



A DECISION-MAKING MODEL FOR ADOPTION OF ENTERPRISE RESOURCE PLANNING TOOLS BY SMALL-TO-MEDIUM SIZE CONSTRUCTION ORGANIZATIONS

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Abstract. Enterprise Resource Planning (ERP) utilization in the construction industry has been limited to large organizations. Significant numbers of construction organizations that have either failed in their efforts to adopt this technology or are not familiar with it are the Small- to Mid-Size Construction Organizations (SMSCOs). Failure in or refusal to adopt ERP by this group, despite all its potential benefits, was the problem addressed in this research.

We propose a decision-making model which organizations could utilize to adopt Enterprise Resource Planning Systems. After a careful review of existing technology models, a new ERP Adoption Model (EAM) has been formulated and projected. This model has incorporated new elements that have been set as its new decision-making core. Furthermore, we identified and ranked the prohibitive criteria that were at play and prevented SMSCO members from successfully adopting and implementing ERP systems in order to increase the understanding of their impact on EAM's processes. Finally, we conducted a case study to analyze the decision-making process of EAM implementation by SMSCOs. ERP Adoption Model (EAM) provides a decision-making tool that construction organizations can use as a road map.

Keywords: Enterprise resource planning, construction information technology, decision making model, small-to-medium size construction organization.

1. Introduction

Although Enterprise Resource Planning (ERP) has been fully implemented by most major industrial sectors, its utilization in the construction industry has been limited to a few large organizations (Tatari *et al.* 2007). The largest groups that have either failed in their efforts to adopt this technology, or are not familiar with it, are Small-to-Mid-Size Construction Organizations (SMSCOs). Why members of SMSCO are not willing or able to adopt ERP, despite all its potential benefits, is the question that is addressed in this research. In addition since no study has been conducted that deals with creation of a decision-making model for adoption of ERP system by SMSCO, this research will develop and test a decision making model to be utilized by members of SMSCO.

Studies that have identified several prohibitive factors, are limited in both their nature and their findings (Skibniewski, Ghosh 2009; Chung *et al.* 2008). Findings have been limited to case studies and survey-based evidence established using statistical analysis. Presently, there is no large-scale empirical study that addresses the issue of why the use of ERP is not as widespread as it should be in SMSCOs. After identification of the problem to be resolved by this research and an extensive literature review was completed, a questionnaire was designed and utilized as the primary instrument to survey the SMSCO sector in

order to identify the Prohibitive Criteria, their interrelationships, and their hierarchical ranking. The participants in the survey were chosen from the members of SMSCO in United States of America, Mid Atlantic region. These surveys were conducted in fall and winter of 2007.

2. Literature review

Many organizations are in the process of implementing ERP systems; however, the success rate for these systems remains historically low. A study by Žabjek *et al.* (2009) indicates that approximately 90% of the projects are regarded as failures. Taking into account critical success factors and risks associated with the implementation, Chakraborty and Sharma (2007) also argued that 90% of all ERP implementations are considered as failures in terms of project management. A number of studies have investigated the poor performance of ERP projects (Paulk 2004; Roeding *et al.* 1999). Some of the user-related factors that have contributed to this failure are rejection, under-utilization, and lack of technological capabilities, let alone the complex nature of the projects themselves (Luo, Strong 2004). Kwak *et al.* (2011) indicate that even if the system is installed on time and within budget, it cannot be successful if users perceive that the system is useless for organizational processes or feel there are difficulties in utilizing it.

In the current literature, writers have identified the following major common obstacles: time, cost, and evaluation (Frisk, Planten 2004).

Time

According to Frisk and Planten (2004), the time it takes to realize the benefits of ERP implementation is one of the four major problems in IT benefit management. Webb (1998), believes that organizations cannot afford to spend years implementing technology solutions. He indicated that in some industries, lengthy implementation can provide competitors with enough time to threaten or even overtake the market position of the implementing organization.

Cost

Chen (2001) reported that the total ERP cost including software, hardware, consulting, and internal personnel can easily run as high as 2–3% of a company's revenues. The cost to implement a new ERP can range anywhere from \$2 million to \$4 million for a small firm, to over \$1 billion for a large company. Cotteller *et al.* (1998), reported a breakdown of the implementation costs for ERP system integration as follows: software, 16%; hardware, 32%; system integration, 38%; and headcount, 14%.

Evaluation

Current literature has concentrated on evaluating the system and its immediate impact, rather than focusing on its strategic potential and its match with an organization's overall goal and strategy. Kefi (2002) emphasized the importance of identifying the strategic context before implementing a system or starting an IT project in order to achieve the right business focus.

Frisk and Planten (2004) showed that an analysis of the objectives and influence of the various stakeholders is a common part of many of the evaluation studies. External and internal stakeholders of the project (Huang 2003) are mentioned. Although stakeholders appear to be an essential part of the evaluation, there is a lack of explanation of how they should be identified and included in the evaluation (Frisk, Planten 2004; Choenni *et al.* 2003; Van Grembergen, Van Bruggen 1998; Griffith, Remenyi 2003).

By far the most significant criteria that need to be carefully analyzed when it comes to evaluation of ERP are the financial aspects. Most organizations are very conscious of this factor and the impact that it might have on their operation. When dealing with financial criteria, we must be concerned with the metrics used to measure them; after all, one cannot adequately evaluate something that has not been correctly quantified. Relying only on subjective measurements will not produce reliable results.

Organizations must approach the investment in ERP as capital asset expenditure, an asset that needs time to mature in order to pay dividends. Taking a short-term view in evaluating ERP will not truly reflect the potential benefits and costs. Experience has shown the ERP implementation process can take anywhere from two to five

years to be completed (Gunson, Blasis 2001). Cost benefit analysis has been mentioned as the method organizations use most frequently to evaluate and justify their investment in ERP. Because this method of analysis has such an important influence on the evaluation process, it needs to be examined in greater detail.

