AN IMPLEMENTATION STRATEGY FOR INTEGRATED ENTERPRISE SYSTEMS IN CONSTRUCTION

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ABSTRACT

Recently, a significant proportion of major construction companies embarked on the implementation of integrated IT solutions such as ERP systems to better integrate their various business functions. However, these integrated systems in construction present a set of unique challenges, different from those in the manufacturing or other service sector industries. Up to now, there have been many cases of failure in implementing ERP systems, so it is critical to identify and understand the factors that largely determine the success or failure of ERP implementation. The paper provides a structured model to identify factors affecting the success of ERP systems in both adoption and implementation. The proposed model adapted TAM, D&M IS Success Model, and the fundamentals of project management in ERP implementation as the theoretical backgrounds. Therefore, this model is theoretically sound and can be helpful to provide better understanding about the success of ERP systems.

KEYWORDS: ERP, Information Systems Planning, Success Factors

INTRODUCTION

Enterprise Systems (ES), also called Enterprise Resource Planning (ERP) systems, are among the most important business information technologies to emerge in the last decade. While no two industries' Enterprise Systems are the same, the basic concept of Enterprise Systems is mainly focused on standardization, synchronization and improved efficiencies. It is basically the successor to material resource planning (MRP) and integrated accounting systems such as payroll, general ledger, and billing. The benefits of Enterprise Systems are huge: coordinating process and information, reducing carrying costs, decreasing cycle time and improving responsiveness to customer needs (Elarbi 2001).

Traditionally, the construction industry has been faced with the problem of getting and keeping projects on schedule, under budget, and safe with the quality specified by the owner and/or architect/engineer (A/E). Although the construction industry is one of the largest contributors to the economy, it is considered to be one of the most highly fragmented, inefficient, and geographically dispersed industries in the world. To overcome this inefficiency, a number of solutions have long been offered.

Recently, a significant proportion of major construction companies embarked on the implementation of integrated IT solutions such as Enterprise Systems to better integrate their various business functions, particularly those related to accounting procedures and practices. However, these integrated systems in construction present a set of unique challenges, different from those in the manufacturing or other service sector industries. Each construction project is characterized by a unique set of site conditions, a unique performance team, and a temporary nature of the relationships between project participants. That makes a construction business

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organization need extensive customization of pre-integrated business applications from ERP vendors. Unfortunately, such an extensive customization can lead a construction firm to ERP implementation failure. For these reasons, finding the best implementation strategy for integrated Enterprise Systems is mandatory to maximize the benefits from such integrated IT solutions in engineering and construction firms.

In most cases, the cost of a full-scale ERP implementation in a large organization can easily exceed $100 million, and the implementation usually takes at least 2 years to complete. Not only do ERP systems need plenty of time and money to implement, even successful implementations can disrupt a company's culture, create extensive training requirements, and lead to productivity losses. Furthermore, many experts say that over 50 percent of U.S. firms experience some degree of failure when implementing advanced manufacturing or information technology. Unfortunately, many companies have already experienced significant troubles trying to implement ERP systems, and these poorly executed implementations have had serious consequences. One recent survey revealed that 65 percent of executives believe ERP implementation has at least a moderate chance of damaging their business. Obviously, it is very important to identify and understand the factors that impact heavily on the success or failure of ERP implementation (Umble and Umble 2002).

RESEARCH OBJECTIVES

The main objective of this paper is to provide strategic planning for successful ERP implementation in construction firms. To do so, the proposal will identify the factors affecting ERP implementation success or failure, and analyze these factors according to the level of significance that affects the success of ERP. To achieve the goal of the study, the following research questions are addressed as primary research objectives:

1) What are the factors affecting ERP implementation success or failure?
   - What factors can lead users to use or intend to use ERP systems?
   - What factors can make ERP implementation projects successful?
   - What are the relationships between factors?
2) How can we define the success of ERP implementation?
   - What are the indicators to evaluate ERP implementation success?
   - What are the relationships between success indicators?
3) How do we approach implementation to avoid failure?
   - What factors should be considered most heavily to avoid failure?
   - What are the relationships between factors and success indicators?
   - What should we do in order to make ERP implementation projects successful?

Based on the questions above, this paper will provide the research model for achieving such goals.

