

INVESTIGATING THE INFLUENCE OF PROJECT MANAGEMENT ON ERP SYSTEM INTEGRATION

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ABSTRACT

The purpose of this study is to examine the influence of project management on enterprise resource planning (ERP) system integration. A model was developed, and data gathered through a survey instrument to test the hypothesized model relationships. The model relationships were tested using factor analysis and multiple linear regression analysis. The results indicate that ERP system integration results in differential performance benefits to firms; further, project management increases the performance benefits that accrue from ERP systems integration. The findings suggest that increased performance benefits are obtained when firms ensure that ERP system integration and project management go in tandem with each other.

Keywords: ERP System Integration, Operational Performance, Project Management.

INTRODUCTION

The global enterprise resource planning (ERP) market has registered dramatic growth in the past nearly three decades, from about \$1 billion in 1990 (Mabert, Soni, & Venkataramanan, 2000) to about \$35 billion in 2018 (Kostoulas, Anderson, & Pang, 2019). Early implementers deployed ERP system modules that addressed intra-firm activities pertaining to the finance, logistics, and human resources functions. Firms after stabilizing their intra-firm deployments, turned their attention to extending their implementations with the addition of modules that addressed inter-firm activities pertaining to the firms' suppliers and customers across the supply chain (Seddon, Calvert, & Yang, 2010; Kurbel, 2016).

Past studies indicate that ERP system deployments result in improvements in a firm's operational performance (Mabert, Soni, & Venkataramanan, 2001; Madapusi & D'Souza, 2012). The early intra-firm ERP system deployments enabled firms to streamline and integrate

their data and process flows (Mabert et al., 2001; Hitt, Wu, & Zhou, 2002). Firms then fine-tuned their existing deployments over time to better serve their business needs and also added modules to extend their ERP systems to their suppliers and customers. Integrating and extending the ERP system across the supply chain helped firms further improve their operational performance (Hendricks, Singhal, & Stratman, 2007; Madapusi & Ortiz, 2019).

That said, various studies indicate that nearly half of all ERP system implementations face problems and fail to achieve their stated objectives (Hong & Kim, 2001; Vemuri & Palvia, 2006). The intriguing aspect about most failures is that even though firms had technically deployed their ERP systems successfully, they were unable to extract business benefits from them. Researchers suggest that this is mainly due to firms failing to undertake effective project management tasks and activities in parallel with the technical deployment and integration of their ERP systems (Chen, Law, & Yang, 2009; Badewi & Shehab, 2015; Badewi, 2016).

Researchers such as Stratman (2007), and Roh & Hong (2015) indicate that a systems concept underlies ERP system modules that support various intra and inter-firm activities. Their findings suggest that the integration between the various ERP system modules facilitates a systems deployment approach that would enable firms to enhance their performance. Chen et al. (2009), and Ara & Al-Mudimigh (2011) indicate that significant performance benefits accrue to firms that focus on project management tasks while deploying their ERP systems. Their findings suggest that the benefits of ERP system deployments are maximized when project management practices are leveraged to facilitate ERP systems integration.

In this study, we seek to advance this stream of research by examining the moderating influence of project management on the relationship between ERP system integration and operational performance. Firms that implement more modules will obtain benefits pertaining to the business activities at which the modules are targeted. This is because firms will derive increased benefits owing to the linkages among the different modules. As firms fine-tune their ERP systems over time they customize the various modules to better suit their business needs. Moreover, firms that effectively manage their project management tasks over the ERP system life cycle can reduce their module deployment times and reap enhanced benefits from their ERP systems. The above ongoing process results in enhanced performance as firms leverage project management tasks to unlock the potential worth of ERP systems integration.

The rest of the paper proceeds in the following manner. First, we first provide a brief literature review that leads to the development of a research model. Next, we test the model through a survey conducted on production firms in India that have deployed ERP systems. The data were then analyzed and evaluated to test the model relationships. Lastly, we provide an overall summary and discuss the implications of the findings.

LITERATURE REVIEW

Past research indicates that a systems concept underlies ERP systems and that a project management-based implementation approach can enhance performance benefits for firms. Davenport (1998), Davenport, Harris, & Cantrell (2004), and Bjelland & Haddara (2018) indicate that 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. The integration of various modular applications through a combination of tools, technologies, and fit strategies results in the seamless coordination of business activities throughout the firm.

