to assess multicollinearity. The VIF values ranged from 1.199 to 5.496, which is well below the threshold value of 10 (Hair et al., 1998). The above tests indicate that multicollinearity is not a major problem in this study.

Next, the regressions assumptions of linearity of the phenomena measured, constant variance of the error terms, independence of the error terms, and normality of the error term distribution were examined. The assumption of linearity was assessed through an analysis of residuals and partial regression plots. Scatter plots of residuals plotted against predicted values showed that there was no non-linear pattern to the residuals thus ensuring that the assumptions of linearity are met. An examination of the partial regression plots also confirmed the linearity of the model relationships.

A perusal of the scatter plots confirmed that there were no patterns of increasing or decreasing residuals thus indicating constancy of the residuals across values of the independent variables. To assess the independence of the error terms the residuals were plotted against a sequencing variable, the respondent number, which represents the order in which the responses were collected. A perusal of the plot of the residuals against the respondent number indicated no consistent pattern thus confirming the independence of the residuals.

Several methods were used to check the normality of the error term distribution - an examination of the histograms of residuals, a visual check on whether the distributions approximate normal distributions, and the use of normal probability plots. The results indicated that there were no major problems associated with non-normality of the variables. A perusal of the residuals and the partial regression plots also did not indicate the presence of significant residuals that can be classified as outliers and hence no observation was excluded from the analysis.

Control for Demographic Variables

A test on whether demographic data influences the relationships hypothesized in this research study was conducted by running standard linear regression analyses and developing regression models to analyze the effects of each of the 18 control variables. The 18 control variables tested were business unit size in terms of the number of employees and Rupee sales; percentage of business unit's sales generated from manufacturing and service; business unit characteristics in terms of unionization, sector, and origin; percentage of business from make-to-order (MTO) to make-to-stock (MTS); percentage of business unit sales by type of production flow (project, job shop, batch, repetitive, flow); type of industry; and type of ERP system (single vendor, BoB, in-house developed). The results indicate that no model was fitted for any of the control variables.

Regression Models

A test for hypothesis 1a – the implementation status of individual ERP system modules contribute to changes in performance – was conducted by running standard linear regression analyses and developing separate regression models to analyze each of the 10 performance measures. The results of the regression analysis are presented in Table 23. The table shows the size of the standardized regression coefficients (β), coefficients of determination (R^2), and the F ratios (F) for the fitted models. Only significant parameter estimates of the fitted models are shown. All non-significant parameter estimates are omitted from the table. The regression models indicate that the quality management module is statistically significant for all the 10 performance measures. This suggests that as the status of implementation of the quality management module increases, changes in firm performance for all the 10 measures also increases.

Table 23
Significant Relationships Between Implementation Status of ERP Modules and Changes in Performance

Implementation Status of ERP Modules	Changes in Performance														
	Inventory Management			Information Quality			On-time Delivery			Standardization			Profitability		
	β	R²	F	β	R²	F	β	R²	F	β	R²	F	β	R²	F
FI	.145 *	.021	4.301*												
CO	.154 *	.024	4.913*	.229 ***	.053	11.174***				.162 *	.026	5.433*	. 140 *	.020	4.043*
PM	.210 **	.044	9.317**				.156 *	.024	5.043*	.193 **	.193	7.752**	.171 *	.029	6.019**
MM	.160 *	.026	5.288*												
PP	.185 **	.034	7.145**	.150 *	.022	4.623*	.181 **	.033	6.827**				.163 *	.026	5.462*
SD													.139 *	.019	3.975*
LO				.201 **	.040	8.423**				.161 *	.026	5.379*	.180 **	.033	6.754**
QM	.193 **	..037	7.793**	.190 **	.036	7.489**	.138 *	.019	6.920*	.168 *	.028	5.822*	.187 **	.035	7.279**
SCM													.152 *	.023	4.767*
CRM													.226 ***	.051	10.785***
APO/APS				.158 *	.025	5.157*									

Implementation Status of ERP Modules	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	R²	F	β	R²	F	β	R²	F	β	R²	F	β	R²	F
FI	.246 ***	.061	12.967***	.155 *	.024	4.964*	.183**	.034	7.001**	.182 **	.033	6.904**	.146 *	.021	.4.356**
CO	.236 ***	.055	11.805***	.167 *	.028	5.770*							.173 *	.030	6.176*
PM	.271 ***	.074	15.972***	.176 *	.031	6.437*	.166 *	.027	5.683*	.190 **	.036	7.508**	.195 **	.038	7.936**
MM	.289 ***	.083	18.265***	.155 *	.024	4.954*	.175 *	.031	6.356*						
PP	.263 ***	.069	14.973***	.141 *	.020	4.058*	.188 **	.035	7.382**	.167 *	.028	5.800*			
SD	.262 ***	.069	14.865***				.166 *	.027	5.676*	.169 *	.029	5.924*	.141 *	.020	4.077*
LO	.216 **	.047	9.870**	.154 *	.024	4.868*							147 *	.022	4.462*
QM	.269 ***	.072	15.652***	.212 **	.045	9.473**	.188 **	.035	7.356**	.159 *	.025	5.196*	.205 **	.042	8.823*
HR	.151 *	.023	4.684*												
SCM	.140 *	.020	4.029*												
CRM	.140 *	.020	4.040*							.191**	.036	7.603**	.171 *	.029	6.049*

Note

Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler

All β values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

The plant maintenance module is statistically significant for nine of the 10 performance measures (except information quality). The production planning module is statistically significant for eight out of the 10 performance measures (except standardization and competitive advantage) and the controlling module for seven of the 10 performance measures (except on-time delivery, user satisfaction, and customer satisfaction). Two of the modules – financials and general logistics – are statistically significant for six of the 10 performance measures. Information quality, on-time delivery, standardization, and profitably are the performance measures not significant for the financials module; whereas, inventory management, on-time delivery, user satisfaction, and customer satisfaction are non-significant for the general logistics module.

The sales and distribution module is statistically significant for five of the 10 performance measures (except inventory management, information quality, on-time delivery, and information availability) and the CRM module for four of the 10 performance measures (except inventory management, information quality, on-time delivery, standardization, information availability, user satisfaction). The supply chain management (SCM) module is significant for two performance measures – profitability and return on investment (ROI). The human resources and the APO/APS model are statistically significant for one performance measure, ROI and information quality respectively. No model was fitted for the E-commerce and the project system modules.

The regression model for the ROI performance measure is the best fitted model and shows that 11 of the 14 modules are statistically significant (except the project system, E-commerce, and the APO/APS modules). The status of the implementation of the materials management module is the most important variable tested for predicting ROI. The size of the β, R^2, and the F values for seven of the 13 modules, besides the materials management module, further indicates that these modules are important variables for predicting ROI. The β values for the controlling and the general logistics modules indicate that they are the most important variables for predicting information quality. The β values for the plant maintenance module indicate that it is the most important variable for predicting inventory management. Also, the β values for the quality management module indicate that it is an important variable for predicting information availability, user satisfaction, and competitive advantage. The CRM module is the most important variable for predicting profitability.

A synthesis of the discussion pertaining to the above results indicates that 12 of the 14 modules were supported in the test for hypothesis 1a. Except for the project system and the E-Commerce modules, all the other modules made a significant contribution to one or more of the 10 performance measures even though the contribution of each module varied with each of the performance measures. The interpretations of these results are discussed in detail in chapter 5.

A test for hypothesis 1b – the implementation status of a holistic ERP system contributes to changes in performance – was conducted by running standard linear regression analyses and developing regression models to analyze the synergistic changes in performance resulting from the implementation of a holistic ERP system. Summated scales were constructed to measure the holistic implementation status of the ERP system comprising of all the 14 modules. Hair et al. (1998) indicates that the use of summated scales helps portray complex concepts in a single measure while reducing measurement error and are appropriate for research studies where generalizability of results is important. The internal consistency of the holistic implementation status scale was estimated using Cronbach's Alpha. Internal consistency analysis using the SPSS 12.0 program yielded a reliability coefficient of 0.876 for the holistic implementation status scale. Further, an examination of the bivariate correlations between the multiple correlation coefficient calculated for the holistic ERP implementation status and each of the 10 performance measures indicates that the correlations ranged from .144 to .332 thus indicating criterion-related validity.

The results of the regression analysis are presented in Table 24. The table shows the size of the standardized regression coefficients (β), coefficients of determination (R^2), and the F ratios (F) for the fitted models. Only significant parameter estimates of the fitted models are shown. All non-significant parameter estimates are omitted from the table.

Table 24
Significant Relationships Between Holistic Implementation Status of ERP System and Changes in Performance

Implementation Status of ERP System	Changes in Performance														
	Inventory Management			Information Quality			On-time Delivery			Standardization			Profitability		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
Holistic ERP System	.205**	.042	8.788**	.188**	.035	7.325**	.144*	.021	4.239*	.183**	.033	6.966**	.220**	.044	10.260**

Implementation Status of ERP System	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
Holistic ERP System	.332***	.110	24.944***	.200**	.040	8.409**	.212**	.045	9.432**	.212**	.045	9.595**	. 226***	.051	10.829***

Note

β: All values are standardized regression coefficients.

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

The regression models indicate support for the relationship between a holistic implementation status of the ERP system and synergistic changes in performance. This suggests that as the implementation status of a holistic ERP system increases, changes in each of the 10 performance measures also increases. The regression model for the ROI performance measure is the best fitted model. About 11% of the variation in ROI is explained by the holistic implementation status scale. The F value of 24.944 indicates that there is a less than .1% chance that an F value this large for ROI would happen by chance alone. The size of the β values for the other performance measures also indicates a good fit for the regression models. A synthesis of the discussion pertaining to the above results indicates support for the first hypothesis 1b.

To further understand the relationships hypothesized in hypothesis 1b, the holistic implementation status variable was dichotomized as "low" and "high." The "low" category comprised of frequency percentile values less than 33.33% and the "high" category greater than 66.67%. A test for hypothesis 1b was conducted by running univariate ANOVA and the results are presented in Table 25.

Table 25
Significant Relationships Between Holistic Implementation Status of ERP System and Changes in Performance (ANOVA)

Implementation Status of ERP System	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Holistic ERP System	12.328	12.328	9.072** (1,135)	7.848	7.848	8.755** (1,135)	6.179	6.179	5.362* (1,135)	7.932	7.932	6.194* (1,135)	15.851	15.851	10.235** (1,135)

Implementation Status of ERP System	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F	SS	MS	F
Holistic ERP System	49.873	49.873	27.258*** (1,135)	8.782	8.782	8.672** (1,135)	12.984	12.984	9.588** (1,135)	17.984	17.984	8.678** (1,135)	26.151	26.151	11.890*** (1,135)

Note

Significance: * p < .05, ** p < .01, *** p < .001

Figure 6 presents the profile plots for three high performing measures (ROI, profitability, competitive advantage) and three low performing measures (on-time delivery, standardization, information availability).

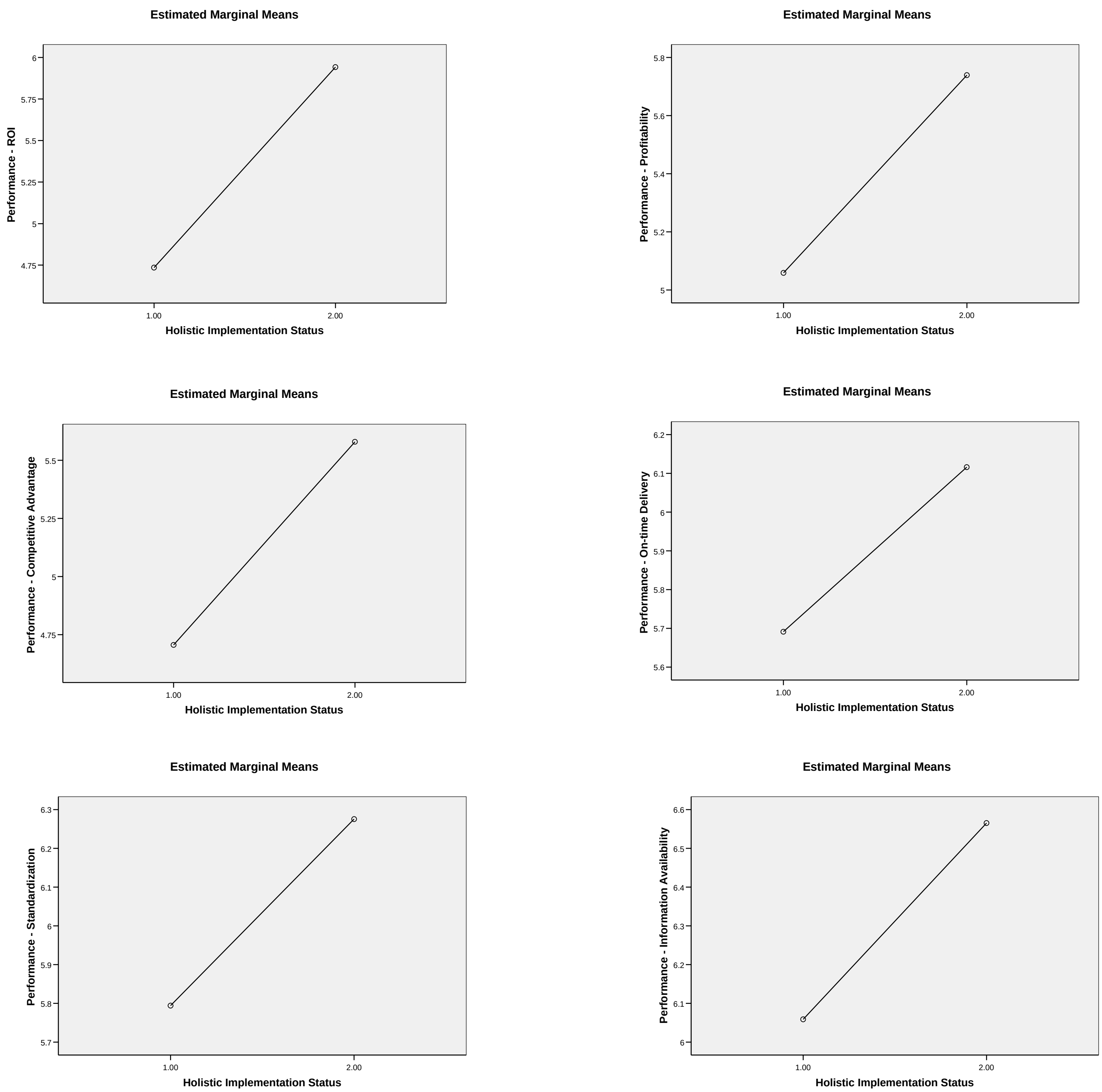


Figure 6. Significant Effects Between Holistic Implementation Status of ERP System and Changes in Performance.

The effect size and statistical power for ROI, profitability, and competitive advantage are .070, .081, .168 and .888, .928, .999 respectively. The effect size and statistical power for on-time delivery, standardization, and information availability are .038, .044, .060 and .633, .695, .832 respectively. A perusal of the profile plots in Figure 6 indicates a linear relationship between the holistic ERP implementation status and changes in performance. The profile plots for the other four performance measures not shown in Figure 6 also exhibit a similar relationship. These profile plots suggest that performance increases with increases in holistic ERP implementation status. The slope of the profile plots indicate that for the same holistic ERP implementation statuses, increases in ROI, profitability, and competitive advantage are greater than increases in on-time delivery, standardization, and information availability. The interpretations of these results are discussed in detail in chapter 5.

The results in Table 23 indicate that the project system and the e-commerce modules individually do not make a significant contribution to any of the 10 performance measures. The results in Table 24, however, reveal that a holistic ERP system contributes significantly to all the 10 performance measures. To further understand these relationships, three holistic implementation status scales were constructed – a 12 module summated scale (excluding the project system and e-commerce modules) and two 13 module summated scales (excluding the e-commerce and project system modules, respectively). A test for hypothesis 1b was conducted by running standard linear regression analysis and the results are presented in Table 26. The results in Table 26 indicate that the implementation of the 13 module holistic ERP system (excluding the e-commerce module) results in higher benefits when compared to the 12 module ERP system (excluding the project system and e-commerce modules), the 14 module ERP system, and the 13 module ERP system (excluding the project system module).

Table 26

Significant Relationships Between Different Holistic Implementation Statuses of ERP System and Changes in Performance

Implementation Status of ERP System	Changes in Performance														
	Inventory Management			Information Quality			On-time Delivery			Standardization			Profitability		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
Holistic ERP System (14 modules)	.205**	.042	8.788**	.188**	.035	7.325**	.144*	.021	4.239*	.183**	.033	6.966**	.220**	.044	10.260**
Holistic ERP System (12 modules excluding project system and e-commerce)	.211**	.045	9.375**	.195**	.038	7.906**	.148*	.022	4.486*	.180**	.032	6.745**	.221**	.049	10.335**
Holistic ERP System (13 modules excluding e-commerce)	.211**	.045	9.365**	.193**	.037	7.804**	.152*	.023	4.754*	.185**	.034	7.089**	.224***	.050	10.577***
Holistic ERP System (13 modules excluding project system)	.205**	.042	8.788*	.189**	.036	7.413**	.139***	.019	3.981***	.179*	.032	6.639*	.218**	.048	10.031**

Implementation Status of ERP System	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
Holistic ERP System (14 modules)	.332***	.110	24.944***	.200**	.040	8.409**	.212**	.045	9.432**	.212**	.045	9.595**	. 226***	.051	10.829***
Holistic ERP System (12 modules excluding project system and e-commerce)	.338***	.114	25.986***	.199**	.040	8.310**	.217**	.047	9.965**	.212**	.045	9.494**	.224***	.050	10.606***
Holistic ERP System (13 modules excluding e-commerce)	.339***	.115	26.105***	.201**	.041	8.501**	.217**	.047	9.927**	.213**	.045	9.531**	.226***	.051	10.854***
Holistic ERP System (13 modules excluding project system)	.332***	.110	24.826***	.198**	.039	8.232**	.212**	.045	9.462**	.212	. 045	9.483**	.224***	.050	10.604***

Note

β: All values are standardized regression coefficients.

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

A test of the hypothesis 1b using the four holistic ERP implementation status scales and a summated scale as a measure of overall performance was conducted and the results are shown in Table 27. Analysis of the table reveals additional support to the findings that the 13 module holistic ERP system (excluding the e-commerce module) provides higher benefits to firms. The interpretations of these findings are discussed in Chapter 5.

Table 27
Significant Relationships Between Different Holistic Implementation Statuses of ERP System and Overall Change in Performance

Implementation Status of ERP System	Overall Change in Performance (10 Performance Measures)		
	β	R^2	F
Holistic ERP System (14 modules)	.285 ***	.081	17.823***
Holistic ERP System (12 modules excluding project system and e-commerce)	.288 ***	.083	18.227***
Holistic ERP System (13 modules excluding e-commerce)	.290***	.084	18.502***
Holistic ERP System (13 modules excluding project system)	.283***	.080	17.562***

Note

β: All values are standardized regression coefficients.

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

A test for hypothesis 2a – CSFs moderate the relationship between the implementation status of individual ERP system modules and changes in performance – was conducted by running standard linear regression analyses and developing separate regression models to analyze the moderator effects of each of the 13 CSF measures. Summated scales were constructed for each of the 13 CSF measures. The results of the regression analysis are presented in Tables 28a to 28d.

Table 28a
Significant Interaction Relationships Between Implementation Status of ERP Modules and Changes in Performance

Implementation Status X CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Top Management X															
SD				.661*	.018	4.524*							.670 *	.018	4.789*
EC	-.616 *	.017	4.132 *												
Planning X															
CO													.780*	.024	6.070*
PP							-.688**	.026	6.992**						
SD													.728**	.026	6.744**
QM							-.978**	.029	7.767**						
SCM													.888*	.020	5.034*
APO/APS													1.430*	.018	4.067*
User Support X															
FI	.749*	.022	5.170*	. 814**	.026	6.798**							.848**	.028	7.685**
MM				.675*	.016	4.256*							.806*	.023	6.359*
PP				.768*	.024	6.159*									
SD	.920*	.035	8.416*	.863**	.031	8.184**							.983***	.04	11.238***
QM							-.894*	.020	4.783*						
SCM													.873*	.015	4.119*
CRM													-1.426*	.021	5.916*
Project Management X															
PS													-.765*	.017	4.255*
SD				.699**	.016	4.015**									
QM							-.757*	.017	3.904*						
HR	.718*	.019	4.395*												
Training X															
FI	.578*	.018	4.275*				.686*	.026	6.036*				.600*	.020	4.663*
PP													.611*	.019	4.446*
PS				1.033*	.025	6.235*									
SD	.624*	.019	4.342*										.616*	.018	4.275*
HR	.712*	.022	5.122*				.671*	.020	4.531*				.711*	.022	5.172*
SCM				-.609*	.016	3.963*									
Learning X															
FI													.539*	.015	3.888*
CO													.706*	.022	5.866*
PP				.538*	. 016	4.015*									
SD													.632*	.021	5.393*
Data Accuracy X															
SCM				-.891*	.019	4.190*									

Note
Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler
β: All values are standardized regression coefficients
Significance: * p < .05, ** p < .01, *** p < .001

Table 28b
Significant Interaction Relationships Between Implementation Status of ERP Modules and Changes in Performance

Implementation Status X CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Alignment X															
CO													.701*	.016	3.876*
PP	.694*	.017	4.004 *	.841*	.026	6.032*							.740	.020	4.797*
HR	.848*	.025	5.685*												
Consultants X															
FI										-.708*	.030	6.690*	-.702*	.030	6.204*
CO													-.696*	.029	6.198*
MM													- 675*	.021	4.407*
SD													-.785*	.035	7.296*
QM										-.655*	.020	4.379*	-.642*	.020	4.292*
HR				-.590*	.019	3.932*				-.677*	.025	5.494*			
Implementation Team X															
FI	.987*	.023	5.308*	.916*	.020	4.921*							1.227*	.027	6.374*
CO	1.265*	.029	6.654*	1.160*	.024	6.174*							.950*	.022	5.049*
PP	1.002*	.024	5.543*	1.059*	.027	6.673*							. 919*	.023	5.259*
SD				.824*	.018	4.450*									
QM							-1.068*	.019	4.633*						
Communication X															
FI				1.646*	.047	10.588*									
CO				1.119*	.020	4.448*									
PP	1.086*	.019	3.935*	1.565*	.039	8.703*									
SD				1.379*	.028	6.113*									
Organizational Culture X															
FI													1.001***	.040	11.701***
CO													.794**	.026	7.595**
MM													.930**	.033	9.695**
PP													.673*	.020	5.904*
SD													.823**	.028	7.994**
QM							-.632*	.016	4.031*						
HR													.582*	.015	4.335*
SCM													.692*	.017	4.912*
National Culture X															
FI							-.692*	.019	4.026*	-.916**	.033	7.390**			
CO	-.772*	.027	5.795*				-.701*	.022	4.764*	-.867**	.034	7.695**			
PS	-.848***	.049	10.558***				-.524*	.019	4.020*						
MM										-.885*	.029	6.518*			
PP							-.680*	.020	4.44*	-1.214***	.063	14.772***			
SD										-.792*	.025	5.482*			
QM										-.759*	.026	5.912*			

Note
Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler
β: All values are standardized regression coefficients
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

Table 28c

Significant Interaction Relationships Between Implementation Status of ERP Modules and Changes in Performance

Implementation Status X CSFs	Changes in Performance: Return on Investment β	ΔR²	ΔF	Information Availability β	ΔR²	ΔF	User Satisfaction β	ΔR²	ΔF	Customer Satisfaction β	ΔR²	ΔF	Competitive Advantage β	ΔR²	ΔF
Top Management X															
PP				.656 *	.018	4.081 *									
HR	1.094***	.055	13.919 ***	.888 *	.036	8.394 *									
Planning X															
SCM				1.114**	.031	7.740**	1.014**	.026	7.362**						
APO/APS															
User Support X															
FI	.833**	.027	7.285**	.687*	.018	4.476*									
MM	.652*	.015	4.205*												
PP				.676*	.018	4.408*	.170**	.001	.312**						
SD	.672*	.019	5.024*	.652*	.018	4.273*									
QM													-1.023**	.026	7.352**
HR	.639*	.018	4.631*												
SCM				1.336**	.036	8.779**									
Project Management X															
FI	.932**	.033	8.531**	.784*	.023	5.789*									
SD				.832*	.022	5.526*									
HR	.			1.011**	.037	9.351**									
SCM				1..334***	.052	13.327***									
Training X															
FI	.626*	.022	5.237*												
HR	.708*	.022	5.192*	.955*	.040	9.418*				.607*	.016	3.929*			
SCM										-.628*	.017	4.251*			
Learning X															
LO										.670*	.017	4.449*			
QM													-.598*	.014	3.878*
SCM							.773*	.022	4.943*						
Alignment X															
LO	-.651*	.014	4.079*												
QM	-.849*	.020	6.280*												
SCM				.670*	.019	5.034*									
APO/APS							-1.087*	.020	6.245*						

Note

Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler

β: All values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

Table 28d
Significant Interaction Relationships Between Implementation Status of ERP Modules and Changes in Performance

Implementation Status X CSFs	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Consultants X															
FI	-.629*	.024	5.196*							-.630*	.024	5.214*	-.903*	.049	10.976*
CO													.588*	.021	4.595*
MM	-.851*	.034	7.656*	-.640*	.019	3.982*							-.964*	.043	9.496*
PP													-.679*	.029	6.529*
PS										-.871*	.020	4.289*			
SD	-.643*	.023	5.083*`										-1.011*	.057	12.886*
QM										-.805*	.032	7.127*			
HR				.651*	.023	4.809*									
SCM				-.569*	.020	3.986*									
Implementation Team X															
CO				.960*	.017	4.294*									
QM													-.996*	.016	3.982*
APO/APS				1.667*	.017	4.410*									
Data Accuracy X															
MM				-.965*	.019	4.538*									
SCM	-.878*	.018	4.450*	-.835*	.016	3.910*				-1.261*	.037	8.859*	-.939*	-.021	4.856*
APO/APS	-.665*	.020	5.000*	-.751*	.026	6.245*	-.782*	.028	7.000*	- .761*	.026	6.154*			
Communication X															
EC				-1.602*	.023	5.535*									
Organizational Culture X															
MM										.646*	.016	4.038*			
LO										.708*	.019	4.705*			
HR	.621*	.017	4.634*	.813**	.030	7.092**									
SCM				.871*	.028	6.483*									
National Culture X															
FI				-1.018**	.040	8.771**	-.951**	.035	8.308**	.785*	.024	5.522*			
CO										-.656*	.019	4.284*			
MM				.973**	.035	7.593**	-.950**	.034	7.858**	-.770*	.022	4.929*			
PP				-.753*	.024	5.161*	-.726*	.023	5.246*						
SCM							-.707*	.018	3.903*						

Note
Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler
β: All values are standardized regression coefficients
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

The results presented in the tables show the size of the standardized regression coefficients (β), the changes in the coefficients of determination (ΔR²), and the changes in F ratios (ΔF) for the fitted models. Only significant parameter estimates of the fitted models are shown. All non-significant parameter estimates are omitted from the tables. The tables further indicate that both positive as well as negative interactional effects on performance are present. The positive relationships in the tables indicate that the interactional relationships have a beneficial impact on performance; whereas negative relationships demonstrate an adverse impact on performance.