A survey conducted by van Everdingen *et al.* (2000) among mid-size organizations in the European market found that the potential size of the ERP market just in Europe among SMSCOs exceeds the staggering amount of \$50 billion per year. This study also found that SMSCO members are interested the following functional areas: purchase and sales order management, inventory and materials management, production and assembly, transportation, service and maintenance, marketing and sales, warehouse management, financial accounting, and human resource management.

In an article in the April 2000 issue of *Communication of the ACM*, van Everdingen *et al.* (2000) presented the results of a survey which identified the selection criteria utilized by SMSCOs, here listed in order of importance: fit flexibility, cost, user-friendliness, scalability, and support. In addition, this same study's data show that European mid-size companies tend to focus on product characteristics rather than on the vendor of the product. It was concluded that it made little difference whether the vendor was a market leader, an international oriented company, or a company with a superior image. In order to obtain higher efficiencies from IT adoption, the business process needs to expand to a wider transformation of the entire process (Nitithamyong, Skibniewski 2004).

In addition, Anderson (2001) identified the following additional obstacles to ERP adoption by SMSCOs: (1) conservatism of the ownership group; (2) the high risk of litigation following the use of innovative solutions that subsequently fail; (3) high rates of change in technology and business solutions; (4) lack of user training investment; (5) the overselling of benefits by IT solution providers; (6) the lack of standardization leading to incompatibilities, conflict, and too many choices.

Shi and Halpin (2003) indicate that another problem is a lack of additional practical functionalities that would suit SMSCO members – such as functionalities for handling earned value, percent complete, cost forecasting for determining project progress, scheduling, budgeting, project tracking, procurement process, and reporting. These authors also caution that the size of the system or its scale needs to be adjusted to fit the construction operations of SMSCOs.

The suitability and implementation status of ERP systems in contractor firms has been studied and it has been noted that the majority of contractor firms are aware of the ERP systems, but very few organizations have implemented such systems (Ahmed *et al.* 2003). Ahmed *et al.* (2003) concluded that the major reason for this lack of implementation was the size of the investment in time and money required. Shi and Halpin (2003) stated that the unique nature of the construction industry acts as a barrier to implementation of ERP systems.

Decision making is an important part of any construction project manager’s daily tasks. The research conducted by Dean and Sharfman (1996) showed that strategic decisions are influenced by the process used. More specifically, managers who used analytical techniques made decisions that were more effective than those who did not, and managers who engaged in the use of power or pushed hidden agendas were less effective than those who did not.

The decision-making model mostly consists of a number of stages. Researchers have commented on the confusing nature of many recorded instances of ERP decision making (Saint-Leger, Savall 2001; Sammon, Adam 2000; Sammon, Lawlor 2001) and the presence of political decision making (Shakir 2000; Sammon, Lawlor 2001).

Technology Acceptance Model (TAM) is among the most popular technology adoption models. It was designed specifically to explain computer usage (Davis *et al.* 1989) and the role of behavioral intention to use the system. A key purpose of TAM is to provide a basis for tracing the impact of external factors on internal beliefs, attitudes, and intentions (Davis 1989). As indicated previously, TAM is focused on users of IT applications and therefore was singled out for additional investigation for possible adoption.

3. Why a new model

The decision-making process in an SMSCO is rather complicated, driven by a number of construction specific variables. These variables and their unique nature cannot be clearly defined by existing technology-acceptance models. The existing models, mostly based on TAM’s deterministic approach to the process of decision making, while very simple, do not offer adequate solutions to the problems encountered. It became obvious that when dealing with technology adoption models a more SMSCO oriented yet simple model was required.

Flexibility & Self Expression

Current models utilize a deterministic approach in their process, and therefore are not able to provide much flexibility and consideration for self regulation to the

decision maker. The question became, in order to overcome this can a model be created which provides a high degree of flexibility and an opportunity for SMSCO to self express the particulars of their own unique operations to decision making process?

Simple but Complete

Current models which are based on TAM rely on an oversimplified process and thus neglect impact of prohibitive criteria and group’s cultural aspects of decision making process applicable to SMSCO. Question to ask was, can a model be generated that would provide a level of simplicity required to provide for consideration of the impact of prohibitive criteria and group’s cultural aspects on the decision making process?

4. Conceptual ERP adoption model (EAM)

We adopted the model that incorporated the paradigm shift proposed by Bagozzi (2006) with its theoretical roots in TAM to become the starting point for our new model. The factors influencing our decision to adopt this model were as follows: adaptability of proposed “new core” to construction industry requirements, introduction and existence of the self-regulation concept, theoretical underpinning, linear relationship between various elements, and theoretical testimony. Considering all these factors, we have proposed a new ERP Adoption Model (EAM) as shown in Fig. 1.

EAM as shown in Fig. 1 consists of eight different elements: (1) problem identification; (2) information search; (3) planning; (4) selection/short list; (5) evaluation; (6) self-regulation; (7) choice; (8) implementation. EAM begins with problem identification and ends with implementation. EAM has a deterministic core, but some of the processes are iterative and could be done concurrently. Each process results in deliverables that are used by another process.

As indicated, activity among some of the processes is highly iterative even though the EAM overall has a sequential progression that takes the organization from problem identification to implementation. The iterative sequence of activities is associated with the self-regulation element of the model.