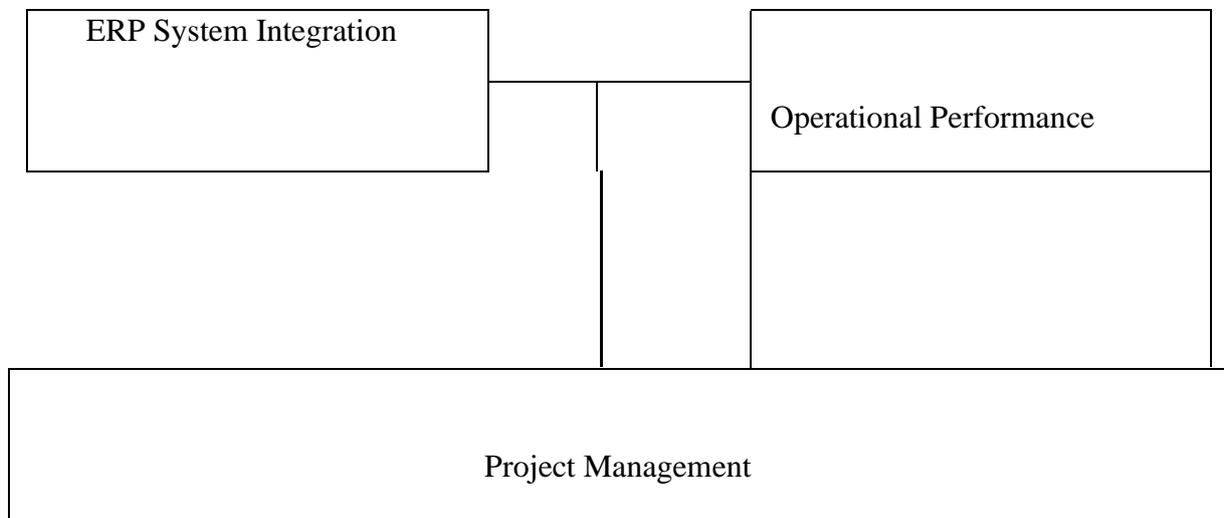
Bendoly & Jacobs (2005), Stratman (2007), Bendoly (2013), and Hwang & Grant (2016) examine the integration of various modules comprising the ERP system. Their studies indicate that the modules comprising the ERP system embed integration-enabling technologies thereby enabling cross-functional information flows. Past ERP research studies indicate that firms derive operational performance benefits by implementing more modules of the ERP system (Mabert et al., 2001; Gattiker & Goodhue, 2004; Madapusi & D'Souza, 2012).

Researchers such as Poston & Grabski, (2001), Kumar, Maheshwari, & Kumar (2003), and Madapusi & Ortiz (2019) demonstrate that ERP system operational benefits accrue to firms with effective usage of the system over a number of years. The findings of the above studies suggest that higher levels of benefits accrue as more and more ERP modules are implemented, and the modules are fine-tuned over time. ERP system deployments typically address intra- and inter-firm activities and achieve operational benefits such as improved inventory management, standardization, and on-time delivery (Mabert, Soni, & Venkataramanan, 2003; Hawking & Stein, 2004; Madanhire & Mbohwa, 2016).

Firms generally reported success in their ERP system deployments; however, there are many failures in implementing these systems (Buckhout, Frey, & Nemeč Jr., 1999; Vemuri & Palvia, 2006; Momoh, Roy, & Shehab, 2010). Firms faced hardships in successfully completing their implementations and achieving effective integration due to numerous project management challenges. Most firms adopted a project management-based implementation approach to overcome their implementation difficulties. Studies indicate that firms which effectively focus on project management tasks will achieve implementation success (Carroll, 2008; Tsai, Shaw, Fan, Liu, Lee, & Chen, 2011; Taniguchi & Onosato, 2017). Those firms which effectively manage their project management activities can shorten their implementation time and harness significant benefits from their ERP systems. The ERP system integration and its relationships to changes in operational performance, and the moderating influence of project management on the above relationship are shown in the Figure 1 below.