The results in Tables 28a and 28c indicate that the regression coefficient for the interactive effect of the human resources module and the top management CSF on ROI (+1.094) has the greatest magnitude and highest significance among all the models involving the moderating effect of this CSF. There are interaction effects present between the top management CSF and sales and distribution module on information quality and profitability. Also, interaction effects are present between the top management CSF and the production planning module on information availability. The E-commerce module shows a negative interactive effect with the top management CSF on inventory management.

A perusal of the interaction effects of the planning CSF on various modules in Tables 28a and 28c reveals that the APO/APS module has the greatest magnitude effect on profitability (+1.430). The planning CSF also interacts with the controlling, sales and distribution, and the SCM modules to cause changes in profitability. The planning CSF further interacts with the SCM module to increase information availability and user satisfaction. There are negative interactions between the planning CSF and the production planning and the quality management modules on on-time delivery.

Five of the ERP system modules – financials, materials management, sales and distribution, SCM, CRM – in Tables 28a and 28c indicate significant interactive effects with the user support CSF on profitability. The regression coefficient for the interactive effect of the user support CSF and the CRM module has the highest magnitude on profitability (-1.426) among all the models involving the moderating effect of this CSF. There are interaction relationships present between the user support CSF and four ERP system modules – financials, materials management, sales and distribution, and human resources modules – and ROI. The user support CSF interacts with four ERP system modules – financials, production planning, sales and distribution, SCM – to affect information availability. The user support CSF further interacts with four ERP system modules – financials, materials management, production planning, sales and distribution – to impact information quality. There are also interactions present between the user support CSF and two ERP system modules on inventory management, and one ERP system module on user satisfaction and competitive advantage. There is also a negative interaction present between the quality management module and the user CSF on on-time delivery.

The results in Tables 28a and 28c indicate that the regression coefficient for the interactive effect of the SCM module and the project management CSF on information availability (+1.334) has the greatest magnitude and highest significance among all the models involving the moderating effect of this CSF. Three other ERP system modules – financials, sales and distribution, human resources – interact with the project management CSF to affect changes in information availability. Interactive relationships between the project management CSF and various ERP system modules also impact inventory management, information quality, on-time delivery, profitability, and ROI.

Four of the ERP system modules – financials, production planning, sales and distribution, human resources – in Tables 28a and 28c interact with the training CSF to impact the profitability measure. The regression coefficient for the interactive effect of the project system module and the training CSF on information quality has the highest magnitude (+1.033) among all the models involving the moderating effect of this CSF. The training CSF interacts negatively with the SCM module to impact information quality. Interaction relationships between the training CSF and three ERP system modules – financials, sales and distribution, human resources – affect inventory management. There are also interactions present between the training CSF and various ERP system modules on on-time delivery, ROI, customer satisfaction, and information availability.

Tables 28a and 28c indicate significant interaction effects between the learning CSF and three ERP system modules – financials, controlling, sales and distribution – on profitability. The regression coefficient for the interactive effect of the learning CSF and the SCM module on user satisfaction (+.773) has the highest magnitude among all the models involving the moderating effect of this CSF. Interaction relationships are present between the learning CSF and various ERP system modules on information quality, customer satisfaction, and competitive advantage.

Three ERP system modules – materials management, SCM, APO/APS – and the data accuracy CSF in Tables 28a and 28d negatively impact information availability. The regression coefficient for the interactive effect of the data accuracy CSF and the SCM module on customer satisfaction has the highest magnitude (-1.261) among all the models involving the moderating effect of this CSF. The APO/AP module also interacts with the data accuracy CSF to adversely affect customer satisfaction. Negative interaction relationships are present between the data accuracy CSF and the SCM and APO/ASP modules on ROI, and the SCM module on information quality and competitive advantage.

In tables 28b and 28c significant interactions are present between the alignment CSF and the controlling and production planning modules on profitability. The regression coefficient for the interactive effect of the alignment CSF and the APO/APS module on user satisfaction has the highest magnitude (-1.087) among all the models involving the moderating effect of this CSF. The alignment CSF interacts with the general logistics and the quality management modules to negatively impact ROI. Interaction relationships are also present between the alignment CSF and various ERP system modules on information quality and information availability.

Tables 28b and 28d indicate the presence of significant negative interactions between five ERP system modules – financials, controlling, materials management, sales and distribution, quality management – and the consultants CSF on profitability. There are negative interaction relationships indicated between 4 ERP system modules – financials, controlling, materials management, production planning, sales and distribution – and the consultants CSF on competitive advantage. Negative interaction relationships are also present between various ERP system modules and the consultants CSF on standardization and customer satisfaction. The regression coefficient for the interaction effect of the consultants CSF and the human resource and the controlling modules on information availability and competitive advantage respectively are the only positive effects among all the interaction models involving this CSF.

The regression coefficient for the interactive effect of the APO/APS module and the implementation team CSF on information availability, in Tables 28b and 28d, has the greatest magnitude (+1.667) among all the models involving the moderating effect of this CSF. Four ERP system modules – financials, controlling, production planning, sales and distribution - interact with the implementation team CSF to affect information quality. There are also significant interactions present between three ERP modules – financials, controlling, production planning – and the implementation team CSF on inventory management and profitability. The implementation team CSF negatively interacts with the quality management module to affect on-time delivery and competitive advantage.

Tables 28b and 28d show that four ERP system modules – financials, controlling, production planning, sales and distribution – interact with the communication CSF to impact information quality. The regression coefficient for the interaction effect of the communication CSF and the financials module on information quality has the highest magnitude (+1.646) among all the models involving the moderating effect of this CSF. The communication CSF also interacts with the production planning module to cause changes in inventory management. The tables also indicate that the interaction between the communication CSF and the E-commerce module negatively impacts information availability.

A perusal of the interactive effects of the organizational culture CSF on seven ERP system modules, in Tables 28b and 28d, reveals that the financials module has the greatest magnitude and the highest significance effect on profitability (+1.001). The other six ERP system modules that interact with the organizational culture CSF to impact profitability are the controlling, materials management, production planning, sales and distribution, human resources, and SCM modules. Interaction relationships are present between the organizational culture CSF and two ERP system modules on information availability and customer satisfaction. There is also a negative interaction between the organizational culture CSF and the quality management module on on-time delivery.

The results in Tables 28b and 28d indicate that there are significant interactions between six ERP system modules – financials, controlling, materials management, production planning, sales and distribution, quality management – and the national culture CSF on standardization. All these interactions are, however, negative suggesting that increase in national culture CSF elements adversely affects the standardization of the firms’ processes. The regression coefficient for the interactive effect of the national culture CSF and the production planning module on standardization has the highest magnitude (-1.214) and significance effect among all the models involving the moderating effect of this CSF. Negative interaction relationships are present between four ERP system modules and the national culture CSF on on-time delivery and user satisfaction. There are also negative interactions between various ERP system modules and the national culture CSF on information availability, customer satisfaction, and inventory management.

A synthesis of the discussion pertaining to the results presented in Tables 28a to 28d reveals partial support for hypothesis 2a. Most CSFs had positive interaction effects with various ERP system modules to affect performance. Negative interaction effects with most ERP system modules were reported mainly for the consultants and the national culture CSFs besides a few others. The results thus indicate that different CSFs interact with different ERP system modules to change the form of the relationship between the implementation status of individual ERP system modules and various changes in performance. To further understand the moderator relationships in hypothesis 2a, the three key model variables - implementation status, performance, CSFs - were dichotomized as “low” and “high.” The “low” category for each of the three variables comprised of frequency percentile values less than 33.33% and the “high” category greater than 66.67%. A test for hypotheses 2a was conducted using univariate ANOVA and examining the results for the joint effects of each of the 14 ERP modules and each of the 13 CSFs on the 10 performance measures. As a representation of the overall results, the analyses for ROI and competitive advantage are shown in Table 29.

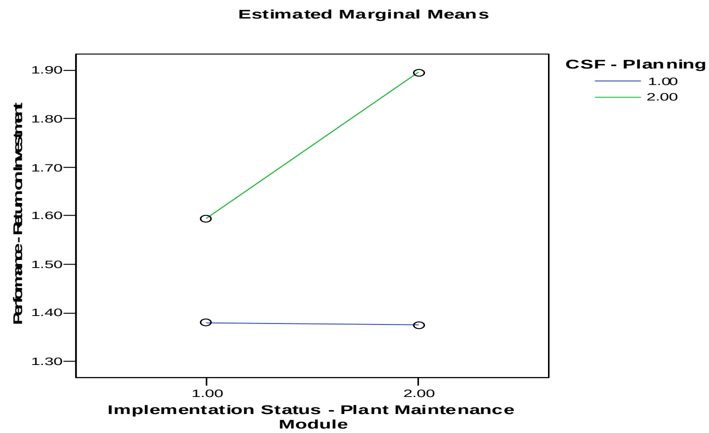
A synthesis of the results from the descriptive statistics and regression analyses indicate that firms scored relatively high on ROI and relatively low on competitive advantage. Also, significant differences in performance were obtained for the interaction effects of the planning and the alignment CSFs and various ERP system modules on ROI and competitive advantage. A perusal of the table indicates that the interaction relationship between the planning CSF and the EC commerce module on ROI had the highest magnitude (+1.242) and significance among all the models involving this CSF. Also, the interaction relationship between the alignment CSF and the SCM module on competitive advantage had the highest magnitude (+2.301) and significance among all the models involving this CSF. The least interaction effects in terms of magnitude and significance were reported between the planning CSF and the plant maintenance module for ROI, and the alignment CSF and the financials module for competitive advantage. The interaction plots of the Table 29 results are shown in Figures 7a, 7b, and 8.

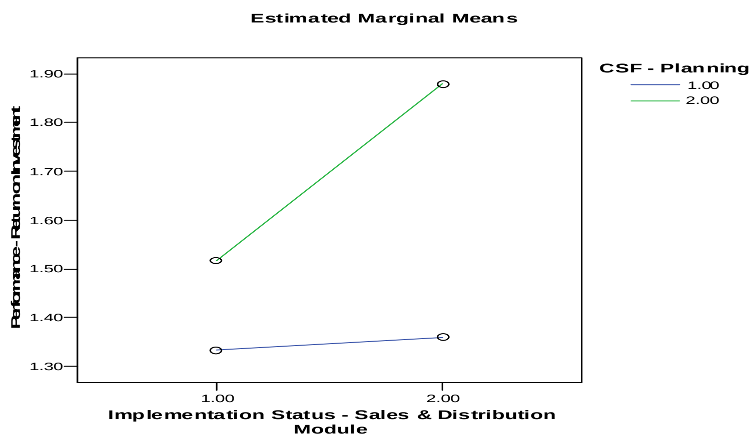
Table 29
Significant Interaction Relationships Between Implementation Status of ERP Modules and Changes in Performance (ANOVA)

Implementation Status of ERP Modules X CSFs	Changes in Performance					
	Return on Investment			Competitive Advantage		
	SS	MS	F	SS	MS	F
Planning X						
FI	.942	.942	4.445* (df 1,132)			
PM	.810	.810	3.926* (df 1,145)			
MM	1.067	1.067	5.206* (df 1,123)			
SD	.893	.893	4.302* (df 1,131)			
EC	1.242	1.242	5.901* (df 1,163)			
APO/APS	.845	.845	3.971* (df 1,163)			
Alignment X						
FI				.952	.952	4.892* (df 1, 36)
SD				1.262	1.262	6.387* (df 1,137)
SCM				2.301	2.301	11.815*** (df 1,166)
EC				1.280	1.280	6.275* (df 1,166)

Note

Modules: FI – Financials, CO – Controlling, PM – Plant Maintenance, MM – Materials Management, PP – Production Planning, SD – Sales and Distribution, GL – General Logistics, QM – Quality Management, HR – Human Resources, SCM – Supply Chain Management, CRM – Customer Relationship Management, APO/APS – Advance Planner and Optimizer/Advance Planner and Scheduler
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$





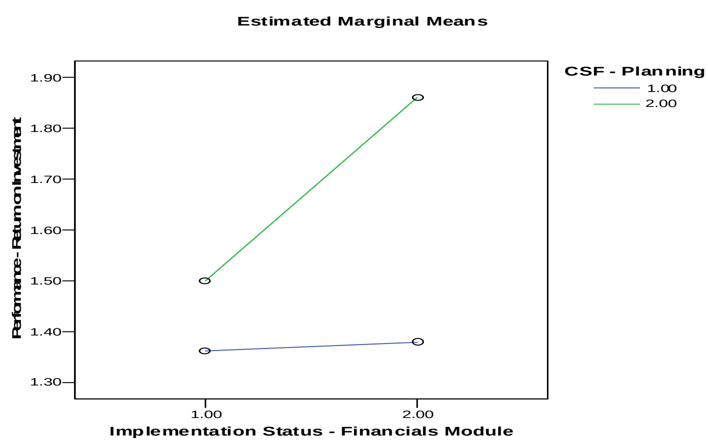


Figure 7a. Interaction Effects Between Implementation Status of Various ERP Modules, Planning CSF, and ROI.

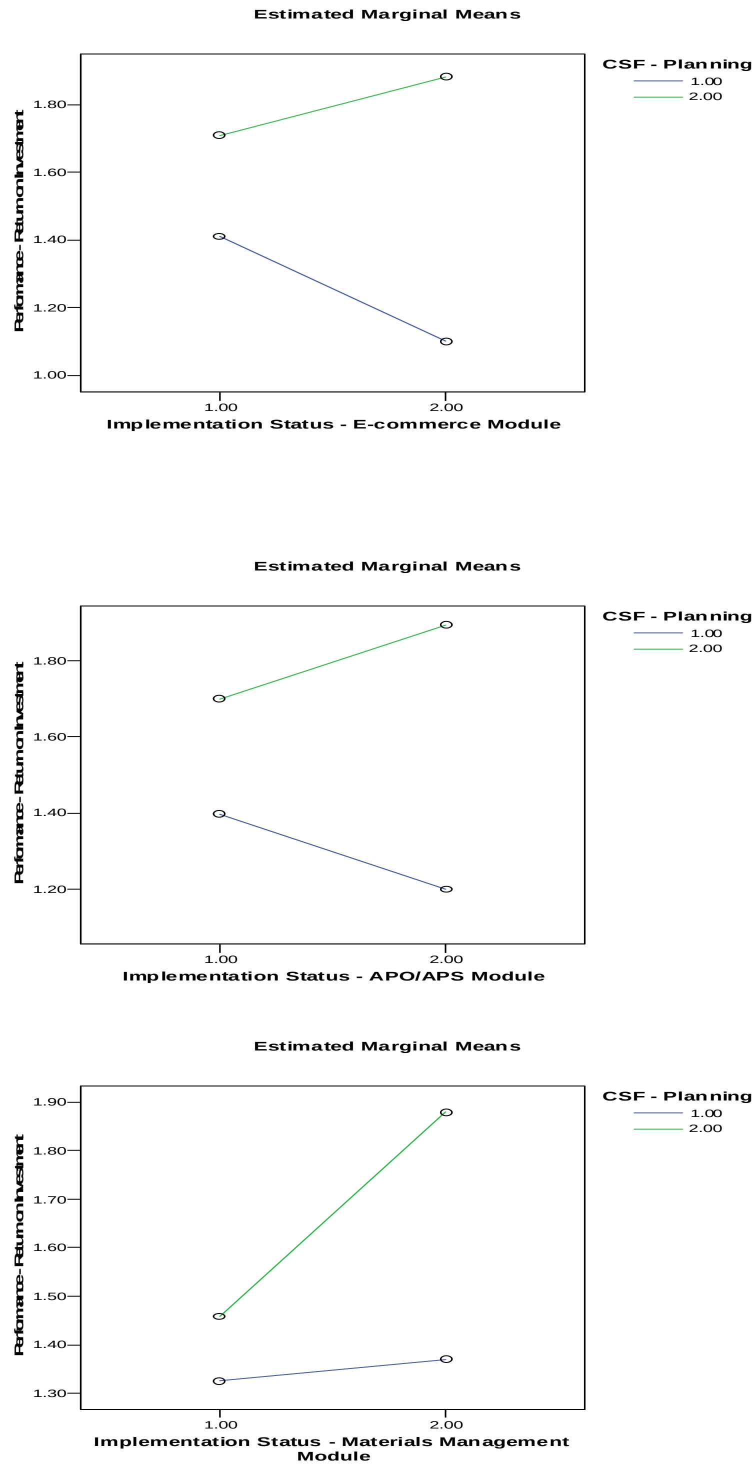


Figure 7b. Interaction Effects Between Implementation Status of various ERP Modules, Planning CSF, and ROI.

The interaction plots of the Table 29 results in Figures 7a and 7b – implementation status of various ERP modules, planning CSF, ROI – indicate that firms, which focus on the planning CSF during the low implementation status of the plant maintenance, sales and distribution, financials, and the materials management modules, obtain increases in ROI. As the implementation status of these four modules increases, firms that continue to focus on the planning CSF obtain greater increases in their ROI. Figures 7a and 7b further indicate that firms that do not focus on the planning CSF during the low implementation status of the E-Commerce and the APO/APS modules experience a decline in their ROI. The ROI increases as firms pay attention to the planning CSFs at higher implementation statuses of these two modules. The interaction plots of the Table 29 results – implementation status of various ERP modules, alignment CSF, competitive advantage – are shown in Figure 8.

The interaction plots in Figure 8 indicate that firms obtain increases in competitive advantage when they focus on the alignment CSF during the low implementation status of the sales and distribution module; however, the interaction between the alignment CSF and the low implementation status of the financials module results in decrease in competitive advantage. As the implementation status of the sales and distribution and the financials modules increases, firms that continue to focus on the alignment CSF obtain greater increases in competitive advantage. The figure further indicates that firms which do not focus on the alignment CSF during the low implementation status of the SCM and the E-Commerce modules experience a decline in their competitive advantage. Competitive advantage increases as firms pay attention to the alignment CSFs at higher implementation statuses. The interpretations of these results are discussed in detail in chapter 5.

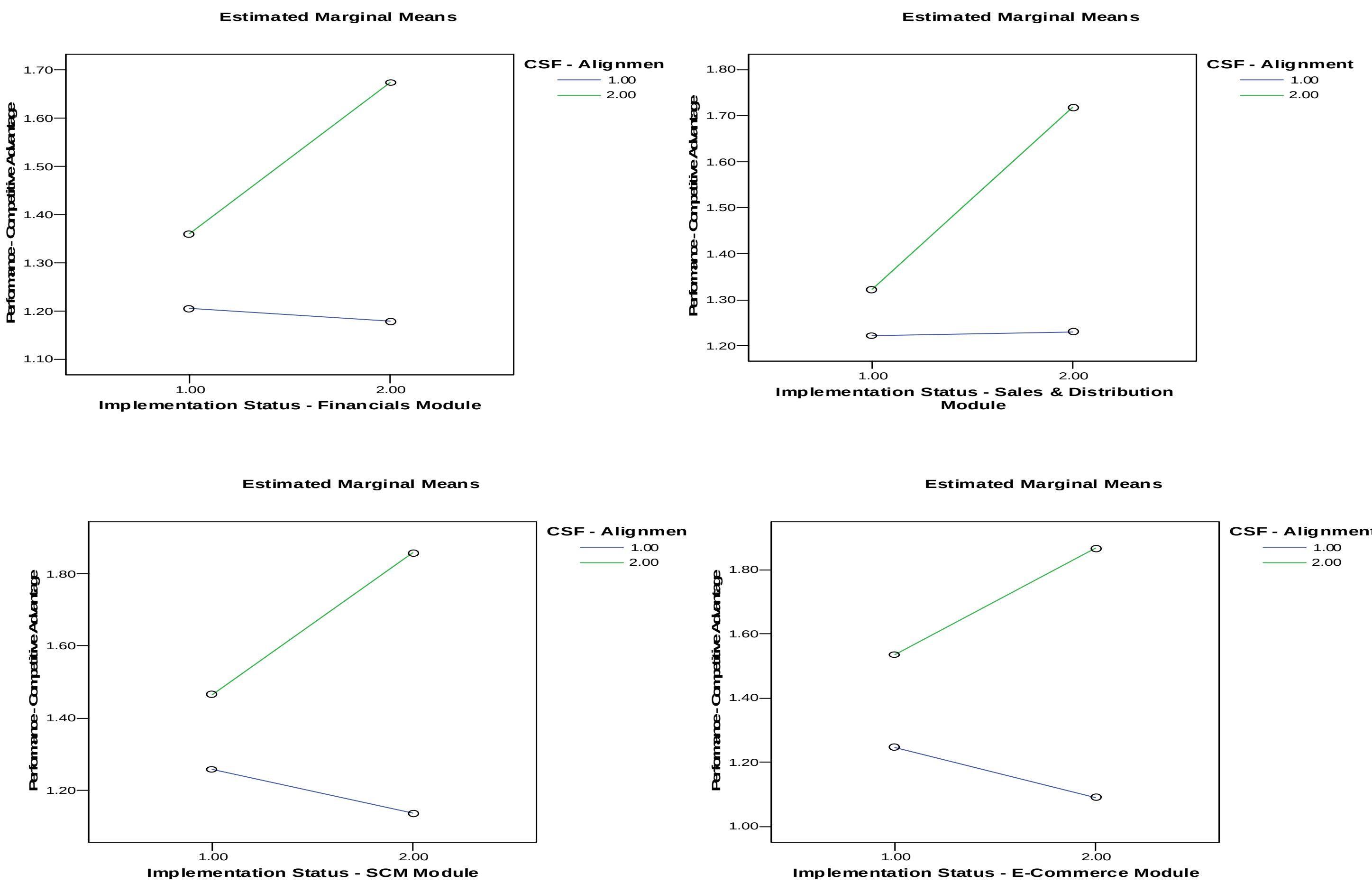


Figure 8. Interaction Effects Between Implementation Status of Various ERP Modules, Alignment CSF, and Competitive Advantage.

A test for hypothesis 2b – CSFs moderate the relationship between the implementation status of a holistic ERP system and changes in performance – was conducted by running standard linear regression analyses and developing regression models to analyze the moderator effects of each of the 13 CSF measures. Summated scales were used for assessing the holistic implementation status of ERP system as well as each of the 13 CSFs. The results of the regression analysis are presented in Table 30. The tables show the size of the standardized regression coefficients (β), the changes in the coefficients of determination (ΔR^2), and the changes in F ratios (ΔF) for the fitted models. Only significant parameter estimates of the fitted models are shown. All non-significant parameter estimates are omitted from the tables.

