International Journal of Information Management 32 (2012) 24–34

Contents lists available at ScienceDirect

International Journal of Information Management

journal homepage: www.elsevier.com/locate/ijinfomgt

The influence of ERP system implementation on the operational performance of an organization

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ARTICLE INFO

Article history:
Available online 23 July 2011

Keywords:
ERP
ERP system implementation status
ERP operational performance

ABSTRACT

We investigate changes in operational performance that result from enterprise resource planning (ERP) system implementation. A literature-based and theory-driven model was developed to examine the relationship between ERP system implementation status and operational performance. Data were gathered through a field study to test the hypothesized relationships. The results indicate that the implementation of each ERP system module influences operational performance measures differently. In addition, the results highlight the varying influence of the implementation of the ERP system, as a whole, on operational performance measures. Our findings suggest that a better understanding of the contribution of ERP systems to operational performance can be obtained if researchers and managers assess changes in operational performance at both the modular and the system levels.

1. Introduction

The global market for enterprise resource planning (ERP) has registered significant growth in the last two decades (Bonasera, 2000; Mabert, Soni, & Venkataramanan, 2000; Reilly, 2005). The global ERP market's revenues were estimated at $65 billion in 2008, $61 billion in 2009, and $65 billion in 2010 (D'Aquila, Shepherd, & Friscia, 2009). Early ERP system implementers deployed modules that primarily addressed intra-firm activities in the finance, logistics, and human resources functions of the organization (Hernandez, 1998; Mabert et al., 2000; Meissner, 2000). As intra-firm ERP implementations stabilized, firms added modules that addressed inter-firm activities (Bendoly & Jacobs, 2005; Hendricks, Singhal, & Stratman, 2007; McGaughley & Gunasekaran, 2007). Because of expanding customer demand, ERP vendors continue to add to their product lines by offering ERP systems that have more depth, complexity, and modular integration.

Investment in ERP systems has been fueled by studies indicating that ERP system implementations result in improvements in operational performance (Cotteleer, 2006; Mabert, Soni, & Venkataramanan, 2001; McAfee, 2002). Mabert et al. (2001) and McAfee (2002) found that intra-firm ERP systems enable firms to standardize, integrate, and streamline their data and process flows. This also provides critical information streams necessary for effective decision-making. Firms fine-tune their installations over time and leverage ERP information to effect improvements in areas such as inventory management and order management. Firms typically add modules that extended the ERP system beyond the enterprise to include suppliers and customers. The ongoing process of stabilizing, fine-tuning, and extending ERP systems has been found to further improve operational performance (Bendoly, Rosenzeig, & Stratman, 2009; Gattiker & Goodhue, 2005; Stratman, 2007).

With the constant growth in scope and level of sophistication of ERP systems, there is increasing interest in the influence of these systems on operational performance at the modular level and at the systems level. Researchers such as Gattiker and Goodhue (2004), Cotteleer and Bendoly (2006), and Stratman (2007) note that an ERP system is much more than a mere collection of information processing modules that support various intra and inter-firm activities. They argue that a systemic concept (i.e., of, and pertaining to, a system) underlies ERP system modules and that the connections and interdependencies among the modules improve operational performance. Past research further suggests that, over time, operational performance improves as employees use the ERP system in different and sometimes unique ways to enhance organizational tasks and processes (Chou & Chang, 2008; Gattiker & Goodhue, 2005; McAfee, 2002; Poston & Grabski, 2001). In this study, we seek to advance this stream of research by first examining whether the implementation status of each ERP module influences operational performance. Then, we investigate whether the implementation status of an ERP system as a whole (a collection of modules that addresses intra and inter-firm activities) influences operational

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doi:10.1016/j.ijinfomgt.2011.06.004

performance. We believe that our investigation of individual and systemic ERP implementations can provide an improved picture of the value of an ERP system to a firm.

The rest of the paper is organized as follows. In Section 2, we examine the theoretical approach that underlies systemic ERP implementations. In Section 3, we elaborate on the research model and postulate hypotheses. Section 4 describes the research methodology. In Section 5 we provide details on the analyses and report results. In Section 6, we discuss the findings, the implications, and the limitations of the study. Finally, Section 7, summarizes the study and suggests directions for future research.

2. Theoretical background

Evidence-based research that links ERP systems characteristics to operational performance measures has alluded to an underlying "systemic approach". However, a well-articulated theoretical rationale for the relationship is lacking. This is particularly true for research that addresses ERP systems implementation. In an effort to move the field forward, we begin our development by offering a theoretically anchored rationale for the relationship between ERP systems implementation and operational performance.

The systemic approach is rooted in general systems theory. According to this school of thought, systems (such as ERP systems) are characterized by a combination of interdependent parts (e.g., ERP system modules) that result in flows across these parts. Among the flows that link parts of a system, the flow of information is viewed as the most critical (Scott, 2003). Hence, an understanding of information flows is necessary to exploit the strength of each of the parts (i.e., ERP modules) and the system as a whole (i.e., the ERP system).

Organizational information processing theory (OIPT), a specific contingency approach that also has roots in general system theory, was developed to explain the information processing phenomena (Galbraith, 1973, 1974, 1977; Huber, 1990; Knight & McDaniel, 1979; Tushman and Nadler, 1978). We concur with prior ERP research (Chou & Chang, 2008; Gattiker & Goodhue, 2004, 2005) that OIPT is an appropriate theoretical lens that takes a systemic approach to explore ERP system implementation and its influence on operational performance. The ensuing discussion uses OIPT as the theoretical underpinning of the relationship between ERP implementation and operational performance.

