

Identifying critical issues in enterprise resource planning (ERP) implementation

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Abstract

Much has been written on implementation of enterprise resource planning (ERP) systems in organizations of various sizes. The literature is replete with many cases studies of both successful and unsuccessful ERP implementations. However, there have been very few empirical studies that attempt to delineate the critical issues that drive successful implementation of ERP systems. Although the failure rates of ERP implementations have been publicized widely, this has not distracted companies from investing large sums of money on ERP systems. This study reports the results of an empirical research on the critical issues affecting successful ERP implementation. Through the study, eight factors were identified that attempts to explain 86% of the variances that impact ERP implementation. There was a strong correlation between successfully implementing ERP and six out of the eight factors identified.

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1. Introduction

In response to the growing global competition, many manufacturing companies have embarked upon enterprise resource planning (ERP) implementation. An ERP system is an integrated software solution that

spans the range of business processes that enables companies to gain a holistic view of the business enterprise. It promises one database, one application, and a unified interface across the entire enterprise [1]. Although the failure rates of these ERP implementations have been highly publicized, this has not distracted companies from investing large sums of money on ERP systems. ERP systems provide companies with the means of integrating their business functions into a unified and integrated business process. As companies implement more enterprise-based systems throughout their organizations, the need

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for integration of these systems becomes even more paramount. Expanding from the functional areas of accounting, human resources, and shop floor control to an enterprise-wide system has become a format for producing full organization integration. AMR Research recently reported that ERP is regaining momentum. The latest data shows the market for ERP will grow from US\$ 13.4 billion in 2003 to a projected US\$ 15.8 billion in 2008, a compounded annual growth rate of 3% [2]. Unfortunately, most ERP implementations have not lived up to their market expectations. ERP implementations are notorious for taking a longer time and costing more money than is projected. Too often, the best-laid plans for full organization integration become mired by system incompatibility, legacy issues, cost overruns, and time extensions [3]. This study presents the results of an empirical study that surveyed manufacturing companies in the Midwestern region of the USA to determine the critical issues affecting ERP implementation. With responses obtained from 36 companies, a factor analytic solution was used to derive factors affecting successful ERP implementation. These factors are feasibility and critical evaluation of ERP systems, project management principles, human resource development, business process reengineering, cost/budget issues IT infrastructure, consulting services, and top management support. The study reveals that about 86.3% of the variances in ERP implementation were explained by the critical factors identified in the study. Two ERP consultants with a combined 30 years experience worldwide in ERP implementations corroborated the results obtained in the study.

2. Past studies

Although ERP systems have gained major prominence in corporations throughout the western world, successful implementation of ERP in business processes continues to elude many companies despite high implementation costs that run as high as 3% of total revenue [4]. These failures were not because the ERP software were coded incorrectly, rather companies failed to match the true organizational needs and systems required to solve the business problems [5]. Unisource Worldwide, Inc. wrote off US\$ 168 million when the company abandoned nationwide implemen-

tation of SAP software [6]. FoxMeyer Drug went bankrupt in 1996 and files a US\$ 500 million lawsuit against SAP, an ERP software provider, blaming SAP for its woes [7]. Dell abandoned a highly publicized SAP implementation following months of delay and cost overruns [6]. The company claimed that SAP was too monolithic to be altered for changing business needs. Dow Chemical wrote off close to half a billion dollars when it switched from a mainframe-based ERP to a client/server architecture ERP system [6]. Implementing ERP causes massive changes that need to be carefully managed to reap the benefits of such complex systems. It is projected that over 70% of Fortune 1000 companies have or will soon install ERP systems and that ERP systems are penetrating the small-to medium size companies with gross revenue less than US\$ 250 million [1]. The inability of these companies to realize competitive advantage from ERP implementation is attributable to failure of proper usage of technology to address changes in the design and structure of an organization. Organizations that realize full benefits of a technology are those that make necessary changes in their organizational structure, strategies, and processes [8].

A number of companies have improved their competitive position by implementing ERP in their business processes. The Earthgrains Company witnessed a net improvement in its operating margin from 2.4 to 3.3% in 1997 as a result of its ERP implementation [9]. The company also improved its on-time delivery to 99% thereby improving its customer satisfaction metric. Similarly, Par Industries improved its delivery performance from 60 to 95%, lead time to customers reduced from 6 to 2 days, repair parts reduced from 2 weeks to 2 days, and WIP inventory dropped 60% [10]. IBM Storage Systems reduced the time to ship a replacement part from 22 days to 3 days, and the time to perform credit check from 20 min to 3 s [11]. By using SAP, the Daimler-Benz and Chrysler merger was able to shave close to ten years in its integration effort [12]. By working together, ERP systems helped Federal Express avoid “isolated kingdoms” [9].