ERP SYSTEMS IN ENGINEERING & CONSTRUCTION FIRMS

Although the business processes of construction companies are different depending on the company's culture and its major area of construction, there are a lot of similarities from the business functions standpoint because of the project based production in construction. We reviewed several construction firms' ERP integrated systems and then derived the general concept of Enterprise Systems structure and major functions for engineering & construction firms as described in Figure 1. The major application areas for engineering & construction firms are Financial Accounting and Project Management. These two core functions are tightly

connected together, and all the other functions support them to streamline the whole business processes. Other functional modules which are not shown in this figure can be included in a certain company's Enterprise System depending on the company needs for its own business area.

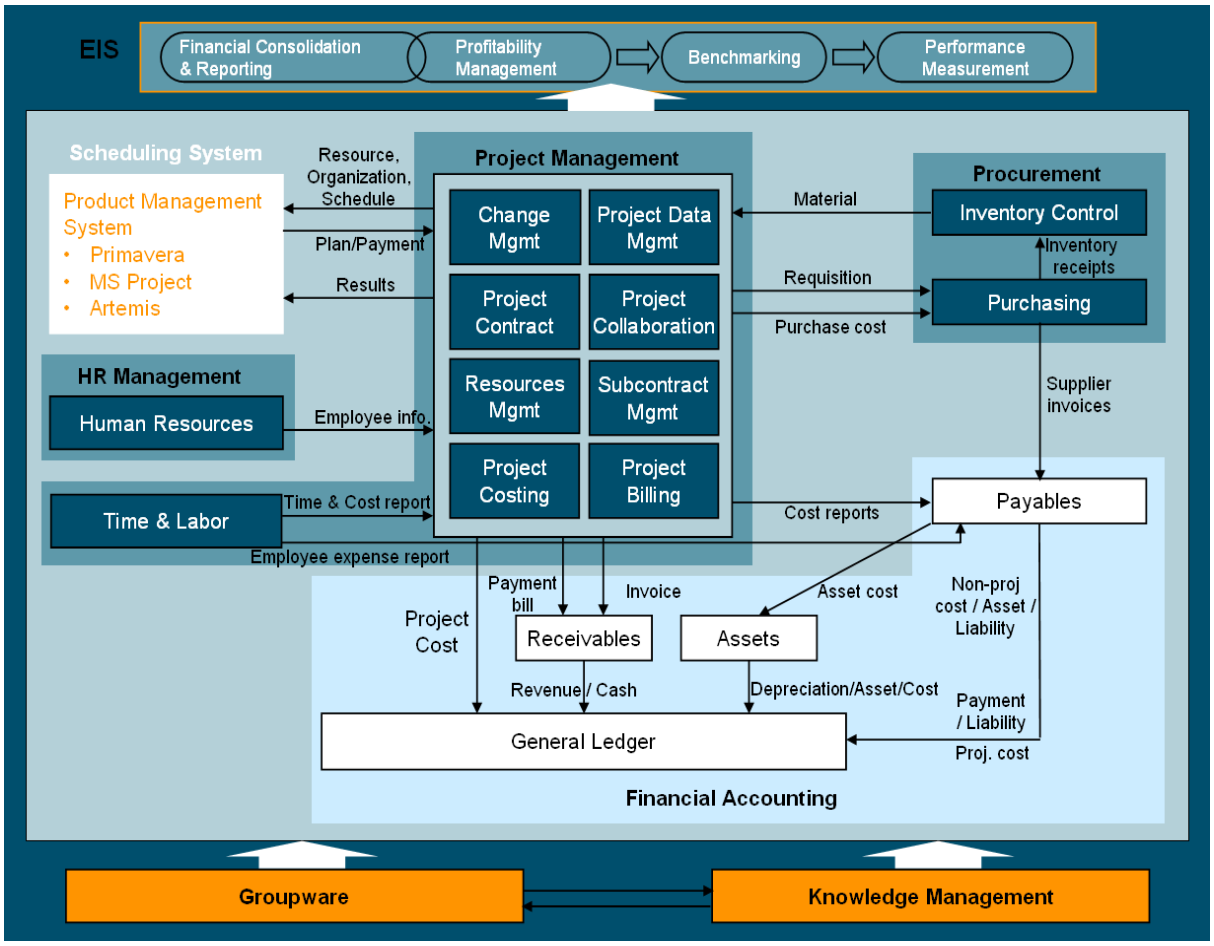

Figure 1. General Concept of the Enterprise System in Construction

Currently, major ERP vendors such as SAP and Oracle provide specific solutions for the construction industry. They claim that their solutions can support all the functions a construction company needs. However, most engineering & construction firms in US have implemented their Enterprise Systems adopting a best-of-breed approach in which separate software packages were selected for each process or function rather than using full packages of major ERP vendors. They picked several modules like Financial Accounting, HR, and etc. from major ERP vendors and pieced together with their own in-house developed software or other third party products using custom-built interfaces. The main reason of using this approach is that construction processes are less standardized than manufacturing: each project has a different owner, is managed by a different project team, requires different specifications, and etc. Therefore, success or failure factors and their significance for ERP implementation in the construction industry may be different from those in the manufacturing industry.

USER ACCEPTANCE MODELS FOR INFORMATION SYSTEMS

