CRITICAL SUCCESS FACTORS FOR THE IMPLEMENTATION OF ENTERPRISE RESOURCE PLANNING (ERP): EMPIRICAL VALIDATION

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ABSTRACT

Implementing an Enterprise Resource Planning (ERP) system project is a difficult and high cost proposition as it places tremendous demands on organization's time and resources. The ERP implementation literature contains many case studies of organizations that have implemented ERP systems successfully. However, many organizations do not achieve success in their ERP implementation projects. Much has been written about implementation and the critical success factors for ERP implementation projects. But there very few studies have scientifically developed and tested constructs that represent critical success factors of ERP implementation projects. Based on a survey of 53 organizations in Australia, the results suggest that a 65 item instrument that measures seven dimensions of ERP implementation is well - validated. It is argued that model proposed in the paper is valuable to researchers and practitioners interested in implementing Enterprise Resource Planning systems.

Keywords: ERP, Implementation, Constructs development, Critical Success Factors

1. INTRODUCTION

The business environment is changing dramatically and in order to stay competitive in the market, organizations must improve their business practices and procedures. Organizations within all departments and functions upgrade their capability to generate and communicate accurate and timely information. The organizations which have successfully implemented the ERP systems are reaping the benefits of having integrating working environment, standardized process and operational benefits to the organization. Not all ERP implementations have been successful. There have been horror stories of ERP implementation and improper implementation has taken the companies to bankruptcy and in several cases organizations decided to abandon the ERP implementation projects. The questions many academicians and researchers have asked what are the reasons of success and failure of ERP implementations. Some of the reasons cited in the literature are lack of support of top management support, resistance from employees, poor selection of ERP systems and vendor etc. Majority of these studies have used case studies to conclude their findings and very few have used the empirical to study the ERP. This research is an attempt to extend the ERP implementation research by defining the conceptual domains constructs and operational measures specific to ERP implementation critical success factors to advance ERP research. The objective of this paper is to develop an instrument for measuring ERP implementation critical success factors. We follow two step processes; first, we identify 12 constructs covering critical success factors for ERP implementation. Second, because the constructs are latent variables, we apply a rigorous procedure for ensuring the psychometric adequacy of the resulting new multi-item measurement scales.

In the first section of this paper, constructs are defined and then a rigorous empirical scale development process in order to identify sets of survey items that exhibit satisfactory levels of reliability and validity. Section 2 presents a brief background of the research context and defines and illustrates the specific constructs for which new measurements scales are developed. The third section provides details on the preliminary scale development methodology and field database. Section 4 describes and reports on results. In section 5, we conclude with a discussion of the implications of our results and usage of the scales, review the limitations of our study, and offer some concluding thoughts.

We conducted a cross-disciplinary literature review encompassing BPR, Change management, MIS, strategic management, innovation diffusion, and operations to develop a framework, construct definitions, and item generation for this study. This process yielded the baseline model depicted and a set of initial measurement scales for twelve theoretically important critical success factors.