Business process integration is more costly, almost by a factor of 3–10 than the ERP software itself. These costs are driven by a variety of factors which include the high consultancy fees charged by consultants and systems integrators, the heavy reengineering focus

generally adopted by implementing companies, and the need to replace high percentage of existing information technology infrastructure in order to support the ERP systems [4]. Mabert et al. [13] gave a breakdown of implementation costs associated with ERP implementation. While the system-based costs averaged 40% of the total cost, the remaining 60% of the cost went to training and professional services. The ERP software cost averaged a mere 15% of the total cost of the system implementation. This has particular implications in the sense that most ERP decisions are driven mostly by software selection, thereby resulting in cost overruns for companies that failed to see the true cost of ERP implementation. Surveys conducted by Harvard Business School revealed that despite the high investments in ERP systems, ERP implementations are still mired by cost and schedule overruns, resistance to business process change, unavailability of adequate skills, and overall underachievement relative to the expectation of benefits accruing from ERP [4].

Past studies [1,14–18] have been conducted that attempt to identify critical success factors in ERP implementations. In a study on ERP implementation in China, the authors posit strong considerations for national cultural issues, since critical success factors may vary significantly, depending on the country in which an implementation is carried out [19]. ERP implementations have also been investigated through case studies with varying degrees to describe critical success factors. These include the impact of ERP on job characteristics [20], strategic options open to firms beyond the implementation of common business systems [14,21], means to avoid ERP project failures [22], issues of business alignment [23,24], business process reengineering (BPR) [25], and change management [26]. Other studies have assessed the ambiguous role of large systems as both catalysts and inhibitors to change [27], analyze the special challenges of ERP implementations outside the business world [28], and describe global supply chain [29]. Flexible and responsive global supply chain is considered critical for a company to satisfy end-consumer needs in different markets and to improve integrated performance of the company in a time-based competitive environment. Implementing ERP with or without BPR has been surveyed and analyzed [30]. Theoretical considerations have focused on global business processes [31] and IT architecture

options [32], as well as on enhancement of process engineering and development methodologies [33]. The complex question of how to assess the organizational benefits derived from an ERP system has been addressed by Klaus et al. [26]. This requires looking beyond the implementation phase to considering the operational performance of the system. Markus and Tanis [34] proposed a minimum set of success metrics that would include project metrics, early operational metrics, and long-term business results. The critical challenge in ERP implementation has been to first identify the gaps between the ERP generic functionality and the specific organizational requirements [35]. Too often, ERP adopting companies fail to understand the business requirements which the ERP systems are expected to solve. The congruence between ERP systems and organizational culture is the prerequisite to successful ERP implementation [17,36]. The implementation of an integrated system such as ERP requires that the basic business practices embedded in the ERP system be adapted to the organizational processes and culture.

Cost of ERP implementation typically ranges from 2 to 6% of annual sales, with the cost of the software being just a tip of the iceberg [13]. Unfortunately, many organizations equate successful ERP implementation with the choice of ERP software. While it is imperative that the choice of the software should be considered very carefully, ERP software should not drive the business decision making process. ERP implementation should never be confused with software installation, which is a small fraction of the implementation cost. Implementing an ERP system requires a thorough strategic thinking that allows companies to gain better understanding of their business processes. It is important for companies to be aware of critical issues affecting ERP implementation and give careful considerations to the issues which would lend themselves to smooth rollouts and timely implementation of ERP systems. Through an empirical study, this paper attempts to identify those critical issues that impact successful implementation of ERP systems.

3. The five-stage implementation process

Implementing an enterprise resource planning (ERP) system successfully is extremely important to

future competitive strategy of a company. Management must be aware of the ERP system's strategic role as the backbone in providing the dynamic business systems imperative to new systems implementations. Bringing ERP into full function and getting the most benefits from the system is a comprehensive task that requires paying particular attention to the most critical success factors. Fig. 1 presents a five-stage ERP implementation process that attempts to bring together the most useful aspects from review of the literature and interviews conducted with experienced ERP consultants. Development of the implementation process aided the construction of the survey instrument that was used in this study. The process is split into five phases, each representing a distinct milestone in the ERP process. It is crucial that management conduct a review at the end of each stage to make sure everyone agrees on its outcome before moving on to the next stage. Without the linkages, it is extremely tough and costly to go back and correct mistakes.