Table 30
Significant Interaction Relationships Between Holistic Implementation Status of ERP System and Changes in Performance

Holistic Implementation Status of ERP System x CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Planning							-.757*	.016	4.082*				.891*	.022	5.616*
User Support													.874*	.021	5.707*
Learning													.705*	.017	4.380*
Consultants													-.867**	.036	7.924**
Implementation Team				1.046*	.019	4.582*							1.061*	.019	4.510*
Communication							1.457*	.027	5.021*						
Organizational Culture													.782**	.024	7.185**
National Culture	-.759**	.022	4.866**				-.818*	.026	5.678*	-1.131***	.049	11.489***			

Holistic Implementation Status of ERP System x CSFs	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Consultants	-.662*	.021	4.855*												
National Culture				-.900**	.031	6.775**	-.788*	. 024	5.562**				-1.033***	.051	11.918***

Note

β : All values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

The results in Table 30 indicate that there are interaction effects between the holistic implementation status of the ERP system and eight of the CSFs for various performance measures. The regression coefficient for the interactive effect of the implementation status of the holistic ERP system and the communication CSF on the changes in on-time delivery (+1.457) has the greatest magnitude among all the models. The results further indicate that interaction effects are present between the holistic implementation status of the ERP system and the planning, user support, learning, implementation team, and the organizational culture CSFs, on profitability. The implementation team CSF also interacts with the holistic ERP system implementation status to affect information quality. The interactions for the consultants CSF and the holistic ERP system implementation status are negative for profitability and ROI. Also, the interactions for the national culture CSF and the holistic ERP system implementation status are negative for six performance measures. These negative interactions indicate that firms which focus on the consultants and the national culture CSFs experience a decrease in firm performance on various measures.

A synthesis of the discussion pertaining to the above results reveals partial support for hypothesis 2b. Similar to the results obtained from testing hypothesis 2a, the consultants and the national culture CSFs interact negatively with the holistic ERP implementations status scale to affect performance. The results overall indicate that different CSFs interact with the holistic ERP implementation status to change the form of the relationship between the holistic ERP implementation status and various changes in performance.

To further understand the moderator relationships in hypothesis 2b the three key model variables - implementation status, performance, CSFs - were dichotomized as “low” and “high.” The “low” category for each of the three variables comprised of frequency percentile values less than 33.33% and the “high” category greater than 66.67%. A test for hypothesis 2b was conducted by running univariate ANOVA and examining the interaction results of the holistic

ERP system implementation status and each of the 13 CSFs on the 10 performance measures. As a representation of the overall results, the analyses for the interaction effects of the planning and the alignment CSFs on the ROI and competitive advantage measures respectively are shown in Table 31.

Table 31
Significant Interaction Relationships Between Holistic Implementation Status of ERP System and Changes in Performance (ANOVA)

Implementation Status of ERP System X CSFs	Changes in Performance					
	Return on Investment			Competitive Advantage		
	SS	MS	F	SS	MS	F
Planning	.805	.805	4.225* (1,107)			
Alignment				1.602	1.602	8.880** (1,111)

Note

β: All values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

A synthesis of the results from the descriptive statistics and regression analyses indicate that firms have scored relatively high on the ROI measure and relatively low on the competitive advantage measure. The planning and the alignment CSFs were chosen as there were significant differences in performance measures obtained for the interaction effects of these 2 CSFs and various ERP system modules on ROI and competitive advantage. The interaction plots for the planning and the alignment CSFs with the holistic ERP system implementation status for ROI and competitive advantage respectively are shown in figure 9.

The plots in Figure 9 indicate that firms which focus on the planning CSF during the low implementation status of the holistic ERP system obtain increases in performance. As the holistic implementation status of the ERP system increases, firms that continue to focus on the planning CSF obtain greater increases in performance. The interaction plot of the alignment CSF with the holistic ERP implementation status on competitive advantage demonstrates that firms that focus on the alignment CSF through the deployment process obtain large increases in performance. In contrast, the alignment CSF does not play an important role during low ERP holistic implementation statuses. The interpretation of these results is discussed in chapter 5.

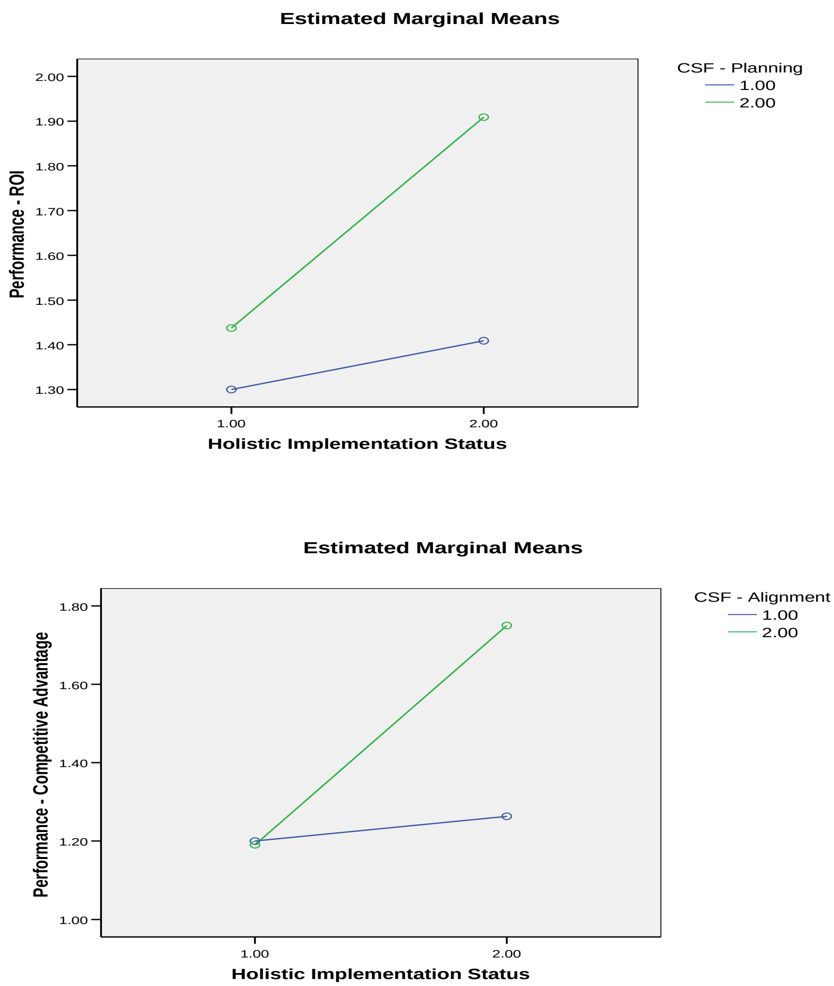


Figure 9. Interaction Effects Between Holistic Implementation Status of ERP System and Planning and Alignment CSFs, on ROI and Competitive Advantage.

To further understand the impact of CSFs on the relationships revealed in Tables 26 and 27, a test of the hypothesis 2b was conducted for the 12 module holistic ERP system and the two 13 module ERP systems (excluding the e-commerce and project system modules, respectively) and the results are given in Tables 32a to 32c. A comparison of the results presented in Tables 30 and 32a reveals that CSF interactions for the 12 module holistic ERP system produce improvements in six performance measures. The results further show a decrease in six performance measures; three additional CSF interactions were revealed and three existing CSF interactions were omitted.

Table 32a
Significant Interaction Relationships Between Different Holistic Implementation Statuses of ERP System and Changes in Performance

Holistic Implementation Status of ERP System^ X CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Planning													.859*	.021	5.535*
User Support													.901*	.022	6.212*
Learning													.691*	.017	4.502*
Consultants													-.798**	.033	7.174**
Implementation Team				1.007*	.018	4.426*							1.125*	.022	5.302*
Communication				1.525*	.028	6.325*									
Organizational Culture													.842*	.027	8.117**
National Culture							-.785*	.023	5.119*	-1.167***	.051	12.002***			

Holistic Implementation Status of ERP System ^ X CSFs	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Top Management	.767*	.015	3.917*												
Consultants	-.650*	.022	5.037*										-.981*	.050	11.507*
National Culture				-.924**	.032	7.000**	-.866*	.028	6.644*						

Note
^ - 12 module holistic ERP system (excluding project system and e-commerce)
β : All values are standardized regression coefficients
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

A comparison of the results presented in Tables 30 and 32b reveals that various CSFs interact with the 13 module holistic ERP system excluding the e-commerce module to produce improvements in nine performance measures. The results further indicate a decrease in four performance measures; two additional CSF interactions were revealed and three existing CSF interactions were omitted.

Table 32b
Significant Interaction Relationships Between Different Holistic Implementation Statuses of ERP System and Changes in Performance

Holistic Implementation Status of ERP System ^ X CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Planning													.878*	.021	5.566*
User Support													.892*	.022	6.085*
Learning													.697*	.016	4.358*
Consultants													-.847**	.035	7.731**
Implementation Team				1.044**	.019	4.715**							1.070*	.020	4.737*
Communication				1.457*	.028	6.224*									
Organizational Culture													.811**	.026	7.773**
National Culture	-.752*	.022	4.902*				-.818*	.026	5.823*	-1.109***	.048	11.295***			

Holistic Implementation Status of ERP System ^ X CSFs CSFs	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Consultants	-.648*	.021	4.784*										-1.028***	.052	12.084***
National Culture				-.891**	.031	6.783**	-.814*	.026	6.108*	-.657*	.017	3.884*			

Note

^ - 13 module holistic ERP system (excluding e-commerce)
β : All values are standardized regression coefficients
Significance: * p < .05, ** p < .01, *** p < .001

A comparison of the results presented in Tables 32a and 32b reveals that CSF interactions for the 13 module holistic ERP system excluding the e-commerce module produce improvements in seven performance measures. The results further show a decrease in seven performance measures; two additional CSF interactions surfaced and one existing CSF interaction was omitted.

Table 32c
Significant Interaction Relationships Between Different Holistic Implementation Statuses of ERP System and Changes in Performance

Holistic Implementation Status of ERP System ^ X CSFs	Changes in Performance														
	Inventory Management			Information Quality			On-Time Delivery			Standardization			Profitability		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Planning													.871*	.022	5.577*
User Support													.882*	.021	5.824*
Learning													.699*	.017	4.527*
Consultants													-.819**	.034	7.384**
Implementation Team				1.007*	.017	4.285*							1.115*	.021	5.036*
Communication				1.522*	.027	6.108*									
Organizational Culture													.811**	.025	7.495**
National Culture							-.782*	.023	4 .962*	-.186***	.052	12.161***			

Holistic Implementation Status of ERP System ^ X CSFs CSFs	Changes in Performance														
	Return on Investment			Information Availability			User Satisfaction			Customer Satisfaction			Competitive Advantage		
	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF	β	ΔR²	ΔF
Top Management	.776*	.016	3.988*												
Consultants	-.665*	.022	5.130*										-.987***	.049	11.364***
National Culture				-.931**	.032	6.960**	-.834*	.026	6.000*						

Note
^ - 13 module holistic ERP system (excluding project system)
β : All values are standardized regression coefficients
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

A comparison of the results presented in Tables 30 and 32c shows that CSF interactions for the 13 module holistic ERP system excluding the project system module produce improvements in six performance measures. The results further indicate a decrease in six performance measures; three additional CSF interactions were revealed and three existing CSF interactions were omitted. The results in Tables 32a and 32c indicate that CSF interactions for the 13 module holistic ERP system excluding the project system module produce improvements in six performance measures. The results further reveal a decrease in eight performance measures. A comparison of the results in Tables 32b and 32c indicates that the 13 module holistic ERP system excluding the project system module results in improvements in seven performance measures. There were also decreases in six performance measures; one additional CSF interaction was revealed and two existing CSF interactions were omitted.

A synthesis of the results presented in Tables 30, and 32a to 32c, and the ensuing discussions indicate that a 13 module holistic ERP system excluding the e-commerce module interacts with various CSFs to produce higher benefits when compared to the 14 module ERP system. Among the two 13 module holistic ERP systems, however, the 13 module system excluding the project system module provides greater benefits. The results further suggest that the 12 module and the 13 module system excluding the e-commerce module broadly provide similar benefits to firms; the 13 module holistic ERP system excluding the project system module, however, results in deceased benefits when compared to the 12 module system.

A test of the hypothesis 2b using the four holistic ERP implementation status scales and a summated scale as a measure of the overall performance was conducted and the results are shown in Table 33. Analysis of the table reveals partial support for the interactional CSF effects of the 13 module holistic ERP system excluding the project system module for national culture, and the 12 module holistic ERP system for consultants. The interpretations of these findings are discussed in chapter 5.

Table 33
Significant Interaction Relationships Between Different Holistic Implementation Statuses of ERP System and Overall Change in Performance

Implementation Status of ERP System	Overall Change in Performance (10 Performance Measures) β	R^2	F
Holistic Implementation Status (14 modules) X			
Consultants	-.752*	.027	6.226*
National Culture	-.740*	.021	5.183*
Holistic Implementation Status (12 modules excluding project system and e-commerce) X			
Consultants	-.707*	.026	5.909*
National Culture	-.743*	.021	5.130*
Holistic Implementation Status (13 modules excluding e-commerce) X			
Consultants	-.732*	.026	6.058*
National Culture	-.757*	.023	5.577*
Holistic Implementation Status (13 modules (excluding project system) X			
Consultants	-.727*	.027	6.100*
National Culture	-.721*	.019	4.707*

Note

β : All values are standardized regression coefficients
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

Additional Analyses

Most ERP researchers report results of analyses conducted at the individual module and the performance level. There is a paucity of studies that examine ERP system issues either at the module or performance category levels. To investigate the hypothesized relationships in this study at the category levels, the data for the key variables in the study – ERP implementation status, performance, CSFs – were factor analyzed and the results are discussed in the first part of this section. The data were subject to regression analyses and the results are discussed in the next part of this section.

The 14 modules forming part of the ERP system were first factor analyzed. Based on a priori criterion the number of factors to be extracted was entered as two in the SPSS 12.0 program. As discussed in chapter 2, ERP research indicates that firms typically implement modules that first address key intra-firm activities such as finance, logistics, and human resources (Hernandez, 1998; Appelrath & Ritter, 2000). Firms, after stabilizing their internal ERP deployments then extend their implementations to include inter-firm activities with the addition of modules such as SCM, CRM, E-Commerce, and APO/APS (Miller, 1999; Ayers, 2001; Tyler, 2002; Yen et al., 2002). The above suggests that factor analysis of the 14 modules forming part of the ERP system should result in two factors, factor one comprising of intra-firm modules and factor two inter-firm modules.

Visual inspection of the correlation matrix of the 14 modules revealed that most correlations were greater than 0.30 and the correlations in the anti-image correlation matrix were small. The measure of sampling adequacy was meritorious at 0.862 and the Bartlett's test of sphericity was significant. Hence, the data are appropriate for conducting factor analysis. The 14 modules forming part of the ERP system were factor analyzed using a varimax rotation. The total variance extracted by the two factors was 50.31%. Table 34 indicates that 10 modules loaded onto factor one and the remaining four modules onto factor two. As per the a priori criterion, factor one (intra-firm module sub-system) consists of modules that firms implement to address intra-firm activities and factor two (inter-firm module sub-system) comprises of modules that firms deploy to address inter-firm activities. The factor loadings for the 10 modules in the intra-firm module sub-system range from 0.384 to 0.902 and those for the four modules in the inter-firm module sub-system from .583 to .710. Hair et al. (1998) and Nunnally and Bernstein (1994) recommend consideration of factor loadings of 0.30 and above as the minimum acceptable level and the results of the factor analysis of the 14 ERP system modules satisfies this criteria.

Table 34
Module Component Analysis Factor Matrix

ERP System Modules	Factor 1 (Intra-firm module sub-system) Loadings	Factor 2 (Inter-firm module sub-system) Loadings
Financials	**.902**	.044
Materials Management	**.899**	.042
Sales & Distribution	**.859**	.067
Production Planning	**.807**	.217
Quality Management	**.713**	.216
Controlling	**.677**	.191
General Logistics	**.537**	.191
Plant Maintenance	**.519**	.280
Human Resources	**.475**	.321
Project Systems	**.384**	.097
CRM	.078	**.710**
SCM	.161	**.698**
E-Commerce	.142	**.604**
APO/APS	.132	**.583**

The internal consistency of the two module sub-system scales was estimated using Cronbach's Alpha. Internal consistency analysis using the SPSS 12.0 program yielded a reliability coefficient of 0.888 for the intra-firm module sub-system scale and .578 for the inter-firm module sub-system scale. The reliability coefficient for the intra-firm module sub-system scale meets the generally agreed upon lower limit of .70 (Hair et al., 1998). Hair et al. (1998) suggest that Cronbach's alpha of 0.60 can be considered in exploratory research. Extensive research of ERP literature indicates that this research study is probably the first to attempt to establish the composition and scope of the ERP system by factor analyzing modules. In this exploratory research context, the reliability coefficient for the inter-firm module sub-system scale at .578 can be considered acceptable even though it is marginally lower than Hair et al.'s (1998) recommended Cronbach's alpha of 0.60. An examination of the reliability analysis results for the two module sub-system scales indicates that removal of module items with low factor loadings did not result in any significant improvement of scale reliabilities and hence no module items were deleted based on this criterion. To confirm that the items were accurately assigned to each of the two module sub-system scales, item-to-scale correlations were calculated for all items as shown in Table 35.

Table 35
Item-to-Scale Correlations for Module Scales

ERP System Modules	Intra-firm module sub-system scale	Inter-firm module sub-system scale
Financials	**.861**	.253
Controlling	**.715**	.306
Plant Maintenance	**.598**	.286
Materials Management	**.853**	.264
Production Planning	**.820**	.374
Project System	**.436**	.134
Sales & Distribution	**.820**	.282
General Logistics	**.584**	.284
Quality Management	**.764**	.295
Human Resources	**.562**	.315
SCM	.301	**.797**
CRM	.243	**.629**
E-Commerce	.282	**.591**
APO/APS	.249	**.652**

As indicated in Table 35, the highest loading for each item is associated with the module sub-system scale that the item is intended to measure. As each item had the highest correlation with the module sub-system scale it was intended to measure and smaller correlations with the other scale, this bivariate correlational analysis confirms that each of the items was properly assigned.

Visual inspection of the correlation matrix of the 10 performance measures revealed that all correlations were greater than 0.30 and the correlations in the anti-image correlation matrix were small. The measure of sampling adequacy was meritorious at 0.90 and the Bartlett's test of sphericity was significant. Hence, the data is appropriate for conducting factor analysis. The 10 performance measures for evaluating the benefits of ERP system implementations were factor analyzed and the results are presented in Table 36. The latent root criterion as well as the scree test criterion indicates that all the 10 performance measures loaded onto a single factor accounting for 57.26% of the total variance.

Table 36
Performance Component Analysis Factor Matrix

Performance	Factor Loadings
Return on Investment	.799
Information Availability	.788
On-Time Delivery	.763
Profitability	.757
Competitive Advantage	.756
User Satisfaction	.751
Customer Satisfaction	.751
Inventory Management	.740
Standardization	.735
Information Quality	.734

The results in Table 36 indicate that all the 10 performance measures had factor loadings exceeding 0.70 and these varied within a narrow range from .734 to .799. The internal consistency of the aggregate performance scale was estimated using Cronbach's Alpha. Internal consistency analysis using the SPSS 12.0 program yielded a reliability coefficient of 0.914 for the overall performance scale. An examination of the reliability analysis results for the overall performance scale indicates that removal of performance measure items with low factor loadings did not result in any significant improvement of scale reliabilities and hence no performance items were deleted based on this criterion.

Visual inspection of the correlation matrix of the 56 items (shown in Table 21) belonging to the 13 CSFs revealed that most correlations were greater than 0.30 and the correlations in the anti-image correlation matrix were small. The measure of sampling adequacy was 0.893 (meritorious) and the Bartlett's test of sphericity was significant. Hence, the data is appropriate for conducting factor analysis. The 56 CSF items were factor analyzed using a varimax rotation. Although 14 factors emerged from the factor analysis with Eigen values greater than 1.0, interpretation of the scree test suggests there are 10 factors. The total variance extracted by these 10 factors is 64.33%. The results of the factor analysis are presented in Table 37.

Several steps were taken to select the items for the various factors. The first step involved retaining only items with factor loadings greater than 0.40. This is consistent with the conservative approach advocated by researchers such as Hair et al. (1998) and Nunnally and Bernstein (1994) who recommend consideration of loadings of 0.40 and above as significantly important when compared to the minimum acceptable level of 0.30. A perusal of the factor analysis results indicates that two items, 15-2c "written guidelines exist to structure strategic ERP planning in our business unit" and 15-11d "all employees understand the concept and the value of integrated data available from the ERP system," did not meet the 0.40 factor loading criteria and hence were deleted. To avoid problems of cross-loadings (greater than 0.40), two items, 15-2b "management actively works to alleviate employee concerns about the introduction of the ERP system" and 15-3b "ERP system plans are redesigned as required to meet evolving conditions" were deleted as they loaded onto multiple factors. The items were assessed for their contribution to the scale reliabilities.

Table 37
Ten CSF Factor Analysis

CSF Items	(Factor Loadings)									
	1	2	3	4	5	6	7	8	9	10
15-1a	**.819**	.095	.163	.143	.159	-.063	.118	.085	.133	.053
15-1b	**.781**	.165	.186	.138	.224	-.003	.010	.050	.003	.095
15-1c	**.774**	.270	.038	.094	.070	.006	-.055	.065	.020	.111
15-1d	**.754**	.221	.230	.274	.077	.072	.079	.069	.077	.050
15-1e	**.636**	.319	.263	.123	.139	.120	.212	.076	-.053	.228
15-1f	**.747**	.200	.206	.024	.132	.065	.199	.222	.014	.025
15-3e	**.555**	.137	.268	.087	.300	.209	.371	.040	.065	.065
15-3a	**.472**	.083	.390	.135	.110	.170	.393	.214	.024	-.144
15-5d	.155	**.803**	.193	.152	.139	.122	.142	.037	.053	.009
15-5c	.167	**.780**	.173	.149	.133	.060	.171	.127	.037	.168
15-5a	.306	**.775**	.200	.072	.134	.150	-.014	.214	.104	.037
15-5b	.312	**.753**	.185	.066	.166	.087	.012	.146	.018	.074
15-5e	.182	**.752**	.280	.148	.192	.033	.166	.003	.068	.124
15-6a	.124	**.534**	.316	.310	.086	-.018	.189	.083	.028	.117
15-4b	.276	.318	**.696**	.102	.017	.094	.115	.071	-.022	.317
15-4c	.283	.268	**.692**	.214	.179	.085	.050	-.002	.077	.075
15-4e	.193	.362	**.690**	.168	.127	.065	.153	.094	.067	.132
15-4a	.343	.294	**.662**	.276	.152	.147	.059	.189	.041	-.011
15-4d	.344	.262	**.644**	.130	.284	.058	.120	.171	.013	.069
15-6b	.253	.376	**.484**	.172	.088	-.053	.303	.099	-.051	.088
15-3f	.008	.039	.102	**.734**	.112	.002	.047	.098	.115	.119
15-13d	.193	.182	.098	**.646**	.103	.067	-.019	.132	-.068	.026
15-13e	.313	.216	.170	**.637**	.017	.096	.078	.060	.007	.021
15-2a	.395	.228	.162	**.551**	-.038	.109	.392	.042	-.027	-.009
15-14a	.068	.171	.200	**.549**	.178	-.057	-.132	.199	-.050	-.082
15-14b	.148	.092	.230	**.416**	.348	.267	-.130	-.116	.019	-.041
15-10a	.115	.127	.205	.078	**.758**	.169	.041	.111	.188	.064
15-10b	.222	.163	.030	.98	**.711**	.213	.114	.199	.181	.103
15-10c	.110	.215	.161	.101	**.705**	.328	.161	.223	.142	.109
15-10d	.148	.254	.086	.116	**.600**	.164	.127	.253	.124	.049
15-6c	.195	.286	.210	.157	**.476**	-.052	.363	.155	-.013	.062
15-12b	.072	.134	.042	.044	.206	**.833**	.156	.062	.124	.115
15-12c	.058	.137	.049	.020	.196	**.764**	.126	.075	.233	.048
15-12a	.032	.29	.146	.139	.156	**.740**	.020	.034	.137	.124
15-3c	.168	.213	.113	-.038	.2503	.127	**.740**	.091	.045	.130
15-3d	.184	.395	.177	.227	.276	.112	**.519**	.096	.152	.093
15-2d	.333	.293	.300	.385	.061	.117	**.481**	.110	.066	.217
15-8a	.200	.100	.258	.210	.213	-.022	.178	**.791**	.009	-.035
15-8b	.182	.22	.067	.229	.256	.096	.026	**.728**	-.002	.025
15-8c	.164	.279	.079	.093	.338	.165	.087	**.619**	.150	.043
15-11b	.073	.108	-.040	.093	.191	.198	.012	.056	**.806**	.116
15-11a	.122	.014	.034	.015	.141	.037	.166	-.007	**.752**	.089
15-11c	-.041	.069	.112	-.034	.095	.270	-.070	.046	**.729**	-.030
15-9c	.129	.162	.134	-.020	.149	.128	.043	.114	.076	**.766**
15-9a	.068	.111	.054	.117	.088	.005	.172	-.081	.011	**.713**
15-9b	.099	.084	.142	.000	.022	.363	-.110	-.013	.150	**.531**

A perusal of the reliability analysis results for each of the CSF scales indicates that removal of items with low factor loadings did not result in any significant improvement of scale reliabilities and hence no items were deleted based on this criterion. The factor analysis results presented in Table 37 indicate that a few items loaded onto the CSFs different from those conceptualized in the questionnaire. A brief description of each of the factors obtained from the factor analysis is given below. Factor 1 – top management support – consists of top management CSF items 15-1a to 15-1f and also includes two user support CSF items: 15-3a “employees understand how they fit into the new ERP defined processes” and 15-3e “management actively ensures user participation and involvement to foster user support for the ERP system.” Stratman and Roth (2002) indicate that top management plays a vital role in implementing change strategies to cope with the operational changes resulting from the deployment of ERP systems. This suggests that items 15-3a and 15-3e reflect top management’s support in ensuring that users seamlessly transition into the ERP work environment and hence can be considered as part of the top management factor.