OIPT focuses on the limited ability of organizations to process information. Uncertainty is a central concept in the theory that drives the need for information processing. When uncertainty is low, firms typically use four mechanisms to increase coordination among interdependent organizational tasks – hierarchy of authority, rules and programs, planning and goal setting, and narrow span of control. However, when uncertainty is high, firms tend to address it in two ways. One approach is to reduce the need for information that is processed through the use of slack resources, self-contained tasks, or environment management. The other approach is to increase the capacity to process information through the use of information systems (IS) or lateral relations (Galbraith, 1977). Low uncertainty environments are an anomaly in today's world (Galbraith, 2000, 2002) and hence our focus will be on the choices that ERP systems afford the firm in high uncertainty environments.

Prior research has typically examined ERP system implementation using early OIPT approaches (Galbraith, 1973, 1974, 1977) wherein IS was considered 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. However, Galbraith's later studies (Galbraith, 1994, 2000, 2002; Galbraith, Downey, & Kates, 2002; Galbraith, Lawler, & Associates, 1993; Mohrman, Galbraith, Lawler, & Associates, 1998) 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. In this study, we use Galbraith's later IS-based OIPT approach to discuss how ERP systems (modular as well as holistic) offer firms strategic options to reduce the need for information processing and/or increase the capacity to process information. In addition, we explore ERP research that attempts to tie such information processing advantages to the operational performance of the firm.

2.1. Reducing the need for information processing

High environmental uncertainty tends to increase the number of exceptions referred up the hierarchy. This overloads the firms' coordination mechanisms and prompts managers to look for ways to reduce the information needed to coordinate activities. Firms can act in three ways to reduce the information that is processed – create slack resources, create self-contained tasks, or manage their environment.

2.1.1. Creation of slack resources

Firms can reduce the number of exceptions by simply reducing their performance levels (Galbraith, 1977; Scott, 2003). For example, firms could increase their order delivery time. The longer the delivery time, the higher will be the probability that firms can complete the job on time. The longer delivery times also permit the creation of work-in-process inventories that act as a buffer against machine breakdowns, quality rejects, etc. Thus, fewer exceptions will arise, less information needs to be processed, and the exceptions can be handled by the existing hierarchies. However, reducing performance levels consumes more resources (for example, longer delivery times generate work-in-process inventories which, in turn, absorb capital that could be put to better use). It is also possible that this could have a negative influence on customer satisfaction. Hence, these slack resources could represent substantial costs to the firm.

An ERP system can reduce or obviate the need for firms to use slack resources. ERP systems provide access to a vast amount of real-time managerial information (for example, resource status such as inventory, or product development status, and hence delivery times). Cotteleer and Bendoly (2006) observe that, over time, firms fine-tune their ERP systems and leverage supply chain information to effect improvements in operational performance in areas such as order delivery time. Bendoly et al. (2009) suggest that firms which efficiently use ERP-sources information enhance operational performance in areas such as process standardization and on-time delivery performance.

2.1.2. Creation of self-contained tasks

The creation of self-contained tasks emphasizes the use of groups or units to handle projects, products, processes, customers, etc. This eliminates the use of shared resources, reduces the division of labor, and results in the point of decision being moved closer to the source of information (Galbraith, 1977, 2000, 2002; Scott, 2003). For example, a self-contained unit could have its fabricating and assembly operations, its own testing facilities, etc. This reduces scheduling conflicts, and improves delivery times. There are, however, costs associated with the use of self-contained groups such as a reduction in skill specialization, and costs associated with the division of labor.

Firms can configure their ERP systems to facilitate the use of self-contained units. Markus, Tanis, and Fenema (2000), and Koch (2001) suggest that firms can configure their ERP systems in different ways at the operational level, the business activity level, and the business process level. For example, firms that implement the human resources and the logistics-related modules can use self-service features to provide employees with greater discretion to handle activities such as purchasing. This contributes to better inventory management. The ability to customize user profiles, parameters, and processes, allows the firm to localize decision making in self-contained units; leverage cross-module ERP information flows and develop multi-tasking capabilities. Such module configurations get fine-tuned over time, and allow the firm to further improve operational performance.

2.1.3. Environmental management

Firms can modify their environment through the use of co-operative mechanisms (implicit, contracting, co-opting, etc.) whereby they interact with other entities in the environment to manage uncertainty (Fairbank, Labianca, Steensma, & Metters, 2006; Galbraith, 1977, 2000, 2002). For example, the implementation and configuration of logistics, supply-chain and customer relationship ERP modules, allows firms to proactively manage their organizational domain as well as relations with elements (e.g., suppliers and customers) in the value chain. The "best practices" embedded in these modules serve as information coordination mechanisms that facilitate standardization of processes and reduces the uncertainty faced by firms (Cotteleer & Bendoly, 2006; Hendricks et al., 2007; Yusuf, Gunasekaran, & Abthorpe, 2004).

2.2. Increasing the capacity to process information

Reduction in exceptions referred up the decision hierarchy can also be achieved by increasing the firm's capacity to process information. A firm can act in two ways to increase its information-processing capacity – invest in IS, or create lateral relations.

2.2.1. Investing in information systems

Galbraith (1977, 2000, 2002) and Scott (2003) indicate that firms can invest in IS to increase the capacity of existing channels of communication, create new channels, and introduce new decision mechanisms. Past research suggests that firms should consider four IS dimensions while handling uncertainty – decision frequency, scope of the database, degree of formalization, and the decision mechanism (Galbraith, 1977; Goodhue, Quillard, & Rockart, 1988; Goodhue, Wybo, & Kirsch, 1992).