2. MODEL DEVELOPMENT

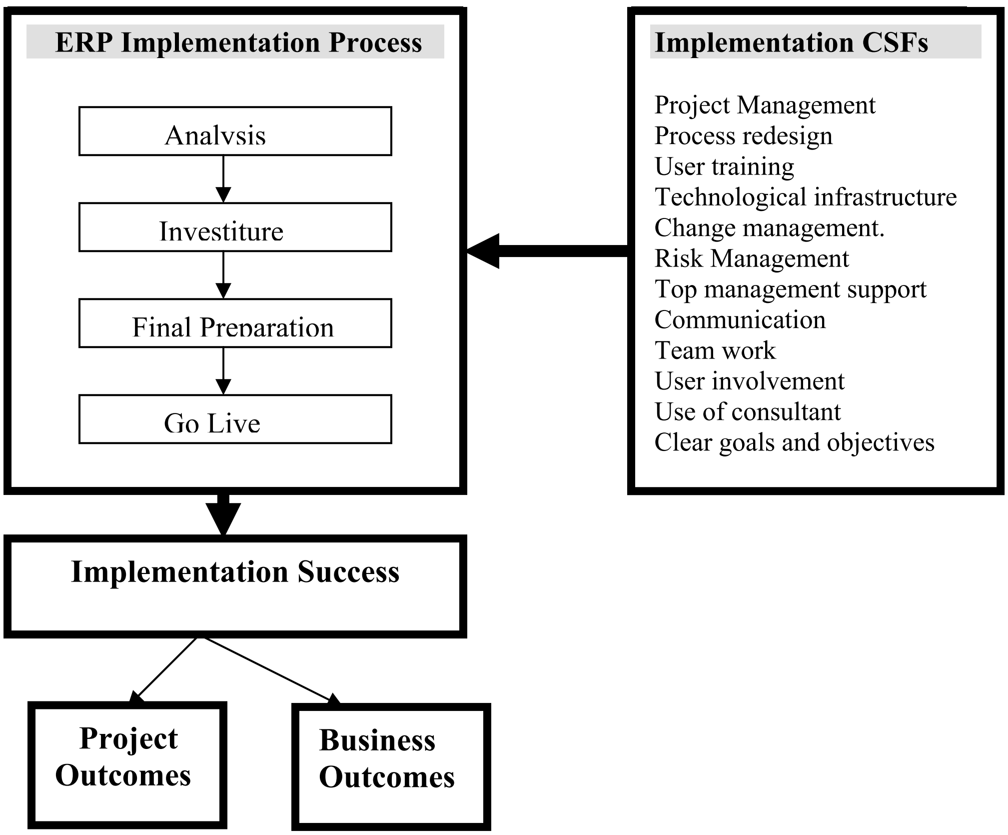

Figure 1: Enterprise Resource Planning Systems implementation framework.

Figure 1 illustrates the conceptual model developed for this study. Drawing from multiple literature bases, we introduced an integrative, conceptual framework of what we call "integrated ERP implementation," which is comprised of a set of theoretically important constructs. This framework has been developed based on the project life cycle approach, in which the ERP implementation project goes through different phases before it goes live. There are number of factors that affect the ERP implementation process are termed in this study as implementation critical success factors. Upon the completion of ERP implementation project, performance is measured by a mix of project outcomes and the project and business outcomes (intended business performance improvement).

3. CONCEPTUAL DOMIANS OF CSFS FOR ERP IMPLEMENTATION

Since the model constructs are latent variables, which cannot be measured directly, multi-item scales, each composed of a set of individual items, were needed to obtain indirect measures of each construct. The items listed in this section represent the scales as drawn from the practitioners, and refined through an expert judge-based manual sorting process [1]. These scales were further refined (and some items were dropped) as a result of an empirical test of a survey instrument containing these initial scales.

Critical success factors (CSF) are widely used in the information systems arena [2]. CSFs can be understood as the few key areas where things must go right for the implementation to be successful. Past studies have identified a variety of CSFs for ERP implementation, among which context related factors consistently appear. Following are the commonly identified CSFs identified by several researchers and are pertinent for the success of ERP implementation project.

3.1 Project Management

Project Management involves the use of skills and knowledge in coordinating the scheduling and monitoring of defined activities to ensure that the stated objectives of implementation projects are achieved. The formal project implementation plan defines project activities, commits personnel to those activities, and promotes organizational support by organizing the implementation process.

3.2 Business Process Reengineering

Another important factor that is critical for the success of ERP implementation is the Business Process Reengineering. It is defined by [3] as"the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed". Organizations should be willing to change their businesses to fit the ERP software in order to minimize the degree of customization needed. The implementation of ERP requires examination of many business processes, which believed to be one of the important and beneficial results of the implementation of ERP system.

3.3 User training and education

In ERP implementation process many projects fail in the end due to lack of proper training. Many researchers consider users training and education to be an important factor of the successful ERP implementation [4] [5] [6] [7] [8]. The main reason for education and training program for ERP implementation is to make the user comfortable with the system and increase the expertise and knowledge level of the people. ERP related concept, features of ERP system, and hands on training are all important dimensions of training program for ERP implementation. Training is not only using the new system, but also in new processes and in understanding the integration within the system – how the work of one employee influences the work of others.

3.4 Technological infrastructure

[8] and [9]argued that adequate IT infrastructure, hardware and networking are crucial for an ERP system's success. It is clear that ERP implementation involves a complex transition from legacy information systems and business processes to an integrated IT infra-structure and common business process throughout the organization. Hardware selection is driven by the firm's choice of an ERP software package. The ERP software vendor generally certifies which hardware (and hardware configurations) must be used to run the ERP system. This factor has been considered critical by the practitioners and as well as by the researchers.

3.5 Change management

Change management is a primary concern of many organizations involved in ERP project implementation [4]. Many ERP implementations fail to achieve expected benefits, possibly because companies underestimate the efforts involved in change management.

