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MODELING WITH PARTIAL LEAST SQUARES CRITICAL SUCCESS FACTORS INTERRELATIONSHIPS IN ERP IMPLEMENTATIONS

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Abstract

This research-in-progress paper proposes the use of a statistical approach named Partial Least squares (PLS) to define the relationships between Critical Success Factors (CSFs) for ERP implementation projects. Some researchers have noted that there are relationships between these CSFs. However, no one has yet tried to define in a formal way these relationships. In this paper we present an overview of the PLS approach and provide an application example of the PLS method where we use two CSFs: those related to project sponsor role and project manager role. However, our research is being extended to all of the CSFs within our own CSFs unified model.

Keywords: Enterprise resource planning, partial least squares, ERP implementation.

Introduction

Over the past years, Enterprise Resource Planning (ERP) implementation projects success has been treated as one of the main issues in ERP research. Several studies have been published related with the Critical Success Factors (CSFs) in ERP implementation projects. Although there is the empirical evidence that CSFs are interrelated, there is a lack of formal studies that analyze the relationships between them. This research in progress study attempts to analyze how a set of CSFs for ERP implementation projects are interrelated.

The starting point for this present research is the assumption, that the different CSFs are interrelated. This assumption is supported by some studies (Baker et al. 1974, Pinto and Slevin 1989, Lechler and Gemünden 2000) that are not specifically associated with ERP implementation projects. According to Lechler and Gemünden (2000) "the detailed analysis of interactions among the success factors is necessary and provides information for further inquiry concerning the series of effects that lead to project success or failure". This study is also important for managers to predict the success chances of their ERP implementation projects through the control and monitorization of these CSFs. In order to model the relationships between CSFs, we explore the possibility of using a statistical approach named Partial Least Squares (PLS). This paper is structured as follows. First we describe the background of this study. Next, we present the research methodology proposal to analyze the interdependence between CSFs. Then, we describe in detail the PLS method and apply it to an illustrative example of CSF relationship. Finally, we present some considerations and further work.

Background

Rockart (1979) was the first author that applied the CSF approach in the information systems area. He proposed the CSF method to help CEOs specify their own information needs about issues that were critical to their organizations, so that information systems could be developed to meet those needs. According to his account, CSFs are "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization". Based in a set of studies published by several authors, containing commented lists of CSFs in ERP implementations, Esteves and Pastor (2000) unified these lists and created a CSFs unified model (see figure 1). The advantage of this model is that it unifies a set of studies related with lists CSFs identified by other authors; the CSFs are categorized in different perspectives and, each CSF is identified and defined.

	Strategic	**Tactical**
Organizational	• Sustained management support • Effective organizational change management • Adequate project team composition • Good project scope management • Comprehensive business re-engineering • Adequate project sponsor role • Adequate project manager role • Trust between partners • User involvement and participation	• Dedicated staff and consultants • Appropriate usage of consultants • Empowered decision makers • Adequate training program • Strong communication inwards and outwards • Formalized project plan/schedule • Reduce trouble shooting
Technological	• Avoid customization • Adequate ERP implementation strategy • Adequate ERP version	• Adequate infrastructure and interfaces • Adequate legacy systems knowledge

Figure 1. The Unified Critical Success Factors Model (source: Esteves and Pastor 2000)

A detailed explanation of this model can be found in Esteves and Pastor (2000). Regarding the relationships between CSFs in ERP implementation projects, we found an exploratory case study made by Akkermans and van Helden (2002). They present a dynamic model of the CSFs interrelations, and they conclude that "all CSFs were interrelated in the sense that changes in one of them influenced all the others, directly or indirectly" (Akkermans and van Helden 2002, p. 45). Ang et al. (2002) also found some causal relationships between the CSFs for Materials Requirements Planning (MRP) implementations by using a multi-case study approach. MRP systems are the antecedents of ERP systems. Ang et al. (2002) propose some linkages between a set of CSFs.

Research Methodology Proposal

The aim of this study is to investigate the relationships among CSFs and between CSFs and ERP implementation project success. Data for this study is being collected using a questionnaire survey. Part of the questionnaire is presented in appendix A. It has three parts: project description, project general characteristics and the questions related with the different CSFs. Our research methodology has four important steps:

- **Development of the questionnaire** – this step is done.
- **Data collection** – we are currently seeking respondents and defining our sample.
- **Data analysis** – this step is to analyze the items reliability. Individual item reliability is assessed by examining the loadings and cross-loadings of each of the construct indicators. There are two possible techniques: Cronbach's alpha test and composite reliability.
- **PLS usage** - we attempt to use Partial Least Squares (PLS) to establish the relationship between the different CSFs. PLS is a well established technique for estimating path coefficients in structural models and has been widely used in various research studies (see next section for a PLS overview). PLS method has gained interest and use among researchers in recent years because of its ability to model latent constructs under conditions of non-normality and small to medium sample sizes (Chin 1998, 2000).