The first dimension, decision frequency, refers to the length of time between decisions. The length of time depends on whether information flows are periodic or continuous (Galbraith, 1977). ERP systems typically fall under the continuous information flow category. In such environments, firms need to periodically augment their plans to reflect unexpected events. The frequency of such augmentation will, of course, depend on the levels of uncertainty surrounding the task/decision. The second dimension, the scope of the database, has been conceptualized as being either local or global (Goodhue et al., 1992). ERP systems use an integrated database to consolidate data and provide local and global information for effective decision-making. The ERP system can be configured to grant users selective access to information depending on their work roles (Clemmons & Simon, 2001; Koch, 2001; Markus et al., 2000).

The third dimension refers to the degree of formality of the collection and reporting processes (Goodhue et al., 1992). The ERP system standardizes business processes and serves as an efficient tool to identify critical events and help coordinate diverse outputs across supply chain resources. For example, it has been used to standardize financial and accounting processes throughout the firm. The fourth dimension refers to the capacity of the decision-making mechanism to process information and select alternatives (Galbraith, 1977; Huber, 1990). ERP systems continually collect information and provide timely availability of the information for decision-making. Also, these systems can be configured to capture information on local or global databases depending upon the specific needs of the firm (Koch, 2001; Markus et al., 2000). The continuous availability of information helps firms tackle process bottlenecks, reduce variability and promote even flow, thereby improving an important component of operational performance, i.e., delivery times (Cotteleer & Bendoly, 2006).

2.2.2. Creating lateral relations

Galbraith (1977, 2000, 2002), and Scott (2003) indicate that lateral relations help move the level of decision-making to where the information exists rather than bringing the information up to the point of decision-making. Firms use various mechanisms to move decisions down the hierarchy to the point of information origin. The extent to which lateral relations are used for this purpose will vary depending on the degree of uncertainty faced by the firm. ERP systems link processes across modules to coordination needs through mechanisms such as email, groupware, intranets, etc. (Bendoly & Jacobs, 2005; Galbraith, 2002; McGaughley & Gunasekaran, 2007). This matching of processes to coordination needs helps the firm build standardized decision-making structures/ processes that positively influence operational performance by moving operational decisions to lower organizational levels, thereby freeing those in higher echelons to focus on long-range strategic decisions.

3. Research model

The preceding discussion indicates the different ways by which ERP systems can be used to reduce uncertainty and improve operational performance. Clearly, firms can achieve their operational performance objectives by choosing one or a combination of strategies. For example, firms can deploy a single module to a business area and obtain operational benefits. Alternately, firms can implement a combination of modules that addresses multiple business areas. The systemic approach suggests that this combination of modules is more than just a collection of modular capabilities. Instead, it represents a system that, over time, offers capabilities that are greater than the sum of its parts (modules). Prior research (Chou & Chang, 2008; Gattiker & Goodhue, 2005; McAfee, 2002; Poston & Grabski, 2001) has attempted to partly examine some of the above issues separately. However, studies that have taken a systems view of the phenomenon with adequate scientific rigor are, by and large, absent. The paucity of theory-driven models provides a weak foundation for empirical work. This study attempts to address this research gap by investigating whether a relationship exists between the implementation status of the ERP system and changes in operational performance. Galbraith's relatively recent works (Galbraith, 1994, 2000, 2002; Galbraith et al., 2002, 1993; Mohrman et al., 1998) on IS-based OIPT provide the theoretical underpinnings for evaluating the operational performance benefits that accrue from the status of the ERP system implementation. Fig. 1 shows our general model of the relationship between ERP implementation status and operational performance.

3.1. ERP system implementation status

Several studies have demonstrated a significant relationship between the number of modules implemented and the time since implementation on the one hand, and operational performance on the other (Gattiker & Goodhue, 2005; Mabert et al., 2001; McAfee, 2002). A review and synthesis of relevant methodological studies yielded 14 modules commonly cited by researchers and vendors as comprising the ERP system (e.g., Appelrath & Ritter, 2000; Francalanci, 2001; Hernandez, 1998; Mabert et al., 2000; Madapusi, 2008; Olhager & Selldin, 2003; Yusuf et al., 2004). The 14 modules identified in the literature are: financials, controlling, plant maintenance, materials management, production planning, project

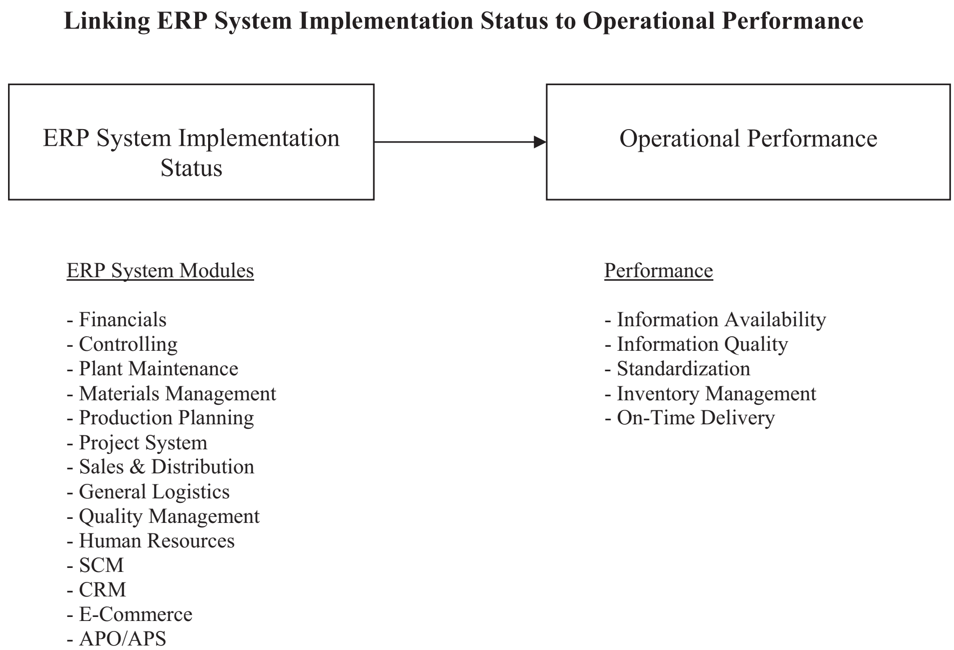

Fig. 1. Linking ERP system implementation status to operational performance.

