DIMENSIONS OF ERP IMPLEMENTATIONS AND THEIR IMPACT ON ERP PROJECT OUTCOMES

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ABSTRACT

Many ERP implementations fail to achieve their hoped-for benefits and require investments that are often much larger than originally estimated. There is also a need to progress toward more theoretically grounded ERP implementation research. The present paper constitutes a step in that direction and proposes a conceptualization of ERP implementation scope that rests on three dimensions: Breadth, Depth, and Magnitude. The results of an exploratory study of 31 ERP implementations provide support for this conceptualization and show that the three dimensions are differentially related to project outcomes.

Keywords: ERP implementation, ERP scope, ERP project outcomes

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The market for enterprise resource planning (ERP) software and their implementations continues to be substantial with its 2003 value estimated at $23 billion [4]. However, despite the extensive implementation experience gained over the years, ERP implementations continue to be fraught with difficulties. According to some estimates these are more than 200% late and more than 170% over budget [16], 50% of ERP projects fail to achieve their hoped-for benefits [1], deliver less than 60% of what is expected [16], and sometimes even contribute to poor organizational performance and lower earnings [2, 7, 8, 12]. Over the years, many private, as well as public organizations have suffered substantial losses after either terminating their ERP projects before completion or stopping the use of their ERP systems altogether following implementation [e.g., 5, 6, 9, and 14].

Given the importance of ERP for businesses and the continuing difficulties experienced with their implementations, there is a need to better understand the ERP implementation phenomenon. This should allow more reliable assessments of their organizational benefits and better estimates of the resources required for their implementation. Identifying the relevant characteristics of ERP implementation projects and developing a typology of ERP implementations can be useful tools in this regard. While [13] represents an important first step in this direction, the ERP implementation characteristics they identified and the taxonomy they proposed can be improved in several ways. The present paper proposes a theoretically grounded set of ERP implementation characteristics and a taxonomy of ERP implementation scope.

The objective of the present paper is to take a step towards the development of a theoretical foundation for ERP implementation research by extending Parr and Shanks' [13] work on an ERP implementation taxonomy and addressing its shortcomings. One shortcoming of this work stems from the fact that Parr and Shanks did not indicate how they arrived at their categories. Thus, while intuitively appealing, their taxonomy lacks formal empirical support. Its other shortcomings concern the selection of some of the ERP implementation characteristics and their measurement and are discussed below. The present paper proposes modifications to the Parr and Shanks [13] framework to address these shortcomings and examines a slightly different set of characteristics with data obtained from 31 ERP implementations. The results suggest that ERP scope or size can be viewed as being formed of three dimensions, labeled ERP implementation breadth, depth, and magnitude. These three dimensions, which can be relatively easily and objectively assessed, are also found to differentially relate to different ERP project outcomes.

Parr and Shanks [10] argued that categorizing ERP implementations as either "Phased" (i.e., successive implementation of a series of modules) or "Big Bang" (i.e., implementing all ERP modules at once) was too coarse, and proposed a three-category taxonomy. Based on interviews with ten project managers who provided data for 42 ERP implementation projects they assessed five categories of ERP implementation characteristics: Physical Scope (i.e., number of sites and regions in which the ERP is implemented), BPR Scope (i.e., whether the business process reengineering effort is local or global, and whether it is aligned with ERP), Technical Scope (i.e., how much the ERP software is modified), Module Implementation Strategy (i.e., what modules to implement and how they will be integrated to existing systems), and Resource Allocation (i.e., project schedule and budget).

These characteristics and the items used to measure them are listed in Table 1.

ERP IMPLEMENTATION CHARACTERISTICS

Based on these characteristics, three ERP implementation types were identified [13]: Vanilla, Comprehensive and Middle-road. Vanilla projects were characterized by the least ambitious and lower risk implementations that affected a small number of users. They also focused on the implementation of core ERP functionalities with minimal BPR. At the opposite end were Comprehensive projects which were ambitious implementations affecting a large number of users in multiple sites. They also entailed major BPR efforts and implemented the complete set of ERP software functionalities. Finally, Middle-road implementations were characterized as being mid-way between Vanilla and Comprehensive: they affected a relatively large number of users in multiple sites, but implemented only the core functionalities of ERP and entailed some BPR.