PLS Method

In this section we explain in detail the PLS method. We start by an overview of the PLS method, then we discuss the issue of sample size, and finally we describe the statistics that must be worked out with the PLS method.

PLS Overview

Structural Equation Modeling (SEM) techniques such as LISREL, EQS, and AMOS have become very popular especially in social sciences. According to Chin and Newsted (1999), SEM techniques provide researchers with the flexibility to perform any of the following tasks: model relationships among multiple predictor and criterion variables; construct unobservable latent variables; model errors in measurements for observed variables; statistically test a priori substantive/theoretical and measurement assumptions against empirical data (i.e., confirmatory analysis). One of the SEM techniques is the Partial Least Squares (PLS) method. PLS was developed by Herman Wold (1981) by building on his mid-1960s work with fixed point algorithms. Nowadays, PLS is a well-established technique for estimating path coefficients in structural models and has been widely used in various research studies (e.g. Chin et al. 1996, Wixon and Watson 2001). The conceptual core of PLS is an iterative combination of principal component analysis relating measures to constructs, and path analysis allowing the construction of a system of constructs (Thompson et al. 1995). The hypothesising of relationships between measures and constructs, and between constructs and other constructs is guided by theory. The estimation of the parameters representing the measurement and path relationships is accomplished using Ordinary Least Squares (OLS) techniques. PLS can be a powerful method of analysis because of its minimal demands on measurement scales, sample size, and residual distributions (Wold 1985). Although PLS can be used for theory confirmation, it can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing (Chin and Newsted 1999). Chin and Newsted (1999, p. 337) mentioned that PLS method is congruent with a large percentage of research where:

- The objective is prediction, and/or
- The phenomenon in question is relatively new or changing and the theoretical model or measures are not well formed, and/or
- The model is relatively complex with large numbers of indicators and/or
- There is an epistemic need to model the relationship between latent variables and indicators in different modes (i.e., formative and reflective measures) and/or
- The data conditions relating to normal distributions, independence, and/or sample size are not met.

All these assumptions are verified in our research problem. Therefore, we consider PLS the adequate method to establish the relationship between CSFs in ERP implementation projects.

Our Example

Based on a literature review and a web survey, we defined an interdependence model between project sponsor, project manager roles and ERP implementation project success. We started by providing a definition for both the project sponsor and the project manager figures:

- The ERP project sponsor is the person devoted to promote the ERP project, who has the ownership and responsibility of obtain the project resources. He must control and monitor the project, helping remove obstacles in order to facilitate the success of the ERP project. Usually this figure is a senior executive of the company.
- The ERP project manager is the person devoted to continuously plan, lead and control the project in its several tasks. He is also responsible for ensuring that the scope is properly and realistically defined and updated, and communicating it to the whole company. One of his/her most important tasks is to promote good working relationships across the project team and stakeholders.

Operationalization of Constructs

Our three constructs were developed based on items from existing instruments, both from IS and ERP studies, and the ERP literature:

- ERP Project Sponsor - ERP project sponsor was operationalized as the person responsible for: reviewing the project scope, showing commitment along the project, and providing support for the project manager and team members.
- ERP Project Manager - ERP project manager was operationalized as the person responsible for: providing support for team members, Motivating team members, Involvement, Skills, Monitoring and tracking the project, and reporting to steering committee.
- ERP Implementation Project Success - Although there are different studies analyzing CSFs for ERP implementation projects (see section 2 – background), few of them define what is a successful ERP implementation project. According to Markus and Tanis (2000), optimal success refers "to the best outcomes the organization could possibly achieve with enterprise systems, given its business situation, measured against a portfolio of project, early operational, and longer term business results metrics". This construct was operationalized as: finishing on time, on budget, obtaining the expected functionality, the system is being used by its intended users, and implemented in the correct way taking into account the organizational an cultural values of the organization.

Our Proposed PLS Model

Our constructs relationships model is represented in figure 2 with the standard notations of the SEM approach. Based on these interdependencies, we define three hypotheses for further research:

H1 - there is a positive relationship between project sponsor role and project manager role
H2 - there is a positive relationship between project sponsor role and the success of the ERP implementation project.
H3 - there is a positive relationship between project manager role and the success of the ERP implementation project.