The ERP implementation process is divided into five major phases (Fig. 1). These phases are preceded by a critical look at a company's strategic enterprise architecture and surrounded by change management and business development components. The strategic enterprise architecture analyzes the driving motive for implementing an ERP system while change management and business development seek to integrate the human resource dimension and coordinate daily operations with the new business process design, respectively. In phase one, project preparation, a comprehensive planning process involving people handling leadership roles, establishing budget targets, and determining the project plan to be followed. In second phase, the business blueprint, the analysis of existing business process provide the background for system selection before extensive education and training on functionality and configuration gives the project team the needed insight to map the new process design. A sound project management framework acts as a significant condition for achieving overall success with an ERP system [8]. The third phase, realization, focuses on developing the technical foundation while testing each process design on a conference room pilot. In the fourth phase, final preparation, the entire process design integration is tested under full data load and extreme situations. Simultaneously, the people intended to use the system

and those influenced by it will go through the education and training needed to understand how data flow through the system and how the system is operated at each point in the supply chain. Finally, the go live and support phase emphasizes process flow optimization and continuous expansion of the system to enjoy new competitive advantage. Knowledge gained from the development of these phases served as the groundwork for the design of the study. The items in the questionnaire ranged from the driving motives of the implementation to the enforcement of change management and business process development in the organization.

4. The study

Based on a review of the literature and with extensive personal interviews with ERP consultants that culminated to the development of the five stages of ERP implementation, a questionnaire was developed that identified items that are critical to successful implementation of ERP. The last question asked the respondents to rate the extent to which ERP has been successfully implemented in the respective companies. The questionnaire was pre-tested with ERP practitioners to ensure its validity and consistency. Of the 689 companies listed in the APICS Region V membership list only 200 companies were identified as either implemented ERP or are in the process of implementing ERP. This group was identified through personal contacts and through phone calls to the companies to determine their level of involvement with ERP. The questionnaire was mailed to the 200 companies that are located in the Midwestern region of the United States. Of the 200 questionnaires mailed, 36 questionnaires were returned for a response rate of 18%. Though the authors would like to have received more questionnaires, the moderate number of respondents could be attributed to constrained time schedule among ERP project team leaders who are often key resources in their respective companies and sensitivity of strategic information although full confidentiality was guaranteed. Five companies responded through phone calls stating that company policies prohibit them from completing the survey.

Two approaches were used to test for the non-response bias. As stated earlier, the 200 companies