Factor 2 – training – consists of training CSF items 15-5a to 15-5e and also includes a learning CSF item 15-6a “benchmarking is used to identify cutting-edge ERP techniques.” Stratman and Roth (2002) indicate that learning activities can be designed so that the firm is able to identify cutting-edge techniques from internal sources. This suggests that benchmarking forms an integral part of a firm’s ERP training program and hence provides support for inclusion of item 15-6a as part of the training factor. Factor 3 – project management – consists of the project management CSF items 15-4a to 15-4e as well as a learning CSF item 15-6b “cross-functional groups meet regularly to discuss new uses for the ERP system” from the learning CSF. Stratman and Roth (2002) indicate that ERP project management activities include ongoing and continuous incremental improvement initiatives. This suggests that the item 15-6b can be construed as falling under the project management factor.

Factor 4 – culture – consists of three organizational culture CSF items 15-13f, 15-13d, 15-13e; two national culture CSF items 15-14a, 15-14b; and one planning CSF item 15-2a. Item 15-14a concerns the national culture dimension of power distance and measures whether the ERP system facilitates business unit supervision of employees. This item thus has a close bearing on item 15-13d which measures the degree of control within a business unit. Power distance to a large extent determines the parochial versus the professional nature of employee behavior (measured by 15-13f) as well as the pragmatic versus normative behavior of the business unit (measured by 15-13e). The planning item 15-2a measures the flexibility of the business unit to constantly align their ERP system capabilities to their business goals. This business unit flexibility depends on whether employees are given the autonomy to respond to changing business conditions and is measured by item 15-14b. A synthesis of the above discussion indicates that factor 4 can be broadly construed as a culture factor representing the overall culture of the business unit.

Factor 5 – implementation team – consists of implementation team CSF items 15-10a to 15-10d as well as a learning CSF item: 15-6c “ERP improvement suggestions are regularly collected from multiple employee levels.” Stratman and Roth (2002) indicate that the responsibilities of the ERP implementation team include refining and adapting the ERP system on an ongoing basis to support evolving business needs. This provides support for the inclusion of item 15-6c under the implementation team factor.

Factor 6 – communication – consists of three communication CSF items 15-12a to 15-12c. Factor 7 - user support - consists of two user support CSF items 15-3c and 15-3d and a planning CSF item 15-2d “strategic ERP planning includes inputs from all functional areas.” Stratman and Roth (2002) indicate that strategic ERP planning is a collation of user inputs which facilitates the employees' absorptive capacity to understand and effectively use the ERP system. This suggests that the item 15-2d forms part of the user support factor. Factor 8 – alignment – consists of three alignment CSF items 15-8a, 15-8b and 15-8c. Factor 9 – data accuracy – consists of three data accuracy CSF items 15-11b, 15-11a and 15-11c. Factor 10 – consultants – consists of three consultants CSF items 15-9a, 15-9b and 15-9c. As mentioned earlier in this section, four factors – 11 to 14 – have been omitted from analysis on the basis of the scree test criterion. These four factors together account for 9 items – two alignment CSF items 15-8d, 15-8e; three national culture CSF items 15-14c, 15-14d, 15-14e, one consultants CSF item 15-9d; and one learning CSF item 15-6d. Internal consistency analysis using the SPSS 12.0 program was undertaken and the Cronbach's Alpha for each of the 10 CSF scales is presented in Table 38.

Table 38
Summary of Items Omitted from 10 CSF Scales & Cronbach's Alpha

CSFs	Final Number of Items	Cronbach's Alpha
Top Management Support	8	.922
Training	6	.923
Project Management	6	.917
Culture	6	.818
Implementation Team	5	.868
Communication	3	.848
User Support	3	.818
Alignment	3	.853
Data Accuracy	3	.730
Consultants	3	.633
Total	46	

The results presented in Table 38 indicate that the reliability of all the scales except that of the consultants scale is above the recommended level of 0.70. Hair et al. (1998) suggests that the reliability criterion may be decreased to 0.60 in exploratory research. Hence, the data accuracy scale with a reliability coefficient of .633 is included in this study. To confirm that the items were accurately assigned to each CSF scale, item-to-scale correlations were calculated for all items and the results are presented in Table 39.

Table 39
Item-to-Scale Correlations for 10 CSF Scales

CSF Items	CSF Scales									
	1	2	3	4	5	6	7	8	9	10
15-1a	**.860**	.419	.524	.421	.427	.136	.455	.375	.212	.207
15-1b	**.829**	.466	.569	.431	.427	.189	.447	.399	.139	.252
15-1c	**.783**	.463	.449	.428	.206	.140	.392	.324	.117	.251
15-1d	**.857**	.528	.615	.555	.434	.231	.521	.398	.188	.234
15-1e	**.860**	.496	.579	.391	.449	.227	.539	.462	.138	.204
15-1f	**.795**	.537	.625	.380	.308	.215	.513	.309	.056	.344
15-3a	**.709**	.437	.597	.458	.455	.287	.555	.465	.162	.137
15-3e	**.767**	.494	.588	.444	.556	.401	.647	.438	.251	.316
15-5a	.571	**.865**	.620	.433	.499	.325	.498	.498	.249	.290
15-5b	.553	**.853**	.600	.416	.468	.251	.492	.430	.165	.299
15-5c	.495	**.878**	.608	.440	.483	.255	.602	.442	.177	.348
15-5d	.482	**.876**	.575	.433	.469	.279	.543	.382	.167	.257
15-5e	.519	**.900**	.654	.453	.516	.266	.578	.383	.198	.333
15-6a	.450	**.748**	.632	.530	.456	.222	.510	.417	.159	.320
15-4a	.647	.628	**.855**	.589	.517	.318	.518	.499	.184	.246
15-4b	.588	.621	**.858**	.427	.382	.257	.526	.358	.122	.473
15-4c	.572	.559	**.836**	.483	.453	.274	.480	.364	.197	.263
15-4d	.650	.598	**.864**	.505	.575	.278	.568	.504	.170	.284
15-4e	.564	.626	**.881**	.467	.443	.163	.607	.422	.062	.277
15-6b	.570	.622	**.786**	.465	.443	.163	.607	.422	.062	.277
15-13d	.400	.405	.419	**.819**	.317	.172	.363	.374	.043	.162
15-13e	.522	.472	.517	**.786**	.361	.217	.436	.358	.083	.261
15-13f	.233	.265	.316	**.714**	.260	.144	.330	.298	.127	.159
15-2a	.586	.488	.516	**.669**	.347	.227	.522	.343	.109	.179
15-14a	.273	.340	.363	**.711**	.285	.100	.268	.399	.044	.083
15-14b	.305	.313	.340	**.640**	.360	.354	.262	.238	.191	.192
15-10a	.354	.395	.427	.345	**.834**	.407	.407	.452	.370	.248
15-10b	.426	.417	.384	.325	**.830**	.443	.451	.491	.381	.286
15-10c	.405	.486	.453	.369	**.900**	.528	.488	.520	.366	.336
15-10d	.386	.448	.416	.321	**.775**	.367	.426	.488	.282	.206
15-6c	.498	.540	.547	.431	**.726**	.238	.582	.522	.152	.269
15-12a	.217	.229	.274	.253	.350	**.849**	.293	.249	.339	.276
15-12b	.267	.306	.278	.231	.463	**.917**	.359	.289	.364	.348
15-12c	.256	.283	.255	.241	.446	**.866**	.352	.272	.419	.300
15-3c	.433	.406	.434	.263	.457	.297	**.844**	.344	.185	.273
15-3d	.535	.627	.556	.472	.583	.300	**.872**	.452	.267	.295
15-2d	.651	.595	.685	.570	.463	.321	**.852**	.447	.203	.364
15-8a	.460	.390	.496	.438	.492	.154	.455	**.897**	.121	.109
15-8b	.405	.443	.411	.421	.527	.285	.379	**.890**	.160	.146
15-8c	.418	.484	.413	.373	.503	.388	.437	**.859**	.311	.235
15-11a	.202	.174	.153	.121	.290	.282	.254	.177	**.847**	.220
15-11b	.180	.220	.156	.153	.360	.410	.243	.236	**.856**	.283
15-11c	.063	.137	.109	.042	.271	.389	.105	.135	**.740**	.174
15-9a	.205	.256	.256	.175	.227	.177	.272	.092	.151	**.783**
15-9b	.201	.228	.240	.153	.213	.368	.220	.106	.259	**.687**
15-9c	.294	.345	.348	.158	.321	.276	.335	.230	.232	**.811**

The results in Table 39 indicate that the highest loading for each item is associated with the CSF scale, which the item is intended to measure. As each item had the highest correlation with the CSF scale it was intended to measure and had smaller correlations with other scales, the results of the bivariate correlational analysis confirm that all the items was properly assigned.

As discussed earlier in this section, two module sub-system factors and one aggregate performance factor were obtained from the factor analysis of the 14 ERP system modules and 10 performance measures respectively. Summated scales were constructed to measure the two module sub-systems of the ERP system and the overall change in performance. Regression models were developed to analyze the overall change in performance resulting from the implementation of the intra-firm and inter-firm module sub-systems. The results of the regression analysis are shown in Table 40.

Table 40
Significant Relationships Between Two Holistic ERP Module Sub-systems and Overall Change in Performance

Implementation Status of ERP Module Sub-Systems	Overall Change in Performance (Factor - 10 Performance Measures)		
	β	R^2	F
Intra-Firm Module Sub-system	.281***	.079	17.215***
(Factor - comprising of 10 modules - Financials, Controlling, Plant Maintenance Materials Management, Production Planning, Project Systems, Sales & Distribution, General Logistics, Quality Management, Human Resources)			
Inter-Firm Module Sub-system	.159*	.025	5.208*
(Factor - comprising of 4 modules - (SCM, CRM, E-commerce, APO/APS)			

Note

β : All values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

The percentage of total variance in the aggregate change in performance that is explained by the intra-firm module sub-system is 7.9%. The results indicate that firms experience overall change in performance when they implement the 10 modules forming part of the intra-firm module sub-system. The results in Table 40 indicate that the percentage of total variance in the overall changes in performance that is explained by the inter-firm module sub-system is 2.5%. The results further indicate that firms obtain overall change in performance when they implement the four modules comprising the inter-module sub-system.

As discussed earlier in this section, 10 CSFs were obtained from the factor analysis of all the CSF items. Summated scales were constructed for each of the 10 CSF measures. Regression models were developed to analyze the overall change in performance resulting from the interactions between the 10 CSFs and the intra-firm and inter-firm module sub-systems. The results of the regression analysis are shown in Table 41. The regression results in Table 41 indicate that there are interaction effects between the intra-firm module sub-system and the implementation team and the consultants CSFs on the overall change in performance. The interaction effect of the consultants CSF is, however, negative indicating that as elements of this CSF increases there is a decrease in overall firm performance. There are no interactive effects between the intra-firm module sub-system and the other eight CSFs on overall firm performance.

The table also indicates that there are significant interactions between the inter-firm module sub-system and the data accuracy CSF on the overall change in performance. The interaction effects of the data accuracy CSF is, however, negative indicating that as elements of this CSF increases there is a decrease in overall firm performance. The above results indicate that firms obtain overall performance benefits when they focus on the implementation team CSF while implementing the intra-module sub-system. Also, firms that focus on the consultants and the data accuracy CSFs will obtain decreased performance benefits when implementing the intra-module and inter-module sub-systems respectively.

Table 41
Significant Interaction Relationships Between Two Holistic ERP Module Sub-systems and Overall Change in Performance

Implementation Status of ERP Module Sub-systems X CSFs (each of 10 CSF Factors)	Overall Change in Performance (10 Performance Measures)		
	β	ΔR^2	ΔF
Intra-Firm Module Sub-system X			
Implementation Team	.870*	.015	4.542*
Consultants	-.757*	.027	6.108*
Inter-Firm Module Sub-system X			
Data Accuracy	-.836*	.026	6.092*

Note

β : All values are standardized regression coefficients

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$

Summary

In this chapter the results of the statistical procedures used to test the hypotheses were presented. First, the results pertaining to the demographic profile for the business units as well as the respondents' characteristics were shown. Then, the results of the factor analyses and regression analyses used in this study were presented. Additional analyses were conducted to further understand the hypothesized relationships.

The business unit characteristics indicated that a cross-section of business units of different sizes, operating in different industries, using different production processes, and implementing different ERP vendor systems were represented in the sample. The individual characteristics of the respondents revealed that a majority of the respondents belonged to the middle and top management levels and had considerable experience in the IT and ERP arena.

Factor analysis and item analyses indicated that the instrument used to gather data for this study had high reliability and validity.

The results of the regression analyses demonstrate support for hypothesis 1a wherein 12 modules (except the project system and the E-Commerce modules) made a significant contribution to one or more of the 10 performance measures even though the contribution of each module varied with each of the performance measures. Hypothesis 1b was supported indicating that as the implementation status of a holistic ERP system increases synergistic changes in firm performance results. Further investigation demonstrated that a 13 module holistic ERP system provided the greatest synergistic benefits to firms. The regression results show partial support for hypothesis 2a indicating that different CSFs interact with different ERP system modules and impact various performance measures. Hypothesis 2b also has partial support indicating that there are interaction effects between the holistic implementation status of the ERP system and eight of the 13 CSFs, and various performance changes. Additional analyses revealed partial support for the accrual of the greatest synergistic benefits with the deployment of a 13 module holistic ERP system.

Factor analysis was conducted on the three key model variables – ERP system modules, CSFs, and performance. The regression results using the factors derived from the factor analysis of the above variables indicates that firms which implement intra and inter-module sub-systems obtain overall performance benefits. The univariate ANOVA results suggest that firms that focus on CSFs throughout the implementation process garner greater performance benefits than those that stress CSFs during the initial deployment stage. In chapter 5, conclusions of the research study are discussed along with the implications of this study for both academicians and practitioners. Then, future research directions are proposed.

CHAPTER 5

DISCUSSION OF RESULTS

Introduction

The final chapter consists of a discussion of the results of the study. The first part of this chapter discusses improvements that were made to previous instruments used in enterprise resource planning (ERP) research studies followed by an explanation of the analysis results. Then, the implications of the study to academicians and practitioners, the limitations of the study, and suggestions for future research are discussed.

Measurement Instrument Improvement

In this study, efforts made to develop as well as improve on previous instruments used in ERP as well as other system studies were successful. The scales used to measure the implementation status of the ERP system were developed from the White's (1990) just-in-time (JIT) and Berry's (1996) quality studies. Minor changes were made to the scales used by these two researchers to allow for sharper delineation in the measurement of the implementation statuses of the modules. Internal consistency analysis yielded a Cronbach's alpha of 0.876 for the holistic ERP implementation status scale. ERP literature suggests that ERP systems can be considered to broadly comprise two module sets that address intra-firm and inter-firm activities respectively. The above findings were substantiated through factor analysis of the 14 modules comprising the ERP system, which yielded two factors. The first factor, intra-firm module sub-system, consists of 10 modules – financials, controlling, plant maintenance, materials management, production planning, project management, sales and distribution, general logistics, quality management, and human resources. The factor loadings for these 10 modules ranged from 0.384 to 0.902 and the Cronbach's alpha for this scale was .888. The second factor, inter-firm module sub-system, comprises of four modules – supply chain management (SCM), customer relationship management (CRM), electronic-commerce (E-Commerce), and advanced planner optimizer/advanced planner scheduler (APO/APS). The factor loadings for these four modules ranged from .583 to .710 and the Cronbach's alpha for this scale was .578, which in an exploratory research context can be considered acceptable. In addition, item-to-scale correlations confirmed that the items were accurately assigned to each of the two module scales.

ERP research suggests that implementations result in overall improvements in firm performance. The factor analysis results of the 10 performance measures – inventory management, information quality, on-time delivery, standardization, profitability, return on investment (ROI), information availability, user satisfaction, customer satisfaction, competitive advantage – support the above findings. All the 10 performance measures loaded onto a single factor. The factor loadings ranged from .734 to .799 and the internal consistency of the overall performance scale yielded a reliability coefficient of 0.914. The reliability of the overall performance scale in this study compares favorably with those of similar scales used in literature (Stratman and Roth, 2002). Stratman and Roth's (2002) "improved business performance" scale uses 16 items to measure performance. Their scale, however, predominantly comprises of operational improvement and business goals realization items. The overall performance scale in this study improves on Stratman and Roth's (2002) scale by including parsimonious items that capture firm performance across different ERP implementation statuses. The items in the overall performance scale assess changes in informational, transactional, and organizational benefits accruing to firms from their ERP system deployments.

The items comprising the 13 critical success factors (CSFs), as mentioned in chapter 3, were drawn from multiple studies and hence comparisons of the CSFs with other studies' scales are made to the extent possible in the ensuing paragraphs. Each of the 13 CSFs were factor analyzed separately; 10 of the CSFs loaded onto a single factor; these being top management support, planning, user support, project management, training, learning, implementation team, data accuracy, communication, and national culture. Two factors were extracted from each of the remaining three CSFs – alignment, consultants, and organizational culture. One of the factors from the two-factor solution for the consultants and the organizational culture CSFs were dropped as they were single item factors. Also, one of the factors from the two-factor solution for the alignment CSF was dropped due to a potential confounding issue between the time element in this factor and the time element measured through the implementation status scale.

The scale used to measure top management support (reliability of .916) improved substantially on Stratman and Roth's (2002) "executive commitment" scale (reliability of .88). This improvement was due to removal of two of the seven items from the Stratman and Roth (2002) scale and the inclusion of an item in the top management support scale that assessed the role of the cross-functional steering committee in the implementation process. The two excluded items from the Stratman and Roth (2002) scale were "Functional managers willingly assign resources to the ERP project as they are needed" and "Executive management is enthusiastic about the possibilities of ERP." A perusal of the items comprising the top management support scale suggests that they encompass the purported measures of the two excluded items and hence were redundant.

The reliability of the scale used to measure planning (.869) in this study did not change from the "strategic IT planning" scale (.87) used by Stratman and Roth (2002). The planning scale, however, improved on Stratman and Roth's (2002) scale by including only four of their six scale items. The two excluded items from the Stratman and Roth (2002) scale were "Strategic IT planning is a continuous process' and 'Top Management is not involved in IT planning." These two items were redundant as the remaining four items adequately measured all relevant facets of the planning CSF.

The reliability of the scale used to measure user support (.858) in this study did not change from the "change readiness" scale (.86) used by Stratman and Roth (2002). The user support scale, however, improved on Stratman and Roth's (2002) scale by including only four of their eight scale items. An item that assessed whether management actively ensures user participation and involvement to foster user support for the ERP system was included in the user support scale in this study. The four items of the excluded Stratman and Roth (2002) scale were "Employees have input into how their jobs will change with new ERP business processes," "The roles of all employees under the ERP system have been clearly communicated," Employees are not prepared for a series of ERP-related changes as the system evolves," and "ERP-focused changes to the employee reward system have been communicated." A perusal of the above four excluded items suggests that these measures implicitly form part of the existing five items that make up the user support scale and hence were redundant.

The reliability of the scale used to measure project management (.916) in this study did not change from the project management planning scale (.91) used by Stratman and Roth (2002). The project management scale in this study, however, improved on Stratman and Roth's (2002) scale by including only four of their eight scale items. An item that assessed whether ERP project changes are clearly documented was included in the project management scale used in this study. The four items of the excluded Stratman and Roth (2002) scale were "The responsibilities of project team members are clearly defined," "Problems found during reviews of external project members are not tracked to closure," "Measurements are used to determine the status of project tasks," and "The ERP project leader is able to track project tasks to completion." A perusal of the above four excluded items suggests that these measures implicitly form part of the existing five items that make up the project management scale and hence were superfluous.

The Cronbach's alpha for the scale to assess training (.931) improved substantially over Stratman and Roth's (2002) ERP training scale (.86). This improvement was due to the removal of three of the eight items from the Stratman and Roth's (2002) scale, which were repetitive with the other five items and hence redundant. The three excluded items from the Stratman and Roth (2002) scale were "Training materials have been customized for each specific job," "We seldom update training materials to reflect system changes," and "All users have been trained in ERP system skills."

The reliability of the learning scale (.805) was lower than that of the learning scale (.85) used by Stratman and Roth (2002). This could be due to only four of the eight items of the Stratman and Roth (2002) scale being used in this study's learning scale and hence probably did not cover all facets of the learning measure. The four excluded Stratman and Roth (2002) items were "We keep track of ERP developments related to our industry," "Internal groups meet regularly to share new methods of using the ERP system," "Business experiments are conducted to evaluate potential improvements in the way we use ERP," and "External ERP experts are invited to suggest better ways to use the ERP system."

The Cronbach's alpha for the implementation team support scale (.892) was lower than that of the "IT skills" scale (.93) used by Stratman and Roth (2002). This could be due to only four of the eleven items of the Stratman and Roth (2002) scale being used in this study's implementation team support scale which probably did not cover all aspects of the implementation team measure. The seven excluded Stratman and Roth (2002) items were "There is a high degree of technical expertise in the IT organization," "The database administration is an expert in the ERP database management system," "Internal IT team members understand custom ERP software programs," "The IT staff have the technical ability to conduct a formal validation of all system changes," "IT staff are able to analyze the technical impact of proposed system changes," "IT staff communicate with functional use groups in the ERP entity," and "The IT organization provides a service to the business."

The Cronbach's alpha for the other six CSF scales ranged from a low of .648 to a high of .853. The 10 CSF scales (given in Table 38), which resulted from the factor analysis comprising of the 56 items belonging to the 13 CSFs, comprised of items that cross-loaded across the 13 CSFs. This precluded the assessment of the measurement improvement for these scales against existing scales in literature. The overall improvement over existing measures and the high reliability of the existing as well as developed scales could be due to the careful selection of the target population for this study. Most of the respondents to the survey were managers with hands-on experience in managing the implementation of ERP systems and thus have an informed perspective and a good understanding of their ERP systems than respondents in other survey studies.

Discussion of the Findings

In the first phase of this research study, ERP was characterized as a 14 module system that included all of a firm's business applications and firms could improve their performance with the implementation of one or more modules. The identification of these 14 distinct but interrelated ERP modules, through a synthesis of literature, facilitates the use of a systems approach to understanding ERP thus providing a foundation for the second phase of the study.

Further, cross-study comparisons yielded 10 performance measures to evaluate ERP implementation benefits as well as 14 CSFs for facilitating system deployment. A theoretical model was developed to illustrate the relationships associated with ERP system implementation. The model indicated that different ERP system implementation statuses result in differential performance benefits accruing to firms; and CSFs influence the relationship between ERP system implementation status and changes in performance. Data were gathered through a cross-sectional survey of production firms that had implemented ERP systems for testing the linkages proposed in the model. Multiple linear regression and univariate ANOVA were used for hypotheses testing. The results of these analyses were presented in chapter 4. A summary of the findings and implications of this research study are presented below.

ERP System Implementation Status and Changes in Performance

The first hypothesis H1a was supported by the results of the regression analyses for 12 of the 14 modules. The findings suggest that there is a positive relationship between the implementation status of individual ERP system modules and changes in performance. Significant differences were found in the regression models for the financial and controlling modules (six and seven out of the 10 performance measures respectively). ERP system research indicates that firms are early implementers of these two modules, which can be considered to form part of the financials category, as one of the weakest business links is the management of cost and productivity. The high means for the implementation status for these two modules (3.61 years for the financials module and 2.23 years for the controlling module) as well as their high implementation rate (93.1% and 61.7% of the surveyed firms for the financials and the controlling modules respectively) lends supports to the above findings. Also, the easy availability of information from the ERP system results in quick benefits from the implementation of these two modules such as shortened financial close cycles and timely budget-to-actuals information. These early visible benefits in turn strengthen employee buy-in to the firm's ERP deployment. The standardization of budgeting and reporting practices and procedures, through reengineering of business practices to conform to the ERP system or vice versa, enables the firm to make real-time decisions that help them stay on budget or shift business direction as required.