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 14 modules are represented by the explanatory variables in the relationship depicted in Fig. 1 and their implementation status is expected to contribute in varying degrees to operational performance. A description of each of the 14 modules is provided in Exhibit 1.

3.2. Operational performance

Researchers have suggested that ERP implementation could have a significant influence on operational performance (Cotteleer & Bendoly, 2006; Cottelleer, 2006; Gattiker & Goodhue, 2004, 2005). A synthesis of relevant methodological studies yielded five measures commonly used to evaluate the operational performance of ERP systems (e.g., Davenport, 1998; Hawking & Stein, 2004; Mabert et al., 2000; Mabert, Soni, & Venkataramanan, 2003; Madapusi, 2008; Madhavan, 2000; Sarkis & Sundarraj, 2003). These measures are: information availability, information quality, standardization, inventory management, and on-time delivery. These five operational performance measures are represented by the response variables in the relationship depicted in Fig. 1. A description of the performance measures is provided in Exhibit 2.

3.3. Systemic approach to ERP implementations

Studies indicate that single-module ERP implementations that are fine-tuned over time and that target specific business needs, result in benefits to the firm (Hitt, Wu, & Zhouo, 2002; Klaus, Rosemann, & Gable, 2000). However, a significant number of ERP researchers suggest that firms improve their operational performance considerably when they implement a complete ERP system and periodically fine-tune the system to meet unique business needs (Bendoly & Jacobs, 2005; Gattiker & Goodhue, 2005; McAfee, 2002; Poston & Grabski, 2001). Research in other IS systems implementation areas provides additional support for the systemic concepts that underlie ERP systems. For example, in their empirical studies on material requirements planning (MRP) and manufacturing resources planning (MRP II) system implementations, Schroeder, Anderson, Tupy, and White (1981), White, Anderson, Schroeder, and Tupy (1982), and Duchessi, Schaninger, Hobbs, and Pentak (1988), demonstrate that the more complete the system and longer the system is operational, the higher is the likelihood of performance enhancement. Other system implementation studies in areas such as just-in-time (White, 1990), and quality (Berry, 1996) also suggest that the more complete the deployment and longer the usage of the system, the greater the performance benefits.

Over time, OIPT has evolved as researchers factored in the ubiquitous role of IS in helping firms handle uncertainty. Galbraith's recent works on IS-based OIPT (Galbraith, 1994, 2000, 2002; Galbraith et al., 2002; Mohrman et al., 1998) underscore the above systemic concepts that underlie ERP systems. In his various publications, Galbraith suggests that firms should integrate their front-office and back-office operations through IS-based module extensions so as to enhance performance. Moreover, the findings from his studies suggest that firms which implement modular systems and integrate them over time will obtain improved performance benefits. A synthesis of Galbraith's IS-based OIPT and ERP research findings indicates that firms that implement one or a few modules of an ERP system may derive benefits that are restricted to the functional areas and business activities targeted by these modules. The more modules that firms implement, the greater will be the benefits derived from the ability to address cross-functional needs. Firms will also engage in continuously fine-tuning their ERP systems to better serve business needs. This dual process of implementation and fine-tuning is expected to result in changes in performance. We investigate this phenomenon by testing the relationships proposed in Fig. 1 with the following hypotheses:

H1. The implementation status of individual ERP system modules contributes to changes in operational performance.

H2. The implementation status of an ERP system contributes to changes in performance.

Exhibit 1
Descriptors of the ERP system modules.

Financials:	This module constitutes the operational aspects of the general accounting and financial information for a business unit.
Controlling:	This module represents a business unit's cost structures and the factors that influence them.
Materials management:	This module comprises all activities related with material acquisitions such as purchasing, inventory, and warehouse.
Production planning:	This module addresses the different phases, tasks, and methodologies used in the planning of production and the process of production itself.
Sales and distribution:	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:	This module contains the tools and reports necessary to analyze and manage the status in supply-chain forecasts.
Project system:	This module handles all aspects of activities, resource planning, and budgeting of complex tasks.
Plant maintenance:	This module takes care of the maintenance of plant systems and supports graphical representations, connection to geographic information systems, and detailed diagrams.
Quality management:	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:	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:	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:	This module extends the scope of ERP systems to include automating functions such as sales, marketing, customer service, and collaborative order management.
E-commerce:	This module facilitates access to ERP processes and data from anywhere in the world through web-enabled ERP systems and portals.
Advance planner optimizer/ advance planner scheduler:	This module extends ERP systems to enable handling of complex processes such as shelf-life considerations, alternate routing, intermediate storage accounting, change-over matrixes, clean-down time considerations, and fixed capacity storage constraints.

Exhibit 2
Descriptors of the operational performance measures.

Information availability:	Information availability refers to the changes in the availability of integrated real-time information from the ERP system.
Information quality:	Information quality refers to the changes in the availability of consistent and reliable information from the ERP system.
Standardization:	Standardization refers to the streamlining and rationalization of business processes as well as information flowing through the firm.
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.
On-time delivery:	On-time delivery refers to changes in the order management/order cycle that facilitate on-time delivery of products/services to customers.