FIGURE 1

THE RELATIONSHIP BETWEEN ERP SYSTEM INTEGRATION AND OPERATIONAL PERFORMANCE AS MODERATED BY PROJECT MANAGEMENT



Past ERP research indicates that firms can leverage their ERP systems and enhance their business performance with the implementation of more and more modules that increasingly address their various business needs as well as through effective system use and fine-tuning over a number of years. Tushman & Nadler (1978), Mohrman, Galbraith, & Lawler III (1998), and Galbraith's (1977, 2000, 2002) organizational information processing studies suggest that appropriate information systems' could be leveraged to adopt a combination of approaches to meet uncertainty and enhance a firm's operational performance. Such approaches involve effectively handling uncertainty by deploying integrated ERP systems, which reduce the need for information processing as well as increase the need for information processing,

thereby increasing the coordination of internal and external business activities. These studies further suggest that the implementation of modular systems and their integration and fine-tuning 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 significant performance benefits from the implementation of more and more ERP modules, and fine-tuning these modules over time. Accordingly, the first linkage in the model in Figure 1 suggests that a relationship exists between ERP system integration and changes in a firm's operational performance.

H1: ERP system integration contributes to changes in operational performance.

A synthesis of ERP system research indicates that firms that effectively manage their project management activities can successfully implement their ERP systems. Also, a project management-based implementation approach enables firms to effectively integrate, use, and fine-tune the modules of the ERP system over a number of years. This results in enhanced performance benefits accruing to firms from their ERP systems. Tushman & Nadler (1978), Mohrman et al. (1998), Galbraith (2000, 2002), and Galbraith, Downey, & Kates's (2002) organizational information processing studies indicate that the technical implementation of information systems' in organizations should be accompanied in parallel by appropriate project management activities. Their studies suggest that firms should focus on project management activities to successfully implement and integrate information systems. The findings of these studies, in the context of this research study's objectives, suggest that project management activities influence the relationship between ERP system integration and changes in a firm's operational performance. Accordingly, the second linkage in the model in Figure 1 suggests that project management moderates the relationship between ERP system integration and changes in a firm's operational performance.

H2: Project Management moderates the relationship between ERP system integration and changes in operational performance.

METHODOLOGY

The data collection instrument was initially developed from a synthesis of ERP system as well as other relevant research studies considered pertinent to this study's objectives. The questionnaire development involved a three-step process – inputs from focus groups of academicians and practitioners, a pre-test in a graduate ERP class, and a pilot study in a production firm that had implemented ERP. Feedback from the respondent groups was incorporated at each step of the questionnaire development process. The final questionnaire collected information pertaining to business unit characteristics, respondent characteristics, ERP system integration, project management tasks critical to ERP system implementation, and changes in operational performance measures due to the ERP system deployment.

Operational Definitions

Independent Variables

A synthesis of different types of methodological studies yielded four questions that assessed the integration of ERP systems (Gattiker & Goodhue, 2004; Davenport et al., 2004; Stratman, 2007). The first question assessed whether the implementation of more ERP modules increases performance benefits. The second question surveyed whether fine-tuning of ERP modules over time increases performance benefits. The third question assessed whether internal coordination of business activities increased with implementation of more ERP modules. The fourth question surveyed whether the implementation of more ERP modules increases the external coordination of business activities. The data for each of the questions were obtained using a 7-point Likert type scale ranging from 1 (disagree) to 7 (agree).

Dependent Variables

A synthesis of different types of methodological studies yielded three operational performance measures commonly cited by researchers as used to evaluate the performance of ERP systems (Poston & Grabski, 2001; Mabert et al., 2003; Tarafdar & Roy, 2003; Madapusi & D'Souza, 2012). The performance measures are inventory management, standardization, and on-time delivery. The data for each of the performance measures were obtained using a 7-point Likert type scale ranging from 1 (disagree) to 7 (agree).

Moderating Variable

Project management refers to the coordination, scheduling, and the monitoring of tasks and activities to ensure successful ERP system implementation (Weston Jr., 2001; Chen et al., 2009; Tsai et al., 2011). Five items were used to assess project management. The first question assessed whether the tasks to be performed during the ERP project are clearly defined. The second question surveyed whether there was a formal management process to track external consultant activities. The third question assessed whether project tasks were reviewed on a periodic basis. The fourth question surveyed whether the project leader was experienced in project management. The fifth question assessed whether all project changes are clearly documented. The data for each of the five items were measured using a 7-point Likert type scale ranging from 1 (disagree) to 7 (agree).