[5] identify organizational change is the body of knowledge that is used to ensure that a complex change, like that associated with a new big information system, gets the right results, in the right timeframe, at the right costs. Generally, one of the main obstacles facing ERP implementation is resistance to change. [11] points out that the resistance to change is one of the main hurdles faced by most companies. Resistance can be destructive since it can create conflicts between actors, it can be very time consuming. To implement an ERP systems successfully, the way organizations do business will need to change and ways people do their jobs will need to change as well [12].[13] propose the recurring improvisational change methodology as a useful technique for identifying, managing, and tracking changes in implementing an ERP system. Change Management is important and one of the critical success factors identified in the literature. It is imperative for success of implementation project starting at the initial phase and continuing throughout the entire life cycle.

3.6 Management of Risk

Every Information technology implementation project carries important elements of risk; hence it is probable that progress will deviate from the plan at some point in the project life cycle. ERP implementation project risks are described as uncertainties, liabilities or vulnerabilities that may cause the project to deviate from the defined plan. Risk management is the competence to handle unexpected crises and deviation from the plan [14]. The implementation of ERP system project is characterized as complex activity and involves a possibility of occurrence of unexpected events. Therefore, risk management is to minimize the impact of unplanned incidents in the project by identifying and addressing potential risks before significant consequences occur. It is understood that the risk of project failure is substantially reduced if the appropriate risk management strategy is followed.

3.7 Top Management Support

Top management support has been consistently identified as the most important and crucial success factor in ERP system implementation projects [4]. [14] define top management to provide the necessary resources and authority or power for project success. Top management support in ERP implementation has two main facets: (1) providing leadership; and (2) providing the necessary resources. To implement ERP system successfully, management should monitor the implementation progress and provide clear direction of the project. They must be willing to allow for a mindset change by accepting that a lot of learning has to be done at all levels, including themselves [10].

3.8 Effective Communication

Communication is one of most challenging and difficult tasks in any ERP implementation project. It is considered a critical success factors for the implementation of ERP systems by many authors [5]. It is essential for creating an understanding, an approval of the implementation and sharing information between the project team and communicating to the whole organization the results and the goals in each implementation stage. In addition to gaining approval and user acceptance, the communication will allow the implementation to initiate the necessary final acceptance. The communication should start early in the ERP implementation project and can include overview of the system and the reason for implementing it be consistent and continuous.

3.9 Team work and composition

ERP team work and composition is important throughout the ERP implementation project. An ERP project involves all of the functional departments and demands the effort and cooperation of technical and business experts as well as end-users. According to a survey conducted by [6], ERP implementation team comprises of, functional personnel and management, IT personnel and management, top management, IT consultants, ERP vendor , parent company employees, management consultants, hardware vendor.

The ERP team should be balanced, or cross functional and comprise a mix of external consultants and internal staff so the internal staff can develop the necessary technical skills for design and ERP implementation. According to [16] survey, having competent members in the project team is the fourth most important success factor for IS implementation. Further, the members of the project team(s) must be empowered to make quick decisions.

3.10 User Involvement

User involvement refers to a psychological state of the individual and is defined as the importance and personal relevance of a system to a user. It is also defined as the user's participation in the implementation process. There are two areas for user involvement when the company decides to implement an ERP system: (1) user involvement in the stage of definition of the company's ERP system needs, and (2) user participation the implementation of ERP systems. The functions of the ERP system rely on the user to use the system after going live, but the user is also a significant factor in the implementation.

3.11 Use of consultants

Due to the complexity of implementing an ERP system, it requires the use of either internal or external experts who are knowledgeable about the installation and software. Many companies prefer or must have external consultants to perform ERP implementation. [4] revealed in their research on ERP implementation that consultants may be involved in different stages of the ERP project implementation. Clearly, it is critical success factor and has to be managed and monitored very carefully.

3.12 Goals and Objectives

Clear goals and objectives are essential to guide an ongoing organizational effort for ERP implementation as it usually exceeds the time frame for a typical business project. Clear goals and objectives were the third most critical success factors in a study of MRP implementation. It is important to set the goals of the project before even seeking top management support [14]. The "triple constraint" of project management specifies three often competing and interrelated goals that need to be met: scope, time, and cost goals. There must also be clear definitions of goals, expectations, and deliverables. Finally, the organization must carefully define why the ERP system is being implemented and what critical business needs the system will address.