4. Research methodology

This research study used a field survey to obtain data from firms in India across a variety of production environments. A survey instrument 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. The data were analyzed using multiple linear regression analysis.

4.1. Instrument development

Dillman's (2000) tailored design method (TDM) for constructing the questionnaire was followed. The initial questionnaire was developed from a synthesis of ERP and other relevant system literature. It was validated through a four-step process – (1) inputs from focus groups of academicians in the US and India, (2) inputs from focus groups of practitioners in the US and India, (3) a pre-test using a graduate MBA (ERP) class in India, and (4) a pilot study in an Indian production firm that had implemented ERP. Feedback was incorporated at each step of the above questionnaire development process which allowed for an incremental and comprehensive development of the survey instrument. The final questionnaire included items that assessed business unit characteristics, respondent characteristics, implementation status of ERP modules, and benefits obtained from the ERP implementation.

4.2. Operational definitions

4.2.1. ERP system implementation status

The scales used to gather data on each of the modules were drawn from the Berry (1996), and White, Pearson, and Wilson (1999) studies. Data for these 14 modules were obtained using the mid-point of the assessment scale consisting of the following ranges of implementation statuses: not implemented (NI; scored "0"), implementation started within the last year (0 to <1 year; scored ".5"), implementation started 1 or more but less than 3 years ago (1 to <3 years; scored "2"), implementation started 3 or more but less than 5 years ago (3 to <5; scored "4"), and implementation started 5 or more years ago (5+; scored"6").

4.2.2. Operational performance

Items representing the five performance measures were designed to capture information on the changes in operational performance attributed to ERP system implementations. The data for each of the five performance measures were obtained using a 7-point Likert type scale ranging from 1 (disagree) to 7 (agree).

4.3. The sampling frame

Firms that were pre-dominantly engaged in production activities and belonging to the Confederation of Indian Industry (CII) and its affiliated associations formed the target population of this study. The CII, founded in 1885, is India's premier business association and the production firms represented in the CII can be considered as leaders in the use of information technology (IT) systems such as ERP. The production firms in the CII member directories 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 directories indicate 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 small and medium enterprises (SMEs), and hence can be considered as representative of India's production sector. Three thousand one hundred and seventy seven production firms were identified from the CII member directories. Telephone calls were made to each of the 3177 firms 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 short-listing of the names of 900 firms from the target population.

4.4. Data collection

Following Dillman's (2000) recommendations the questionnaire was mailed in two waves. Two hundred and thirty one responses were received for a response rate of 25.67%. Fifteen questionnaires with incomplete data and 13 questionnaires pertaining to service firms were discarded. The effective sample used for analysis was 203 firms – an effective response rate of 22.56%. In an attempt to assess non-response bias, follow-up calls were made to a random sample of non-respondents ($N = 34$; about 5% of the non-respondents) 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. Also, a perusal of the data separately compiled for all firms surveyed ($N = 203$), firms returning questionnaires from the first wave ($N = 115$), and firms returning questionnaires from the second wave ($N = 88$) indicates that that there was no systematic non-response bias present.

Podsakoff and Organ's (1986) recommendations for avoidance of common method bias were followed. 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. As a post-hoc test, Harmon's one factor test was used to assess whether common method bias is a problem in this study. Five factors with Eigen values greater than one were extracted from all the measures in this study and in total accounted for 63.05% of the total variance. The first factor accounted for 30.02% 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.

5. Analyses and results

5.1. Firm and respondent characteristics

The survey questionnaire gathered data on the size of the firm, firm type and origin, industry type, the type of ERP system implemented, and respondent characteristics. Results of the descriptive tests indicate that the sample is a good representation of the Indian production sector under consideration in this study. Most of the sampled firms belong to the private sector and represented 82.26% of the sample; public sector firms accounted for 15.76% of the sample and joint sector firms 1.98% of the sample. A majority of firms were of Indian origin and comprised 77.34% of the sample; multinational firms of foreign origin represented 19.7% of the sample while joint ventures constituted 2.96% of the sample. Sixty seven percent of the sample fell into one of 10 major industry groups. Business units in the automotive industry were the most frequently represented group accounting for 21.7% of the sample; and the next most frequently represented group was machinery and equipment representing 9.9% of the sample. Forty one point four percent of the sample had over 1000 employees; and 66% of the sample had at least 500 employees.

Firms that implemented a single vendor ERP system comprised 65% of the sample; best-of-breed (BOB) ERP systems represented 6.9% of the sample; and home-grown ERP systems accounted for 28.1% of the sample. SAP was the dominant ERP system implemented (29.6%) followed by Oracle/PeopleSoft (10.3%), with the rest being distributed among numerous ERP vendors. A majority (92.1%) of the respondents possessed more than 10 years of work experience. About half (50.7%) of the respondents were C-level managers; and 39.9% belonged to middle level management. A significant number (86.2%) of the respondents work in the IT/IS area. Ninety seven point five percent of the respondents had completed at least a bachelor's degree. As part of the pre-survey procedures, telephone calls were made to each of the surveyed firms to determine who would be the best person to contact in the sampled firms. The data indicates that the typical IT/IS respondent possesses a managerial background and has been specifically drafted from the general managerial ranks to the IS area for spearheading the ERP system implementation. This suggests that the respondents were knowledgeable about ERP systems and competent to evaluate the ERP systems in place at their sites.

5.2. Regression models

The data set was first examined to assess its suitability for multiple regression analyses. A review of the correlation matrix between the independent variables in this study revealed that multicollinearity was not a problem. Regressions assumptions were next examined. In particular, we reviewed assumptions of linearity, constant variance of the error terms, independence of the error terms, and normality of the error term distribution. No violations of the assumptions were found. Finally, a multiple regression was conducted to test whether demographic data influences the hypothesized relationships. No model was found to fit any of the demographic variables.