The above framework can be improved in three ways. First, characteristics that are antecedents of ERP implementation processes can be separated from characteristics that reflect consequences of those implementations. For instance, while the time and budget allocated to an ERP project (i.e., Resource Allocation in [13]) are important ERP implementation characteristics, they typically depend on a series of management decisions made prior to implementation. As a result, viewing them as an ERP project's defining characteristics risks confusing an antecedent variable with a consequence variable, i.e., ERP implementation scope is an important driver of how much time and money a project will require. Moreover, an ERP project's duration and cost can not be accurately known until the project is completed. Therefore, an ERP implementation characterization that includes project budgets and schedules would be very difficult to specify early on, reducing its utility.

Similarly, the decision regarding whether an ERP will be integrated to existing systems in a module by module fashion as opposed to first implementing all modules and then integrating them (i.e., Decision 2 in Module Implementation Strategy in [13]) is related more to how the modules of an ERP will be integrated rather than to the size of the project.

Table 1: Variables and Measures Used in [13] and in the Present Study

Variable (measure) used in [13]	Variable Name in the Present Study	Measure Used in the Present Study	Mean (std. dev.; min.-max.)
Resource Allocation (Time)	Project length	# of months	17.9 (12.2; 3-60)
	Project effort	# of man-months (000)	1.85 (2.68; 0.012-11.28)
Resource Allocation (Budget)	Project budget	M US$	19.4 (33.2; 0.44-125)
Technical Scope (1= no modification to ERP; 2= minor modification; 3= major modification)	ERP Customization	Extent of modification done to ERP to customize the software (1-10)	2.9 (1.96; 1-8)
Physical Scope (1= single site; 2= multiple sites, regional; 3= multiple sites, international)	ERP Breadth	1= single site; 2= multiple sites in one state; 3= multiple sites in multiple states; 4= multiple sites, international	2.9 (1.0; 1-4)
Physical Scope (number of users: 1= small, <100; 2= medium, <200; 3= large, >200)	ERP Depth	(# of users of the ERP software)	1120 (1882; 8-8000)
	Business Process Automation Increase	(% of processes that are automated after ERP) – (% of processes that were automated before ERP)	0.29 (.24; 0.0-0.85)
BPR Scope (1= Alignment to ERP; 2= Global BPR; 3= Local BPR)	BPR Magnitude	(% of activities in reengineered processes that were modified) * (extent of modification 1-10)	3.75 (2.65; 0.2-8.1)
	BPR Depth	(# of employees whose activities changed)	6047 (13222; 20-65000)
	BPR Breadth	1= small number of people within a dept.; 2= a department; 3= more than one department; 4= a region; 5= more than one region	4.3 (0.9; 2-5)

A second way in which Parr and Shanks' [13] framework can be strengthened is by improving some of the items used to assess ERP implementation characteristics. For example, their BPR scope was measured with a three point scale where 1, 2 and 3 represented "Alignment to ERP", "Global BPR", and "Local BPR". However, it is not clear how these items form a scale or a continuum since "Alignment to ERP" is not necessarily something less than "Global BPR" or "Local BPR".

In fact, aligning an organization to an ERP system is likely to entail significant BPR for many organizations as ERP implementations often require major transformations and adjustments to the organization and its processes [10].

Finally, the relationships between different ERP implementation characteristics need to be empirically investigated. This is necessary not only to study the ways in which they can be combined to form categories of a taxonomy, but also to examine their potential impact on ERP implementation outcomes.

ERP IMPLEMENTATION SCOPE: A NEW CONCEPTUALIZATION

By first identifying a meaningful theoretical construct and important characteristics that reflect it, a taxonomy and measurement of the construct can be obtained. The focal concept of the present paper is ERP Implementation Scope and, as discussed above, a better

definition and assessment of this construct is likely to go a long way towards better understanding and estimating ERP implementation costs and benefits. Scope is important not only because it specifies what benefits can be obtained, but also because it defines the changes to managerial autonomy, task coordination and process integration that an ERP implementation will bring to an organization [10].