The results indicate that the quality management module was statistically significant for all the 10 performance measures. The plant maintenance and the production planning module were statistically significant for nine and eight of the 10 performance measures respectively. Significant differences were also found in the performance of the general logistics (six out of 10 performance measures), sales and distribution (five out of the 10 performance measures) and the materials management modules (four out of 10 performance measures). Research indicates that the above modules can be characterized as forming part of the logistics category, which coordinates and manages all of a firm's value chain activities from procurement to distribution. Research also indicates that firms use ERP information to leverage their logistics category modules to obtain early transactional benefits. On the supply side, firms use information on materials availability, transportation, and labor to configure changes across the product life cycle in tune with changing business conditions. On the demand side, planning forecasts that are updated in real-time allow planners to achieve higher utilization of plant capacity as well as materials. The high means for the implementation status of these modules (ranging from 1.55 years for the plant maintenance module to 3.66 years for the materials management module) indicates that firms implement these modules early on in the implementation process. This could be the reason for the significant relationships between the logistics category as a whole and various performance measures. The low mean value for the project system module (.92 years), which research indicates as forming part of the logistics category, and its low implementation rate (31% of the surveyed firms) probably accounts for its lack of relationship with any of the 10 performance measures.

The human resources module (mean implementation status of 1.72 years; 57.6% implementation rate among surveyed firms), which can be characterized as forming part of the human resources category, was significant only for the ROI measure. The above suggests that firms have not fully leveraged the capabilities of this module. ERP research indicates that this module is typically heavily customized to conform to local practices. Most of the surveyed firms probably focused on initially customizing and automating employee transaction activities like payroll and benefits management. Firms are yet to realize the full benefits from this module deployment due to under-utilization of module capabilities such as employee lifecycle management, self-service options, and workforce deployment.

Significant differences were found in the performance of the CRM (four out of 10 performance measures), SCM (two out of 10 performance measures) and the APO/APS modules (one out of 10 performance measures). The low means for the implementation status of these modules (ranging from .38 years for the CRM module to 1.02 years for the SCM module) as well as their low implementation rate (ranging from 16.7% for the APO/APS module to 30.5% for the SCM module) could account for the low performance gains from these modules. ERP research indicates that firms implement modules such as CRM, SCM, and APO/APS, which can be considered to form part of the extension category, that are associated with inter-firm activities after having stabilized their intra-firm deployments. The above results lend support to these findings and suggest that most firms are yet to leverage their transactional data for real-time decision support and problem monitoring across the supply chain. The lack of support for the E-commerce module (mean implementation status of .45 years; 16.7% implementation rate among surveyed firms), which research indicates as being part of the extension category, also shows that most firms have not Web-enabled their ERP systems. ERP research indicates that implementing an agile supply chain solution is facilitated by firms Web-enabling their ERP systems to enable real-time information exchange between supply chain partners. The initial gains that firms obtained from implementing the CRM and the SCM modules further lends support to ERP research findings on the need for firms to Web-enable their ERP systems to garner supply chain benefits.

ROI is statistically the most important performance measure as it is significant for 11 out of the 14 modules thus suggesting that most firms were able to obtain speedy and early ROIs from their ERP systems. The quality management module is the most important variable for predicting the changes in information availability, user satisfaction, and competitive advantage measures. This suggests that the availability of seamless integrated real-time information from the ERP system is essential for the effective performance of tasks associated with quality planning, inspection, and control. In addition, a unified approach to total quality management increases the ability of the firm to meet competitive challenges and enhance its market position. The controlling module is the most significant variable in predicting information quality and typically contains the tools and reports necessary to analyze and manage budgeting and cost structures. This suggests that the quality of information flowing through the supply chain has a direct bearing on cost and budgeting activities.

The plant maintenance module is an important variable in predicting inventory management and standardization. This underscores the importance of the maintenance of plant systems for efficient management of the production process. The graphical representations, connection to geographic information systems, and detailed diagrams forming part of the plant maintenance module helps standardize the order-to-market flow cycle. The production planning module is a significant predictor of changes in on-time delivery. This suggests that the effective use of the different phases, tasks, and methodologies used in both the planning of production and the process of production helps firms meet delivery deadlines. The CRM module is an important variable for predicting the changes in firm profitability and customer satisfaction. CRM extends the scope of ERP systems to include automating functions such as sales, marketing, customer service, and collaborative order management. The streamlining of downstream processes to facilitate customer order management thus serves to increase customer satisfaction as well as improve firm profitability.

The first hypothesis H1b was supported by the results of the regression analyses. The results indicate that there is a positive relationship between the holistic implementation status of the ERP system and synergistic changes in performance. The profile plots in Figure 6 further suggest that initial performance gains accrue to firms with low implementation statuses. As the firms' implementation status increases, performance gains also increase. This reinforces the findings of ERP and other relevant system research, which indicate that firms derive increased benefits as their implementation status increases with full benefits being obtained with a holistic implementation status. The above suggests that the integrated nature of the ERP system facilitates real-time decision making thus helping firms implement supply chain solutions to keep pace with the rapid changes in market demand and supply.

Additional analysis revealed that firms which implement a 13 module holistic ERP system, excluding the e-commerce module, derive the greatest synergistic benefits. The above suggests that firms which implement more than the 13 modules excluding the e-commerce module will not obtain increased benefits from adding more modules; on the contrary, firms may experience a decrease in performance.

Influencers of ERP System Implementation Success

The second hypothesis H2a, which suggests that CSFs influence the relationship between the implementation status of ERP system modules and changes in performance, was partially supported by the results of the regression analyses. The interaction plots in Figures 7 and 8 suggest that firms obtain initial gains when they focus on CSFs during their low implementation statuses. Firms, however, that emphasize CSFs throughout the entire implementation cycle obtain greater benefits. In contrast, firms that do not emphasize CSFs either during the low or the high implementation statuses do not obtain improvements and even suffer declines in performance.

Top Management

There were significant interactions between the top management CSF and four ERP system modules on various performance measures. The positive interactive effect of the top management CSF and the human resource module showed the greatest magnitude and the highest significance on ROI besides information availability. This could be due to quick and visible benefits arising from the executive support for customizing and automating payroll and benefits management tasks. Positive relationships for the top management CSF and the production planning module on information availability suggests that there is good support for leveraging information and generating feasible production plans to optimize manufacturing with demand. The positive interactive effect of the top management CSF and the sales and distribution module on information quality and profitability suggests that managerial support for facilitating the obtainment of up-to-date demand side information has a bearing on the quality of information obtained as well as the profitability of transactions. Negative relationships were indicated for the top management CSF and the E-commerce module on inventory management. This could be due to the firms' top management not having invested the time and resources necessary to leverage the use of E-commerce module capabilities such as e-procurement.

Planning

Significant interactions between the planning CSF and six of the ERP system modules were found for various performance measures. Interaction relationships were present for the planning CSF and four of the ERP system modules for the profitability measure. This underscores the importance of continuous adaptive planning for a successful ERP system deployment and its impact on the firm's bottom-line. The strong interaction effect between the planning CSF and the APO/APS module on profitability highlights the importance of planning complex processes such as shelf-life considerations, alternate routing, and capacity storage constraints, and their resultant impact on profitability. Positive relationships were indicated between the planning CSF and the SCM module on profitability, information availability, and user satisfaction. Firms leverage ERP system information to improve their planning and execution capabilities. This, in turn, facilitates better management of inter-firm supply chain operations and hence impacts profitability. Negative relationships were found between the planning CSF and the production planning and the quality management modules on on-time delivery. These negative interactions suggest that there is a planning disconnect within the firm with regard to ensuring the quality of activities pertaining to the order management cycle.

User Support

There were significant interaction effects between the user support CSF and eight ERP system modules for various performance measures. These interaction relationships lend strong support to ERP research findings that implementations are more about people rather than process or technology. The results underscore the important role played by users in ensuring ease of accurate information retrieval, better inventory management, quicker ROI, and more profitable transactions. Positive relationships were found between user support and the financials module for inventory management, information quality, profitability, ROI, and information availability. The extensive report facilities in the financials module require accurate information, and user support is instrumental in ensuring their real-time availability. The linkages between the financials module (for example the accounts payable submodule) and materials management (for example the purchasing submodule) could explain the influence of user support on gains in inventory management.

Significant positive interactions were found between the user support CSF and the sales and distribution module on inventory management, information quality, profitability, ROI, and information availability. The importance of user support is due to the intensive transactional nature of the sales and distribution module as it links and integrates with all the other modules to impact informational and transactional performance. There were positive interactions between the user support CSF and the production planning module on information quality, information availability, and user satisfaction. This highlights the importance of user support in both the planning of production and the process of production itself. Negative relationships were found between the user support CSF and the CRM module on profitability. The low implementation status for this module could be a reason for this negative interaction as users' are yet to familiarize themselves with the full capabilities of this module. Negative interactions were also found between the user support CSF and the quality management module on on-time delivery and competitive advantage. This suggests that the surveyed firms are yet to adopt a unified quality planning approach to their order management cycle activities and this in turn affects their competitive positioning in the market place.

Project Management

Significant interactions were found between the project management CSF and six ERP system modules on various performance measures. Interaction relationships were present for the project management CSF and four of the ERP system modules for the information availability measure. ERP research indicates that the practice of excellent project management techniques over the ERP life cycle is crucial for successful ERP system deployment. Effective project management activities help firms leverage ERP information to obtain greater insights into supply chain activities. Supply chain activities gain the most when compared to other functional activities as evident in the strong interaction relationship between the project management CSF and the SCM module. Significant positive interactions were found between the project management CSF and the human resources module on inventory management and information availability. This could be due to the key role that good project management design and execution plays in the effective use of workforce analytics and hence the impact on these performance measures.

Negative relationships were found between the project management CSF and the quality management and the project system module on on-time delivery and profitability respectively. The negative interaction for the quality management module again highlights the lack of infusion of quality planning activities into the order management cycle. The negative interaction for the project system module suggests a lack of focus on long-term project management activities associated with resource planning and the budgeting of complex tasks that are typically associated with project system module applications.

Training

Significant interactions were found between the training CSF and six of the ERP system modules on various performance measures. Interaction relationships were present for the training CSF and four ERP system modules for the profitability measure. This suggests that training activities across the financials, logistics, and the human resources sub-systems have a bearing on profitability. Positive relationships were found between the training CSF and the human resources module on inventory management, on-time delivery, profitability, ROI, information availability, and customer satisfaction. This reveals that firms focus on human resources activities associated with employee life cycle management and hence register gains across informational, transactional, and organizational measures. There are positive interaction relationships between the training CSF and the financials module on inventory management, on-time delivery, profitability, and ROI. This shows that training activities that focus on the operational aspects of the general financial and accounting function have a beneficial impact on transactional and organizational performance measures.

The strong interaction between the training CSF and the project system module on information quality suggests that training for activities associated with data procurement for resource planning and budgeting of complex tasks results in accurate information output. The findings also suggest that training activities which focus on the sales and distribution cycle impact profitability. Negative interactions were found between the training CSF and the SCM module on information quality and customer satisfaction. This suggests that firms need to focus on training activities targeted at accurate data gathering so as to leverage the inter-firm planning and execution capabilities of the SCM module.

Learning

Significant positive interactions were found between the learning CSF and seven ERP system modules on various performance measures. Interaction relationships were found between the learning CSF and three ERP system modules for the profitability measure. The positive interactions with the financial and the controlling modules indicate that suggestions for new and improved ERP system usage have a beneficial impact on the firms' financial and cost practices. Improvements in the firms' bottom-line suggest that firms encourage the building up of skill-sets and knowledge to leverage the intensive transactional capabilities of the sales and distribution module. The strong interaction between the learning CSF and the SCM module on user satisfaction suggests that users experiment with the ERP system to improve inter-firm operations. There is a negative relationship between the learning CSF and the quality management module on competitive advantage. This highlights the need for firms to use external benchmarking for the planning and controlling of quality management activities.

Data Accuracy

Significant negative interactions were found between the data accuracy CSF and three ERP system modules on various performance measures. Negative interaction relationships were present between the data accuracy CSF and the SCM and the APO/APS modules for five and four performance measures respectively. The strong negative interaction between the data accuracy CSF and the SCM module on customer satisfaction suggests that lack of data integrity in the ERP system affects decision-making quality and hence customer satisfaction. The SCM module also indicates negative interactions for the information quality, ROI, information availability, and competitive advantage measures. The APO/APS module exhibits negative interactions for the ROI, information availability, user satisfaction, and customer satisfaction measures. The negative interactions for both these modules could be due to the firm's lack of control over information that comes into the ERP system from supply chain partners. The low mean implementation status as well as the low implementation rate for these two modules suggests that firms are not yet cognizant of this deficiency in the data collection process.

Alignment

The alignment CSF had significant interactions with seven of the ERP system modules for various performance measures. Positive relationships were found between the alignment CSF and the production planning module on inventory management, information quality, and profitability. This indicates that there is good integration of plant scheduling and execution systems with the ERP system's production planning processes. The alignment CSF has significant interactions with the controlling module on profitability. This suggests that a good fit between the firm's cost and budgeting structures and the ERP system's processes has a bearing on the firm's bottom-line.

Negative interactions were found between the alignment CSF and the quality management and the general logistics modules on ROI. These negative interactions demonstrate that there could be key mismatches between various quality and logistic processes embedded in the ERP system and the firms' business processes. There is a strong negative interaction between the alignment CSF and the APO/APS module on the user satisfaction measure. This indicates that firms are yet to align their supply chain planning and optimization processes at the strategic, tactical, and operational levels. The positive interaction between the alignment CSF and the SCM module on information availability, however, suggests that firms are cognizant of the need to fine-tune their inter-firm module processes.

Consultants

Significant interactions were found between consultants and nine ERP system modules on various performance measures. These associations were, however, mostly negative suggesting that performance declines as the interaction between consultants and the implementation status of most modules increases. Five ERP system modules had negative interactions with the consultants CSF on the profitability and competitive advantage measures. Standardization, ROI, information quality, and information availability were the other performance measures that registered a decline.

The interaction between the consultants CSF and the human resources and the controlling modules on information availability and competitive advantage were the only positive ones. The human resources module components are typically highly customized to ensure adherence to local reporting requirements. The positive interaction could be the result of the key role played by consultants in facilitating this local customization. ERP research indicates that consultants play an important role in facilitating ERP system deployments from project inception to system upgrades. The positive interaction with the controlling module could be due to the influence of consultants in configuring the controlling module to firm-specific needs. The module, when configured to aggregate work activities along different dimensions, enables consolidation and monitoring of all performance related information vis-à-vis competitors.

The results of this study, however, indicate that consultants mostly exert a negative influence on the implementation process. This could be due to the paucity of consultants with the requisite product, business, technical, and inter-personal skills to guide the implementation process. The findings suggest that firms could invest resources in developing consultants internally rather than outsource these skills.

Implementation Team

The implementation team CSF has significant interactions with six ERP system modules on various performance measures. Significant interaction relationships are present between the implementation team CSF and the financials module on inventory management, information quality, and profitability. ERP research indicates that firms typically deploy the financials module before other modules as early visible benefits will ensure employee buy-in. The implementation team members play a vital role in ensuring the success of this partial deployment. Significant interaction relationships were found between the implementation team CSF and the controlling and the production modules on inventory management, information quality, and profitability. These positive associations suggest that the implementation team members' focus on ensuring data integrity results in increased information quality. Firms could have deployed their best information technology (IT) and functional resources as the focus on cost structures and production processes resulted in the slashing of inventories and contributed to increases in the bottom-line.

There is a strong positive interaction between the implementation team CSF and the APO/APS module on information availability. This suggests that the implementation team members are aware of the need to have adequate information to enable the APO/APS module users to carry out complex planning and scheduling activities. Negative interactions were found between the implementation team CSF and the quality management module on on-time delivery and competitive advantage. This could be due to quality related skill-set inadequacies among the implementation team members.

Communications

Significant interactions were found between the communications CSF and five ERP system modules on various performance measures. Four ERP system modules – financials, controlling, production planning, sales and distribution – have positive interactions with the communications CSF on information quality. This suggests that firms have successfully integrated user input into the communication process to ensure the data integrity of the ERP system. Significant negative interactions were found between the communication CSF and E-commerce module on information availability. This could be due to weak or incompatible system links with supply chain partners, which impacts the availability of requisite information necessary to successfully conduct transactions. Overall, the low support for the interaction effects of the communication CSF was unexpected as ERP research indicates that ongoing communication within the firm throughout the implementation life cycle is essential for ERP system success. This could be due to firms relying more on informal channels to disseminate as well as collect pertinent user input on the ERP implementation. This lack of an open information policy could, however, potentially lead to problematic implementations as they may result in delayed employee buy-in.

Organizational Culture

The organizational culture CSF has significant interaction relationships with nine ERP system modules on various performance measures. Interactions relationships were present for seven ERP system modules on the profitability measure. ERP research indicates that ERP system implementations cause major organizational transformations in firms. The findings suggest that firms follow a socio-technical approach in deploying their ERP system and that successful implementation impacts the firms' profitability. The organizational culture CSF interacts with the human resources module to influence profitability, ROI, and information availability. This was as expected as typically the human resources function focuses on efficient human capital management – from recruitment to post termination benefits. The negative interaction between the organizational culture CSF and the quality management module on on-time delivery suggests that a quality culture is yet to take root among the surveyed firms and hence adversely affects the order cycle.

National Culture

Significant interactions were found between the national culture CSF and eight ERP system modules on various performance measures. These associations were mostly negative suggesting that performance declines as the interaction between national culture elements and implementation status increases. The standardization measure registered the highest decline with six ERP system modules – financials, controlling, materials management, production planning, sales and distribution, and quality management – exhibiting negative interactions with the national culture CSF. ERP research (Krumbholz & Maiden, 2001) suggests that ERP vendors provide generic off-the-shelf solutions which could cause implementation problems when they are deployed across different cultures. There is, however, an increasing trend of ERP vendors providing country-specific packages with embedded local practices so that national culture differences do not come to the fore during implementations. Hence, firms that focus on national culture differences could face a decline in various performance measures. The financials, controlling, materials management and production planning modules were the most affected by negative interactions with the national culture CSF. This could be due to the high implementation status of these modules. As firms continue to focus attention on the national culture CSF through the ERP implementation process, performance decreases.

The results in Table 23 indicate that the e-commerce and the project system modules do not contribute to improvements in any of the ten performance measures. A perusal of the results in Tables 28a-28d further indicates that none of the CSFs interact with the E-commerce module to improve performance. This adds support to the finding that firms should focus on implementing a 13 module system (excluding the E-commerce module). The project management CSF is the only one that interacts with the project system module to improve profitability. The APO/APS module contributes to improvements in only one performance measure – information quality. Two CSFs – planning and implementation team – interact with the APO/APS module to improve profitability and information availability respectively. The above suggests that firms should implement the project system and the APO/APS modules only when they have specific business needs to meet – for example, projects and contracts in the case of the project system module, and integrating global and local supply chain planning in the case of the APO/APS module.

The results in Table 23 indicate that the human resources module contributes to changes in only one performance measure – ROI. The results in Tables 28a-d, however, indicate that seven CSFs interact with the human resources module to improve six of the ten performance measures. The interaction between the human resource module and the training CSF alone accounts for five of the six performance measures that registered improvements. The results in Table 23 also indicate that the SCM module contributes to changes in two performance measures – profitability and ROI. The results in Tables 28a-d, however, indicate that seven CSFs interact with the SCM module to improve six of the ten performance measures. The interaction between the SCM module and the planning CSF alone accounts for improvements in three of the six performance measures. The above discussion suggests that CSFs are crucial in helping firms leverage module capabilities and improve performance.

The second hypothesis H2b, which suggests that CSFs influence the relationship between holistic ERP implementation status and synergistic changes in performance, is partially supported by the results of the regression analyses. The interaction plots in Figure 9 indicate that firms that emphasize CSFs during their holistic low implementation status register improvements in performance. As their holistic implementation status increases, firms that continue to focus on CSFs obtain greater increases in performance. The plots further suggest that firms stress relevant aspects of the CSF appropriate to their module implementation status to obtain desired benefits.

Six CSFs – planning, user support, learning, consultants, implementation team, organizational culture – interact with the holistic ERP system to impact the profitability measure. The significant interaction of the planning CSF indicates that dynamic alignment of ERP system capabilities and business needs has a bearing on the firm's profitability. The garnering of user support through user involvement in the ERP system implementation process, aided by a supportive organizational culture, further influences the firm's bottom-line. The responsive support of the implementation team to user needs and the freedom to experiment with ERP system capabilities also contributes to increases in the firm's profitability.

Significant negative relationships were found between the consultants CSFs and holistic ERP implementation status, on the profitability and ROI measures. This suggests that the firm's performance decreases when consultants are involved in the ERP system implementation process. These findings are in tune with the negative interactions obtained between the consultants CSF and individual ERP modules on various performance measures. The dearth of ERP talent in the country could be a reason why firms are forced to manage with consultants who lack the multi-faceted skills required to facilitate successful deployment. This in turn affects the quality of the ERP implementation process.

Significant negative interactions were found between the national culture CSF and holistic ERP implementation status, on the inventory management, on-time delivery, standardization, information availability and competitive advantage measures. These results are in tune with the negative interactions obtained between the national culture CSF and individual ERP modules on various performance measures. Two reasons can be attributed to the negative influence of national culture elements on the ERP system implementation. The first reason could be that the surveyed firms implement the India-customized ERP system offerings of the ERP vendors and hence there is minimal influence of the national culture elements of ERP vendors embedded in the systems. The second reason is that India is a mix of Asian, Anglo, and Latin European cultures and hence cannot be classified into any of the world's major cultural groupings (Hofstede, 1980). This composite cultural mix is attributed to the country's amalgamation of native and various colonial cultures as well as economic development that have resulted in the reduction of the influence of national culture. The above suggests that a focus on national culture elements negatively impacts the ERP system implementation process.

Further investigation revealed that firms which deploy a 12 module holistic ERP system derive marginally higher synergistic benefits due to the interaction effects of various CSFs when compared to the two 13 module holistic ERP systems (excluding the e-commerce and the project system modules, respectively) and the 14 module holistic ERP system. The beneficial interaction effects of the CSFs between the 12 and the two 13 module ERP systems are, however, mixed; some performance measures improved whereas there has been a decrease in others. The above suggests that firms obtain higher synergistic benefits when they emphasize CSFs while implementing a 12 module holistic ERP system or any of the two 13 module systems. Firms that focus on CSFs while implementing additional modules beyond the 12 or 13 module holistic ERP systems do not obtain increased synergistic performance benefits.

A perusal of the results in Tables 24 and 30 indicate that five CSFs interact with the holistic ERP system to improve profitability. The results also indicate that the implementation team CSF interacts with the holistic ERP system to improve information quality. This suggests that the competency of the implementation team members is critical in ensuring ERP information quality. The results further indicate that the communication CSF interacts with the holistic ERP system to improve on-time delivery. This suggests that firms need to develop and maintain open and honest communication channels in order to improve their order management process. The above discussion underscores the importance of CSFs in helping firms leverage holistic ERP system capabilities to improve performance.

Additional Analyses

In chapter 4, two module sub-system factors and one overall performance factor were obtained from the factor analysis of the 14 ERP modules and 10 performance measures respectively. ERP research suggests that firms first deploy and consolidate intra-firm modules and then extend the ERP system to include inter-firm modules. The results of the factor analysis and a perusal of the mean implementation status of the modules lend support to the above findings. The first module sub-system factor consists of 10 modules that address intra-firm activities and the second module sub-system factor comprises of four modules that cater to inter-firm activities. The findings from the regression analysis suggest that firms obtain overall performance benefits with the implementation of the intra and inter-module sub-systems. These results for the intra-module sub-system model are similar to those obtained with the holistic ERP system model. This suggests that most of the surveyed firms have implemented the intra-firm module sub-system and are yet to stabilize their inter-firm module sub-system deployment.

As discussed in chapter 4, 10 CSFs were obtained from the factor analysis of all the CSF items. The results from the interaction analysis of these CSFs with the intra-module sub-system suggest that firms obtain overall performance benefits when they focus on the implementation team CSF. On the other hand, firms that focus on the consultants and the data accuracy CSFs will obtain decreased performance benefits when implementing the intra-module and inter-module sub-systems respectively. These results are similar to those obtained with the holistic ERP system model except there is no significance for the data accuracy CSF. This suggests that the focus on the data accuracy CSF for the intra-module sub-system deployment overrides the negative effect of inaccurate inter-firm data.