5.2.1. Testing Hypothesis H1

Hypothesis H1 was tested using separate regression models for each performance measure. The results of the regression analysis are presented in Table 1. They indicate partial support for Hypothesis H1.

The table provides the size of the standardized regression coefficients (β), coefficients of determination (R^2), and the F ratios (F) for the fitted models. To enhance readability and to facilitate ease of interpretation, only "significant" parameter estimates of the fitted models are provided. All non-significant parameter estimates are omitted from the table. A review of the output of the regression analysis indicates that eight of the 14 modules were supported. Except for six modules (project system, sales and distribution, human resources, SCM, CRM, and E-Commerce), all the other modules made a significant contribution to one or more of the five performance measures. Key findings on the performance enhancing abilities of the each of the ERP modules are as follows:

1. The quality management module is the only module that is significantly correlated with all the five performance measures.
2. Three modules are significantly correlated with four of the five performance measures. These modules are the controlling module, the plant maintenance module and the production planning module.

Table 1
Testing Hypothesis H1. Hypothesis 1: Relationships between implementation status of ERP system modules and operational performance.

Implementation status of ERP system modules	Performance														
	Inventory management			Information quality			On-time delivery			Standardization			Information availability		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
FI	.145*	.021	4.301*										.155*	.024	4.964*
CO	.154*	.024	4.913*	.229***	.053	11.174***				.162*	.026	5.433*	.167*	.028	5.770*
PM	.210**	.044	9.317**				156*	.024	5.043*	.193**	.037	7.752**	.176*	.031	6.437*
MM	.160*	.026	5.288*										.155*	.024	4.954*
PP	.185**	.034	7.145**	150*	.022	4.623*	.181**	.033	6.827**				.141*	.020	4.058*
GL				.201**	.040	8.423**				.161*	.026	5.379*	.154*	.024	4.868*
QM	.193**	.037	7.793**	190**	.036	7.489**	.138*	.019	6.920*	.168*	.028	5.822*	.212**	.045	9.473**
APO/APS				.158*	.025	5.157*									

Modules: FI – financials, CO – controlling, PM – plant maintenance, MM – materials management, PP – production planning, GL – general logistics, QM – quality management, APO/APS – advance planner and optimizer/advance planner and scheduler
All β values are standardized regression coefficients
* Significance: $p < .05$.
** Significance: $p < .01$.
*** Significance: $p < .001$.

Table 2
Testing Hypothesis H2. Hypothesis 2: Relationships between implementation status of ERP system and operational performance.

Implementation status of ERP system (14 modules)	Performance														
	Inventory management			Information quality			On-time delivery			Standardization			Information availability		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
ERP system	.205**	.042	8.788**	.188**	.035	7.325**	.144*	.021	4.239*	.183**	.033	6.966**	.200**	.040	8.409**
Implementation status of ERP system (8 modules)	**Performance**														
	Inventory management			Information quality			On-time delivery			Standardization			Information availability		
	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F	β	R^2	F
ERP system	.222***	.049	10.426***	.228***	.052	11.047***	.145*	.021	4.335*	.198*	.039	8.216*	.219**	.048	10.152**

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

3. The general logistics module is significantly correlated with three performance measures.
4. The financials and the materials management modules are significantly correlated with two performance measures.
5. The APO/APS module is significantly correlated with only one performance measure.
6. Six of the modules (the project system, sales and distribution, human resources, SCM, CRM, and the E-Commerce modules) were not found to be significantly correlated with any of the performance measures.

When the regression analyses results are viewed from a change in operational performance perspective the key findings are as follows:

1. The regression model for information availability is the best fitted model and shows that seven modules are statistically significant (except the project system, sales and distribution, human resources, SCM, CRM, E-Commerce, and the APO/APS modules).
2. The quality management module has the most significant influence on the information availability performance measure. In addition, the size of the β, R^2, and the F values for two of the modules (controlling, and plant maintenance), besides the quality management module, further indicates that these modules are important variables for predicting information availability.
3. The βs for the controlling module and the general logistics modules indicate that they have the most significant influence on changes in information quality.
4. The β for the plant maintenance and the quality management modules indicate that they have the most significant influence on improving inventory management.
5. The β for the production planning and the plant maintenance modules indicate that they have the most significant influence on enhancing on-time delivery and standardization respectively.

5.2.2. Testing Hypothesis H2

Multiple regression analysis was used to test Hypothesis H2. The regression models assessed the changes in performance resulting from the implementation of the ERP system as a whole. A summated scale was constructed to measure the implementation status of the ERP system. A test for internal consistency of the 14-module implementation status scale yielded a Cronbach's Alpha of 0.876. The results of the regression analysis indicate full support for Hypothesis H2 and are presented in the first part of Table 2. The Table provides 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 provided. As before, all non-significant parameter estimates are omitted from the table to enhance readability and interpretation.

The regression models indicate support for the relationship between the implementation status of the ERP system and changes in performance. This suggests that as the implementation status of the ERP system increases, operational performance is significantly influenced. The regression model for the inventory management performance measure is the best fitted model. The size of the β values for the other performance measures also indicates a good fit in the regression models.