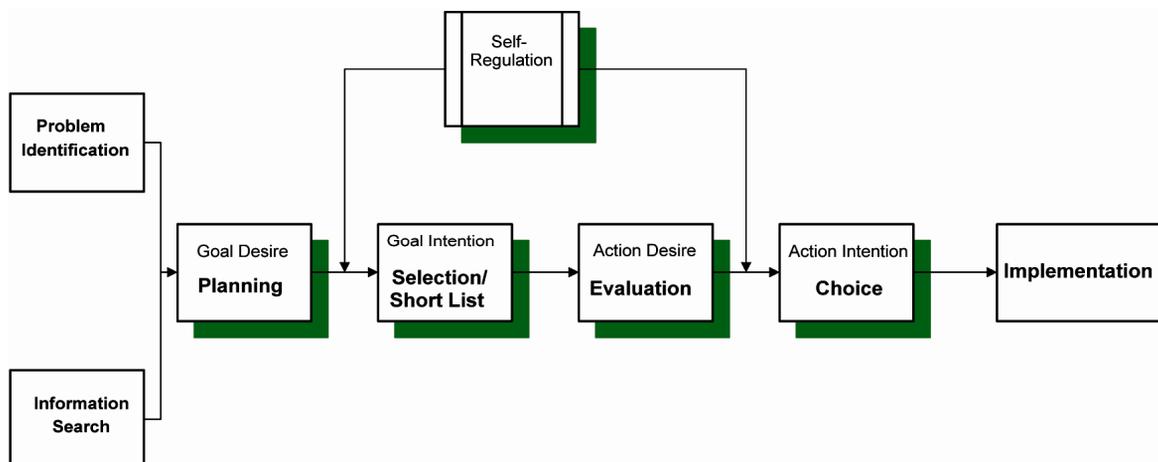


Fig. 1. The proposed ERP adoption model

Problem Identification

Problem identification must be initiated by an investigative/project team that can complete an organizational review and verify or deny the existence of a problem. Individual team members need to be selected in such a way that the team has a cross-functional and multidisciplinary capability. Various methodologies can be utilized to verify the nature and scope of the problem. In-house self-evaluation or outside reviews could be viable alternatives. Existence of “No Problem” answers must be considered and accepted if that be the case. However, if a problem is identified by the team it must be clearly defined and tabulated.

Information Search

The information search should be an iterative process since information will always be feeding the planning process. It could consist of two principal elements: information screening and information sources. Some of the key factors that must be considered are as follows: (1) the type and nature of the information that is to be gathered; (2) the credibility of the sources, whether internal or external; (3) the credibility of the information that was obtained; (4) reliability of the sources whether internal or external; (5) reliability of the information obtained; (6) outside references; (7) client referrals from the vendors; (8) the possibility of information overload and confusion.

Planning

Organizations must commit to and spend a significant amount of time in the planning process. Each organization must develop an acquisition strategy that reduces uncertainty associated with the process. The planning team must define the organization's requirements for the ERP solution. Each team must establish its individual criteria for selection, evaluation, and choice stages prior to contacting any vendors or looking at an ERP solution.

These criteria must be based on information that is gathered from end users and other sources. The defined criteria then need to be utilized to complete various processes within each stage, such as market analysis, grid/matrices for selection, and choice processes. The organization's planning team must consider as many applicable issues as possible. In this stage, the initial participation of representatives for various end-user groups is a critical element. During market analysis, the acquisition team should determine who the major players are in the marketplace for the ERP system that they are seeking. There must be a fixed number of deliverables that are to be produced at the end of the process.

Selection/Short List

The selection/short list is the intermediary stage between the planning/filtering processes and the evaluation stage. Within this process the following two principal actions must be considered: “evaluate RFI/RFP/RFQ responses, and create a short list of vendors/technologies”.

Completion of proper evaluation of RFI/RFP/RFQ must be the main concern of the project team at this stage. Some recursive activities between this process and the planning process will probably occur. The deliverable of this stage is a short list of vendors that need to be thoroughly evaluated.

Evaluation

Evaluation is a very critical and complicated process that the project team must conduct. Critical factors the team must consider include the following: strategic match, stakeholders' influence, system specific, organizational impact, life-cycle approach, and financial criteria. Within this process, vendors, the functionalities provided by ERP system, and technical issues must be evaluated. The criteria and strategies that are established during the planning process should be utilized to complete the evaluation. The deliverables of this stage must consist of a vendor and functionalities/modules.

Self-Regulation

Within our research, we have paid particular attention to the nature of self-regulation, with its variables and constraints. Self-regulation was introduced into EAM in order to account for the possible impact of the “human agency” into the decision-making process. When properly conducted, self-regulation will allow for a reality check that is critical to the success of the technology adoption. Existence of Self-Regulation element allows decision makers in an SMSCO or any other organization, to incorporate factors that are unique to their organizations into the decision making process. Addressing the issues raised as a result of implementation of Self-Regulation element will prevent future problems that could be detrimental to the entire process.

Choice

This stage is the natural culmination of the evaluation process. Once the deliverable of the evaluation process has become clear it must be recommended to the entire ownership group. In the case of SMSCOs, it is of the utmost importance to obtain the approval of the majority, if not all, of the ownership group. This stage was singled out so that the ownership group has an opportunity to independently review the finding and make a full commitment to implementation.

Implementation

The last stage of the EAM consists of the final series of activities required for SMSCOs to successfully select and implement an ERP system. The negotiation part of this stage should consist of the business and legal segment, culminating in signing the final contract.