Since ERP systems are considered an innovative information system, previous research on user acceptance models for information systems (IS) can be helpful to understand the success of ERP system adoption. This paper deals with two prevalent models related to IS acceptance, which are the Technology Acceptance Model and the DeLone & McLean (D&M) IS Success Model.

Technology Acceptance Model (TAM)

Davis (1986) introduced the Technology Acceptance Model (TAM), adapting the Theory of Reasoned Action (TRA), specifically modified for modeling user acceptance of information systems. The goal of TAM is to explain the determinants of computer acceptance related to user behavior across a broad range of end-user computing technologies and user populations. In addition, TAM provides a basis for tracing the impact of external variables on internal beliefs, attitudes, and intentions. TAM was formulated in an attempt to achieve these goals by identifying a small number of primary variables suggested by previous research dealing with the cognitive and affective determinants of IS acceptance, and using TRA as a theoretical background for modeling the theoretical relationships among these variables (Davis et al. 1989).

In this model, perceived usefulness and perceived ease of use are of primary relevance for IS acceptance behaviors as shown in Figure 2. Perceived usefulness is defined as the prospective user's subjective probability of increase in his or her job performance using a specific information system within an organization. Perceived ease of use indicates the degree to which the prospective user expects the target system to be free of effort. TAM proposes that external variables indirectly affect attitude toward using, which finally leads to actual system use by influencing perceived usefulness and perceived ease of use. As indicated by Legris et al. (2003), all the relations among the elements of TAM had been validated through empirical studies. The tools used with TAM had proven to be of quality and to yield statistically reliable results (Legris et al. 2003).

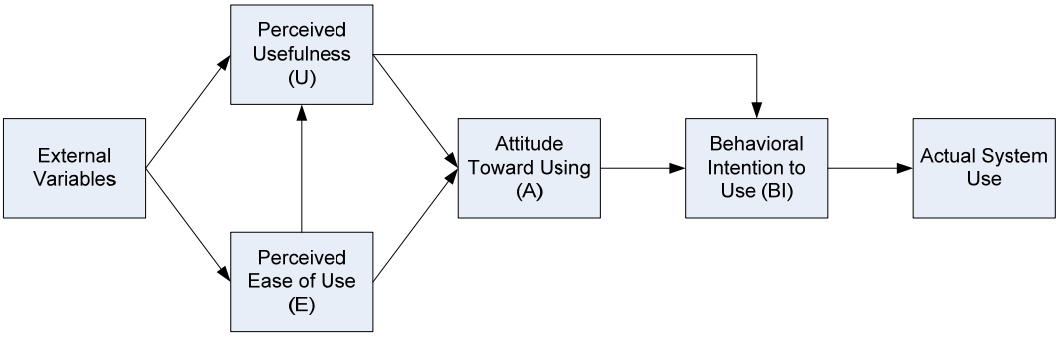

Figure 2. Technology Acceptance Model (Davis et al. 1989)