The results in Table 1 indicate that, when evaluated independently, six of the fourteen modules (project system, sales and distribution, human resources, SCM, CRM, and the E-Commerce modules) do not contribute significantly to performance. The results in the first part of Table 2, however, reveal that the ERP system (comprising of 14 modules – inclusive of the above six modules that were not significant in Table 1) contributes significantly to all the five performance measures. This suggests that the six modules that were not significant in Table 1 contribute to operational performance, albeit indirectly, due to systemic synergies underlying the ERP system. This finding opens up an interesting line of inquiry on the marginal utility derived from implementing the six modules (found to be not significant as shown in Table 1). That is, are firms systemically better-off with a limited 8-module ERP system rather than a full-blown 14-module ERP system? To investigate and better understand this issue, another summated scaled was constructed comprising of the eight modules that were found to be significant in Table 1. The internal consistency of the 8-module scale was estimated using Cronbach's Alpha. Internal consistency analysis yielded a reliability coefficient of 0.860. A test for Hypothesis H2 was conducted by running multiple regression analysis and the results are presented in the second part of Table 2. The results indicate that the implementation of the 8-module ERP system provides higher systemic benefits when compared to the 14-module ERP system.

6. Discussion

ERP systems represent a significant investment and a major source of operational performance improvement for firms. In this paper, we examined the influence of ERP system implementations on operational performance. We moved beyond prior early-OIPT-based ERP research (Chou & Chang, 2008; Gattiker & Goodhue, 2004, 2005) and used an IS-based OIPT lens (Galbraith, 2000, 2002; Galbraith et al., 2002) to explore the influence of ERP systems implementation on operational performance. Data were gathered through a field study of production firms. The results indicate support for prior arguments (Cottelleer, 2006; Mabert et al., 2001; McAfee, 2002; Poston & Grabski, 2001) that ERP system implementation is significantly related to operational performance. Our findings advance current thinking by confirming that ERP system implementations influences operational performance, at both, the modular and the systemic levels (Cotteleer & Bendoly, 2006; Gattiker & Goodhue, 2004, 2005; Klaus et al., 2000).

Empirical support for our hypothesized model provides two insights. First, differences in ERP system implementation status result in varying performance benefits for the firm. That is, as the implementation status of the ERP system module increases, operational performance is significantly influenced. This suggests that to obtain realistic estimates of return on investment (ROI), firms must evaluate the returns associated with implementation of the ERP system over time.

Second, the results make clear that as the implementation status of the ERP system increases, operational performance improvements intensify. This suggests that firms should adopt a holistic and systemic approach to effectively exploit synergistic enhancements derived from the ERP system. Our findings are discussed in more detail below.

6.1. Modular and systemic contributions to performance enhancement

6.1.1. Performance enhancements at the modular level

Past research (Cotteleer & Bendoly, 2006; Gattiker & Goodhue, 2005) indicates that the ERP system's influence increases over time. Our results support such arguments and our analyses further demonstrate that differences in module implementation status leads to differing operational performances. Below, we discuss the most significant influences on operational performance. Areas where our findings differed from prior research are also highlighted.

6.1.1.1. Overall operational performance enhancement. The implementation status of the quality management module (mean implementation status = 2.24 years, percentage of sampled firms that implemented this module = 66%) has the most significant influence on overall operational performance. Viewed through the IS-based OPIT lens (Mohrman et al., 1998), the above suggests that a total quality management approach, driven by strategies to reduce information needs and increased information processing capacity, could increase the firm's ability to meet competitive operational challenges. This is in line with literature (Ferdows & Meyer, 1990), which suggests that quality initiatives nurture the seeds of lasting improvements in firm performance.

6.1.1.2. Information quality enhancement. The implementation status of the controlling module (mean = 2.23 years, 61.6% of firms) is the most significant predictor of the information quality performance measure. This module typically contains the tools and reports necessary to analyze and manage budgeting and cost structures. Our findings are in line with IS-based OPIT (Galbraith, 2000), which suggests that the effective use of the controlling module's formal collecting and reporting processes could have a direct bearing on handling uncertainties related to cost and budgeting activities and hence positively influences the quality of information flowing through the supply chain.

A significant relationship was also noted between the implementation status of the APO/APS module and information quality. The APO/APS module typically handles activities related to demand forecasting and consensus, and strategic and tactical network optimizations. Our finding underscores the importance of firms leveraging quality information to better manage environmental uncertainty.

6.1.1.3. Inventory management and standardization enhancements. The implementation status of the plant maintenance module (mean = 1.55 years, 46.8% of firms) is an important contributor to enhancing inventory management and standardization. Our findings confirm that graphical representations, connection to geographic information systems, and detailed diagrams forming part of the plant maintenance module helps standardize and improve the order-to-market flow cycle (Madapusi, 2008).

6.1.1.4. On-time delivery enhancement. The implementation status of the production planning module (mean = 2.96 years, 80.3% of firms) is a significant predictor of changes in on-time delivery. This increase in information available on the different phases, tasks, and methodologies used in both the planning of production and the process of production helps firms tackle bottlenecks, promote even flow, and meet delivery deadlines (Cotteleer & Bendoly, 2006).

6.1.1.5. Insignificant relationships. In the paragraphs below we highlight a few ERP modules that did not demonstrate anticipated enhancements to operational performance.

The implementation status of the human resources module was not found to be significantly related to any of the five performance measures. This was a surprising finding given the reasonably high mean (1.72 years) and percentage (57.6% of firms). However, IS-based OIPT and ERP research (Madapusi, 2008; Mohrman et al., 1998) indicates that this module is often heavily customized – from applicant screening to payroll accounting to employee development. Therefore, our findings seem to suggest that firms may not yet have realized the full benefits from this module, perhaps, due to a focus on automating employee transaction activities and underutilization of other module capabilities such as employee lifecycle management, self-service options, and workforce deployment.

The implementation status of the sales and distribution module was not found to be significantly related to any of the five performance measures. This was another surprising finding given the relatively high mean (3.40 years) and percentage (89.7% of firms). Again, IS-based OIPT and ER research (Madapusi, 2008; Mohrman et al., 1998) indicate that this module is highly integrated and intensively transactional in nature. Hence, the benefits from this module could be subsumed under the performance gains from other ERP system modules. That is, the sales and distribution module contributes more to the performance gains of the ERP system as a whole (through other modules) rather than as an individual module.