Data Collection

To obtain data on the implementation of ERP systems, production firms that formed part of the Confederation of Indian Industry (CII) member directory were identified as the population for this study. This approach resulted in the selection of the names of 900 firms from the target population. The questionnaire was mailed out in two waves and a total of 231 responses were returned for a response rate of 25.67% (231/900). Fifteen questionnaires with incomplete data and 13 questionnaires pertaining to service firms were discarded. The effective sample used for analysis was 203 firms (203/900 – response rate of 22.56%). The sample data were compiled separately – firms surveyed in the first wave (N = 115), and firms surveyed in the second wave (N = 88) – and examined. The data indicated that the response rates for the demographic characteristics were similar across firms surveyed in the first and second waves. The above findings suggest that the results of the study were not influenced by non-response bias. Podsakoff and Organ's (1986) pre-hoc techniques for avoidance of common method bias were followed. This involved the use of pre-hoc techniques such as scale re-ordering, use of a purposive sampling technique, and the adoption of a multi-mode survey method to increase the survey response rate. Post-hoc techniques involved the use of Harmon's one-factor test. A single factor that accounted for most of the variance did not emerge, suggesting that the study did not suffer from common method bias.

ANALYSIS & RESULTS

The survey questionnaire gathered demographic data pertaining to the size of the firm, firm type and origin, industry, unionization, production system used, ERP system implemented, and respondent characteristics.

Firm and Respondent Characteristics

The number of employees over 1,000 was the category most frequently represented accounting for about 42% of the sample. More than half the firms in the sample have a mix of both unionized and non-unionized environments and represent about 55% of the sample. A majority of the organizations are of Indian origin (78% of the sample) and belong to the private sector (82% of the sample). Make-to-order was the primary production system used by firms

in the sample (62%), with a repetitive type production flow being the one most frequently represented (26%). A wide variety of industries are represented in the sample. The majority of industries (67% of the sample), however, fall into one of ten major industry groups with the automotive industry accounting for 21% of the sample.

The majority of the respondents possess more than 10 years of work experience accounting for 92% of the sample and about 57% have been with the present organization formore than 10 years. More than half the respondents belong to the top management category and account for 51% of the sample. This is closely followed by the middle management category (40% of the sample). A majority of the respondents work in the information technology/systems area and represent 85% of the sample. Ninety nine percent of the respondents possess a bachelor’s degree and above, with nearly 59% having a master’s degree.

The majority of the organizations in the sample implemented a single vendor ERP system representing 68% of the sample. SAP is the dominant ERP system implemented by 29% of the sampled organizations. In-house developed ERP systems represent the second most dominant ERP system implemented among the sampled firms accounting for 26% of the sample.

Factor Analysis

The data were examined to assess their suitability for conducting factor analysis. Visual inspection of the correlation matrix for the project management and the operational performance factors 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 mediocre to meritorious and the Bartlett’s tests of sphericity was significant. Hence, the data were appropriate for conducting factor analysis. The data for the project management factor were first factor analyzed. The results of the factor analysis are shown in Table 1. An examination of the factor loadings (using latent root criterion and scree test) indicated that all the items correctly loaded on a five-factor solution, with factor loadings exceeding 0.70 and accounting for about 75.87% of the variance. Internal consistency analysis (Cronbach’s Alpha) for the project management factor scale was 0.92. A summated scale was developed for the project management variable.

**TABLE 1
OPERATIONAL PERFORMANCE COMPONENT ANALYSIS FACTOR MATRIX**

onal Performance	ctor Loadings
y Management	0.680
lization	0.639
Delivery	0.779

1) Cronbach’s Alpha = 0.78

The data for the operational performance factor were then factor analyzed. The results of the factor analysis are shown in Table 2. An examination of the factor loadings (using latent root criterion and scree test) indicated that all the items correctly loaded on a three-factor solution, with factor loadings exceeding 0.64 and accounting for about 69.94% of the variance. Internal consistency analysis (Cronbach’s Alpha) for the operational performance scale was 0.78. A summated scale was developed for the operational performance variable.

**TABLE 2
PROJECT MANAGEMENT COMPONENT ANALYSIS FACTOR MATRIX**

Management	ctor Loadings
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tasks to be performed during the ERP project are clearly defined.	0.881
a formal management process to track external consultant activities.	0.858
tasks are reviewed on a periodic basis.	0.862
Project leader is experienced in project management.	0.864
Project changes are clearly documented.	0.889

1) Cronbach's Alpha = 0.92

Regression Analysis

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, and no violations were noted. Hence, the data were appropriate for conducting regression analysis.