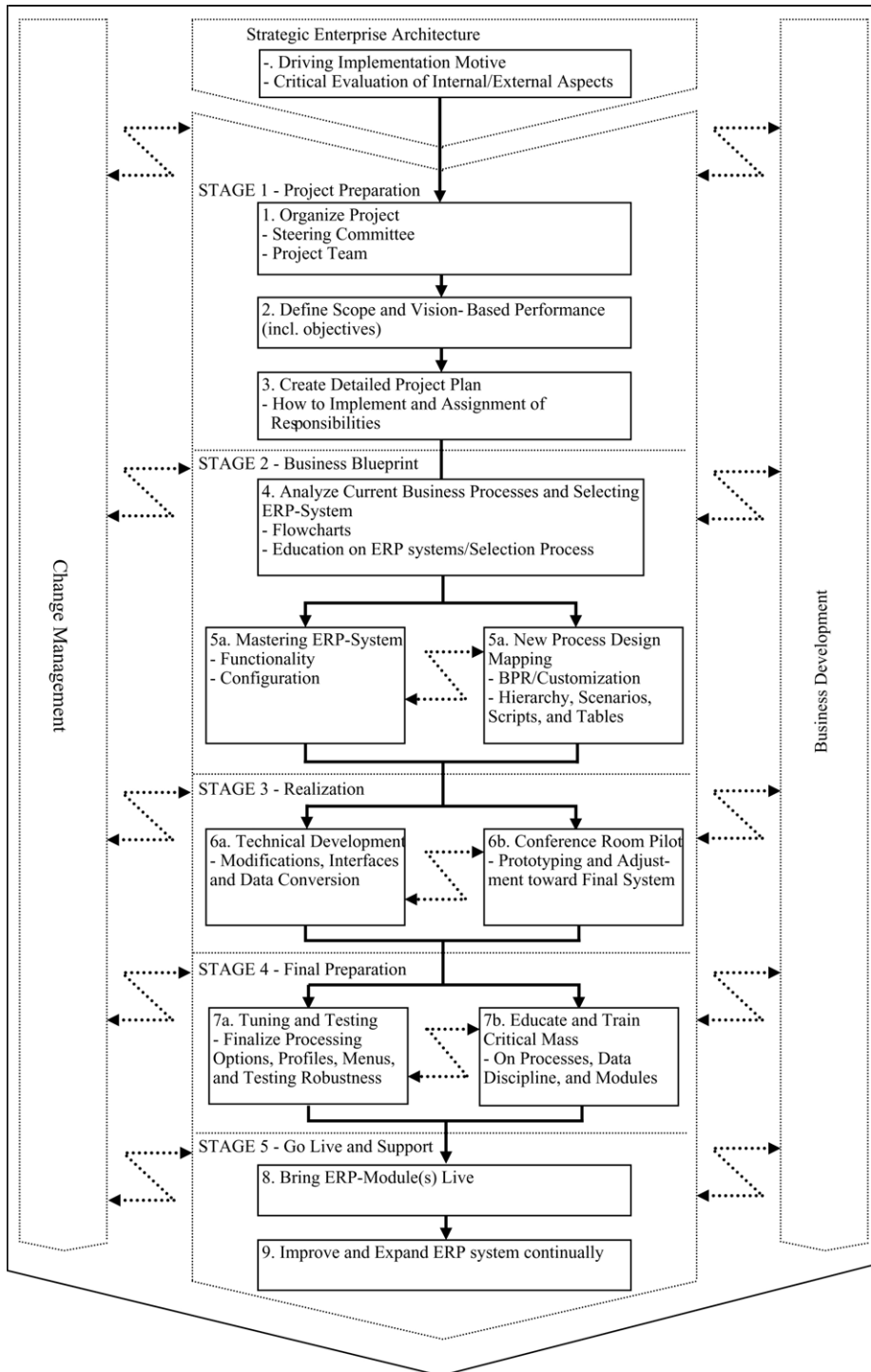


Fig. 1. A five-stage ERP implementation process.

Table 1
Company characteristics and ERP drivers of respondents

	Frequency	Percent
Primary business areas of respondents		
Energy	2	5.6
Construction	1	2.8
Manufacturing-consumer	11	30.6
Manufacturing-industrial	18	50.0
Manufacturing-IT	3	8.3
Communications	1	2.8
Number of employees in companies implementing ERP		
0–100	1	2.8
101–500	19	52.8
501–1000	4	11.1
1001–5000	5	13.9
5001–10,000	2	5.6
≥10,000	5	13.8
Company total sales (world-wide) in 1999		
<US\$ 10 million	1	2.8
US\$ 10 million; <US\$ 100 million	20	55.6
US\$ 100 million; <US\$ 500 million	6	16.7
US\$ 500 million; <US\$ 1 billion	1	2.8
US\$ 1 billion; ≤US\$ 10 billion	6	16.7
>US\$ 10 billion	2	5.6
ERP implementation strategy		
Parallel	13	36.1
Direct cutover	9	25.0
Pilot study	4	11.1
Planned common	7	19.4
Other	3	13.9
Likelihood of recommending the ERP system to other companies		
Very unlikely	4	11.1
Somewhat unlikely	5	13.9
Somewhat likely	9	25.0
Likely	11	30.6
Very likely	2	5.6
None response	5	13.8
Total cost of ERP system		
<US\$ 100,000	3	8.3
US\$ 100,000; <US\$ 1 million	10	27.8
US\$ 1 million; <US\$ 5 million	10	27.8
US\$ 5 million; ≤US\$ 100 million	7	19.4
>US\$ 100 million	1	2.8
None Response	5	13.9
Drivers for implementing ERP		
Competitors	1	2.8
Customers	1	2.8
Internal business process	24	66.7
Market condition	5	13.9
Y2K	3	8.3
Other	2	5.6
Initiator of ERP Systems		
Top management	24	66.7

Table 1 (Continued)

	Frequency	Percent
Middle management	9	25.0
Employees	1	2.8
Other	2	5.6
Satisfaction level of ERP system		
Very dissatisfied	1	2.8
Somewhat dissatisfied	5	13.9
Somewhat satisfied	9	25.0
Satisfied	7	19.4
Very satisfied	10	27.8
None response	4	11.1

selected because their knowledge and involvement with ERP implementation. First, a comparison of the annual turnover, number of employees, and total asset between the group that responded and the group that did not respond was conducted. The *t*-test revealed that there were no significant differences between the two groups. Second, using the *t*-test, we examined the differences in responses to the items between the 36 respondents and two ERP consultants. The consultants who are affiliated with Ernst & Young [37] and Price Waterhouse Coopers [38] have a combined ERP implementation experience of 30 years. The *t*-test revealed that there were significant differences in two out of the 39 items (about 5% of the items), thus indicating lack of bias. Furthermore, item-by-item correlations between the two groups (respondents and consultants) averaged 0.65, which indicated a significant inter-rater agreement. Therefore, the results of non-response bias suggest that there was no evidence of non-response bias even with the low response rate.