Significant interaction relationships between the implementation team CSF and the intra-firm module sub-system could be due to inclusion of the learning item "ERP improvement suggestions are collected from multiple employee levels." This suggests that the effectiveness of the implementation team is enhanced as they fine-tune their skill-sets in accordance with user needs, which accounts for the significant interaction differences. ERP research suggests that learning is a continuous process and intensifies as implementation status increases. As mentioned earlier in this section, most of the surveyed firms have low mean implementation statuses for the inter-firm module sub-system; this coupled with the low implementation rate suggests that significant interactions for learning could result as the implementation status for inter-firm modules increases.

Analysis of the descriptive statistics of the overall success measure indicates that nearly 82.27% (N = 167) of the surveyed firms reported that their ERP systems implementation was a success. Most firms (88.66%) indicated that an increase in the number of modules implemented as well as fine-tuning these modules over time increased their performance benefits. About 88.67% of the firms reported that their internal coordination activities increased with the implementation of more ERP modules; in contrast, only 79.31% of the firms indicated an increase in the external coordination of their business activities across the supply chain. This could be due to the higher implementation status of the intra-module as compared to the inter-module sub-system.

Contributions of the Study

This study contributes theoretically and methodologically to the understanding of ERP systems. ERP systems were defined as a collection of 14 modules that allowed for operationalizing of this construct for this study. Thirteen CSFs were identified as facilitating the implementation process and 10 performance measures for evaluating ERP deployment benefits. A model was developed that allowed for testing the theoretical underpinnings of the relationships between ERP system implementation status, CSFs, and performance. The linkages presented in the model were tested and the results broadly indicate support for the model.

Most ERP system research focus on the piece-meal analysis of implementation issues due to high incidences of deployment delays and failures. These studies indicate that similar problematic implementation issues dominate the ERP markets in both the developed and the developing countries (Buckhout et al., 1999; Lall, 2003). Hence, understanding the ERP system concept, the role of each ERP system module, its interactions with CSFs, and how these affect performance is essential for effective implementation of ERP systems in both the developed and the developing countries.

This study used a theory driven approach to field-test an ERP system implementation model in the Indian ERP market. The findings suggest that the implementation of 12 of the individual ERP modules make varying significant contributions to one or more of the 10 performance measures. Firms that implement a holistic ERP system or intra-firm and inter-firm module sub-systems obtain overall performance benefits. All the 13 CSFs have varying significant interactional effects with individual ERP system modules to impact one or more of the 10 performance measures. Interactional effects were also present for firms that implement a holistic ERP system as well as intra-firm and inter-firm module sub-systems. The findings from the regression runs conducted on the demographic variables suggest that ERP systems are adaptable and flexible across firm size, industry, and the type of production environment.

The analysis presented in this study advances the understanding of ERP systems by suggesting that firms derive benefits by implementing individual ERP system modules and that their integration helps the firm derive aggregate benefits. Previous ERP research has not investigated the integrative effects of the ERP system modules. This study drew upon previous research to build an integrated model of ERP system implementation, which highlights the importance of firms adopting a socio-technical approach to their ERP deployments. Empirical support is provided for the suggested linkage between Galbraith's (1977) information processing model and the ERP system implementation model. The findings suggest that ERP systems can be implemented in accordance with the organizational configurations suggested by Galbraith in his various studies. Galbraith (1977) indicates that firms change their organizational configurations in response to changing uncertainty. The survey results indicate that the extent of implementation and the usage of ERP modules vary across business units thus giving rise to different ERP configurations. This suggests that firms could use equifinal ERP configurations as a link between their internal and external environments. Future ERP system implementation models developed could further explore this linkage.

Managers who focus on CSFs throughout the ERP implementation process, i.e. focus on the “people component” of implementations, contribute significantly to successful deployments. This study demonstrates that CSFs are crucial in facilitating the implementation process. As performance benefits vary with implementation status it is important that managers focus on holistic integration to derive maximum synergistic gains. ERP equifinal configurations comprised of various levels of module integration, coupled with support from CSFs, will determine how best managers can meet the needs of their firms in their respective competitive environments. This combination, rather than ERP implementation per se, is the key factor for Indian production firms in their quest for improved performance.

The study’s findings suggest that there are as many small and medium firms that invest in ERP systems as large firms. The firms are, moreover, spread across various industries and use one or more different production processes. The above suggests that the common denominator for implementing ERP systems is integration of activities and leveraging system capabilities to achieve business objectives. The study’s findings reveal that firms “must” deploy the quality management module as it contributes significantly to all performance measures. This is in tune with production literature (Ferdows & Meyer, 1990), which suggests that quality initiatives nurture the seeds of lasting improvements in firm performance. Implementation of more and more modules results in a cumulative buildup of ERP system capabilities culminating in the greatest synergistic benefits being obtained with the deployment of a 13 module holistic ERP system. The optimal sequence of implementation of these 13 modules, however, could vary with different firm-specific contingencies. Managers should recognize that the complex interrelationships between modules could also result in different optimal sequence paths of module deployment leading to high performance. The findings further suggest that merely throwing more modules (beyond the 13 modules identified in this study) at existing business problems do not cause them to be resolved. On the contrary, they could tend to reinforce old ways of doing things. It is well known that technological advances of any nature bring change. ERP is no exception. Managers should focus attention on all 13 CSFs identified in this study to handle pre-implementation expectations and fears; implementation realities; and post-implementation blues. A well-implemented holistic ERP system would enable managers adopt a 'fly-by-wire' approach to continuously and proactively monitor firm activities.

Though numerous suggestions to practicing managers could be made based on the study's findings, one key area that could "make" or "break" ERP deployments is ensuring information quality. The results indicate that information quality has a high mean value among ERP implementers. The results, however, further indicate that only five out of 14 ERP modules contribute significantly to improvements in information quality; moreover, information quality ranks eighth among performance improvements that result from the deployment of a holistic ERP system. The above suggests that managers do recognize the importance of information quality as a critical business concern. This recognition, however, has not been translated into information quality improvements at the individual module as well as the holistic implementation status levels. As the same information is used by different decision-makers for different tasks, managers must realize that dirty information has adverse ripple effects across the firm. If ERP information is not of high quality, then the whole system becomes suspect and recovering data integrity may well nigh be impossible once it is compromised.

Investigation into the reasons for the low performance of the information quality measure suggests that firms are affected by information inflows from outside sources such as from customers and suppliers. The results of the regression analyses for the interaction effects of the data accuracy CSF indicate negative relationships for two of the four modules that form part of the inter-firm module sub-system – the SCM and the APO/APS modules – with the exception of the materials management module. The negative interaction effect of the data accuracy CSF with the intra-firm module – materials management – could be due to the tight integration of the module components with SCM module components. The regression results for the negative interaction effect of the data accuracy CSF with the two modules forming part of the inter-firm module sub-system validates the contention that ERP systems in the sampled firms tend to be contaminated by dirty inter-firm information flows. The lack of interactions between the data accuracy CSF and the other modules forming part of the intra-firm module subsystem (except for the materials management module) further suggests that data accuracy is not a key concern at the intra-firm level also.

The above discussion suggests that it is imperative that managers clearly define information quality goals, plan for trade-offs if any (for example cost versus quality), focus on all elements of the data accuracy CSF, and establish a framework to assess information quality issues. Managers could foster an information quality culture that ensures that all employees and supply chain partners understand the concept and value of integrated ERP information. Maintaining information integrity requires awareness and control of dirty information right from the pre-implementation stage of the ERP system deployment. The above could be addressed by the use of data migration and conversion tools to automate the conversion and interface process from the firm's legacy as well as supply chain partners' systems to the ERP system. Managers could ensure compatibility between firm data requirements and the ERP system in terms of data format and the relationships among entities as represented by the underlying data model. The maintenance of high quality ERP information would help lay the foundation for the deployment of data warehouses to manipulate data for analysis as well as facilitate the integration of data mining into business processes thus leading to optimized business decision-making.

Over the past decade and a half, ERP has come to mean many things – information systems (IS), enterprise resource management (ERM), enterprise systems (ES) – to many people – academicians, practitioners, and vendors. The ambiguity surrounding the term ERP allowed the confusing proliferation of research in alternate fields of study. In this study, ERP is defined as a broad and universal "umbrella" system that includes all of a firm's value chain business applications that are integrated into a firm's IS infrastructure. This definition of ERP encompasses and focuses attention on two broad streams of research that have emerged over the years – ERP as an IT system, and ERP as a management system. The "ERP as an IT system" research stream focuses on implementation and maintenance issues (Jacobs and Bendoly, 2003). The challenges involved in getting the system up and running dominate this research area. The "ERP as a management system" research stream focuses on operational and usage issues (Jacobs and Bendoly, 2003). The strategic use of the ERP system and its impact on business performance dominate this research area.

The well publicized failures and delays associated with ERP deployments has directed most research efforts at systems issues such as configuration, design/redesign of business processes, maintenance, customization, and upgrades. The bulk of research in this area is dominated by descriptive and case studies, with empirical and modeling studies gaining prominence in the past few years only. There is a paucity of research in the managerial use of

ERP systems to improve business performance. There are not many studies that have evaluated the usage of ERP on business activities such as inventory management and on-time delivery. There are yet fewer studies that have addressed the impact of ERP on performance parameters such as customer satisfaction and competitive advantage. This research study bridges the gap between the systems and managerial considerations of ERP. This study addresses system issues such as the optimal set of modules to implement and the CSFs that facilitate deployment. Such system issues in turn are linked to managerial issues such as which module or holistic ERP system deployments lead to improvements in various business activities and what CSFs firms should focus on to improve the performance of various modules or the holistic ERP system. Such a consideration of system and managerial issues in tandem underscores the importance of aligning ERP system deployments with evolving business needs to maximize performance benefits.

Limitations of the Study

Some caution should be exercised when interpreting the results of this study. The cross-sectional design of the study precludes casual statements and only indicates that a correlation exists between ERP systems, CSFs, and changes in performance. There are also many additional possible predictors of changes in performance. The sampled population was composed predominantly of firms in the automotive sector (21.7%), therefore, the findings may not be equally generalizable to other industries. A global ERP system implementation model was developed and field-tested in India; therefore, the findings may not be generalizable across other developing as well as developed countries. This study examined ERP system implementations in the Indian production environment. Service firms may place a different emphasis on various ERP system modules and performance measures; therefore, the generalizability of the study's findings may not be fully applicable to them.

There is a possibility of systematic bias due to the use of self-reporting as a means to gather data. Many respondents reported negative outcomes from their ERP implementations, which suggest that their answers were not biased. Future research, however, could benefit from the obtainment of more objective data. The majority of the respondents were information technology/systems managers (86.2%) and managers from other areas in the business unit may have a different perspective on their ERP system implementation. In the context of Indian ERP system implementations, however, discussions with a cross-section of the respondents suggests that most of them possess a managerial background and had been drafted for spearheading the ERP system deployment. Future research could benefit from data obtained from a cross-section of managers across different intra and inter organizational levels as well as work areas.

Suggestions for Future Research

Future research should consider the use of longitudinal designs to capture the lagged effects between ERP system fine-tuning as well as upgradations, and increased performance. The support for the model relationships tested in this cross-sectional study provide a priori justification for the conduct of a longitudinal study. Data gathered through the ERP system pre-implementation, implementation, and post-implementation phases would provide a good indication of the sequence of module implementation. The data would also identify which module components need to be integrated and what CSFs are to be focused on and in what stage of the implementation process. Longitudinal studies would help examine which ERP system configurations are suitable in different types of business environments and how firms can adapt their ERP systems to changes in business conditions.

There has been an increase in the number of module offerings from ERP vendors owing to the relative newness of the ERP field, the rapid rise in ERP technologies, and delivery mechanisms. Future research could help identify ERP system configurations as firms evolve into supply chains and compete and collaborate with other supply chains. The performance measures used in this study are not exhaustive but represent a good mix of informational, transactional, and organizational measures. Developing more objective and quantifiable measures that link the firm's internal and external information flows is needed to test to test the effectiveness of the overall ERP configuration of the firm. The CSFs used in this study represent a well balanced mix of managerial, technical, and organizational measures. Future research could help identify CSF measures that take into account those factors that are critical to suppliers and customers as the firm's ERP system is extended across the supply chain(s).

Future research could collect data from multiple sources within the firm as well as across the supply chain. This gathering of data across multiple managerial levels would enable the investigation of linkages among the module components that support the information flow relating to intra-firm as well as inter-firm activities. The additional use of archival data besides the self-report data would enable confirmation of the study's findings. This study used a global ERP system implementation model and field-tested it in a developing country. This model can be validated by replicating the study in a developed country. This validation would help ERP implementers across the world holistically manage their ERP system deployments and derive maximum benefits from their ERP systems.

Summary

This study provides a theoretical framework and empirical evidence for ERP researchers. This study synthesized previous research to identify the composition of ERP systems, CSFs to facilitate the implementation process, and performance measures to evaluate the benefits that accrue from deployments. The study's findings open up a new line of research into the systemic integration of ERP systems. Analysis of the findings suggests that more variance is explained by holistic implementation statuses than individual modules. The varying interactions of CSFs with different implementation statuses and their differential impacts on performance suggest that ERP researchers need to further explore these interaction relationships.

This study used Galbraith's information processing theory as a framework to develop and field-test a global ERP system implementation model. The findings validate the model and provide a socio-technical foundation for explaining the relationships between the integration of ERP systems and performance. Future research could explore these relationships in the context of extended ERP deployments as firms increasingly encounter business environments where supply chain competition, collaboration, and outsourcing are becoming the norm. Academicians and practitioners can thus leverage the information presented in this research study to enhance their understanding of conceptual and system-oriented ERP system issues, optimize their ERP system implementations, and hence maximize the returns from their ERP systems.

APPENDIX A

PRE-NOTICE LETTER

Date

To

Dear …………,

I am writing this letter to ask for your help in a cross-country academic research study on enterprise resource planning (ERP) systems conducted by a group of researchers at the University of North Texas (UNT) and the Indian Institute of Management Bangalore (IIMB). You are part of a carefully selected sample of production firms in India that have been asked to assist in this survey and we appreciate your assistance. A few days from now, I will be mailing you a request to fill out a brief questionnaire that seeks information on your ERP system implementation (packaged vendor system or home-grown/in-house developed system or hybrid system).

We will be using the survey data to test a global ERP system implementation model that examines the relationships between the relative contributions of ERP system modules, critical success factors, and differential changes in firm performance. This study is an important one, as we believe that our results will enhance your understanding of conceptual and system oriented ERP issues, help optimize your ERP system implementation, and will enable you to maximize the returns from your ERP system.

The questionnaire has been designed to specifically collect the information needed for this study and to minimize the amount of time required to complete it. We anticipate that the questionnaire will take about 25 to 30 minutes for you to complete. Your answers to the survey will be kept strictly confidential (kindly do not give your name and contact details in the questionnaire or the mailing envelope if you wish your responses to be completely anonymous). The names of participating firms and individuals will not be released. Only aggregate results from the answers of the participating firms may be published.

I am writing this in advance because we have found many people like to know ahead of time that they will be contacted. Thank you for your time and consideration. It is only with the generous help of people like you that our research can be successful.

Sincerely,

Prof. Arun Madapusi
Department of Management
College of Business Administration
University of North Texas
Denton, Texas 76203, USA
Telephone Number (US & India)
Email Id

P.S. I will be glad to provide you with a copy of the executive summary of our study's results as a way of saying thanks.

APPENDIX B

FIRST WAVE MAILING PACKET

Date

To

Dear …………,

I am writing this letter to ask for your help in a survey study on enterprise resource planning (ERP) systems conducted by a group of researchers at the University of North Texas (UNT) and the Indian Institute of Management Bangalore (IIMB). This study is part of a multinational research project designed to understand the relationship between the relative contributions of ERP system modules, critical success factors, and differential changes in firm performance. I believe that our research team can use the survey results to help firms enhance their understanding of conceptual and system oriented ERP issues.

Your firm is part of a carefully selected sample of production firms considered among the most progressive Indian firms in understanding and adopting ERP systems (packaged vendor system or home-grown/in-house developed system or hybrid system). Though participation in this study is voluntary, in order for the results to truly represent an evaluation of ERP system implementations, it is important that the questionnaire attached to this letter be completed fully. The questionnaire should take about 25 to 30 minutes to complete and the responses generally consist of circled items and a few short responses. I have enclosed a stamped, self-addressed envelope to expedite the return of your completed questionnaire.

Your answers to the survey will be kept strictly confidential (kindly do not give your name and contact details in the questionnaire or the mailing envelope if you wish your responses to be anonymous). The names of participating firms and individuals will not be released. Only aggregate results from the answers of the participating firms may be published. I deeply appreciate your cooperation and request your response preferably within two weeks to enable our research team to successfully complete this phase of the research project. As a small token of appreciation for your help, I would be glad to provide you with a copy of the executive summary of the study's results as soon as our research team completes its data analysis. If you have any questions about this study please feel free to contact me.

There are no foreseeable risks involved in this study. By completing this survey you are agreeing to participate in this study. If you have any questions about the study, you may contact Prof. Arun Madapusi at Email Id (Telephone Number) or Prof. Richard E. White at Email Id (Telephone Number). This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (Telephone Number) with any questions regarding your rights as a research subject.

Sincerely,

Prof. Arun Madapusi
Department of Management
College of Business Administration
University of North Texas
Denton, Texas 76203, USA
Telephone Numbers (USA & India)
Email Id

<u>Research Project on Enterprise Resource Planning (ERP) Systems</u>

University of North Texas, College of Business Administration, Department of Management
Denton, Texas 76203, USA.
&
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore 560 076, Karnataka, India.

<u>General Instructions</u>

1. The purpose of this survey is to assess the changes in performance that result from the implementation of enterprise resource planning (ERP) systems. Most of the questions in this survey are self-explanatory and follow a standard format that allows you to provide answers in a short period of time. If your business unit has not implemented an ERP system kindly discard this questionnaire.

2. Some questions ask you to check a line or circle a response and others ask for specific information. There are no ‘right’ or ‘wrong’ answers. Different firms respond differently to similar situations and our goal is to understand these differences.

3. There is a separate page of definitions of various modules typically comprising the ERP system enclosed along with this questionnaire. It may be convenient for you to place this ERP system modules definitions page alongside the questionnaire as you answer the questions.

4. This questionnaire consists of 9 pages with a total of 20 questions. Please **answer all questions** as accurately as you can.

5. Your answers to the survey will be kept strictly confidential. The names of participating firms and individuals will not be released. Only aggregate results from the answers of the participating firms will be published.

6. Please return the completed questionnaire in the enclosed self-stamped envelope - **if possible within two weeks**.

7. Your cooperation is greatly appreciated.

Please return the completed questionnaire to (stamped self-addressed envelope enclosed):

Prof. Arun Madapusi / Prof. D. Krishna Sundar
ERP Centre
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore 560 076
Karnataka

I will be happy to clarify and answer any questions that you may have. Please contact:

Prof. Arun Madapusi (Project Coordinator)
Telephone Numbers (US & India)
Email Id

Enterprise Resource Planning (ERP) Systems Survey

All the questions in this questionnaire refer to a business unit. A business unit may be an overall corporation, a company (within a corporation), a group (several divisions), a division, or a plant depending upon your position and the way your company is organized. A business unit is an entity that compiles financial statements such as balance sheet, profit and loss statement, etc.

Please answer this questionnaire consistently with respect to that part of the business unit about which you are most familiar with and that you know the best. Please try to complete all the sections of the questionnaire even if your ERP implementation is still in process. Kindly base your answers on current ERP status and not on anticipated future results.

Business Unit

1. Classify the business unit about which you are most familiar and that you know the best (check one).

_____ 1. Overall corporation
_____ 2. Company (within a corporation)
_____ 3. Group (several divisions)
_____ 4. Division
_____ 5. Plant
_____ 6. Other - please specify ___________________

---

2. Size of the business unit / number of employees (check one).

_____ 1. 0-99
_____ 2. 100-249
_____ 3. 250-499
_____ 4. 500-999
_____ 5. over 1000

---

3. Size of the business unit / annual sales in rupees (check one).

_____ 1. less than 5 crores
_____ 2. greater than 5 crores but less than 100 crores
_____ 3. greater than 100 crores but less than 250 crores
_____ 4. greater than 250 crores but less than 500 crores
_____ 5. greater than 500 crores but less than 1000 crores
_____ 6. greater than 1000 crores

---

4. Please indicate the percentage of your business unit's sales that is generated from manufacturing and service respectively (check one or both; total should add up to 100%).

____ 1. Manufacturing …… __________ %
____ 2. Service …………… __________ %

---

5. Business unit characteristics (check one or more as applicable for each of the three business unit characteristics).

(i) _____ 1. Unionized
_____ 2. Non-unionized
_____ 3. Both

(ii) _____ 1. Private Sector
_____ 2. Public Sector
_____ 3. Other - please specify _____

(iii) _____ 1. Multinational (foreign origin)
_____ 2. Indian (Indian origin)
_____ 3. Other - please specify_____

---

6. Membership of Professional Associations (check one).

_____ 1. Confederation of Indian Industry (CII) Member
_____ 2. Member of any association affiliated to the CII - please specify ____
_____ 3. Other - please specify ____

---

7. Does your business unit 'make to order', 'make to stock', or some combination of both? (check one or both; total should add up to 100%).

____ 1. Make to order …… _____ %
____ 2. Make to stock …… _____ %

---

8. Percentage of your business unit's sales produced by type of production flow (check one or more; total should add up to 100%).

_____ 1. **Project** (Products/units are of different size and complexity and hence require special planning and control. The material flow pattern may be different for each product/unit.)……………………_________ %
_____ 2. **Job shop** (Products/units are produced in small batches in production runs lasting a few hours or days with different equipment setups generally required for each batch. The material flow pattern may be different for each product/unit.)……………………………………………………__________ %
_____ 3. **Batch** (Each product/unit is produced in moderately large batches in production runs lasting several days or weeks with different equipment setups generally required between batches. The material flow pattern may be same or similar for each product/unit.) ……………………….. __________ %
_____ 4. **Repetitive** {Products/units are similar or standardized and are mostly mass produced (assembly line). The material flow pattern is mostly the same for all products/units.}..…………………..…. __________ %
_____ 5. **Flow process** {Mostly standard products are mass produced (almost totally automated processing undertaken). The material flow is continuous.} ……………………………………...…. __________ %

---

9. Type of industry in which your products compete primarily (check one).

_____ 1. Basic Metal/Coal & Lignite/Uranium & Thorium/ Other Metal Ore/Mining & Quarrying
_____ 2. Automotive (Motor Vehicles, Trailers, etc.)
_____ 3. Machinery and Equipment
_____ 4. Fabricated Metal Products (except Machinery and Equipment)
_____ 5. Electronic/Telecommunication Equipment and Components
_____ 6. Computing Machinery & Office Equipment
_____ 7. Travel/Transport & Storage/Other Transport Equipment
_____ 8. Coke/Crude/Petroleum/Natural Gas/Refined Petroleum Products/Nuclear Fuel
_____ 9. Apparel and Textiles
_____ 10. Food Products and Beverages
_____ 11. Publishing/Printing/Media
_____ 12. Rubber/Plastic Products
_____ 13. Paper & Paper Products
_____ 14. Leather & Leather Goods
_____ 15. Wood & Wood Products
_____ 16. Other - please specify
____

Enterprise Resource Planning (ERP) System

10. Which of the following best describes your business unit's ERP implementation? (check any one among the three choices; then check one or more as appropriate for ERP system vendor)

_____ 1. ERP system from a single vendor (_____ SAP, _____ Oracle/People Soft, _____ SSA Global/Baan, _____ Ramco, _____ Others - please specify).
_____ 2. Best-of-Breed ERP system from multiple ERP system vendors (_____ SAP, _____ Oracle/People Soft, _____ SSA Global/Baan, _____ Ramco, _____ Others - please specify).
_____ 3. Totally in-house developed ERP system.

Enclosed with this questionnaire is a separate page of definitions of various ERP modules typically comprising the ERP system. Please read each definition for use in answering questions concerning ERP and your business unit. It may be convenient for you to place this ERP system module definitions page alongside the questionnaire as you answer question 11 below.