5. Prohibitive criteria confirmation questionnaire

One of the initial objectives of this research was to identify the reasons for SMSCO's failure to utilize and or implement ERP systems. A review of literature identified a number of criteria that hereafter are referred to as *Prohibitive Criteria*. Prohibitive criteria are defined as those

criteria that cause an SMSCO to terminate the implementation of ERP. In order to reaffirm these criteria with real-life experiences of members of an SMSCO, it was decided to conduct a paper-based questionnaire. Before the questionnaire was sent out, it was reviewed by three SMSCO executives and two academics. Several detailed meetings were held to ensure that the questionnaire was comprehensive and understandable. Finally, we contacted two hundred participants that included SMSCO construction industry executives, construction management personnel, A/E construction managers, and resident engineers, with detailed working knowledge of operations for a small- to medium-size construction company.

The common denominator among all participants was their knowledge of the day- to-day operation of an SMSCO. In addition, their familiarity with general Web technology applications was targeted. Since we anticipated that this group had not had much experience using ERP, their detailed knowledge of it was not selected as a critical targeting factor.

The majority of respondents were contractors, in one form or another. A combination of general contractors and subcontractors constituted 41% of respondents, indicating a high degree of familiarity with the day-to-day operation of an SMSCO. The next largest group was owners or owners' representatives. For the purpose of this research, and utilizing the federal guidelines defining small- to medium- size business, an upper limit of \$20 million of gross billing was chosen to be the defining limit for an SMSCO.

Based on this definition, 79% of respondents were identified to be members of SMSCOs. This was a clear indication of the sampling validity of this questionnaire. Clearly this group was very familiar with issues facing SMSCOs, either as contractors or as members of other professional categories such as A/E, suppliers, or owners. We checked the respondent's familiarity with Web/IT, and found that a majority of respondents, 76%, were very familiar with Web technology.

Since initial interviews showed that respondents had a minimal familiarity with ERP terminology, it was decided to measure their understanding of the subject by first measuring their familiarity with Web technology. SMSCO executives told us that this would be a good starting point to define the profile of respondents.

A majority of participants had access to the Web. They were not familiar with various ERP/project management tools; however, they were also willing to adjust their business procedures in order to utilize IT-oriented project management tools. Among these participants, a majority did not enjoy the broad and full support of their senior management. Those who were familiar with project management tools had utilized only rudimentary and basic in-house software packages that they had developed.

The majority of participants were familiar with some IT project management tools, with e-mail being the most prominent. Participants also said that cost and time were the areas that could improve most positively as a result of implementing the tool. In addition, they agreed

that the tool could improve communication substantially and that it could also benefit standardization. Finally, the majority, when asked, stated that they had neither used these tools nor would anticipate any increase in their profits; however, of the group that had utilized these tools, the majority said their profits had improved.

The significant majority of participants confirmed cost as a primary prohibitive factor. This was followed by training and infrastructures. Within cost, the subcategory of initial cost was selected as a primary concern among all cost subgroups. Respondents also expressed their significant concern about security, reliability, and level of complications associated with different functionalities. Finally, they identified time as a common denominator among all criteria as another significant prohibitive factor.

Results of the field questionnaire confirmed the findings that were identified by the literature review. Based on the findings of the questionnaire, initial interviews, literature review, and practical applicability, the following prohibitive criteria were selected and set as critical determinants: cost, time, functionalities, and security.

Respondents to the field questionnaire identified the following cost categories as important: initial cost, maintenance cost, and training cost. This finding was supported by the literature review. In order to further isolate the relationship and the impact that the initial cost item might have, it was decided to divide cost into two separate groupings – implementation cost and initial cost.

The literature review identified the time scale as a major prohibitive factor. Time was also a common thread among a number of concerns that were identified by the field questionnaire. Cost, security, and complication of functionalities all are impacted by time, which is the most common denominator.

Having confirmed and selected time as another prohibitive criterion, it was decided that time needed to be subdivided into the following subcategories: production time, implementation time, training time, and technical durability time.

Since one of the objectives of this study was to generate a practical framework for SMSCOs to implement ERP systems, it was decided to analyze the impact of various functionalities that are offered by these systems. The literature we reviewed identified complexities of various functionalities offered by major ERP systems as another prohibitive criterion (Ahmed *et al.* 2003).

The field questionnaire verified the level of concern that SMSCOs have for various functionalities such as project administration, project controls, project collaboration, and project contract management. Respondents expressed their concern about standardization, complications and communication issues. Based on the literature reviewed and results obtained from the questionnaire, we decided to identify the following as subcategories of functionality: project collaboration, modularity/flexibility, project controls, project administration, and project contract management.

The literature review also revealed that system security, data reliability, and legal issues are major prohibitive

criteria. Respondents to the field questionnaire confirmed that security and legal issues are major prohibitive criteria. On two different occasions they expressed significant concern for these issues. Based on the literature review and answers obtained from the field questionnaire, we decided to select the following subcategories for further analysis: data access, data control, data reliability, and legal issues.

6. Prohibitive/self-regulation criteria questionnaire

This research called for the application of the prohibitive/self-regulation criteria to the self-regulating process of EAM. The proposed research model recommended that SMSCOs utilize these criteria in order to self-regulate their requirements and perspectives for a potential new ERP system. Therefore, following the confirmation of prohibitive criteria, a more in-depth investigation of each of these criteria was warranted. This investigation was necessary to measure the relative strength, hierarchical ranking, and impact of the criteria.

In order to examine the impact of these criteria on the level of acceptance and adoptability of existing ERP systems for an SMSCO environment, we decided to design a questionnaire to distribute among a select group of construction industry professionals who are familiar with ERP systems and their applications. A self-administrated Web-based field questionnaire was selected because it offered the most cost effective, yet efficient, method to reach the respondents, who were located all across the world.