Demographic information on the respondents is presented in Table 1. Altogether, over 80% of the respondents came from the manufacturing sector with the industrial accounting for 50% of respondents. Fewer than 53% have number of employees in the range of 101–500. Respondents were fairly split in the implementation strategy adopted with 36 and 25% using the parallel and direct cutover strategies, respectively. Sixty-two percent of respondents would recommend their ERP systems to other companies. This indicates a strong disposition to ERP systems. The key driver for ERP was the internal business process with 67% of the respondents affirming that the need to streamline their internal business process was the key driver to ERP implementation. Seventy-two

percent of the respondents rated the satisfaction level of ERP implementation from “somewhat satisfied” to “very satisfied.” This may imply that even with the negative publicity of ERP, majority of the companies that have implemented ERP are satisfied with their implementations. Along the same line, over 60% of the respondents indicated that they would recommend the ERP system to other companies. Over two-thirds of the respondents reported that the key initiator of ERP system was top management. Based on this preliminary results, one could infer that majority of the companies that responded were pleased with the ERP implementation. ERP implementation has been characterized as a “root canal” surgery [13]. The pain is extremely unbearable during the surgery but things get better soon after the surgery. Table 2 summarizes the ERP systems adopted by the respondents. SAP had the largest number of respondents with 16.7% of the respondents reporting. This is lower than the projected market share of SAP that stands at 30% in 1999 [13]. This reduction in market share may be attributed to increased competition in the ERP vendor market over the past years and the fact that larger number of respondents are in medium-sized companies. SAP, being the flagship of the industry was targeted at larger companies. The implementation time varied from 10

months to 5 years and the return on investment in ERP ranges from 5 to 12% [13].

5. Data analysis

Exploratory factor analysis was used to analyze the company responses. The main reason for using the exploratory factor analysis was to reduce the dimensionality of the attribute data and uncover a smaller number of underlying factors that account for a major amount of the variance in the original measures [39]. Responses for the 38 measured attributes related to ERP implementation were subjected to a factor analytic solution, which reduced observed measurements to eight factors. In contrast to the confirmatory factor analysis, these common factors are not identified a priori. The survey instrument asked that the respondents rate 38 items that impact ERP implementation on a 7-point scale with 1 being the lowest rating. Using SPSS statistical package the scree plot of the eigenvalues from the principal component analysis revealed that there are eight factors. The goal in labeling each of these factors is to come up with a term that best describes the content domain of the attributes that load highly on each factor. The naming of a particular factor is determined by those response variables that load on the factor.

Four methods are identified for assessing the reliability of identified factors, namely (1) the retest method, (2) the alternative form method, (3) the split-halves method, and (4) the internal consistency method [39]. This study adopted the internal consistency method because of its ease of use and it is the general form of reliability estimation used. Cronbach's alpha was used as the reliability coefficient in the evaluation of the degree to which all the items within a subset were homogeneous. Table 4 shows the maximized reliability coefficient ranged from 0.67 to 0.93, indicating that some scales were more reliable than others. Typically, reliability coefficients of 0.70 or more are considered adequate. This leaves only the IT infrastructure as the only factor that slightly fell below the threshold value. The IT infrastructure has only two items and this result may imply that more items needed to be included in this factor to gain a better measure of the factor. Following

Table 2
Primary ERP software used by respondents

ERP software	Frequency	Percent	Market share (%) ^a	Growth (%) ^a
SAP	6	16.7	30	10
J.D. Edwards	4	11.1	5	2
SSA/BPCS	5	13.9	3	–
Oracle	3	8.3	15	14
Visibility	2	5.6	–	–
QAD	1	2.8	2	–
E2 Systems	1	2.8	2	–
MAPICS	1	2.8	2	–
PeopleSoft	1	2.8	9	–
Computer Associate	1	2.8	–	–
Marcam Protean	1	2.8	–	–
CA-Data3	1	2.8	–	–
Infinium	1	2.8	–	–
LPCS	1	2.8	–	–
Syteline	1	2.8	–	–
Vantage by Epicor	1	2.8	–	–
Other	5	13.9	–	–
Total	36	100.0	–	–

^a Source: AMR (2001).

these results, it might be implied that IT infrastructure and human resource development both have little impact on ERP implementation. This would fly in the face of those that tend to equate successful ERP implementation with IT infrastructure. Although the requisite IT infrastructure needed to support the ERP system is much needed, the sole effort should not be directed at choosing the IT infrastructure. To improve the odds of ERP success, companies need a shift in paradigm from viewing ERP implementation as a large-scale IT project to a holistic business undertaking. The emphasis should lie on ERP providing a business solution and not necessarily an IT solution.

5.1. Detailed item analysis

The item score versus the factor-score correlations are used to determine if an item belongs to the factor as assigned, belong to other factors, or should be eliminated. If an item does not correlate highly with any of the factors, it is eliminated. Table 3 shows the Varimax rotation (correlation) matrix for the eight critical factors identified and the individual items that load on each factor. As shown in Table 3, most of the items have high correlations with the factors to which they were assigned relative to the other factors. Summarily, it was concluded that the items had been appropriately assigned to the critical factors. The internal consistency analysis for the factors is given in Table 4. The alpha values for the eight factors ranged from 0.67 to 0.93, with the project management principles being the most consistent.