4. SCALE DEVELOPMENT FOR CSFS OF ERP IMPLEMENTATION

Scale development, or the design and re-finement of multi-item scales employed to measure the constructs are vital to empirical research in management information systems [16]. Establishing the validity of the scales is dependent first upon establishing that they are reliable measures [17]. One of the goals of this research study is to create reliable and valid multi-item scales for measuring the 12 constructs described in Section 2. The content validity of these constructs was tentatively established by extensive literature reviews and interviews with managers and customers of technology-mediated services.

4.1 Item generation

The construct brief discussion provided in Section 3 are necessary, but not sufficient, to advance our understanding of the critical success factors of ERP implementation. Thus, the first step in constructing new multi-item measurement scales is to generate sets of items that tap into the latent constructs and permit us to accurately and reliably assess these constructs from management' perspectives [17]. Some of the constructs involved in this research have been operationalized in previous studies and scales were available for these constructs. However, none of the existing scales was exactly appropriate for re-application in the context of ERP implementation.

4.2 Iterative item refinement

To refine the scales, we adapted [17] widely used methodology for instrument development. This method recognizes that the complexity inherent in many business processes cannot be adequately measured by a single scale. Multi-item measures can reduce measurement error by providing a more robust construct of complex variables through averaging several individual items. The challenge is to develop a set of items that capture the essence of the construct with the desired reliability and validity. [17] recommends an iterative process consisting of several steps.

After the initial item pool was generated, then the items were purified. This purification step is designed to remove the potential for measurement error from the new construct to improve their reliability. Collecting data from an initial sample of respondents helps to address these issues. Specifically, a manual factor technique [18] was used to establish tentative scale reliability and validity, as well as to assess potential problems with the unidimensionality of the constructs. The manual sorting procedures was conducted iteratively, using independent panels of expert judges for each round. The judges had recent industry experience with the implementation and use of ERP software in a business environment.

Each expert judge was given a questionnaire containing short descriptions of each of the proposed constructs, together with a randomized list all of the items generated from the literature. In each round, the panel of expert judges was asked to assign each item to one of the identified constructs. Items that were not consistently grouped into their target construct during this process were considered for rewording or elimination. Note that this sorting procedure follows the technique described in [19], which differs from the traditional Q-sort technique [20] in that there are no restrictions on the number of items which may be placed in any of the defined construct categories.

To assess the pretest scale reliability of the quantitative judgments made by the questionnaire respondents, item placement ratios [19] measure was used as indicator to measure the observed proposition of agreement between judges that is greater than would be expected from chance. The item placement ratios assess both the validity of the generated items and the reliability of the proposed measurement scales. If there is a high degree of interjugde agreement, then the percentage of items place in the target construct will also be high. In addition, scales based on a high degree of construct validity and also exhibit the potential to be reliable.

In table 1 (available from author) we present the final round item-placement ratios for the constructs using [19] format, which provides additional insight into the performance of the proposed measurement scales. Each of the organizational aptitude and performance constructs is listed on the rows of the table. Let us examine, for example, the Project management construct. It has 6 items, so perfect item placement for this construct would be a score of 30 (6 items x 5 judges). In this case, only 25 judge-items were classified as intended, while 5 were classified under not all relevant to any of the critical success factors. The item-placement ratio for Project Management thus equals 25/30 or 83%. According to [19] item placement ratio of 70% or greater is generally considered acceptable. All of the constructs met or exceeded these criteria for the final sorting round.

5. FIELD SURVEY

Satisfied by the apparent reliability and parsimony of our new measurement scales, we moved into the next phase of testing our survey instrument in a field setting. For this phase, the mail survey was targeted at decision makers within the Australian Companies that have implemented Enterprise resource Planning system. The questionnaire used in this study attempted to measure the theoretical model illustrated and discussed in section 2. Prior to piloting the questionnaire, [17] instrument development methodology was adopted to generate the pool of items for each construct. Items were drawn from the literature review and based on the interviews with executives and consultants involved in the implementation of Enterprise Resource Planning. Manual sorting procedure [18] was conducted using industry experts experienced in ERP systems. [21] advocates this approach for new scale development.

Initial survey instrument was pilot tested during mid of 2003 and it was further refined to be ready after a pilot survey was undertaken. The final survey was sent out to the respondents in November - December, 2003 and comprised of 18 questions in eight sections. Data used to test the CSF instrument were obtained from 53 respondents from Australia. Each respondent company had implemented ERP system and the respondents had experience in either been involved in ERP implementation of their organization. The questionnaire was sent through mail to the 500 organizations and 53 usable surveys were received making the response rate to be around 11%. Most of the items in this study were itemized using Likert- Scale, in which respondents were asked to indicate their level of importance for each of the construct items (critical success factors) using their response on a seven point scale.