A useful starting point for defining ERP implementation scope can be found in the EDI literature where the notions of breadth and depth have been identified in relation to the concept of EDI usage [11]. For EDI, breadth of usage refers to the extent to which an organization has established EDI with external trading partners, and depth of usage reflects the proportion of data processing done via EDI. At a fundamental level, both facets represent how much EDI technology has penetrated an organization's business processes. In this respect, the notion of ERP implementation scope is highly similar to EDI usage since it too reflects the extent to which ERP systems are diffused within an organization and its business processes.

ERP Implementation Breadth

The present paper defines ERP implementation breadth as the extent to which the implementation of an ERP system is diffused horizontally across an organization. Capturing such a facet is important as it represents the willingness of an organization to link or integrate its different functional units within or across different geographic regions. In fact, one of the two Physical Scope characteristics measured by [13] assessed the number of sites involved in an ERP implementation. The number of sites across which an ERP is implemented indicates how horizontally widespread that implementation is: an implementation spanning multiple, and geographically dispersed sites can be viewed as having greater breadth than one which is confined to a single site.

At this point it should be noted that an ERP implementation typically entails not only the implementation of ERP hardware and software, but significant BPR as well [5, 15]. However, the BPR associated with a broad ERP implementation can sometimes involve a small number of sites, reflecting large ERP breadth but small BPR breadth. This suggests that assessing the breadth of BPR activities separately from how broadly the ERP is implemented could be important. Thus, similar to ERP breadth, which reflects the dispersion of an ERP implementation across different sites, BPR breadth can also be viewed as reflecting the dispersion of the business process reengineering entailed

by an ERP implementation across different departments and sites.

ERP Implementation Depth

ERP implementation depth is defined here as the extent to which the implementation of an ERP system is vertically diffused in an organization. One indication of how deeply an ERP implementation has permeated an organization is the number of employees it affects. In fact, the second Physical Scope characteristic assessed by [13] which pertains to the number of users involved in an ERP implementation also reflects the depth of an ERP system's implementation. As noted above, it would be important to once more distinguish between the ERP and BPR aspects of an ERP implementation by assessing ERP depth separately from BPR depth. Thus, BPR depth represents the extent to which the business process reengineering activities associated with an ERP implementation are vertically diffused in an organization. Similar to ERP depth, an indicant of BPR depth would be the number of employees affected by BPR in an ERP implementation.

Other ERP Implementation Characteristics

In addition to ERP Implementation breadth and depth, assessing three additional characteristics of ERP implementations would also be important in order to more completely assess ERP implementation scope [3]. BPR exercises typically involve major modifications to how people do their work, and as such represent considerable implementation challenges as well as being an important factor influencing the scope of an ERP project. Thus, an important characteristic that needs to be assessed, over and above breadth and depth, is how much change the BPR associated with an ERP implementation brings to employees' work. Note that BPR breadth and depth only capture how widespread and deep a BPR exercise associated with an ERP implementation affects an organization in terms of the number of different departments, sites and the number of people it affects. However, these do not reflect the extent to which BPR changes the work activities of the people involved. Thus, to fully capture the scope of an ERP implementation we need to assess, in addition to its breadth and depth, the proportion of employee activities which have been modified by the associated BPR, as well as the extent of modification of each activity. This characteristic is labeled BPR magnitude in the present paper.

A second ERP implementation characteristic likely to be related to BPR magnitude is the extent to which the business processes of an organization become more automated via an ERP implementation. BPR exercises are usually undertaken to better rationalize

business processes and to render them more efficient through greater integration and automation. Thus, as a different indicant of BPR magnitude, the increase in business process automation is also likely to be an important characteristic of ERP implementation scope.

A third important characteristic is the extent to which the ERP software needs to be modified in order to conform to an organization's business processes (i.e., ERP customization in [13]). The difficulties and costs associated with such modifications [5] point to their importance as a component of ERP implementation scope.

METHOD

In order to examine the usefulness of the above characteristics in assessing ERP implementation scope, project managers and senior consultants who had supervised or managed at least one ERP implementation project were identified and asked to participate in our study. To identify potential respondents a three-stage 'snowball sampling' approach was utilized. In the first stage, an initial convenience sample of ten project managers was identified. Each project manager was contacted by telephone and was provided with a brief description of the objectives of the research as well as a complete set of interview questions. All ten agreed to participate in the study and were asked to provide the names of other potential respondents. Twelve additional respondents were thus identified and of these, eight accepted to participate in the study. Finally, the second stage respondents provided the names of ten additional potential respondents who were subsequently contacted with seven of them accepting to participate. As a result, the final study sample contained the characteristics of 31 ERP implementation projects as assessed by 25 ERP project managers or supervisors who had been involved in at least one project.