The next issue is to determine the extent to which the identified critical factors correlate with ERP implementation. On a seven-point scale ranging from very unsuccessful to very successful, the respondents were asked to rate how they would characterize ERP implementation in their respective companies. The response to this global item was correlated with the eight factors. The results are shown in Table 5. Six of the eight factors are significant at the 0.01 level. These are project management principles, feasibility/evaluation of ERP system, business process re-engineering, top management support, cost/budget analysis, and consulting services. Top management support, process re-engineering, and consulting services show the strongest correlation with ERP implementation. The correlations of human resource development and IT

infrastructure are weak and not significant. This might imply that either the factors are not properly *loaded* or that these two factors are not as crucial as the other factors in terms of successful ERP implementation.

5.2. Analysis of critical issues

Prior to conducting the factor analysis, the inter-item correlations of the variables, and any variables that correlate at less than 0.40 with all other variables were deleted from the analysis. Consequent to this approach, four variables were eliminated from the analysis. Using the Principal Component Analysis technique as the extraction method and Varimax with Kaiser Normalization as the rotation method, eight critical factors were identified based on the Eigenvalue criterion. The screen-plot (SPSS software) also revealed the presence of eight factors. The eight factors explained 86% of the variances. Table 4 presents the original items that make up each of the eight factors along with their internal consistency.

Items 2 (integrate ERP software into existing business) and 4 (access the integrity of existing databases) were not plausible as their correlations with factors 3 (human resource development) and 8 (consulting services) were statistically non-significant. After taking a closer look at these two items, it is concluded that while all other 36 items belong to what the industry call best ERP practice, the two fell outside this best practice category and thus, should not have been included in the questionnaire. Rather than integrate ERP-software into existing business processes (item 2), successful companies draw their process requirement needs and select the system that best fits these needs to the greatest extent possible. Once these are done, the company would either customize the software or adapt their processes to particular software. Thus, items 2 and 4 were removed from the questionnaire. Two additional items, #19 (have a stress breaker when times are tough) and #30 (have the project team solely designated to the ERP implementation) did not show strong correlation when assigned to factor 7. Essentially, the items did not measure what they were intended to measure (validity) and thus, were not assigned to the appropriate factors. Obviously, having a stress breaker when times are tough (item 19) is an ambiguous question since the item has about equally low correlation within three

Table 3
Varimax rotation of the critical factors of ERP implementation

Factor	Item	1	2	3	4	5	6	7	8
Project management principles (1)	19	0.67	0.37	0.36	0.21	0.35	0.15	0.15	0.13
	25	0.72	0.27	0.30	0.20	0.10	0.17	0.19	0.06
	26	0.80	0.14	0.17	0.19	0.18	0.14	0.29	0.12
	27	0.78	0.37	0.26	0.22	−0.12	−0.16	−0.01	0.12
	28	0.83	−0.18	0.08	−0.24	0.09	0.09	0.20	0.33
	30	0.85	0.17	0.02	0.18	−0.04	0.21	0.12	0.30
	31	0.83	0.08	0.30	0.17	0.28	0.13	0.01	0.01
Feasibility/evaluation of ERP project (2)	24	0.23	0.86	0.03	0.06	0.31	0.09	0.05	−0.02
	25	0.09	0.84	0.19	0.04	0.07	0.24	0.02	0.21
	26	0.47	0.49	0.34	0.20	0.28	0.18	0.11	0.28
	27	0.15	0.83	0.34	0.17	0.11	0.01	0.13	0.27
Human resource development (3)	8	0.53	−0.09	0.61	0.36	0.11	0.12	0.21	−0.17
	16	0.45	0.34	0.65	0.06	0.10	0.12	0.23	0.12
	17	0.30	0.35	0.71	0.15	0.18	0.21	−0.16	−0.02
	18	0.16	0.47	0.54	0.20	0.34	0.26	0.25	0.10
Process re-engineering (4)	1	0.25	−0.04	0.12	0.79	0.00	0.20	0.23	0.20
	5	−0.07	−0.09	0.34	0.49	0.18	−0.03	0.31	0.38
	7	0.44	0.24	−0.01	0.58	0.26	0.16	−0.16	0.27
	9	−0.11	0.33	0.22	0.41	0.51	0.23	0.33	0.24
	10	0.02	0.30	0.06	0.51	0.46	0.22	0.44	−0.21
	15	0.60	0.06	0.29	0.60	0.35	0.08	0.10	0.04
	28	0.21	0.35	0.17	0.75	−0.21	0.06	0.02	0.06
Top management support (5)	11	0.44	0.36	0.12	0.05	0.75	−0.10	0.13	−0.03
	12	0.19	0.15	0.26	−0.04	0.82	0.06	−0.13	0.23
	14	0.36	0.35	0.25	0.27	0.50	−0.15	0.42	0.10
Cost/budget (6)	20	0.21	0.18	0.17	0.18	−0.12	0.79	0.20	−0.02
	21	−0.03	0.59	0.03	0.11	−0.04	0.69	0.35	0.02
	22	0.21	0.03	0.30	0.07	0.18	0.79	0.02	0.29
	23	0.56	0.28	0.41	0.24	0.12	0.42	0.24	0.06
IT infrastructure (7)	3	0.28	0.02	0.10	0.04	0.03	0.20	0.85	0.10
	4	0.63	0.07	−0.07	0.13	−0.05	0.19	0.55	0.17
Consulting services (8)	33	0.30	0.22	0.40	0.16	−0.53	0.11	0.02	0.49
	34	0.45	0.34	0.22	0.14	−0.03	0.25	0.10	0.62
	35	0.41	0.11	0.11	0.11	0.01	0.50	0.27	0.64
Eigenvalue		4.30	3.396	3.252	2.630	2.744	2.104	3.364	2.832
Percentage variance		20.950	12.808	10.085	9.483	8.599	8.276	8.073	8.030
Cumulative variance		20.950	33.759	43.844	53.327	61.926	70.202	78.275	86.305