11. IMPLEMENTATION STATUS OF EACH ERP MODULE IN YOUR BUSINESS UNIT.
Please circle the appropriate responses for this question using the following scale:

NI = Not Implemented
0 to < 1 = Implementation started within the last year
1 to < 3 = Implementation started 1 or more but less than 3 years ago
3 to < 5 = Implementation started 3 or more but less than 5 years ago
5+ = Implementation started 5 or more years ago

ERP Modules			**Implementation Status of ERP Modules**		
1. Financials (FI)	NI	0 to < 1	1 to < 3	3 to < 5	5+
2. Controlling (CO)	NI	0 to < 1	1 to < 3	3 to < 5	5+
3. Plant Maintenance (PM)	NI	0 to < 1	1 to < 3	3 to < 5	5+
4. Materials Management (MM)	NI	0 to < 1	1 to < 3	3 to < 5	5+
5. Production Planning (PP)	NI	0 to < 1	1 to < 3	3 to < 5	5+
6. Project System (PS)	NI	0 to < 1	1 to < 3	3 to < 5	5+
7. Sales and Distribution (SD)	NI	0 to < 1	1 to < 3	3 to < 5	5+
8. General Logistics (LO)	NI	0 to < 1	1 to < 3	3 to < 5	5+
9. Quality Management (QM)	NI	0 to < 1	1 to < 3	3 to < 5	5+
10. Human Resources (HR)	NI	0 to < 1	1 to < 3	3 to < 5	5+
11. Supply Chain Management (SCM)	NI	0 to < 1	1 to < 3	3 to < 5	5+
12. Customer Relationship Management (CRM)	NI	0 to < 1	1 to < 3	3 to < 5	5+
13. E-Commerce (E-Com)	NI	0 to < 1	1 to < 3	3 to < 5	5+
14. Advanced Planner and Optimizer/ Advanced Planner and Scheduler (APO/APS)	NI	0 to < 1	1 to < 3	3 to < 5	5+

---

12. Kindly specify the components or sub-modules implemented under each of the ERP modules.

_____ 1. Financials (FI). The components implemented are: ____

_____ 2. Controlling (CO). The components implemented are:____

_____ 3. Plant Maintenance (PM). The components implemented are: _______________________________________

_____ 4. Materials Management (MM). The components implemented are: ___________________________________

_____ 5. Production Planning (PP). The components implemented are: _____________________________________

_____ 6. Project System (PS). The components implemented are: ____

_____ 7. Sales and Distribution (SD). The components implemented are: ___________________________________

_____ 8. General Logistics (LO). The components implemented are: _______________________________________

_____ 9. Quality Management (QM). The components implemented are: ____________________________________

_____ 10. Human Resources (HR). The components implemented are: ______________________________________

_____ 11. Supply Chain Management (SCM). The components implemented are: ______________________________

_____ 12. Customer Relationship Management (CRM). The components implemented are: ______________________

_____ 13. E-Commerce (E-Com). The components implemented are: ______________________________________

_____ 14. Advanced Planner and Optimizer/Advanced Planner and Scheduler (APO/APS). The components implemented are:
____

_____ 15. Other Module(s) - please specify ____
____

---

13. CHANGES IN THE FOLLOWING PERFORMANCE MEASURES IN YOUR BUSINESS UNIT THAT ARE ATTRIBUTABLE TO YOUR ERP SYSTEM.
Please circle the appropriate responses for this question using the following scale:

D = Disagree
MD = Mostly Disagree
SD = Somewhat Disagree
N = Neither Agree or Disagree
SA = Somewhat Agree
MA = Mostly Agree
A = Agree

	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
Change in Performance Measures	**Change Attributable to the ERP System**						
1. Inventory Management (lower inventory levels, higher inventory levels, better control over inventory, etc.)	D	MD	SD	N	SA	MA	A
2. Information Quality (accurate and reliable information for strategic planning, operational control, etc.)	D	MD	SD	N	SA	MA	A
3. On-time Delivery (improved order management/ order cycle, reduced delivery lead times, etc.)	D	MD	SD	N	SA	MA	A
4. Standardization (streamlining of business processes and business unit facilities, improved business flexibility, etc.)	D	MD	SD	N	SA	MA	A
5. Profitability (increased efficiency, increased profits, improved productivity, etc.)	D	MD	SD	N	SA	MA	A
6. Return on Investment (returns to the business unit from the ERP system)	D	MD	SD	N	SA	MA	A
7. Information Availability (easier access and faster retrieval of information)	D	MD	SD	N	SA	MA	A
8. User Satisfaction (precise information availability, user friendly system, output available in useful format, etc.)	D	MD	SD	N	SA	MA	A
9. Customer Satisfaction (improved customer relations and responsiveness, increased interaction with customers, etc.)	D	MD	SD	N	SA	MA	A
10. Competitive Advantage (new market opportunities identified, improved business unit agility, enhanced competitiveness, etc.)	D	MD	SD	N	SA	MA	A

14. Overall, based on your experience with ERP systems implementation, what is your view of the success of your firm's ERP system?

_____ 1. Disappointing (achieved very little)
_____ 2. Very Successful (went beyond expectations)
_____ 3. Successful (achieved most goals)
_____ 4. Other - please specify ____________________

15. FACTORS CRITICAL TO SUCCESSFUL ERP SYSTEM IMPLEMENTATION IN YOUR BUSINESS UNIT.
Please circle the appropriate responses for this question using the following scale:

D = Disagree
MD = Mostly Disagree
SD = Somewhat Disagree
N = Neither Agree or Disagree
SA = Somewhat Agree
MA = Mostly Agree
A = Agree

Critical Factors	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
	Impact of Critical Factors on ERP Implementation						
1. Top Management Support for the ERP system.							
a. Top management has invested the time needed to understand how ERP will benefit the business unit.	D	MD	SD	N	SA	MA	A
b. The need for long-term ERP support resources is recognized by top management.	D	MD	SD	N	SA	MA	A
c. Top management mandates that ERP requirements have priority over unique functional concerns.	D	MD	SD	N	SA	MA	A
d. Top management has clearly defined the ERP project's business goals.	D	MD	SD	N	SA	MA	A
e. All levels of management support the overall goals of the ERP project.	D	MD	SD	N	SA	MA	A
f. A cross-functional steering committee periodically reviews the ERP project's progress.	D	MD	SD	N	SA	MA	A
2. Planning the implementation of the ERP system.							
a. We constantly review our ERP system capabilities against our business goals.	D	MD	SD	N	SA	MA	A
b. ERP system plans are redesigned as required to meet evolving conditions.	D	MD	SD	N	SA	MA	A
c. Written guidelines exist to structure strategic ERP planning in our business unit.	D	MD	SD	N	SA	MA	A
d. Strategic ERP planning includes inputs from all functional areas.	D	MD	SD	N	SA	MA	A
3. User Support for the ERP system.							
a. Employees understand how they fit into the new ERP defined business processes.	D	MD	SD	N	SA	MA	A
b. Management actively works to alleviate employee concerns about the introduction of the ERP system.	D	MD	SD	N	SA	MA	A
c. An ERP support group is available to answer concerns about ERP job changes.	D	MD	SD	N	SA	MA	A
d. The change readiness of employees impacted by the ERP system is regularly assessed.	D	MD	SD	N	SA	MA	A
e. Management actively ensures user participation and involvement to foster user support for the ERP system.	D	MD	SD	N	SA	MA	A

15. FACTORS CRITICAL TO SUCCESSFUL ERP SYSTEM IMPLEMENTATION IN YOUR BUSINESS UNIT (continued).

	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
4. Project Management for the ERP system implementation.							
a. The tasks to be performed during the ERP project are clearly defined.	D	MD	SD	N	SA	MA	A
b. There is a formal management process to track external consultant activities.	D	MD	SD	N	SA	MA	A
c. Project tasks are reviewed on a periodic basis.	D	MD	SD	N	SA	MA	A
d. The ERP project leader is experienced in project management.	D	MD	SD	N	SA	MA	A
e. All ERP project changes are clearly documented.	D	MD	SD	N	SA	MA	A
5. Training for effective ERP system use.							
a. Specific user training needs were identified early in the implementation.	D	MD	SD	N	SA	MA	A
b. A formal training program has been developed to meet the requirements of the ERP system users.	D	MD	SD	N	SA	MA	A
c. Training materials target the entire business unit task and not just the ERP screens and reports.	D	MD	SD	N	SA	MA	A
d. Employees are tracked to ensure that they have received the appropriate ERP system training.	D	MD	SD	N	SA	MA	A
e. ERP system training review sessions are scheduled on an ongoing basis.	D	MD	SD	N	SA	MA	A
6. Learning to enhance ERP system capabilities.							
a. Benchmarking is used to identify cutting-edge ERP techniques.	D	MD	SD	N	SA	MA	A
b. Cross-functional groups meet regularly to discuss new uses for the ERP system.	D	MD	SD	N	SA	MA	A
c. ERP improvement suggestions are regularly collected from multiple employee levels.	D	MD	SD	N	SA	MA	A
d. ERP experimentation is encouraged even if the proposed improvements are unsuccessful.	D	MD	SD	N	SA	MA	A
7. Implementation Strategy for roll-out of the ERP system.							
a. A single go-live date was used to roll-out the ERP system across our business unit (‘big bang’ strategy).	D	MD	SD	N	SA	MA	A
b. A single go-live date was used to roll-out a sub-set of modules across our business unit (‘mini big-bang’ strategy).	D	MD	SD	N	SA	MA	A
c. Different modules were ‘phased-in’ on different live dates across our business unit (‘phased-in module’ strategy).	D	MD	SD	N	SA	MA	A
d. Different modules were ‘phased-in’ by site/location across our business unit (‘phased-in site’ strategy).	D	MD	SD	N	SA	MA	A

15. FACTORS CRITICAL TO SUCCESSFUL ERP SYSTEM IMPLEMENTATION IN YOUR BUSINESS UNIT (continued).

	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
8. ERP System-Business Alignment.							
a. The processes embedded in the ERP system correspond to our business practices.	D	MD	SD	N	SA	MA	A
b. ERP data items correspond to those used in our business documents.	D	MD	SD	N	SA	MA	A
c. The user interface in the ERP system is well designed to meet our business needs.	D	MD	SD	N	SA	MA	A
d. Significant time and effort is required to customize the ERP system to our business practices.	D	MD	SD	N	SA	MA	A
e. Significant time and effort is required to re-engineer our business practices to conform to the ERP system.	D	MD	SD	N	SA	MA	A
9. Support from Consultants for the ERP system implementation.							
a. Involvement of external consultants in the ERP system implementation is an ongoing effort.	D	MD	SD	N	SA	MA	A
b. The role of external consultants should be phased out by capturing and transferring their expertise to the in-house team.	D	MD	SD	N	SA	MA	A
c. External consultants help streamline our implementation effort and achieve quicker ERP project success.	D	MD	SD	N	SA	MA	A
d. External consultants were changed during the course of the ERP project.	D	MD	SD	N	SA	MA	A
10. Implementation Team support for the ERP system implementation.							
a. The implementation team has the ability to implement, maintain, and upgrade the ERP system.	D	MD	SD	N	SA	MA	A
b. The implementation team actively builds relationships with business managers.	D	MD	SD	N	SA	MA	A
c. The implementation team offers suggestions on how the ERP system can be used to achieve business goals.	D	MD	SD	N	SA	MA	A
d. The implementation team is responsive to end-user needs.	D	MD	SD	N	SA	MA	A
11. Data Accuracy in the ERP system.							
a. Data integrity in the ERP system affects the efficiency of our operations and the quality of our business decisions.	D	MD	SD	N	SA	MA	A
b. Data integrity requires awareness and control of dirty data right from the pre-implementation stage of the ERP system.	D	MD	SD	N	SA	MA	A
c. Maintaining data integrity is an ongoing process that needs to be ensured by all employees.	D	MD	SD	N	SA	MA	A
d. All employees understand the concept and the value of integrated data available from the ERP system.	D	MD	SD	N	SA	MA	A

15. FACTORS CRITICAL TO SUCCESSFUL ERP SYSTEM IMPLEMENTATION IN YOUR BUSINESS UNIT (continued).

	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
12. The role of Communication in the ERP system implementation process.							
a. Open and honest communication throughout the business unit facilitates the ERP system implementation process.	D	MD	SD	N	SA	MA	A
b. Communication is an ongoing process among all employees throughout the ERP system project.	D	MD	SD	N	SA	MA	A
c. Managing user input in the communication process results in greater understanding of organizational needs and quicker acceptance of the ERP system.	D	MD	SD	N	SA	MA	A
13. The role of Organizational Culture in the ERP system implementation process.							
a. It is very easy for my coworkers to access the ERP system to see the status of my work performance.	D	MD	SD	N	SA	MA	A
b. The management is only interested in employees getting work done using the installed ERP system rather than addressing their concerns.	D	MD	SD	N	SA	MA	A
c. Job descriptions and task procedures in our business unit is highly specific and detailed.	D	MD	SD	N	SA	MA	A
d. The ERP system enables tight control by providing very reliable information on how well or badly employees do their work.	D	MD	SD	N	SA	MA	A
e. The ERP system has enabled our business unit to be more market-driven and customer-oriented.	D	MD	SD	N	SA	MA	A
f. The ERP system has enabled me to more clearly identify myself with my job.	D	MD	SD	N	SA	MA	A
14. The role of National Culture in the ERP system implementation process.							
a. The ERP system facilitates close supervision of employees to ensure that they conform to standard work procedures established.	D	MD	SD	N	SA	MA	A
b. Management relies a great deal on me to ensure proper operational processing when I use the ERP system.	D	MD	SD	N	SA	MA	A
c. The ERP system has resulted in changes in job roles that tends to make employees work more individually and not in groups.	D	MD	SD	N	SA	MA	A
d. The short-term results obtained from ERP system implementation is more valuable than it's long-term results.	D	MD	SD	N	SA	MA	A
e. I do not mind my increased workload resulting from the ERP system implementation as it would prove beneficial to my career.	D	MD	SD	N	SA	MA	A

16. INTEGRATION OF ERP SYSEM IN YOUR BUSINESS UNIT.
Please circle the appropriate responses for this question using the following scale:

D = Disagree
MD = Mostly Disagree
SD = Somewhat Disagree
N = Neither Agree or Disagree
SA = Somewhat Agree
MA = Mostly Agree
A = Agree

	Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Mostly Agree	Agree
a. Internal coordination of business activities has increased with implementation of more ERP modules.	D	MD	SD	N	SA	MA	A
b. The implementation of more ERP modules has increased the business unit's performance benefits.	D	MD	SD	N	SA	MA	A
c. The fine-tuning of the ERP system over time has increased the business unit's performance benefits.	D	MD	SD	N	SA	MA	A
d. The implementation of more ERP modules has increased the external coordination of business activities with customers and suppliers.	D	MD	SD	N	SA	MA	A

Personal

17. Please provide details of your work experience:

(i) Total number of years of work experience _____ yrs
(ii) Number of years with this organization _____ yrs

18. Which of the following best represents your current position with the organization? (check one)

_____ 1. Top Management (top managers)
_____ 2. Middle Management (middle managers)
_____ 3. Lower level Management (first line managers)
_____ 4. Team Leaders (facilitators)
_____ 5. Production Line
_____ 6. Other - please specify ____________________

19. What is your current area of work? (check one)

_____ 1. Finance
_____ 2. Engineering
_____ 3. Production
_____ 4. Marketing
_____ 5. Information Technology/Systems
_____ 6. Other - please specify ____________________

20. Please indicate the highest level of education you have completed (check one):

_____ 1. Vocational
_____ 2. College:
___ (i) bachelors
___ (ii) masters
___ (iii) doctorate

Thank you for taking the time to complete this questionnaire. Your assistance in providing this information is deeply appreciated. If there is anything else you would like to tell us about this survey, please do so either separately on a blank sheet or in the body of the questionnaire itself, whichever is convenient.

In the event the enclosed self-stamped return envelope is misplaced please return the completed questionnaire to the following address:

Prof. Arun Madapusi / Prof. D. Krishna Sundar
ERP Centre
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore 560 076
Karnataka

I would be glad to provide you with a copy of the executive summary of the study's results. Please give your name and address below or simply attach your business card in the return envelope so that I can mail/fax the study's results to you or email me at (Email Id) and I can send the same to you as an attachment.

Your name: ______________________________
Title: ______________________________
Company: ______________________________
Address: ______________________________
____
____
Telephone: ______________________________
Fax: ______________________________
Email: ______________________________

Definitions
Enterprise Resource Planning System (ERP) Modules

Some terms used in the questionnaire are defined here to make it convenient for you to refer to them.

Financials (FI): This module constitutes the operational aspects of the general accounting and financial information for a business unit.

Controlling (CO): This module represents a business unit's cost structures and the factors that influence them.

Plant Maintenance (PM): This module takes care of the maintenance of plant systems and supports graphical representations, connection to geographic information systems, and detailed diagrams.

Materials Management (MM): This module comprises all activities related with material acquisitions such as purchasing, inventory, and warehouse.

Production Planning (PP): This module addresses the different phases, tasks, and methodologies used in the planning of production and the process of production itself.

Project System (PS): This module handles all aspects of activities, resource planning, and budgeting of complex tasks.

Sales and Distribution (SD): This module enables the management of all sales and distribution activities such as ordering, sales leads, promotions, competition, marketing, call tracking, planning, mail campaigns, and billing.

General Logistics (LO): This module contains the tools and reports necessary to analyze and manage the status in supply chain forecasts.

Quality Management (QM): This module handles tasks involved in quality planning, inspection and control, and compliance with international quality standards to ensure that a business unit employs a unified approach to total quality management for all its business areas.

Human Resources (HR): This module includes all business processes required to efficiently manage a business unit's human resources needs such as personnel, payroll, recruiting, time management, training, benefits, workforce deployment and analytics, and self-service delivery.

Supply Chain Management (SCM): This module extends the scope of ERP systems to include planning and execution capabilities to manage inter-business unit supply chains operations.

Customer Relationship Management (CRM): This module extends the scope of ERP systems to include automating functions such as sales, marketing, customer service, and collaborative order management.

E-Commerce (E-Com): This module facilitates access to ERP processes and data from anywhere in the world through web-enabled ERP systems and portals.

Advanced Planner and Optimizer/Advanced Planner and Scheduler (APO/APS): This module extends ERP systems to enable handling of complex processes such as shelf-life considerations, alternate routing, intermediate storage accounting, changeover light matrixes, clean-down time considerations, and fixed capacity storage constraints.

APPENDIX C

FIRST WAVE THANK YOU/REMINDER NOTE

Date

To

Dear …………,

Last week a questionnaire seeking to evaluate your ERP system implementation was mailed to you. Your firm's name was carefully chosen from a selected sample of production firms considered among the most progressive Indian firms in understanding and adopting ERP systems (packaged vendor system or home-grown/in-house developed system or hybrid system).

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, we request you to do so at the earliest. We are especially grateful for your help because it is only by asking people like you to share your ERP implementation experiences that we can enhance our holistic understanding of ERP system concepts and associated implementation issues and benefits.

If you did not receive the questionnaire, or it was misplaced, please call or email me and we will get another one in the mail to you today.

Sincerely,

Arun Madapusi

Prof. Arun Madapusi
Department of Management
College of Business Administration
University of North Texas
Denton, Texas 76203, USA
Telephone Numbers (USA & India)
Email Id

APPENDIX D

SECOND WAVE MAILING INTRODUCTORY LETTER

Date

To

Dear …………,

About five weeks back I had written to you seeking your participation in our survey study on the evaluation of enterprise resource planning (ERP) system implementations (packaged vendor system or home-grown/in-house developed system or hybrid system). In case our questionnaire has not reached you, our research team has enclosed a replacement along with a stamped self-addressed envelope for returning the questionnaire once you have completed it. **If you have already returned the completed questionnaire from our previous mailing, we deeply appreciate your help, and also kindly request you to disregard this letter**. If you have not yet returned the completed questionnaire from our first mailing, I request you take this opportunity to mail the same to us.

As indicated in our first mailing, this study is part of a multinational research project conducted by a group of researchers at the University of North Texas (UNT) and the Indian Institute of Management Bangalore (IIMB) that is designed to understand the relationship between the relative contributions of ERP system modules, critical success factors, and differential changes in firm performance. I request your kind participation in this study, as I believe that our research team can use the survey results to help firms enhance their understanding of conceptual and system oriented ERP issues, optimize their ERP implementations, and maximize the benefits derived from their ERP systems.

I am writing this letter to you again due to the significance that each returned questionnaire has to the usefulness of this study. For the results of our study to truly reflect the evaluation of ERP system implementations, it is essential that our research team obtain completed questionnaires from each of the firms that we are contacting. Your firm is part of a carefully selected sample of production firms considered among the most progressive Indian firms in understanding and adopting ERP systems. Though participation in this study is voluntary, in order for the results to truly represent an evaluation of ERP system implementations, it is important that the questionnaire attached to this email be completed fully. The questionnaire has been specifically designed by our research team to collect information critical to this study and should take about 25 to 30 minutes to complete.

Your answers to the survey will be kept strictly confidential (kindly do not give your name and contact details in the questionnaire or the mailing envelope if you wish your responses to be anonymous). The names of participating firms and individuals will not be released. Only aggregate results from the answers of the participating firms may be published. I deeply appreciate your cooperation and request your response preferably within two weeks to enable our research team to successfully complete this phase of the research project. As a small token of appreciation for your help, I would be glad to provide you with a copy of the executive summary of the study's results as soon as our research team completes its data analysis. If you have any questions about this study please feel free to contact me.

There are no foreseeable risks involved in this study. By completing this survey you are agreeing to participate in this study. If you have any questions about the study, you may contact Prof. Arun Madapusi at Email Id (Telephone Number) or Prof. Richard E. White at Email Id (Telephone Number). This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (Telephone Number) with any questions regarding your rights as a research subject.

Sincerely,

Prof. Arun Madapusi
Department of Management
College of Business Administration
University of North Texas
Denton, Texas 76203, USA
Telephone Numbers (USA & India)
Email Id

APPENDIX E

SECOND WAVE THANK YOU/REMINDER NOTE

Date

To

Dear …………,

Last week a questionnaire seeking to evaluate your ERP system implementation was mailed to you. Your firm's name was carefully chosen from a selected sample of production firms considered among the most progressive Indian firms in understanding and adopting ERP systems (packaged vendor system or home-grown/in-house developed system or hybrid system).

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, we request you to do so at the earliest. We are especially grateful for your help because it is only by asking people like you to share your ERP implementation experiences that we can enhance our holistic understanding of ERP system concepts and associated implementation issues and benefits.

If you did not receive the questionnaire, or it was misplaced, please call or email me and we will get another one in the mail to you today.

Sincerely,

Arun Madapusi

Prof. Arun Madapusi
Department of Management
College of Business Administration
University of North Texas
Denton, Texas 76203, USA
Telephone Numbers (USA & India)
Email Id

REFERENCES

Adams, B. (2002). Creating Value with an Instant Close. *Strategic Finance, 84*(3), 48-51.

Ahituv, N., Neumann, S., & Zviran, M. (2002). A System Development Methodology for ERP Systems. *Journal of Computer Information Systems, 42*(3), 56-67.

Al-Mashari, M., & Zairi, M. (2000). The Effective Application of SAP-R/3: A Proposed Model of Best Practice. *Logistics Information Management*, *13*(3), 156-166.

Al-Mashari, M., Al-Mudimigh, A., & Zairi, M. (2003). Enterprise Resource Planning: A Taxonomy of Critical Factors. *European Journal of Operational Research*, *146*(2), 352-364.

AMR Research (2000). *AMR Research predicts enterprise application market will reach $78 billion by 2004*. Retrieved December 20, 2004 from http://www.amrresearch.com/press/files/99518.asp.

AMR Research (2005). *AMR research releases ERP market report showing overall market growth of 14% in 2004*. Retrieved January 20, 2006 from http://www.amrresearch.com/Content/View.asp?pmillid=18358.

Anderson, J.C., & Schroeder, R.G. (1984). Getting Results from your MRP System. B*usiness Horizons*, *May/June,* 57-64.

Ang, J.S.K., Sum, C.C., & Yeo, L.N. (2000). A Multiple Case-Design Methodology for Studying MRP Success and CSFs. *Information & Management, 39,* 271-281.

Appelrath, H.J., & Ritter, J. (2000). *SAP R/3 Implementation: Methods and Tools*. Berlin: Springer-Verlag.

Ash, C.G., & Burn, J.M. (2003). A Strategic Framework for the Management of ERP-enabled e-Business Change. *European Journal of Operational Research*, *146*(2), 374-387.

Ayers, J. (2001). Is Supply Management the Same as ERP? *Information Strategy: The Executive's Journal*, *17*(3), 43-45.

Barker, T., & Frolick, M.N. (2003). ERP Implementation Failure: A Case Study. *Information Systems Management*, *Fall,* 43-49.

Beretta, S. (2002). Unleashing the Integration Potential of ERP Systems. *Business Process Management Journal*, *8*(3) 254-277.

Berry, R.W. (1996). *An Investigation of the Relationship between World Class Quality System Components and Performance*. Doctoral Dissertation, University of North Texas.

Besson, P., & Rowe, F. (2001). ERP Project Dynamics and Enacted Dialogue: Perceived Understanding, Perceived Leeway, and the Nature of Task-Related Conflicts. *Database for Advances in Information Systems*, *32*(4), 47-66.

Bingi, P., Maneesh, K.S., & Jayanth, K.G. (1999). Critical Issues affecting ERP Implementation. *Information Systems Management*, *16*(3), 7-15.

Boss Corporation, Crum, J., & Others. (2000). *Using Oracle Applications*. Que Indiana: Macmillan Publishers.

Bradford, M., & Roberts, D. (2001). Does your ERP system measure up? *Strategic Finance*, *83*(3), 30-34.