In the questionnaire two separate alternatives for ERP systems were identified and defined as follows:

- ERP – existing software packages that aim to integrate the main business functions across all departments within an organization, from vendors such as SAP, Oracle, and IFS;
- Web-based Project Management Systems (WPMS) – any electronic project management system that is applied through an intranet using internet protocols to transmit information.

These two systems were utilized as a measuring instrument for determining the impact of various criteria on the operation of an organization. A pair-wise comparison analysis of the criteria was conducted.

7. Prohibitive/self-regulation criteria data analysis

Utilizing the results obtained from the second questionnaire, a descriptive statistical analysis was conducted to rank each prohibitive criterion and its subcategories using a 9-point Likert scale. In case of each prohibitive criterion and its sub-categories, descriptive statistics for all of the corresponding responses were computed. In addition, in order to assess whether either of the items had a significantly higher or lower value than the other items, multiple paired t tests were carried out. Based on this analysis prohibitive criteria were ranked. Criteria that were not significantly different were placed in the same ranking level.

In the case of Cost Criteria (ERP alternate), the following ranking was established:

- 1 – Implementation Cost;
- 2 – Initial Cost;
- 3 – Maintenance and Training Cost.

In the case of cost criteria for the WPMS alternate, no significant differences were found among the four cost criteria. Results from the analysis conducted for time criteria for the ERP alternate indicated the following ranking:

- 1 – Technical Durability Time;
- 2 – Production & Training Time;
- 3 – Implementation Time.

The only difference observed for the WPMS alternate was that production as a prohibitive criterion dropped to the bottom level.

Functionality criteria ranking for ERP alternate was as follows:

- 1 – Project Controls & Administration;
- 2 – Contract Management;
- 3 – Collaboration & Modularity.

The ranking of the same criteria for WPMS alternate was as follows:

- 1 – Project Controls, Collaboration, and Contract Management;
- 2 – Administration & Modularity.

Security criteria ranking for the ERP alternate was as follows:

- 1 – Reliability;
- 2 – Access, Control & Legality.

In the case of the WPMS alternate, no significant differences were found among the four security criteria.

Overall criteria rankings for both alternates were discovered to be the same. They were as follows:

- 1 – Functionality & Security;
- 2 – Cost & Time.

It was also observed that all four cost criteria are significantly more important for the choice of an ERP alternate than for the choice of WPMS alternate. Administration functionality was also significantly more important for the choice of the ERP alternate than for the choice of the WPMS alternate.

8. Case study

Since available empirical data, relevant to this topic is limited, it was decided to use the case study method to apply and validate the research model with an in-depth investigation of the application of EAM within a particular SMSCO. Particular attention was given to the self-regulation element. Company X, a regional general contractor, was selected for the case study. A project team was assembled under the direct supervision of an executive partner of the firm. The team included three other members representing various affected departments of the organization. Critical criteria that needed to be measured in order to properly evaluate the necessity of change and the existence of a problem were identified. The project team took previously defined prohibitive criteria into account and considered the impact of these criteria within the existing system. The objective of this task was to

identify any problem with the current systems and measure the level and severity of the required changes to the same systems.

The following vendors were selected to be studied for the prepackaged software category: Oracle, SAP, JD Edwards. The following vendors were selected for the WPMS category; Net Suite, Plexus, Ace Project. General information on each vendor was obtained and reviewed.

The team considered the following actions: visit vendors sites, contact vendor references, have vendors provide onsite demonstrations, request that vendors respond to the same RFP, make acquisition a two-step process consisting of technical and price proposals.

In addition to defining the criteria listed in Self-regulation element consisting of (1) the functional requirements; (2) the security requirements; (3) the cost limitations; (4) the time allocation; the team defined and considered the following: (1) their organization's existing technological environment; the technical requirements; (2) the organizational (business, procedural, and policy) requirements; (3) existing processes in the areas that were to be affected by the new software; (4) technical staff role definition; (5) project team training requirements; (6) required maintenance program; (7) role of outside consultants.

The project team then established criteria for the self-regulation, selection, evaluation and choice stages prior to contacting any vendors or looking at ERP solutions. The issue of business process reengineering (BPR) was also considered, and it was understood that ERP implementation would require a new BPR that would result in standardization and improvement in efficiency of operation. ERP implementation was used not just to enhance the existing systems, but rather to change them for the better.

Another issue the team considered was the process of change management. Difficulties in accepting significant required changes in the existing operating process by the staff were anticipated and planned for. Representatives of various end-user groups were sought for initial participation to address this issue.

Deliverables for the planning stage consisted of formation of the planning team, the compilation of RFP, creation of a list of criteria for review of various stages, scoring methodology, schedule, and formation of potential vendors list.

Particular attention was given to the progress of self-regulation. The organization used this stage to introduce a dose of reality into the entire process. During the planning stage it was decided to use the process of self-regulation to account for and match the critical requirements of the organizations with the capabilities offered by various products. The project team adopted the previously identified prohibitive criteria as individual factors that had to be considered in this stage as a filtering element. In addition, the hierarchy established by the findings of the previous questionnaire was adopted. It was concluded that for the purpose of evaluation, weighting factors reflecting the ranking of particular criteria be assigned and utilized. By adopting this methodo-

logy the organization accepted the relative impact of each criterion on the process.

The project team considered the functionalities that were essential for their particular operation. Project controls and administrative functions were ranked the highest among functionalities considered.

There was much discussion about the reliance on the particular system for performing the functionality tasks. Over a period of time, and as a result of providing internal studies that reflected the problems with current systems and possibilities for improvement, the team decided to accept the proposed functionalities as the organization's requirement.