factor categories, except for human resource development where it would belong. Having a project team solely designated to the ERP implementation (item 30) is a more likely situation in companies dealing with special projects. Often time individuals work on multiple projects at the same time. The item should have tested for “Having the team project *leader* solely designated to the ERP implementation,” because most companies often cannot find the resources to let all

project team members be deployed 100% of their time on an ERP implementation even though this might be the right thing to do. Another factor that was supported through the analysis is having top management support and involvement throughout the project. As indicated in the demographic profile, over two-thirds of the ERP projects were initiated by top management. Therefore, their encouragement and support through the project implementation cycle should be invaluable.

Table 4

Internal consistency analysis results for the critical factors of ERP implementation

Critical factors	Original item numbers (see Appendix A)	Items deleted	Alpha
Project management principles	13, 29, 31, 32, 36–38	None	0.93
Feasibility/evaluation of ERP project	24–27	None	0.89
Human resource development	8,16–18	None	0.73
Process re-engineering	1, 5, 7, 9, 10, 15, 28	None	0.81
Top management support	11, 12, 14	None	0.79
Cost/budget	20–23	None	0.81
IT infrastructure	3, 4	–	0.67
Consulting services	33–35	None	0.86

Table 5

Pearson correlation between critical factors and ERP implementation

Critical factors	Correlation
Project management principles	0.579 ^a
Feasibility/evaluation of ERP project	0.499 ^a
Human resource development	0.327
Process re-engineering	0.576 ^a
Top management support	0.695 ^a
Cost/budget	0.431 ^a
IT infrastructure	0.182
Consulting services	0.595 ^a

^a Correlation is significant at the 0.01 level (two-tailed).

Another factor that received a large support was human resource development. Companies should develop detailed plan for training end-users. This factor was reaffirmed in the implementation stages discussed above. User interface in the implementation cycle should be enforced. By having ERP users work with the implementation team from the beginning of the project, this would facilitate the implementation process and lead to speedy and successful implementation of the ERP system.

6. Conclusion and further research

Various authors have offered different sets of critical issues affecting ERP implementation, however, few empirical studies have been conducted to date to validate these factors. The ERP implementation literature provides little guidance to provide an aid to those companies that are about to implement ERP. This paper attempts to empirically identify those factors that are critical to the implementation of ERP systems. The measures undertaken were empirically

based and were shown to be valid and reliable. The reliability coefficient (alpha) of the measures ranges from 0.67 to 0.93. Six of the eight factors were found to be strongly correlated with ERP implementation and all six factors were significant at 0.01 level. These factors are project management principles (accounted for 20.95% of the variance), feasibility and evaluation of ERP project in the firm (12.81%), top management support (9.48%), business process re-engineering (8.60%), consulting services (8.03%), and cost/budget issues (8.28%). Human resource development and IT infrastructure were found to be non-significantly correlated to successful ERP implementation. All eight factors account for 86.3% of the item variance.