To collect the study data, face-to-face or telephone interviews were conducted with twenty respondents, and five respondents completed the study questionnaire via e-mail. All interviews were recorded and transcribed. The structured interview questionnaire assessed the following seven variables: ERP breath, ERP depth, BPR breadth, BPR depth, BPR magnitude, BP automation increase, and ERP customization. The questionnaire also contained items that assessed each project's elapsed time, the effort invested in terms of man months, and the dollar budget allocated to the project. The items used to measure each variable are provided in Table 1.

Characteristics of the Sample

While 15 respondents of the study sample were employed by firms that acted as ERP consultants, six were employed by the companies where the ERP was implemented, two worked for an ERP software provider and two worked as independent consultants. The projects in the sample lasted an average of 18 months with a minimum of 3 months and a maximum of five years. Their budgets averaged 19.4 million US$ and ranged from 440 thousand to 125 million US$. Twenty of the sample projects were implemented in Canada, four involved sites both in Canada and the US, and five were implemented in Europe. The companies in the sample operated in a variety of fields including the transportation, utilities, telecommunications, health care, entertainment, distribution and high-technology industries. Their sizes averaged 12,266 employees with a minimum of 100 and a maximum of 65,000. These characteristics suggest that, while non-random, the study sample exhibits a certain variety and can be deemed relatively representative of ERP implementation projects.

RESULTS

The correlations that were observed between the seven ERP implementation characteristics are shown in Table 2. An exploratory factor analysis with Varimax rotation of these characteristics resulted in three factors with eigenvalues greater than one as shown in Table 3. All variables loaded heavily onto their respective factors while their loadings on the other factors were negligible, and they explained 75% of the common variance. The three factors were also interpretable and suggested a three-dimensional view of ERP scope: breadth, magnitude and depth.

The first factor was labeled **Breadth** as ERP Breadth and BPR Breadth had loadings of .95 and .90, respectively on this factor. ERP Customization also had a loading of .35 on this factor. Recall that ERP Customization was assessed as the extent of modification done to the ERP software so as to customize it to the organization. The fact that the extent of ERP Customization moderately loads on the same factor with the two breadth variables suggests that more widespread and geographically dispersed ERP implementations tend to go together with greater software customization. This may in part suggest that the variety in the business processes and organizational requirements of multiple sites across different geographical locations may at times be too great and difficult to homogenize via extensive BPR in all locations, thus requiring at least some customization of the ERP software.

Table 2: Correlations between ERP Implementation Characteristics

	1	2	3	4	5	6
1. ERP Breadth						
2. BPR Breadth	.76**					
3. BP automation increase	.12	.12				
4. BPR Magnitude	.06	.15	.46**			
5. ERP Customization	.37*	.15	-.38*	-.26		
6. ERP Depth	-.29	-.15	.09	.15		
7. BPR Depth	-.34*	-.16	-.01	-.07	-.03	.30
* p < .05 ; ** p < .01						

Table 3: Factor Analysis of ERP Implementation Characteristics

	Breadth	Magnitude	Depth
ERP Breadth	**95**	-14	-03
BPR Breadth	**90**	07	13
BP automation increase	24	**83**	-12
BPR Magnitude	-08	**69**	42
ERP Customization	35	**-73**	05
ERP Depth	04	03	**81**
BPR Depth	06	-00	**86**
Eigenvalues	2.02	1.84	1.38
Percent of Variance (Total = 75%)	29%	26%	20%

The second factor was labeled **Magnitude** as BPR Automation Increase and BPR Magnitude had loadings of .83 and .69 on this factor, while ERP Customization had a loading of -.73. The negative loading of this variable onto the Magnitude factor is logical because, as mentioned above, ERP customization is an indicant of the extent of BPR. As such, it can be expected to negatively correlate with ERP software customization, i.e., extensive ERP software customization would mean little BPR, since it is the software rather than the organization's processes that are being modified. Conversely, little ERP customization would mean significant BPR in order to fit the organization to the ERP software. Finally, the third factor was labeled **Depth** as ERP Depth and BPR Depth had loadings of .86 and .81, respectively on this factor.