The project team reviewed the security-related issues for their organization and established criteria and standards that would have to be satisfied. Since company X conducted most of its business with various government-related organizations, security was a prime concern. The reliability of data and access to it was identified to be the most prominent of sub-criteria considered. Information items that were considered to be included in this data consisted of bidding, estimating, budgeting, allocating resources, and scheduling values. The current systems were evaluated and their shortcomings were identified. Among the most prominent shortcomings were multiple entry of data, timely availability of data, organization of data, and historical perseverance of data. It was decided to list requirements to be addressed by a new system.

Cost was the next self-regulation group of criteria to be reviewed. Implementation cost was identified to be the most prominent of the group. Other cost categories considered were initial cost, training cost, and maintenance cost. Budget numbers that were proposed and accepted set the marker for the project team when it came to evaluation of a particular system. It was understood that systems with costs over the budgeted amount would not be considered.

Time was the last of the self-regulation criteria that the project team considered. The majority of projects conducted by company X were of short duration. Quick turnaround time of their jobs forced the project team to establish realistic timetables for various time criteria. The project team proposed an implementation schedule that spanned one year.

The most critical of the time sub-criteria considered was technical durability. Technical durability was defined as the time that the current software will be useful before requiring a major upgrade. The ownership group had a substantial problem with this issue. Their major concern was the technical viability of a system over a period of time. Considering that the entire implementation process was anticipated to take about one full year, major concern had to do with advances that would be made in the field that would not be reflected in the particular software package.

Selection/Short List

The project team utilized the findings of the self-regulation element to create an RFP that could be sent to various vendors. Having defined the critical criteria to be

considered in the remaining parts of EAM, the project team utilized the information that was gathered in the information search stage and selected six vendors to be contacted. The vendors were divided into two groups: prepackaged software, and WPMS. As called for by the planning stage, three vendors in each category were analyzed. Once it was decided that these vendors might be able to meet the RFP requirements, initial contacts were made.

During the process of obtaining RFP from vendors, a number of difficulties were faced. Among the most prominent was the nature of vendor interest. Some major vendors did not show any interest in participating in the RFP process. It was understood that they were not interested in participating with a “small organization.” Some other significant vendors indicated that their systems were not totally applicable to an SMSCO. As a result of this and in order to end up with at least three major vendors in each category, the project team was forced to repeat some of the past procedures that had led to the selection of vendors. The recursive nature of this activity was observed among information search, planning, and selection/short list elements. Ultimately two vendors, one from each group, were selected for detailed evaluation.

Critical factors that the team considered included the following: strategic match, stakeholders’ influence, system specifications, organizational impact, life-cycle approach, and financial criteria. Within this process, vendors, the functionalities provided by ERP system, and technical issues were evaluated. The project team developed a scoring methodology that was utilized to evaluate the short-listed vendors. In addition to the overall score, two items – reference and warranty period – were noted and compared.

It was anticipated that vendor evaluation would be carried out over several of the stages within the EAM processes. The recursive nature of the these activities also caused the team to contact vendors again with requests to resubmit, in part or in full, their RFP responses according to the team’s refined criteria.

As for the functional and technical evaluations, they were carried out, in part, during the selection process and then, more intensively, during the complete evaluation. The criteria and strategies that were established during planning were utilized to complete the evaluation. When elements of selection and evaluation were processed, each vendor was reviewed and evaluated based on a system that was developed by the project team. Initially two vendors were selected from each category, and then a vendor from the WPMS group was selected for Company X.

9. ERP adoption model (EAM) discussions

As indicated previously SMSCO represents a large segment of construction industry. Their lack of utilization of ERP systems impacts not only the efficiency and profitability of their operation, but the efficiency and profitability of the entire construction industry. Becoming aware of prohibitive criteria and having a decision making model (EAM) will provide a clear road map to the executives of SMSCO who will be dealing with ERP adoption issues. Currently no such decision making model that clearly incorporates prohibitive criteria exists. Other areas of an SMSCO’s operation that can benefit as a result of EAM’s utilization consist of, increase efficiency & profitability, change management, and business re-engineering. EAM was tested and modified via completion of a case study within an SMSCO environment. The adoptability that has been introduced into the model via Self-Regulation element makes the model applicable to other industrial sectors. It is anticipated that future research will attempt to apply this model in other industrial sectors and document the findings. When we incorporated the findings of the questionnaires and the case study, the theoretical version of EAM was amended to reflect the impact of the findings. The four prohibitive/self-regulation criteria that were discovered to act as prohibitive factors in utilization of ERP systems by SMSCOs were introduced into EAM as shown in Fig. 2. It was observed that the prohibitive/self-regulation criteria in the self-regulation element forced the organization to deal with issues that became critical in their decision-making process.