The main difference between TRA and TAM is the absence of the subjective norm in TAM. The subjective norm is defined as “the person's perception that most people who are important to him think he should or should not perform the behavior in question” (Fishbein and Ajzen 1975). Davis didn’t include the variable subjective norms in TAM because of its uncertain theoretical and psychometric status, and negligible effect on perceived usefulness and ease of use. However, Hartwick and Barki (1994) identified a mixed finding about the subjective norm: after separating their respondents in voluntary and mandatory use contexts, they found that the

subjective norm had a significant impact on the intention in mandatory system use but not in voluntary settings (Hartwick and Barki 1994). For this reason, the updated TAM, also called TAM2, extended the original TAM by including the subjective norm as an additional predictor of intention in the case of mandatory system use. Furthermore, TAM2 incorporated additional theoretical constructs including social influence processes and cognitive instrumental processes. The causal relationships and elements of TAM2 are described in Figure 3.

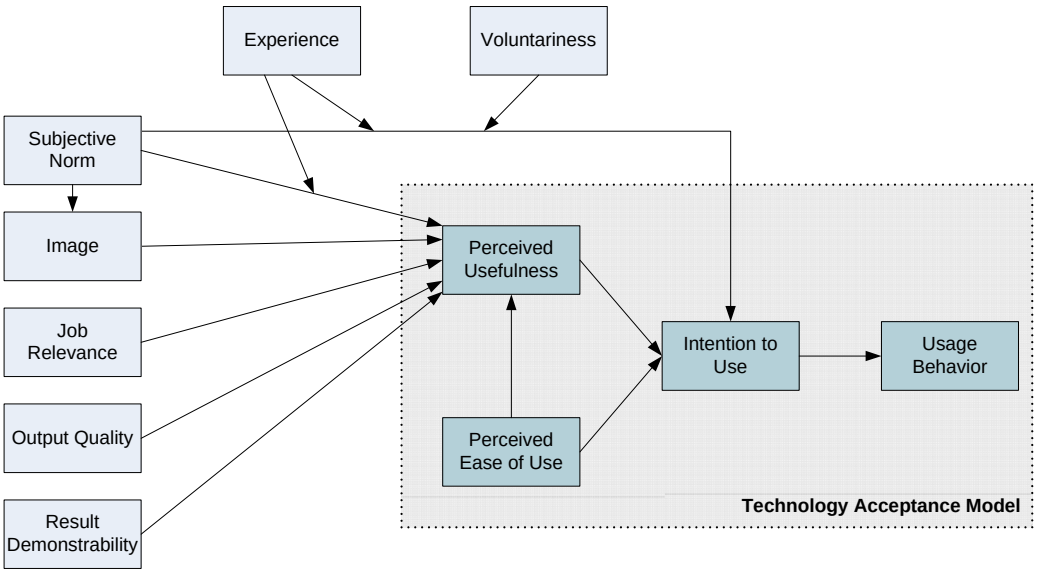

Figure 3. Updated Technology Acceptance Model (Venkatesh and Davis 2000)

DeLone and McLean IS Success Model

In recognition of the importance in defining the IS dependent variables and IS success measures, DeLone and McLean proposed a taxonomy and an interactive model as a framework for organizing the concept of IS success. They defined six major dimensions of IS success – System Quality, Information Quality, Use, User Satisfaction, Individual Impact, and Organizational Impact. Then, a total of 180 articles related to IS success were reviewed using these dimensions to construct the model. DeLone & McLean's IS Success Model, as shown in Figure 4, deals with both process and causal consideration. These six dimensions in the model are proposed to be interrelated rather than independent. These dimensions are defined as follows (DeLone and McLean 1992):

1) System Quality - the measure of the information processing system,
2) Information Quality - the measure of information system output,
3) Use - the recipient consumption in the output of an information system,
4) User Satisfaction - the recipient response to the use of the output of an information system,
5) Individual Impact - the measure of the effect of information on the behavior of the recipient, and
6) Organizational Impact - the measure of the effect of information on organizational performance.