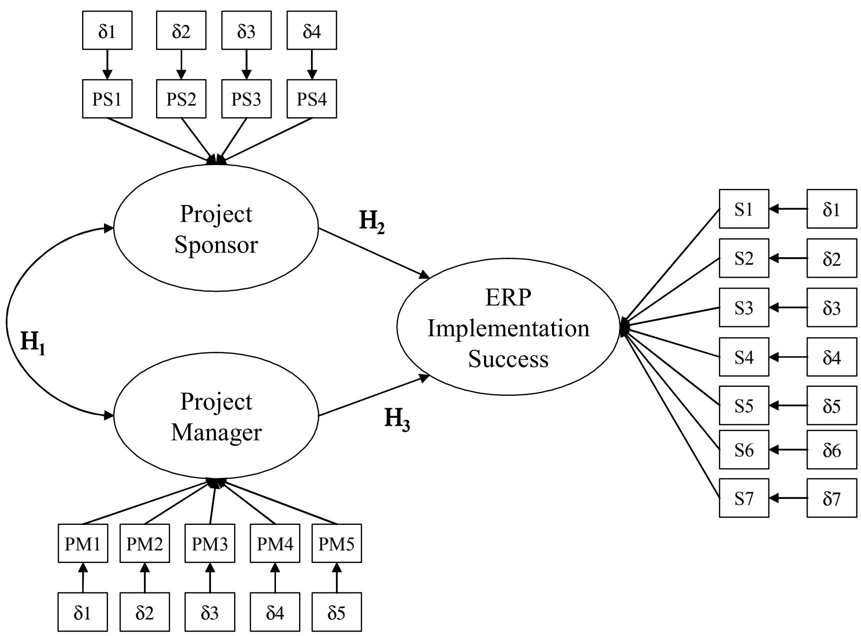

Figure 2. SEM Model for the Relationships Between Project Sponsor, Project Manager and ERP Implementation Success

Figure 2 presents the graphical representation of our PLS model. The variables in squares represent the indicators which in our case are the items resulting from of the developed survey. The variables in squares labelled ?i represent the error associated with each item. The survey to collect data (see appendix A) uses a Likert scale to measure the opinion of respondents in each indicator. As illustrated in figure 2, the model consists of two independent variables (project sponsor and project manager) and one dependent variable (ERP project success). The items may be defined using two measurement models: formative, and reflective models. The reflective model assumes that the manifest variables are a reflection of the latent constructs. In contrast, the formative model assumes that the observed variables form the latent construct. We opted for using formative rather than reflective model since the former are more suitable for prediction since we want to use our PLS model to predict ERP implementation success in future ERP projects.

An alternative to the graphical representation (figure 2) is to represent the model specification using the SEM notation:

$$[ERP\ ProjectSuccess] = [\alpha 1] + [\gamma_{1PS} \quad \gamma_{2PM}]\begin{bmatrix} ProjectSponsor \\ ProjectManager \end{bmatrix} + [\zeta_1]$$

$$\begin{bmatrix} PS1 \\ PS2 \\ PS3 \\ PS4 \end{bmatrix} = \begin{bmatrix} v1 \\ v2 \\ v3 \\ v4 \end{bmatrix} + \begin{bmatrix} \lambda_{1PS} & 0 \\ \lambda_{2PS} & 0 \\ \lambda_{3PS} & 0 \\ \lambda_{4PS} & 0 \end{bmatrix}\begin{bmatrix} ProjectSponsor \\ ProjectManager \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix}$$

$$\begin{bmatrix} PM1 \\ PM2 \\ PM3 \\ PM4 \\ PM5 \end{bmatrix} = \begin{bmatrix} v1 \\ v2 \\ v3 \\ v4 \\ v5 \end{bmatrix} + \begin{bmatrix} 0 & \lambda_{1PM} \\ 0 & \lambda_{2PM} \\ 0 & \lambda_{3PM} \\ 0 & \lambda_{4PM} \\ 0 & \lambda_{5PM} \end{bmatrix}\begin{bmatrix} ProjectSponsor \\ ProjectManager \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \end{bmatrix}$$

$$\begin{bmatrix} S1 \\ S2 \\ S3 \\ S4 \\ S5 \\ S6 \end{bmatrix} = \begin{bmatrix} v1 \\ v2 \\ v3 \\ v4 \\ v5 \\ v6 \end{bmatrix} + \begin{bmatrix} \lambda_{1ERPS} \\ \lambda_{2ERPS} \\ \lambda_{3ERPS} \\ \lambda_{4ERPS} \\ \lambda_{5ERPS} \\ \lambda_{6ERPS} \end{bmatrix}[ERP\ ProjectSuccess] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \end{bmatrix}$$

Considerations and Further Work

This research-in-progress paper proposes the use of a statistical approach named Partial Least squares (PLS) to define the relationships between CSFs for ERP implementation projects. Some researchers have evidenced the relationships between these CSFs, however no one has defined in a formal way these relationships. PLS is one of the techniques of structural equation modeling approach. Therefore, this paper presents an overview of this approach. We provide an example of PLS method modeling application, in this case we used only two CSFs: project sponsor and project manager roles. However, our project will be extended to all the CSFs of the unified model proposed by Esteves and Pastor (2000). To compute the data, we are going to use PLS-graph developed by Wynne Chin. This software has been under development for the past 9 years. Academic beta testers include institutions such as: Queens University, Western Ontario, UBC, MIT, University of Michigan, Wharton University (Chin 2000). After the PLS analysis, we want to develop a simulation application based on the PLS model. This application will help managers in the monitorization of their ERP implementation projects by knowing in each moment the grade of satisfaction in each CSF and its impact of the overall ERP implementation project success.

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