Buckhout, S., Frey, E., & Nemec Jr. J. (1999). Making ERP Succeed: Turning Fear into Promise. *Technology*, *2nd. Quarter,* 60-72.

Caldwell, B. (1998). New IT Agenda. *Information Week*, *711,* p. 30.

Cameron, P.D., & Meyer, S.L. (1998). Rapid ERP Implementation. *Management Accounting*, *80*(6), 58-60.

Chandra, P., & Sastry, T. (1998). Competitiveness of Indian Manufacturing: Findings of the 1997 Manufacturing Futures Survey. *Vikalpa*, *23*(3), 25-36.

Chandra, P., & Sastry, T. (2002). *Competitiveness of Indian Manufacturing: Findings of the 2001 Manufacturing Futures Survey*. Retrieved December 20, 2004 from http://www.iimahd.ernet.in/~chandra/cv.htm.

Chen, I.J. (2001). Planning for ERP Systems: Analysis and Future Trend. *Business Process Management Journal*, *7*(5), 374-386.

Chung, S.H., & Snyder, C.A. (2000). ERP Adoption: A Technological Evolution Approach. *International Journal of Agile Management Systems*, *2*(1), 24-32.

Clemmons, S., & Simon, S.J. (2001). Control and Coordination in Global ERP Configurations. *Business Process Management Journal*, *7*(3), 205-215.

Cohen, J., & Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioral sciences*. Hillsdale, New Jersey: Erlbarum.

Comerford, J. (2000). Plan the Complexity out of ERP Implementations. *Business Journal*, *14*(7), p. 26.

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16,* 297-334.

Cua, K.O., McKone, K.E., & Schroeder, R.G. (2001). Relationships between Implementation of TQM, JIT and TPM and Manufacturing Performance, *Journal of Operations Management*, *19,* 675-694.

Dataquest, (1998). Knitting Yarns of Success. *ERP Demystified – Part II: Strategies for the Enterprise.* 16(24), p15.

Dataquest (2003). *Manufacturing an IT Future*. Retrieved December 20, 2004 from www.dqindia.com/dqtop20/2003/artdisp.asp?artid=49330.

Dataquest (2004). *Packaged software: multi-factor revival*. Retrieved January 20, 2006 from http://www.dqindia.com/dqtop20/2004/ArtIndseg.asp?artid=59645.

Datamonitor (2005). *Manufacturing Applications Model*. Retrieved January 20, 2006 from http://www.datamonitor.com/technology.

Davenport, T.H. (1998). Putting the Enterprise into the Enterprise System. *Harvard Business Review, 76*(4), 121-131.

Davenport, T.H. (2000). The Future of Enterprise System-Enabled Organizations. *Information Systems Frontiers*, *2*(2), 163-180.

Davison, R. (2002). Cultural Complications of ERP. *Communications of the ACM*, *45*(7), 109-111.

De, R. (2004). *Manufacturing: Back on the Rebound*. Retrieved December 20, 2004 from www.dqindia.com/dqtop20/2004/artdisp.asp?artid=60678.

Dillman, D.A. (1978). *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley & Sons.

Dillman, D.A. (2000). *Mail and Internet Surveys: The Tailored Design Method*. (2nd. Ed.) New York: John Wiley & Sons.

Drayer, R., & Wight, R. (2002). Getting the most from your ERP system. *Supply Chain Management Review*, *May/June,* 44-52.

Duchessi, P., Schaninger, C.M., Hobbs, D.R., & Pentak, L.P. (1988). Determinants of Success in Implementing Materials Requirement Planning (MRP). *Journal of Manufacturing & Operations Management, 1*(3), 263-304.

Eisenhardt, K.M (1989). Building Theory from Case Study Research. *Academy of Management Research*, *14,* 532-550.

Evgeniou, T. (2002). Information Integration and Information Strategies for Adaptive Enterprises. *European Management Journal*, *20*(5), 486-494.

Ferdows, K., & Meyer, A.D. (1990). Lasting Improvements in Manufacturing Performance: In Search of a New Theory. *Journal of Operations Management. 9*(2), 168-183.

Flynn, B.B., Schroeder, R.G., & Sakakibara, S. (1990). A Framework for Quality Management Research and Associated Measurement Instrument. *Journal of Operations Management*, *11*(4), 339-366.

Francalanci, C. (2001). Predicting the Implementation Effort of ERP Projects: Empirical Evidence on Sap R/3. *Journal of Information Technology*, *16* (1), 33-48.

Galbraith, J.R. (1973). *Designing Complex Organizations*. Philippines: Addison-Wesley Publishing Company Inc.

Galbraith, J.R. (1974). Organization Design: An Information Processing View. *Interfaces, 4*(3), 28-36.

Galbraith, J.R. (1977). *Organization Design*. Philippines: Addison-Wesley Publishing Company Inc.

Galbraith, J.R. (1994). *Competing with Flexible Lateral Organizations*. New York: Addison-Wesley Publishing Company, Inc.

Galbraith, J.R. (2000). *Designing the Global Corporation*. Jossey-Bass Inc.: San Francisco.

Galbraith, J.R. (2002). Designing Organizations: *An Executive Guide to Strategy, Structure, and Process*. New York: John Wiley & Sons Inc.

Galbraith, J.R., Downey D., & Kates, A. (2002). *Designing Dynamic Organizations: A hands-on guide for leaders at all levels*. New York: AMACOM.

Galbraith, J.R. Lawler III, E.E., & Associates. (1993). *Organizing for the Future: The New Logic of Managing Complex Organizations*. Sa Francisco: Jossey-Bass Publishers.

Gartner (2002). *Frequently asked questions about ERP II*. Retrieved December 20, 2004 from http://www.gartner.com.

Gartner (2003a). *Asia Pacific ERP: the road ahead, 2003-2007*. Retrieved December 20, 2004 from http://www.gartner.com.

Gartner (2003b). *Enterprise application software: winning in the Indian marketplace*. Retrieved December 20, 2004 from http://www.gartner.com.

Gefen, D., & Ridings, C.M. (2002). Implementation Team Responsiveness and User Evaluation of Customer Relationship Management: A Quasi-Experimental Design Study of Social Exchange Theory. *Journal of Management Information Systems*, *19*(1), 47-69.

Gefen, D., & Ragowsky, A. (2005). A Multi-level Approach to Measuring the Benefits of an ERP System in Manufacturing Firms. *Information Systems Management*, *22*(1), 18-25.

Gould, L.S. (2002). ERP: Complexities, Ironies, and Advances. *Automotive Design & Production*, *114*(7), 44-46.

Gowigati, B., & Grenier, B. (2001). The winds of change. *CMA Management*, *75*(8), 34-38.

Gulla, J.A., & Brasethvik, T. (2002). A Model-Driven ERP Environment with Search Facilities. *Data & Knowledge Engineering*, *42,* 327-341.

Gupta, Y.P., & Neel, G.A. (1992). The origin of EDI and changes associated with its implementation. *Industrial Engineering*, *24*(8), 25-29.

Hair, J.F., Anderson, R.E., Tatham, R.L., & Black, W.C. (1998). *Multivariate Analysis.* New Jersey: Prentice Hall.

Harold, J. E. (1997). Evaluating and Implementing EDI at a Small Electronics Manufacturer. *Production and Inventory Management Journal*, *38*(3), 1-5.

Harrold, D. (2001). How Manufacturing Benefits by Understanding ERP and IT. *Control Engineering*, *January,* 26-36.

Hawking, P., & Stein, A. (2004). Revisiting ERP Systems: Benefit Realization. *Proceedings of the 37th. Hawaii International Conference on System Sciences*, p. 8.

Hayman, L. (2000). ERP in the Internet Economy. *Information Systems Frontiers*, *2*(2), 137-139.

Hendrickson, D. (2001). Getting more out of ERP. *EAI Journal*, *December,* 24-27.

Hernandez, J.A. (1998). *The SAP R/3 Handbook*. New Delhi: Tata McGraw Hill Publishing Company Limited.

Hitt, L.M., Wu, D.J., & Zhouo, X. (2002). Investment in Enterprise Resource Planning: Business Impact and Productivity Measures. *Journal of Management Information Systems*, *19*(1), 71-98.

Hofstede, G. (1980). *Culture's Consequences*. Beverly Hills, California: Sage.

Hofstede, G., Neuijen, B. Ohayv, D.D., & Sanders, G. (1990). Measuring Organizational Cultures: A Qualitative and Quantitative Study across Twenty Cases. *Administrative Science Quarterl*y, *35*(2), 286-316.

Holland, C.P., & Light, B. (1999). A Critical Success Factors Model for ERP Implementation. *IEEE Software*, *May-June*, 30-36.

Hong, K.K., & Kim, Y.G. (2001). The Critical Success Factors of ERP Implementation: An Organizational Fit Perspective. *Information & Management*, *40*(1), 25-40.

Hsieh, P.J., & Kleiner, B.H. (1992). New Developments in Inventory and Materials Management. *Logistics Information Management*, *5*(2), 32-35.

Huang, Z., & Palvia, P. (2001). ERP Implementation Issues in Advanced and Developing Countries. *Business Process Management Journal*, *7*(3), 276-284.

Huck, S.W. (2000). *Reading statistics and Research.* USA: Adision Wesley Longman Inc.

IDC (2003). *Worldwide Packaged Applications Forecast and Analysis, 2002-2007: 2003 Reference Guide*. Retrieved December 24, 2004 from http://www.idc.com/getdoc.jsp?containerId=30082.

IDC (2004). *IDC Releases Top 10 Vendors in ERP Applications Market; Market Consolidation Will Continue at Gradual Pace*. Retrieved December 24, 2004 from http://www.idc.com/getdoc.jsp?containerId=pr2004_05_05_094804.

IDC India (2003). *Competition Intensifies in the Indian ERP Space - Market Expected to Cross 800 Crores by 2006*. Retrieved December 24, 2004 from http://www.idcinida.com/pressrel/Show.pressrel.asp?prpath=PRI20020058.htm.

Jacobs, F.R., & Bendoly, E. (2003). Enterprise Resource Planning: Developments and directions for operations management research. *European Journal of Operational Research, 146*(2), 233-240.

Johnson, G. (2000). The Big Kahuna of IT Systems. *Electrical Wholesaling*, *81*(4), p. 36.

Kanungo, S., & Bagchi, S. (2000). Understanding User Participation and Involvement in ERP Use. *Journal of Management Research*, *1*(1), 47-63.

Karakanian, M. (1999). Choosing an ERP Implementation Strategy. *Year 2000 Practitioner*, *2*(7), p1, 6p.

Kawalek, P., & Wood-Harper, T. (2002). The Finding of Thorns: User Participation Enterprise System Implementation. *Database for Advances in Information Systems*, *33*(1), 13-22.

Kennerley, M., & Neely, A. (2001). Enterprise Resource Planning: Analyzing the Impact. *Integrated Manufacturing Systems*, *12*(2), 103-113.

Kerlinger, F.N., & Lee, H.B. (2000). *Foundations of Behavioral Research*. USA: Thomson Learning.

Kharbanda, R. (1999). Enterprise Resource Planning: Baan Implementation by New Holland Tractors India (Pvt) Ltd. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 137-143). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Klaus, H., Rosemann, M., & Gable, G.G. (2000). What is ERP? *Information Systems Frontiers*, *2*(2), 141-162.

Koch, C. (2001). Enterprise Resource Planning: Information Technology as a Steamroller for Management Politics. *Journal of Organizational Change Management*, *14*(1), 64-78.

Kochan, A. (1999). Shortcuts to peak ERP Performance. *Works Management*, *52*(3), 22-25.

Kraemmergaard, P., & Rose, J. (2002). Managerial Competencies for ERP Journeys. *Information Systems Frontiers*, *4*(2), 199-211.

Krajewski, L.L., King, B.E., Ritzman, L.P., & Wong, D.S. (1987). Kanban, MRP, and Shaping the Manufacturing Environment, *Management Science*, *33*(1), 39-57.

Krumbholz, M., & Maiden, N. (2001). The Implementation of Enterprise Resource Planning Packages in Different Organizational and National Cultures. *Information Systems*, *26*(3), 185-204.

Kumar, V., Maheshwari, B., & Kumar, U. (2003). An Investigation of Critical Management Issues in ERP Implementation: Empirical Evidence from Canadian Organizations. *Technovation*, *23*(10), 793-807.

Lall, A. (2003). *Making ERP work for you*. Retrieved December 24, 2004 from http://www.business-standard.com/search/storypage_new.php? leftnm=lmnu7&leftindx =7&lselect=6 &autono=146525.

Lau, R.S.M., Zhao, X., & Lai, F. (2002). Survey of MRP II Implementation and Benefits in Mainland China and Hong Kong. *Production and Inventory Management Journal*, *43*(3&4), 65-71.

Lee, H.L., So, K.C., & Tang, C.S. (2000). The Value of Information Sharing in a Two-Level Supply Chain. *Management Science, 46*(5), 626-643.

Legare, T.L. (2002). The Role of Organizational Factors in Realizing ERP Benefits. *Information Systems Management*, *19*(4), 21-42.

Lewis-Beck, M.S. (1980). *Applied Regression*. Newbury Park, California: Sage.

Li, L.X., Chaudhry, S.S., Chaudhry, P.E., & Wang, Y. (2001). Evaluation of Acquiring and Implementing a Manufacturing Resource Planning System. *Production and Inventory Management Journal*, *42*(3&4), 1-8.

Mabert, V.A., Soni, A., & Venkataramanan, M.A. (2000). Enterprise Resource Planning Survey of US Manufacturing Firms. *Production and Inventory Management Journal*, *41*(2), 52-58.

Mabert, V.A., Soni, A., & Venkataramanan, M.A. (2001a).Enterprise Resource Planning: Measuring Value. *Production and Inventory Management Journal*, *42*(3/4), 46-51.

Mabert, V.A., Soni, A., & Venkataramanan, M.A. (2001b). Enterprise Resource Planning: Common Myths versus Reality. *Business Horizons*, *43*(3), 69-76.

Mabert, V.A., Soni, A., & Venkataramanan, M.A. (2003a). Enterprise Resource Planning: Managing the Implementation Process. *European Journal of Operational Research*, *146*(2), 302-314.

Mabert, V.A., Soni, A., & Venkatramanan, M.A. (2003b). The Impact of Organization size in Enterprise Resource Planning (ERP) Implementations in the US Manufacturing Sector, *Omega, 31*(3), 235-246.

Madhavan, S.K. (2000). Erhardt+Leimer India Limited: Strategic Transformation through ERP. *Vikalpa*, *25*(3), 57-69.

Markus, M.L., Petrie, D., & Axline, S. (2000). Bucking the Trends: What the Future may hold for ERP Packages. *Information Systems Frontier*, *2*(2) 181-193.

Markus, M.L., Tanis, C., & Fenema, P.C. (2000). Multisite ERP Implementations. *Communications of the ACM*, *43*(4), 42-46.

Markus, M.L., Axline, S., Petrie, D., & Tanis, C. (2000). Learning from Adopters' Experience with ERP: Problems Encountered and Success Achieved. *Journal of Information Technology*, *15,* 245-265.

Menezes, J. (1999). Companies urged to reexamine ERP Models. *Computer Dealer News*, *15*(25), p. 16.

Meissner, G. (2000). *SAP: Inside the Secret Software Power*. New York: McGraw-Hill Companies, Inc.

Miller, S.S. (1999). *SAP R/3 Certification Exam Guide*. New York: McGraw-Hill Companies Inc.

Miller, J.G., & Sprague, L.G. (1975). Behind the Growth in Materials Requirements Planning. *Harvard Business Review*, *53*(5), 83-91.

Miltenburg, J. (2002). Computational Complexity of Algorithms for MRP and JIT Production Planning Problems in Enterprise Resource Planning Systems. *Production and Planning Control*, *12*(2), 198-209.

Minahan, T. (1998). Enterprise Resource Planning Strategies not Included. *Purchasing*, *125*(1), 112-127.

Mirani, R., & Lederer, A.L. (1998). An Instrument for Assessing the Organizational Benefits of IS Projects. *Decision Sciences*, *29*(4), 803-838.

Mohrman, S.A., Galbraith, J.R., Lawler III, E.E. and Associates (1998). *Tomorrow's Organization: Crafting Winning Capabilities in a Dynamic World*. San Francisco: Jossey-Bass Inc.

Nah, F.F, Lau, J.L., & Kuang, J. (2001). Critical Factors for Successful Implementation of Enterprise Systems. *Business Process Management Journal*, *7*(3), 285-296.

Nandhakumar, J., Rossi, M., & Talvinen, J. (2002). Planning for 'drift'? Implementation process of enterprise resource planning systems. *Proceedings of the 36th. Hawaii International Conference on System Sciences*, p. 10.

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

Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric Theory*. New York: McGraw Hill:

Olhager, J., & Selldin, E. (2003). Enterprise Resource Planning Survey of Swedish Manufacturing Firms. *European Journal of Operational Research*, *146*(2), 365-373.

Padmanabhan, S. (1999). Implementation of ERP in Large-Scale Organizations: A User's Perspective. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 133-136). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Parr, A.N., & Shanks, G. (2000a). A Model of ERP Implementation. *Journal of Information Technology*, *15,* 289-303.

Parr, A.N., & Shanks, G. (2000b). A Taxonomy of ERP Implementation Approaches. *Proceedings of the 33rd. Hawaii International Conference on System Sciences*, p10.

Pasha, A. (2003). *Enterprise Apps Special: ERP Case Study - Triveni gets a handle on project costing with SAP R/3*. Retrieved December 20, 2004 from http://www.expresscomputeronline.com/20031124/appsspecial08.shtml.

Petroni, A. (2002). Critical Factors of MRP Implementation in Small and Medium-Sized Firms. *International Journal of Operations and Production Management, 22*(3), 329-348.

Podsakoff, P.M., & Organ, D.W. (1986). Self-reports in organizational research: problems and prospects. *Journal of Management, 12*(4), p. 531-544.

Poston, R., & Grabski, S. (2001). Financial Impacts of Enterprise Resource Planning Implementations. *International Journal of Accounting Information Systems*, *2,* 271-294.

Raghuraman, P.G. (1999). IT: Managing Large Scale Change. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 114-126). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Rajani, R. (1999). Going the ERP Way: Important Issues. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 70-79). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Romeo, J. (2001). Less Pain, More Gain in ERP Rollouts. *Network Computing*, *12*(19), 49-56.

Rondeau, P.J., & Litteral, L.A. (2001). Evolution of Manufacturing Planning and Control Systems: From Reorder Point to Enterprise Resource Planning. *Production and Inventory Management Journal, 42*(2), 1-7.

Ross, J.W., & Vitale, M.R. (2000). The ERP Revolution: Surviving vs. Thriving. *Information Systems Frontiers*, *2*(2), 233-241.

Sadagopan, S. (1999). The World of ERP. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 1-16). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Sarker, S., & Lee. A.S. (2002). Using a Case Study to test the Role of Three Key Social Enablers in ERP Implementation. *Information and Management*, *20*(31), 1-17.

Sarkis, J., & Sundarraj, R.P. (2003). Managing large-scale global enterprise resource planning systems: a case study at Texas Instruments. *International Journal of Information Management*, *23,* 431-442.

Sastry, M.V.S.P. (1999). Making ERP Effective. In Sadagopan, S. (Ed.) *ERP: A Managerial Perspective* (pp. 48-55). New Delhi: Tata McGraw-Hill Publishing Company Limited.

Satyan, E. (2002). *Mind the Returns, Never Mind the ROI*. Retrieved December 20, 2004 from www.dqindia.com/content/top_stories/102093001.asp.

Satyan, E. (2003). *Focus: Enterprise Apps: Moving Up to ERP*. Retrieved December 20, 2004 from www.dqindia.com/content/cio_handbook/103021901.asp.

Scheer, A.W., & Habermann, F. (2000). Making ERP a Success. *Communications of the ACM*, *43*(4), 57-61.

Schroeder, R.G, Anderson, J.C., Tupy, S.E., & White, E.M. (1981). A Study of MRP Benefits and Costs. *Journal of Operations Management*, *2*(1), 1-9.

Scott, J.E., & Vessey, I. (2000). Implementing Enterprise Resource Planning Systems: The Role of Learning from Failure. *Information Systems Frontiers*, *2*(2), 213-232.

Sheau, C., Chae, B., & Yang, C.L. (2004). National Differences and ERP Implementation: Issues and Challenges. *Omega*, *32,* 361-372.

Sheldon, D. Jr. (1994). MRP II Implementation. *Hospital Material Management Quarterly*, *15*(4), 48-52.

Shields, M.G. (2001). *E-business and ERP: Rapid Implementation and Project Planning*. New York: John Wiley & Sons, Inc.

Sia, S.K., Tang, M., Soh, C., & Boh, W.F. (2002). Enterprise Resource Planning (ERP) Systems as a technology of Power: Empowerment or Panoptic Control? *Database for Advances in Information Systems*, *33*(1), 23-37.

Sillince, J.A.A., & Sykes, G.M.H. (1993). Integrating MRP II and JIT: A Management rather than a Technical Challenge. *International Journal of Operations and Production Management*, *13*(4), 18-31.

Siriginidi, S.R. (2000). Enterprise Resource Planning in Reengineering Business. *Business Process Management Journal, 6*(5), 376-391.

Slater, D. (1999). What is ERP? *CIO*, *12*(15), p. 86.

Soh, C., Kien, S.S., & Tay-Yap, J. (2000). Cultural Fits and Misfits: Is ERP a Universal Solution? *Communications of the ACM*, *43*(4), 47-51.

Sousa, J.E., & Collado, J.P. (2000). Towards the Unification of Critical Success Factors for ERP Implementations. *10th. Annual Business Information Technology (BIT) Conference*, *Manchester*, p. 9.

Stensrud, E., & Myrtveit, I. (2002). Identifying High Performance ERP Projects. *Norwegian School of Management*, *Discussion Paper 4/2002,* 1-20.

Stratman, J.K., & Roth, A.V. (2002). Enterprise Resource Planning (ERP) Competence Constructs: Two-Stage Multi-Item Scale Development and Validation. *Decision Sciences*, *33*(4), 601-628.

Sweat, J. (1999). Learning Curve. *Information Week*, *746*, p44.

Tarafdar, M., & Roy, R.K. (2003). Analyzing the adoption of enterprise resource planning systems in Indian organizations: A process framework. *Journal of Global Information Technology Management*, *6*(1), p. 21.

Teltumbde, A., Tripathy, A., & Sahu, A.K. (2002). Bharat Petroleum Corporation Limited (BPCL). *Vikalpa, 27*(3), 45-58.

Tyler, G. (2002). ERP Redefines Itself. *Management Services*, *46*(10), 24-28.

Umble, E.J., & Umble, M.M. (2002). Avoiding ERP Implementation Failure. *Industrial Management*, *January/February,* 25-33.

Vosburg, J., & Kumar, A. (2001). Managing Dirty Data in Organizations Using ERP: Lessons from a Case Study. *Industrial Management and Data Systems*, *101*(1), 21-31.

Watanabe, C., & Hobo, M. (2003). Creating a firm self-propagating function for advanced innovation-oriented projects: lessons from ERP. *Technovation, 23*, 1-15.

Weston Jr., F.C. (2001). ERP Implementation and Project Management. *Production and Inventory Management Journal*, *42*(3/4), 75-80.

Weston Jr. F.C. (2003). ERP II: The Extended Enterprise System. *Business Horizons*, *November-December,* 49-55.

White, R.E. (1990). *Post-Implementation Evaluation of Just-In-time Manufacturing*. Doctoral Dissertation, Arizona State University.

White, E.M., Anderson, J.C., Schroeder, R.G., & Tupy, S.E. (1982). A Study of the MRP Implementation Process. *Journal of Operations Management, 2*(3), 145-153.

Willis, T.H., & Willis-Brown, A.H. (2002). Extending the Value of ERP. *Industrial Management and Data Systems*, *102*(1), 35-38.

Worthen, B. (2002). Nestle's ERP Odyssey: Nestle USA's costly and protracted struggle with its SAP project is a cautionary tale for any company intent on an enterprise wide implementation, *CIO*, *15*(15), 62-70.

Wyatt, J. (2002). ERP in the consumer-driven marketplace. *Health Management Technology*, *23*(7), 24-25.

Xu, H., Nord, J.H., Brown, N., & Nord, D.G. (2002). Data quality issues in implementing an ERP. *Industrial Management and Data Systems*, *102*(1), 47-58.

Yen, D.C., Chou, D.C., & Chang, J. (2002). A Synergic Analysis for Web-Based Enterprise Resources Planning Systems. *Computer Standards & Interfaces, 24,* 337-346.

Yu, Z., Yan, H., & Cheng, T.C.E. (2001). Benefits of Information Sharing with Supply Chain Partnerships. *Industrial Management and Data Systems*, *101*(3), 114-119.

Zhang, Z., Lee, K.O.M., Huang, P., Zhang, L., & Huang, X. (2005). A Framework for ERP Systems Implementation in China: An Empirical Study. *International Journal of Production Economics, 98*(1), 56-80.