Testing Hypothesis H1

A test for hypothesis H1 – ERP system integration contributes to changes in operational performance – was conducted by running standard linear regression analyses and developing two sets of regression models. The first set of regression models involved developing regression models to analyze operational performance (Table 3), and the second set of regression models involved developing separate regression models to analyze each of the three operational performance measures (Table 4). The tables show 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 3
RELATIONSHIP BETWEEN ERP SYSTEM INTEGRATION AND OPERATIONAL PERFORMANCE

System Integration	Operational Performance		
	R^2	β	F
Installation of more modules	0.463***	0.215	54.970***
Longing of system over time	0.449***	0.202	50.737***
Coordination of business activities	0.428***	0.184	45.176***
Coordination of business activities	0.389***	0.151	35.737***

- 1) β values are standardized regression coefficients
- 2) Significance: * $p < .05$, ** $p < .01$, *** $p < .001$
- 3) Only significant parameter estimates shown

TABLE 4
RELATIONSHIP BETWEEN ERP SYSTEM INTEGRATION AND EACH OPERATIONAL PERFORMANCE MEASURE

System Integration	Management			Delivery			Information		
	R^2	β	F	R^2	β	F	R^2	β	F
Installation of more modules	0.394***	0.155	36.972***	0.382***	0.146	34.407***	0.354***	0.125	28.746***
Longing of system over time	0.390***	0.152	35.965***	0.285***	0.081	17.737***	0.366***	0.134	31.097***
Coordination of business activities	0.301***	0.091	20.080***	0.371***	0.138	32.058***	0.416***	0.173	42.136***
Coordination of business activities	0.419***	0.175	42.783***	0.330***	0.109	24.485***	0.306***	0.093	20.695***

- 1) β values are standardized regression coefficients
- 2) Significance: * $p < .05$, ** $p < .01$, *** $p < .001$
- 3) Only significant parameter estimates shown

As can be seen from tables 3 and 4, the implementation of more ERP modules has the most significant and positive influence on operational performance, with the inventory management performance measure being impacted the most. This was closely followed by the on-time delivery and the standardization performance measures. The fine-tuning of ERP modules over time increases operational performance, with inventory management being the most statistically significant measure. The standardization and the on-time delivery performance measures respectively come next exhibiting highly significant statistical relationships. The internal coordination of business activities increases with implementation of more ERP modules. The standardization measure was the most statistically significant of all performance measures followed by on-time delivery and inventory management. The implementation of more ERP modules increases the external coordination of business activities. Inventory management was the performance measure that exhibited the most significant statistical relationship followed by on-time delivery and standardization.

Testing Hypothesis H2

A test for hypothesis H2 – project management moderates the relationship between ERP system integration and changes in operational performance – was conducted by running standard multiple linear regression analyses and developing two sets of regression models. The first set of regression models involved developing regression models to analyze the interactional effects of ERP system integration and project management on operational performance (Table 5), and the second set of regression models involved developing separate regression models to analyze the interactional effects of ERP system integration and project management on each of the three operational performance measures (Table 6). The tables shows the size of the standardized regression coefficients (β), 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 table.

**TABLE 5
INTERACTION EFFECTS OF PROJECT MANAGEMENT ON THE
RELATIONSHIP BETWEEN ERP SYSTEM INTEGRATION AND OPERATIONAL
PERFORMANCE**

Interaction Effects (Project Management x System Integration)	Operational Performance		
	ΔR^2	ΔF	
Management x			
Implementation of more modules	0.358**	0.025	7.476**
Fine-tuning of system over time	0.664*	0.019	5.519*
Internal coordination of business activities	0.619*	0.015	4.347*

- 1) β values are standardized regression coefficients
- 2) Significance: * $p < .05$, ** $p < .01$, *** $p < .001$
- 3) Only significant parameter estimates shown

**TABLE 6
INTERACTION EFFECTS OF PROJECT MANAGEMENT ON THE
RELATIONSHIP BETWEEN ERP SYSTEM INTEGRATION AND EACH
OPERATIONAL PERFORMANCE MEASURE**

Interaction Effects (Project Management x System Integration)	Inventory Management		Standardization		On-time Delivery	
	ΔR^2	ΔF	ΔR^2	ΔF	ΔR^2	ΔF
Project Management x						
Implementation of more modules		19	0.597*	0.016	4.099*	
Fine-tuning of system over time			0.621*	0.017	4.010*	

coordination of business activities	*	34	**	0.448**	0.028	7.229**
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- 1) β values are standardized regression coefficients
- 2) Significance: * $p < .05$, ** $p < .01$, *** $p < .001$
- 3) Only significant parameter estimates shown