The above results indicate that the seven ERP implementation characteristics measured in the present study can be viewed as aligned along three dimensions that can be labeled ERP Implementation Breadth, Magnitude and Depth. Given that the seven measured characteristics reflect different aspects of an ERP implementation's scope or size, the factor analysis results suggest that conceptualizing ERP implementation scope

along these three dimensions would be theoretically meaningful.

Implementation Scope and Outcomes

Regression analyses were conducted to explore the relationship between the dimensions of ERP implementation scope and project outcomes. To do so, factor scores calculated for Breadth, Depth, and Magnitude were used as independent variables in three regressions, one for each project outcome that was measured. As shown in Table 4, the results indicated that ERP implementation depth was positively associated with all three outcomes, with standardized betas of .68, .61 and .67 for project duration, project effort, and project budget, respectively (all p's < .001). ERP breadth was also found to affect project budget positively (standardized beta = .34, p < .05). Together, ERP implementation Breadth, Depth and Magnitude explained 43%, 36% and 49% of the variance in project duration, project effort, and project budget, respectively.

Taken together, the above results suggest that ERP implementation scope can be meaningfully assessed via its Breadth, Depth and Magnitude. These three dimensions can provide the theoretical foundation for

developing an ERP implementation taxonomy and allow the categorization of ERP projects according to where they are situated along each dimension. One such approach would be to classify each project according to its score being low or high on each of the three dimensions, resulting in eight categories of ERP implementation scope. Using this approach, the projects of the sample were scored as either low or high on each dimension depending on whether their score on each dimension was below or above the sample mean. As can be seen in Table 5, the eight categories of this categorization approach were each represented by at least one project in the sample, providing preliminary support for such taxonomy.

Table 4: Impact of ERP Implementation Breadth, Depth and Magnitude on Project Outcomes

Independent Variables	Dependent Variable		
	Project Duration (months)	Project Effort (man-months)	Project Budget (M US$)
Breadth	.15	.22	.34*
Depth	.68***	.61***	.67***
Magnitude	-.01	-.08	-.11
Adjusted R-square	.43***	.36***	.49***
* p < .05 ; ** p < .01; *** p < .001			

Table 5: ERP Implementation Scope Categories and Project Outcomes for the Study Sample

Implementation Scope			N	Project Outcome Means		
Breadth	Depth	Magnitude		Duration (months)	Effort (man months)	Budget (M US$)
L	L	L	5	12.4	939	3.58
L	L	H	5			
L	H	L	2			
L	H	H	1			
H	L	L	8	15.5	1166	23.74
H	L	H	4			
H	H	L	1			
H	H	H	4	38.5	6920	162.5

To further explore this taxonomy, mean project outcomes of three project types were examined: Low scope (projects scoring low on all three dimensions), High scope (projects scoring high on all three dimensions), and Mixed scope (projects scoring differently on at least two dimensions)[1]. The results depicted in Table 5 suggest that the three types appear to affect project outcomes differently. High scope projects had significantly higher scores than Mixed or Low scope projects for all three outcomes (all p's < .001 in Scheffe post-hoc test), providing further support for the taxonomy. Although they appear to differ, especially in terms of project budgets, outcome differences between Low and Mixed scope projects were not statistically significant.

[1] Ideally, comparisons need to be made between all eight types. However, given the sample size of the present study, such comparisons would not be meaningful.

CONCLUSION

This paper proposed a new conceptualization and measurement of ERP implementation scope and suggested three characteristics of ERP implementations, i.e., breadth, depth, and magnitude as a means to meaningfully describing the scope of ERP implementations. This view enables a fine grained categorization of ERP projects and provides an informative tool that can be used to better estimate their duration and cost. While exploratory, the paper provides some answers to the question of how to accurately and reliably measure and categorize ERP projects. It also opens new research avenues that will hopefully stimulate the interest of scholars and practitioners working on ERP implementations.

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