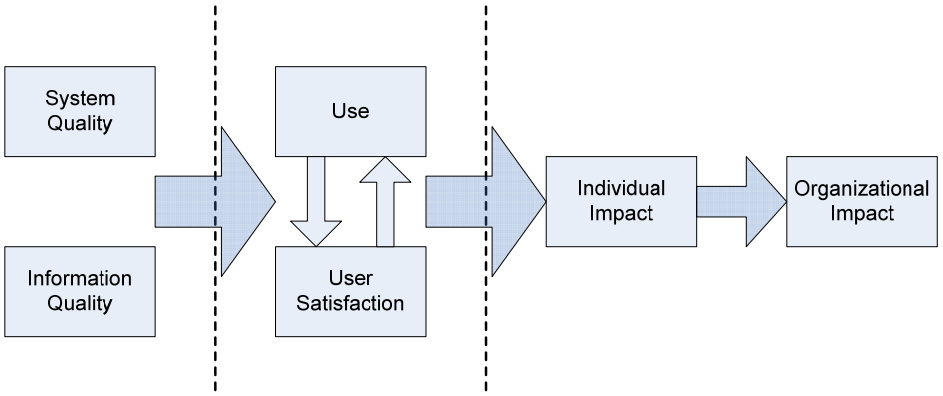

Figure 4. Original D&M IS Success Model (DeLone and McLean 1992)

Until 2003, the association among the measures in D&M IS Success Model had been tested by 16 different empirical studies. The results of these studies validated the causal structure of D&M IS Success Model. Considering the reviews of their original model from the empirical studies, DeLone and McLean established the Updated D&M IS Success Model as shown in Figure 5.

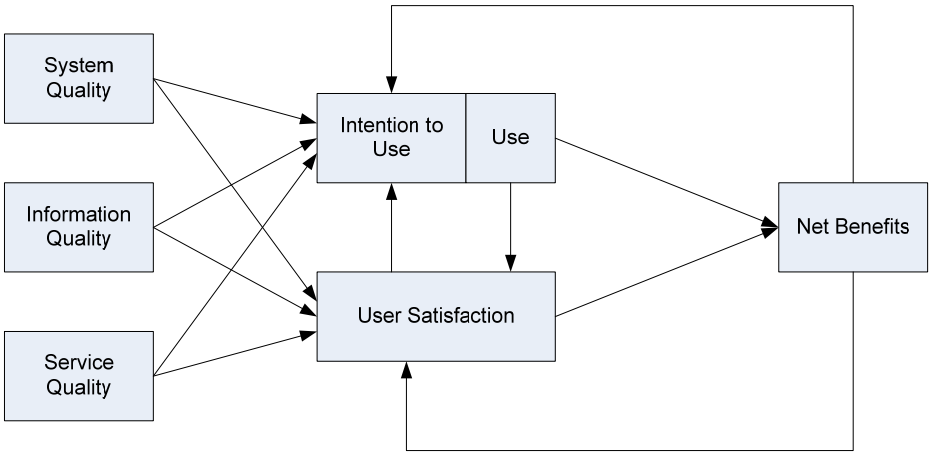

Figure 5. Updated D&M IS Success Model (DeLone and McLean 2003)

In their updated model, DeLone and McLean added 'Service Quality' to the "quality" dimensions in the original model, and collapsed 'Individual Impact' and 'Organizational Impact' into 'Net Benefits'. 'Service Quality' is included as an important dimension of IS success given the importance of IS support, especially in the e-commerce environment where customer service is crucial. The choice of where the impacts should be measured, from individuals to national economic accounts, will depend on the systems and their purposes. DeLone and McLean grouped all the "impact" measures into a single impact category called "net benefit" rather than complicate the model with more success measures for the sake of parsimony.

SUCCESS FACTORS FOR ERP IMPLEMENTATION

What is considered a large project varies from one context to another depending on determinants including complexity, duration, budget and quality of the project. In ERP projects, the complexity depends on the project scope, including the number of business functions affected and the extent to which ERP implementation changes business processes. ERP projects achieving real transformation usually take from one to three years in duration. Resources required include hardware, software, consulting, training and internal staff, with estimates of their cost ranging from $0.4 million to $300 million, with an average of about $15 million (Koch 2002). Therefore, by viewing ERP implementation as a large project in general, we can adhere to the fundamentals of project management for achieving the success of ERP implementation.