As can be seen from Tables 5 and 6, the interaction effect of the implementation of more modules and project management has the greatest influence on operational performance, with the impact on inventory management being the most significant followed by on-time delivery. The fine-tuning of ERP modules over time interacts with project management to impact operational performance; the regression coefficient for the interactive effect of project management and the fine-tuning of ERP modules over time has the highest significance and magnitude for the on-time delivery measure. The internal coordination of business activities positively influences operational performance; the regression coefficient for the interactive effect of project management with internal coordination of business activities on inventory management had the greatest magnitude and significance among all performance measures. There were also significant interaction effects present between project management and internal coordination of business activities with on-time delivery.

An intriguing finding is the absence of an interactional effect between the external coordination of business activities and project management on operational performance. This suggests that though firms were able to leverage project management techniques to enhance internal ERP system integration, they have not been able to extend these project management techniques to effectively handle the streamlining and integration of external downstream and upstream processes. An unexpected finding is the lack of interactional effect of ERP system integration with project management on the standardization operational performance measure. This suggests that though ERP system integration per se positively influences standardization, there could be a possible lack of coordination of project management techniques when it comes to standardizing processes across partner firms. Another unexpected finding is that though there is an interaction effect between the fine tuning of the ERP system over time and project management on operational performance, more fine-grained analysis indicates the lack of such an interaction effect on the inventory management measure. This suggests the possibility that firms in the sample may be reviewing their inventory policies too frequently to suit their evolving business needs, and such reviewing could be having an augmented effect resulting in system nervousness, which in turn affects inventory performance.

DISCUSSION

A model was developed in this research study to illustrate the relationships among ERP system integration, operational performance, and project management. The results indicate broad support for the hypothesized model and highlight two important characteristics related to the implementation of such systems. First, the model indicates that the more modules implemented, greater the internal and external coordination of business activities, and hence increase in operational performance; moreover, the fine-tuning of the ERP system over time also increases operational performance. This suggests that firms must be patient when evaluating the returns associated with their implementing more ERP system modules and their fine-tuning over time to better meet their business needs. Second, the results indicate that project management influences the relationship between ERP system integration and changes in operational performance. That is, firms received greater performance benefits from ERP system integration when the technical implementation was paired with project management.

The first hypothesis was supported by the results of the regression analyses for all four items measuring ERP system integration. This suggests that while firms may desire immediate

benefits as they deploy new ERP system modules, realistically the benefits are more likely to accrue as firms gain experience with the modules and integrate them into their overall operations. All items of the ERP system integration construct exhibit strong significant relationships with the three operational performance measures. This 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; this in turn enhances the ability of firms to meet operational challenges and enhance their market position.

The second hypothesis was partially supported by the results of the regression analyses. Significant interactions were found between project management and the various items measuring ERP system integration (except the external coordination of business activities) on various performance measures (except standardization). Interaction relationships were present for project management and three of the four items of the ERP system integration construct for the on-time delivery performance measure; and two of the four items of the ERP system integration construct and the inventory management performance measure. This suggests that effective project management activities help firms leverage ERP information to obtain greater insights into operational activities. On-time delivery gains the most when compared to other operational performance measures; this suggests that good project management design and execution and effective use of workforce analytics helps firms effectively meet delivery deadlines.

A synthesis of the above discussion indicates that ERP system integration results in differential operational performance benefits for firms. Moreover, project management is crucial in helping firms leverage ERP system integration capabilities and improve performance. Managers, who focus on project management, i.e. focus on the “people component” of ERP system implementations, contribute significantly to successful integrated deployments. As performance benefits vary with ERP system integration, it is important that managers focus on integration activities to derive maximum synergistic gains. ERP deployments comprised of various levels of system integration, coupled with support from project management, will determine how best managers can meet the needs of their firms in their respective competitive environments.

Some caution should be exercised when interpreting the results of this study. The cross-sectional design of the study precludes casual statements and indicates that a correlation exists between ERP systems integration, project management, and changes in operational performance. In addition, this study examined ERP system integration in a production environment; therefore, the generalizability of the study’s findings may not be fully applicable to service firms. Future research should consider the use of longitudinal designs to capture over time the effects among ERP system integration, project management, and increased operational performance.

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Note

This research study has been approved by the Institutional Review Board (IRB), University of North Texas.

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