The measurement analysis emphasizes explanations of the reliability and validity of the new instruments for measuring these constructs. The validity and reliability measure indicate that the instrument has the potential for use in further studies.

5.1 Reliability Analysis

Reliability is one of the most critical elements in assessing the quality of the construct measures [17], and it is a necessary condition for scale validity. A statistically reliable scale provides consistent and stable measures of a construct. Composite reliability estimates are used to assess the inter-item reliability of the measures. Estimates greater than .70 are generally considered to meet the criteria for reliability. Some items may be removed from the construct scales if their removal results in increases in the reliability estimate, however, care must be taken to ensure that the content validity of the measures is not threatened by the removal of a key conceptual element.

As shown in the table below that reliability of each factor is above .75. In table 2, are listed the composite reliability estimates for each of the measurement scales.

5.2 Factor Analysis

An exploratory factor analysis was conducted on the different measures to purify the instrument. Factor analysis was also used to identify underlying factors or the dimensional composition of instrument. Items which were not factor ally pure were eliminated. The data from 53 responses were examined using principal component method. At this stage, items with factor loading of less than 0.5 on each factor or above 0.5 on additional factors should be deleted to purify the measure. After the extraction no items are deleted but the project management items and risk management are loaded on one factor and leaving total of 11 factors with an Eigen value of greater than one. Factor loadings, Eigen value and Cronbach Alpha value are presented in table 4 - 10 in appendix (not included in the paper).

Table 2: Constructs (CSFs) items and reliability values

Constructs	Items	Alpha
Project Management	10	.89
Business Process Reengineering	5	.85
Users training	5	.88
Technological Infrastructure	5	.88
Change management	5	.89
Top Management Support in ERP implementation	5	.87
Communication in ERP Implementation	5	.75
Team Composition in ERP Implementation	5	.81
Users Involvement in ERP Implementation	5	.86
Consultants involvement in ERP implementation	5	.84
Clear Goals of ERP implementation	5	.89

5.3 Content Validity

The content validity of a questionnaire refers to the representative ness of item content domain. It is the manner by which the questionnaire and its items are built to ensure the reasonableness of the claim of content validity. The conceptualization of survey instrument constructs are based on preliminary literature review to form the initial items, the personal interviews with practitioners and experts used for scale purification suggest that the survey instrument has strong content validity.

5.4 Construct Validity Analysis

Construct validity is established by showing that the instrument measures the construct it is intended to measure. Construct validity is evaluated by performing correlation and factor analysis. High correlations considered to indicate construct validity.

It is interesting to observe that the relative strength of the correlation between critical success factors constructs. Project Management critical success factor is strongly correlated with the other success factors, with the exception of consultant's involvement in the implementation process. This may be due to the project management scale contains items such as effective partnership with ERP vendors avoids problems that would be expected to be success factor in the ERP implementation. Business process reengineering correlates most strongly with technological infrastructure (.73), Change management (.73) and User involvement (.77). Change management and ERP training to users are strongly correlated indicating the overarching nature of these success factors implementation project. Top management involvement is correlated highly with user involvement, demonstrating the close relationship between business processes and team members in an ERP environment. Based on the estimated correlations, the strongest relationship between the critical success factors project management, business process reengineering, change management, top management involvement and user involvement.

CONCLUSION

The primary contributions of this paper are the definition of new constructs associated with the ERP implementation and the development of new multi-item measurement scales for measuring these constructs. Unlike much prior ERP implementation research, our study takes a grounded theory approach using ERP experts' perceptions. Future ERP implementation empirical research linking these constructs in causal models in an ERP will benefit significantly from the existence of relevant construct definitions and good measurement scales. A secondary contribution of this work is the demonstration of a rigorous empirical scale and item development process.

Like any research, our approach and our results have some limitations. First, the use of convenience samples in the pre- and pilot-tests may have limited our insights early in the process. The use of random sampling in the final data analysis, however, alleviated much of the concern regarding this issue. A second limitation is the fact that our experts manual sorting approach resulted in some scales having only three indicators. While this may prove to be a limitation in some applications and some models, identification methods do exist that support their re-use in new models (Bollen, 1989).

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