There is vast project management literature in the field of organizational research. Several researchers have developed sets of fundamental project success factors which can significantly improve project implementation chances (Pinto and Slevin 1987; Shenhar et al. 2002). In addition, several researchers have identified the best practices and risks related to IS projects such as ERP implementation. Akkermans et al. (2002) provided success factors for ERP implementation based on a broad literature review followed by a rating of the factors by 52 senior managers from US firms that had completed ERP implementations. Ewusi-Mensan (1997) identified reasons why companies abandon IS projects based on surveys of canceled projects in Fortune 500 companies in the US. Keil (1998) proposed significant software project risks based on a Delphi study of experienced software-project managers in Hong Kong, Finland, and the US (Akkermans and Helden 2002; Ewusi-Mensan 1997; Keil et al. 1998). Based on this literature, Ferratt et al. (2006) grouped the best practice questions together forming four success factors for ERP implementation as follows (Ferratt et al. 2006):

1) top-management support, planning, training, and team contributions,
2) software-selection efforts,
3) information-systems area participation, and
4) consulting capability and support.

Ferratt et al. (2006) validated these success factors through the empirical study of ERP projects. They also provided five outcome questions, which were shown to be significantly correlated and should therefore be combined to form a single outcome factor, effectiveness. Their regression analysis proved that all the success factors can affect the outcome significantly, so now these factors can be considered the representative success factors in ERP implementation.

ERP SUCCESS MODEL

Figure 6 shows the proposed model, referred to as the ERP Success Model. As we discussed in the previous sections, the success of ERP systems can be classified into two categories; the success of ERP adoption and the success of ERP implementation. For the successful ERP adoption, we use already proven user acceptance models for IS such as TAM and D&M IS Success Model as the starting point. The model develops the rationale for the causal relationship based on these combined theoretical backgrounds and incorporates three main dimensions for identifying the truth about the success of ERP systems; success factors, intermediate constructs, and success indicators.

The model also considers the success of ERP implementation based on the reviews on the fundamentals of project management. The success factors suggested by Ferratt et al. (2006) will be used in the model because these were already validated in the previous research and

confirmed by several experts interviewed. We hypothesize these factors directly affect perceived usefulness, and finally lead to ERP success or failure. Furthermore, we include "Project Success" as an additional success indicator to clarify its impact on the other success indicators. Project success will be evaluated in terms of time, budget, quality and scope as usual project management contexts applied.

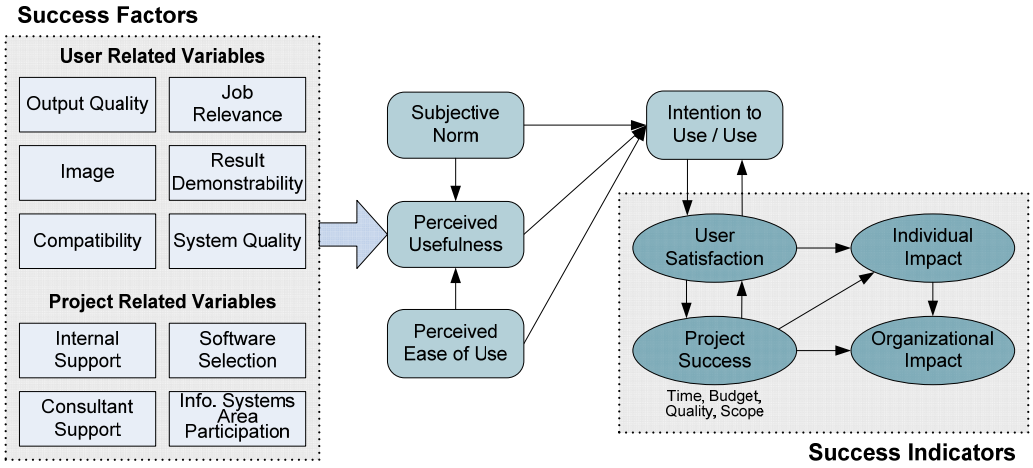

Figure 6. Proposed ERP Success Model

One important point to be noted in this model is that "Subjective Norm" is included in the intermediate constructs because ERP systems are usually used in mandatory settings. The causal relationship related to this factor is as similarly applied to TAM2, which was already validated. Based on the proposed model, this paper provides the instrument for the empirical study to identify the success of ERP systems as shown in Appendix A.