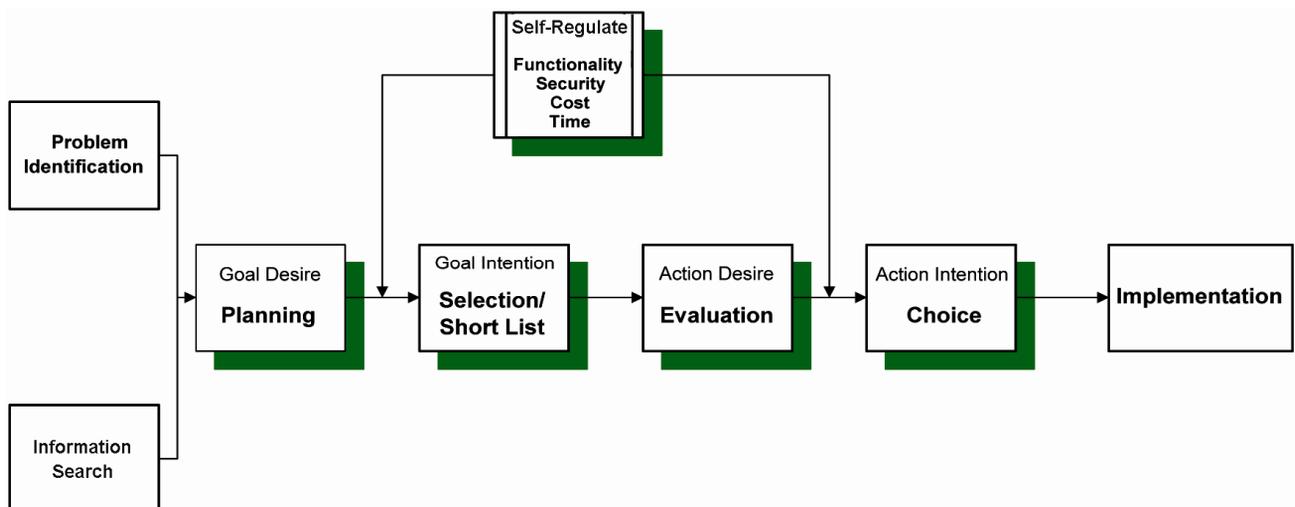


Fig. 2. ERP adoption model (EAM)

Utilizing this concept, the organization had an opportunity to conduct a self-evaluation of its current procedures and operations. This self-evaluation allowed the compilation of a list of requirements that were both realistic and reflective of the organization.

Reflectivity is a critical issue that must be considered by each organization. Within the construction industry in general, and SMSCOs in particular, it is a known and accepted fact that each organization's operation is unique. Therefore, in order for the organization to utilize any decision-making model, that model must be able to address the organization's uniqueness, and the organization must be able to reflect on who they are. EAM allows for this reflectivity through utilization of prohibitive/self-regulation criteria. As a result of having to deal with these criteria, the SMSCOs will have to establish goals and objectives, review its current procedures, identify its current shortcomings, develop realistic requirements for the new system, and prepare and provide adequate resources to implement the system.

Hierarchical Ranking of Criteria

Successful completion of the case study in general, and the observed impact of the self-regulation element of EAM in particular, provided strong evidence to support the validity of the hierarchical rankings of prohibitive/self-regulation criteria. Having to deal with prohibitive/self-regulation criteria, in the order that they were proposed, forced the organization to set realistic goals and objectives at a very early stage of the decision-making process.

In addition, while the ranking of the criteria had to be maintained, their subcategories could be redefined in broader terms to include organization-specific items. For example, while one company defines payroll as a task to be included in the administrative section of the functionality criterion, another company can place it within the contract management section of functionality. This flexibility allows each SMSCO to tailor the process closer to its actual operation.

Prohibitive/Self-Regulation Criteria

When dealing with functionalities, it became apparent that the issue of modularity is very significant. It is critical for SMSCOs to be able to adopt a limited version of an ERP system that could be subsequently added on to. Systems that are able to provide capabilities in a modular format will have a substantial advantage over their counterparts that must be adopted as whole. SMSCOs can justify and handle the adoption of new modular ERP systems a lot easier and quicker.

When dealing with security in the case study, access level by employees and other collaboration members became an issue that had to be dealt with. SMSCOs, more so than their larger counterparts, will have difficulty accepting access to their sensitive data. In order to overcome this problem, it is recommended that the project team utilize educational resources that any vendor would be able to provide in order to establish a comfort level for the ownership group.

As anticipated, cost, as a prohibitive/self-regulation criterion, has a significant impact on the overall decision-making process. For example, company X within the element of self-regulation of EAM had to deal with the issue of cost. Company X conducted a cost-benefit analysis and utilized its findings to compute a budget item that included individual line items for different cost categories. Even though ranking for the cost criterion placed it third among all criteria, its impact must not be taken lightly. The allocation of cost and its assignment by the organization must be considered. SMSCOs must consider the associated cost items not only as a direct project expense, but rather as a capital expenditure that needs to be treated as an asset. Company X was able to justify the substantial expenditure required by treating it as an asset that was to be depreciated over a period of time. When reviewing time as prohibitive/self-regulation criterion it must be understood that technical durability is rightly an issue that must be considered. However, it is important for the organization to establish an understanding of its requirements and not be concerned with every new "gadget." As long as the system is capable of addressing the needs of the organization, it must be considered as adequate.

Vendor Participation

As it was observed during the case study, vendor participation in the processes of EAM must not be taken for granted. Some vendors are not interested in participating even though they claim to have software that would be suitable for SMSCOs since the potential account will be small. In order to overcome this problem, SMSCOs must plan to play a proactive role when it comes to solicitation. In order to find a vendor that is willing to work with the organization, an ample amount of employee time must be provided.

Process Reengineering

It should be anticipated that each SMSCO will have a unique set of business processes that have been successful in the past. Customizing the functionalities of a new system for an existing organization will generate a number of dilemmas. It is expected that each organization would like to minimize the changes in its business processes; however, ERP systems cannot always be customized to fit existing operations successfully. After all, ERP systems bring a whole new way of thinking to an existing operation that has been deemed change-worthy. It is recommended that SMSCOs consider changing their existing processes to fit the ERP system rather than the other way around.

The timing of this change is also critical. If both ERP implementation and business process changes were to be completed at the same time, the organization would face number of difficult scenarios. SMSCOs must complete reengineering their operation prior to implementing the ERP system. In addition, for a period of time shortly after ERP system implementation, a parallel set of operational procedures should be carried out so that the organization becomes more confident in the new system.