6.1.2. Performance enhancements at the systemic level

Hypothesis H2 was fully supported, suggesting that there appears to be a systemic underpinning to ERP system implementations. As the implementation status of the ERP system as a whole advances, its ability to provide operational performance improvements is enhanced. We believe that empirical support for Hypothesis H2 accrued because the ERP system is tightly coupled (Galbraith, 2000; Galbraith et al., 2002; Gattiker & Goodhue, 2004), allowing for better coordination among a firm's value-adding activities. Our finding should be viewed as a call for a shift in thinking from the traditional modular view of ERP to a more holistic view of ERP system and a systemic approach to ERP implementations. We posit that such an approach provides for a more effective exploitation of the ERP system.

Our analysis confirmed that firms implementing an 8-module ERP system derived greater systemic benefits that those that employed all 14 modules. Firms extend their ERP system beyond organizational boundaries. The integrated nature of the ERP system helps lock-in and amplify the benefits of additional modules. However, we opine that the law of diminishing marginal utility may apply to ERP system implementations. That is, extending module implementation beyond a certain "critical" number may not provide the firms with further performance improvements. Indeed, firms that exceed the critical number (in the Indian context, it is 8 modules) may experience a decrease in operational performance through such actions.

6.2. Implications for theory and practice

The rapid advances in the ERP field have resulted in research being driven more by practice than theory. Though the findings from these pre-dominantly descriptive and prescriptive studies are valuable, there is a need for appropriately anchored research. Prior empirical work used early-OIPT frameworks (e.g., Gattiker & Goodhue, 2004, 2005). In this study we move the research stream forward by using an IS-based OIPT approach (Galbraith, 2000, 2002; Galbraith et al., 2002) to examine the relationship between ERP systems implementation and operational performance.

IS-based OIPT (Galbraith, 2000, 2002; Galbraith et al., 2002) helps us place ERP in a stronger nomological net to examine how ERP systems offer firms the options to reduce the need for information processing and/or increase the capacity to process information. The findings suggest that the implementation of ERP system modules provide unique strategic options for firms to reduce the need and/or increase the capacity to process information, and usage and fine-tuning of the modules over time breeds learning benefits that improve returns from these modules. Our findings further suggest that ERP systems facilitate handling uncertainty using options that call for reducing the need and/or increasing the capacity to process information. Finally, as the implementation status of such systemic

ERP systems increases, significant operational performance benefits appear to accrue.

Pil and Cohen (2006) suggest that firms modularize their products in unique ways and the resulting modular capabilities limit imitation opportunities and provide innovation advantages. We extend these arguments to an ERP system implementation context and suggest that initial ERP module implementations typically tend to be standard vendor offerings. The best practices embedded in vendor-configured modules are available to all firms and hence are more likely to provide similar operational performance benefits and hence competitive parity. As the implementation status of the ERP modules increases, firms continuously improve on the modules to better serve their specific business needs. The exploitation of such modular capabilities tends to be mainly limited to the specific business activities targeted by the modules.

Our research suggests that a modular approach may limit the usefulness of the ERP system for the firm. Moving away from a typical modular mind-set to a systemic mind-set would help firms leverage synergistic value. Moreover, a systemic mind-set would give managers reason to pause and consider overall business needs before incorporating additional modules. This mind-set would also serve to catalyze decision making as managers seek to match the ERP implementations to evolving business needs. Finally, it would provide management with an opportunity to integrate ERP best-practices across modules. Over time, the accumulated tacit knowledge will be difficult to imitate (Srivardhana & Pawlowski, 2007) and could provide the firm with an enduring competitive advantage.

6.3. Limitations of the study

The results should be interpreted with caution owing to the cross-sectional nature of the study. As business conditions evolve, firms may expand the scope of their implementations beyond the enterprise. Hence, additional module implementations (beyond the 8-module ERP system in the Indian context, for a typical firm in the production sector) may be necessary to better handle internal and external environmental uncertainty. In later years, as the implementation status of the existing module implementations such as SCM, CRM, and E-Commerce increases, significant relationships with operational performance measures could occur. Firms should, however, first consider whether their systemic business needs are going to be met before embarking on any additional module implementation. The current study was conducted on firms in the production sector of the Indian economy. Hence, caution should also be exercised in applying the study's findings to firms operating in a pre-dominantly service environment or to countries in other parts of the world.

7. Conclusion

In this study, a conceptual model was developed and a survey instrument constructed to gather data for testing the hypothesized model relationships. The results indicate that the contributions of different ERP system modules vary with different measures of operational performance and that a systemic ERP system implementation contributes to operational performance changes. Because performance varies with implementation status, it is important that managers focus on holistic integration to derive maximum systemic gains. It is the systematic combination of modules, rather than ERP implementation per se, that dictates performance enhancement.

Our findings suggest that an 8-module ERP system provides optimal systemic benefits for the stereotypical firm in the Indian production sector. The findings also suggest that merely throwing more modules (beyond the eight modules identified in this study) at existing business challenges may not help either. On the contrary, they could very well exacerbate the situation. Longitudinal studies would help to further validate the findings of this study.

We hope future research extends our line of thinking and considers the use of longitudinal designs to capture and tease out the time delayed effects between ERP system fine-tuning (at the module and sub-module levels) as well as upgradation, and changes in operational performance. Data could also be collected from multiple sources within the firm. Multi-source studies would enable the investigation of linkages among the modular components that support intra-firm and inter-firm information flows and their role in helping firms manage environmental uncertainties.

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