CONCLUSION

This paper provides a structured model to identify factors affecting the success of adoption and implementation of ERP systems. Most previous research related to ERP systems has only focused on either user acceptance or implementation success. The proposed model adapted three theoretically validated models such as TAM, D&M IS Success Model, and the fundamentals of project management in ERP implementation. Therefore, this model is theoretically sound and can be helpful in providing understanding about the success of ERP systems.

Even though the benefits from successful Enterprise Systems are huge, there have been many cases of failure in implementing such systems. Clearly, it is critical to identify and understand the factors that largely determine the success or failure of the implementation. This study will identify the causes of failure and analyze them according to their significance. This information and strategy is one of the key issues of ERP Systems in the business domain, and can reduce tremendous ERP adoption and implementation risks. This will be valuable information to decision makers in construction organizations when they consider implementing or upgrading their information systems.

APPENDIX A: ITEMS IN THE SURVEY OF ERP USERS IN CONSTRUCTION

(Response choices – 7 point scale from strongly disagree to strongly agree)

Success Factors

(User related variables)

- Output Quality
  - The quality of the output I get from the ERP system is high.
  - I have no problem with the quality of the ERP system's output.
- Job Relevance
  - In my job, usage of the ERP system is important.
  - In my job, usage of the ERP system is relevant.
  - I have access to the ERP system, but I prefer to use non-ERP tools.
- Image
  - People in my organization who use the ERP system have more prestige than those who do not.
  - People in my organization who use the ERP system have a high profile.
- Result Demonstrability
  - I have no difficulty telling others about the results of using the ERP system.
  - I believe I could communicate to others the consequences of using the ERP system.
  - I would have difficulty explaining why using the ERP system may or may not be beneficial.
- Compatibility
  - I have no difficulty in exporting data from the ERP system to other systems or software I currently use.
  - I have no difficulty in importing data to the ERP system from other systems or software I currently use.
- System Quality
  - I think the ERP system is very reliable.
  - I do not worry about data loss when I use the ERP system.
  - I do not find system errors very often when I use the ERP system.

(Project related variables)

- Internal Support
  - Our top management supported ERP implementation project well.
  - Training for the ERP system was very helpful for me to understand and use it.
  - Someone asked me some questions and opinions related to the ERP system during its implementation.
  - Our ERP implementation progressed well as was originally planned.
- Software Selection
  - The ERP software our company is using can support our business processes well.
  - The functionality of the ERP software our company is using is very good.
- Consultant Support
  - I think consultants led us to a right direction during ERP implementation.
  - I think consultants can help us to have a successful ERP implementation.
- Information Systems Area Participation
  - The business functions of the ERP system are well defined.
  - The ERP system covers our necessary business functions very well.

Intermediate Constructs

• Subjective Norm
  - Others in my work group strongly support my using the ERP system.
  - I would like very much to use the ERP system because others in my work group think I should use it.
  - Senior management strongly supports my using the ERP system.
  - I would like very much to use the ERP system because senior management thinks I should use it.
• Perceived Usefulness
  - Using the ERP system improves my performance.
  - Using the ERP system improves my productivity.
  - Using the ERP system improves my effectiveness.
  - Overall, using the ERP system is very useful in my job.
• Perceived Ease of Use
  - I find the ERP system easy to use.
  - I find it easy to get the ERP system to do what I want it to do.
  - My interaction with the ERP system is clear and understandable.
• Intention to Use / Use
  - Assuming I have access to the ERP system, I intend to use it.
  - I have access to the parts of the ERP system when I need to do my job.
  - I use the ERP system whenever I need it.
  - About how many hours a week do you use the ERP system?
  - What are the three functions of the ERP system you use the most?

Success Indicators

• User Satisfaction
  - I am very satisfied with Information quality of the ERP system.
  - I am very satisfied with performance of the ERP system.
  - Overall, I am very satisfied with the ERP system.
• Individual Impact
  - With the ERP system, I do not need to do "repetitive work" again.
  - The ERP system can help me make effective decisions.
• Organizational Impact
  - With the ERP system, my organization saves operating costs.
  - With the ERP system, my organization increases revenues.
  - After ERP implementation, the stock price of my organization went up.
• Project Success
  - The ERP implementation project was completed on time.
  - The ERP implementation project was completed within the budget as initially planned.
  - I think the quality of our ERP system is very good.
  - The scope of our ERP system is well matched with our company's needs.

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