Finally, all of the proposed changes ultimately deal with people. Therefore, the process of change management must be people friendly. The people in the organization should be encouraged to buy into the process. The following strategies may help with this: introduce the change incrementally, educate the staff on the benefits of the proposed changes, show strong senior management commitment to changes, and provide adequate training time for the staff. An issue that was not considered as strongly as it should have been in the case study was the impact of suppliers and subcontractors' potential utilization of the ERP system. Members of SMSCOs usually collaborate with suppliers and subcontractors that are either the same size or most often smaller than they are. Therefore in order for the ERP system to be a successful collaborative tool, the role to be played by these second-tier users must be reviewed.

Sub-contractor's Participation

The sub-contractors and supplier to SMSCO whom are considered to be second-tier users' technical capabilities must be studied and correctly documented. Their familiarity with and use of computer technology applications in their operation must be realistically verified.

Without adequate infrastructure, second-tier users will not be able to either provide data in necessary formats or access the information available. Attempts must be made to either encourage the existing second-tier users to adopt proper infrastructure and technical know-how or to find new suppliers and subcontractors that can properly participate in a collaborative environment.

Iterative Nature of EAM's Elements

The self-regulation element of EAM is designed to have an iterative influence on the entire process. The thinking behind this fact was to allow the iterative nature of this element to address the issues that arise from the self-evaluation conducted by the organization. The nature of the iterative processes indicates activities/feedback/adjustment/input. It is anticipated that as a result of completing the self-regulation element, the project team might have to revisit the process starting with the selection/short list element. However, it should be pointed out that the iterative nature of self-regulation can impact both ends of the main decision core.

10. Conclusions and recommendations

This research set out not only to formulate the reason(s) why SMSCOs fail to utilize ERP systems, but also to propose a decision-making model which could be utilized when these companies decide to adopt an ERP system. This research has delivered valid conclusions as the result of a case study and analysis that was completed utilizing the data obtained through two separate field questionnaires. Contributions of this research consisted of the following major items:

1. Obtaining data as a result of two field questionnaires. These data were utilized to confirm the existence of prohibitive criteria and their hierarchical ranking.

2. Identification and confirmation of prohibitive criteria. As a result of the surveys, the prohibitive criteria were identified and their existence was verified.
3. The impact of the prohibitive criteria on decision making was analyzed, and a hierarchical ranking of them was established.
4. ERP Adoption Model (EAM). The proposed model EAM can be utilized by SMSCOs as a decision-making tool when dealing with ERP adoption issues.
5. EAM utilization case study. The completion of the case study revealed the applicability of EAM in a real-world situation.

The answer to both questions rose previously about creation of a model that could address flexibility, self expression capability; impact of prohibitive criteria, and group's cultural aspects was affirmative. EAM's structure and its iterative nature offers the decision maker maximum flexibility. Self regulation element can be utilized by the decision maker to incorporate the particulars of SMSCO's operation including cultural aspects into the decision making process. In addition this element incorporates the impact of prohibitive criteria in the decision making process.

Even though this research delivered valid findings; it had shortcomings as a result of certain limitations. The SMSCO community's lack of familiarity with the concept of ERP impacted the information that was obtained for this research. The time required studying IT-related technology in general, and ERP in particular, presented an issue since science advances rapidly in this area. Due to the limited time available for this research and the temporary nature of the construction industry, it was not possible to accommodate some market changes.

In the future, case studies and empirical research should investigate the relationship among the various elements of the model. In addition, the relationship among various elements and the external factors that have an impact on them must be studied. Establishing SMSCO-wide ERP implementation standards would be another topic of interest. The addition of such standards would increase the ability of the ERP community to better address the needs and requirements of SMSCO clients.

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SPRENDIMŲ PRIĖMIMO MODELIS, TAIKOMAS ĮMONĖS IŠTEKLIŲ PLANAVIMO PRIEMONĖMS PARINKTI MAŽOSE IR VIDUTINĖSE STATYBOS ORGANIZACIJOSE**S. S. Negahban, G. B. Baecher, M. J. Skibniewski****Santrauka**

Įmonės ištekliai buvo planuojami tik didelėse statybos organizacijose. Daugelis statybos organizacijų, kurios arba nesugebėjo pritaikyti šios technologijos, arba nėra susipažinusios su ja, yra mažos ir vidutinio dydžio statybos organizacijos. Nesugebėjimas pritaikyti arba atsisakymas naudoti įmonės išteklių planavimą nepaisant visų jo pranašumų – problema, kuri ir sprendžiama šiame tyrime. Siūlomas sprendimų priėmimo modelis, kurį organizacijos galėtų taikyti įmonės išteklių planavimo sistemoms pasirinkti. Naujas įmonės išteklių planavimo pasirinkimo modelis buvo suformuluotas ir parengtas, prieš tai nuodugniai išanalizavus esamus modelius. Į šį modelį buvo įtraukta naujų elementų, kurie ir sudarė naujo sprendimų priėmimo modelio esmę. Be to, identifikuoti ir nustatyti prioritetai tų kriterijų, kurie trukdė mažoms ir vidutinio dydžio statybos organizacijoms sėkmingai taikyti ir įgyvendinti įmonės išteklių planavimo sistemas, siekdami pagerinti šių kriterijų poveikio įmonės išteklių planavimo procesams supratimą. Galiausiai atliktas tyrimas, kurio tikslas – išanalizuoti įmonės išteklių planavimo sprendimų priėmimo procesą mažose ir vidutinio dydžio statybos organizacijose. Įmonės išteklių planavimo pasirinkimo modelis yra sprendimų priėmimo priemonė, kurią statybos organizacijos gali naudoti tarsi kelių žemėlapių.

Reikšminiai žodžiai: įmonių išteklių planavimas, statybos informacinės technologijos, sprendimų priėmimo modelis, maža ir vidutinio dydžio statybos organizacija.

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