Successful enterprise resource planning system implementation depends on effective project management principles. Firms implementing or considering implementing an ERP system or any system that attempts to integrate internal functions with planning and execution activities of both customers and vendors are at risk if they do not understand basic project management fundamentals [38]. Top management support is very invaluable in ensuring that ERP projects come to fruition. This support might include providing strategic direction by being actively involved in various high-level cross-functional implementation teams. The top management support factor has next to the strongest correlation to ERP implementation of all the other factors identified. Implementation of an ERP system is not a matter of changing the hardware or software systems, instead it entails transforming the company to a higher level of performance through a streamlined business process. When carefully conceived and successfully executed, ERP systems can change the way companies conduct

business for the better. Identification of these critical factors permits managers to obtain a better understanding of issues surrounding ERP implementation. Managers can use the factors identified and validated in this study to better prepare themselves for a successful implementation of ERP systems. This study provides insights to companies who are either embarking on ERP implementation or considering implementing ERP systems. Successful implementation of ERP mandates continuous monitoring and self-diagnosis throughout the implementation process. The major contributions of this study can be summarized as follows:

- ERP implementation should not be viewed as just an IT solution but as a system that would transform the company into a more efficient and effective organization. Emphasis on IT infrastructure was the least correlated factor to successful ERP implementation.
- Successful implementation of ERP is intricately tied to top management setting the strategic direction of the implementation process. This factor correlates the highest with ERP implementation among all the factors identified in the study. This is accomplished by a continuous support and monitoring of the implementation process. A mere lip service or lukewarm support from top management is the “kiss of death” for any ERP implementation.
- Sound and thorough understanding of project management principles and its application is critically linked to successful ERP implementation. This is accomplished by establishing the scope of the project, establishing the project team and their responsibilities with clear statement of work, and

defining the performance objectives. The project management factor correlates very strongly with successful ERP implementation.

7. Limitations of the study

First, the results obtained from this study may not be generalizable considering the size of the sample, however, the results provide valuable insights for managers and executives associated with ERP implementation. Given the target group used to conduct the study, one would expect a higher response rate greater than the 18% reported. Although, the non-response analysis was conducted and found to be inconsequential, future studies should explore ways to increase the size of the sample group and the response rate. Second, we identified a total of 38 items which were loaded amongst eight factors. For a more comprehensive study, more items should be included in the survey to assess the critical issues in ERP implementation. Three out of the eight factors were loaded with three or less number of items. Ordinarily, one should expect each factor to be loaded by at least five items.

The use of perceptual measures of ERP implementation success, although a common practice in the literature is highly subjective and lacks the credibility of hard data. More quantifiable measures such as actual versus projected implementation time, actual versus projected cost of implementation, operational efficiencies such as cycle time reduction, return on investment on the ERP project, and increased market revenue would have provided a better understanding of ERP implementation success.

Appendix A. The 38 items used for measuring the critical factors of ERP implementation.

The items noted by an asterisk (*) were dropped to improve the reliability of the analysis. Respondents were asked to rate the items on a 7-point scale with 1 being the least favorable.

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- | | |
|-----|---|
| 1. | Integrate ERP with other management information systems. |
| 2.* | Integrate ERP-software into existing business processes. |
| 3. | Consider the existing IT infrastructure. |
| 4.* | Access the integrity of existing database(s). |
| 5. | Initially map out business processes. |
| 6. | Simplify (that is re-engineered) business processes in the initial stage. |
| 7. | Standardize the business processes to the extent possible. |
| 8. | Consider ERP as an integrated business-wide system. |

Appendix A (Continued)

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9. Ensure data robustness (no loss of data) between the business processes.
 10. Ensure data accuracy (no change of data) between the business processes.
 11. Experience strong support/commitment from upper-management.
 12. Communicate effectively with employees.
 13. Have a tight focus/control on the ERP implementation.
 14. Demonstrate close cooperation between IT and business managers.
 15. Consider if the ERP system was right for the company.
 16. Introduce the ERP system as a weapon against outside competition rather than reduction in number of internal employees.
 17. Include all employees in the implementation.
 18. Train employees extensively.
 - 19.* Have a stress breaker when times are tough.
 20. Track implementation cost very closely.
 21. Consider all risk factors (i.e., failure or delay of implementation, exceeding budget, etc.).
 22. Determine the return on investment (ROI) on the ERP implementation.
 23. Establish a clear vision for the ERP system in the initial stage.
 24. Develop performance measures for system.
 25. Establish appropriate deadlines/milestones (i.e., what to achieve by what date).
 26. Have a timely implementation.
 27. Have a detailed project plan (i.e., what activities to cover at what stage).
 28. Have a step-by-step implementation (i.e., one function implemented ERP at a time.)
 29. Carefully pick the right (i.e., the most knowledgeable and dedicated) employees for the ERP project team(s).
 - 30.* Have the project team solely designated to the ERP implementation.
 31. Have people with strong knowledge of financial and manufacturing processes present in the project team(s).
 32. Have project team members take ownership.
 33. Utilize outside consultant group only when in-house expertise was not present.
 34. Value the managerial support provided by the consultant group.
 35. Value the technical support provided by the consultant group.
 36. Maximize utilization of in-house expertise.
 37. Have ERP project team members carefully organize the ERP implementation.
 38. Properly educate the project team and key individuals about the ERP implementation.
 39. How would you characterize your company's overall success in implementing ERP?
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