Forecasting Risk and Risk Consequences on ERP Maintenance

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Abstract— There are many studies which show that a number of IT projects fail. If focus is made on costs, it is possible that 80% of overall IT investment is waste of money, in other words, 20 per cent benefits and 80 per cent waste. Great efforts are made to adopt and implement Enterprise Resource Planning (ERP) Systems but success cannot be guaranteed. Successful implementation also depends on properly maintained ERP system. ERP is said to be a backbone of an organization. Due to this fact, ERP systems should be maintained using proper strategy to drive the ERP system towards the successful implementation. A number of risks threaten these projects. There is very limited publication regarding risks related to ERP maintenance risks and how to manage maintenance failure. To address this, we are proposing a strategy to foresee the risks and achieving maintenance goals. It will be helpful for ERP managers and professionals to manage ERP projects. It will also fill the existing gap in literature.

Index Terms: ERP, Risks, Management, Managing failure, Maintenance.

I. INTRODUCTION

Computers have become an integral part of the everyday life of every company with dreams of consistent growth through increased profit. In today's competitive business environment, a comprehensive IT strategy is critical for the success of an enterprise. In fact, since the time of mainframes Information Technology (IT) has been seen as an enabler of business.

Enterprise Resource Planning (ERP) is one the most common systems implemented by firms around the world. These systems allow the modeling, automation, and integration of company business processes, grouping all data into a single database, and providing relevant and updated information for decision making and control. ERP system implementation is a decision which should be taken with strategy and that can be motivated by business and technical factors to improve processes, establish a common platform, improve links to clients and suppliers, or reduce data errors [1], [2]. ERP system implementation lasts between one and three years [3] and requires significant effort. Firms spend from hundreds of thousands of dollars to several million dollars [4]. This investment is used to buy the system, acquire software licenses, train ERP users, integrate the ERP with other systems, contract specialized consultants, and carry out Business Process Reengineering. Despite the effort, and even if the implementation process has been completed satisfactorily, the success of ERP adoption is never guaranteed. It depends on both effectiveness and performance during the post implementation stage [5], [6], [7].

Once the implementation process finishes, the ERP does not remain static. It must be maintained to meet rapidly changing business needs given the strategy followed by the firm. In addition, ERP professionals have to correct bugs, deploy new versions, take into account user requirements, and continue improvements to the system. If the company does not properly maintain the ERP system, failures will arise, performance will decrease, and the expected benefits will not be obtained. This may even lead to early retirement of the ERP application. Hence, ERP maintenance becomes a key process in the post implementation stage. This fact is reflected in the associated business activity. A report [8] indicated that ERP maintenance revenues amounted to $10,375 million in 2006. This represents 36 percent of total ERP revenues. Moreover, this study forecasts that revenues will continue to grow, adding up to $15,390 million in 2015. In spite of this, ERP maintenance has scarcely been researched in previous literature, although this is changing. Various surveys show that interest in the post implementation stage has recently increased. However, unexplored issues remain. ERP maintenance is ambiguous because there is no clear framework to indicate the goals that ERP professionals should pursue. In addition, these complex environment projects are threatened by a wide range of critical risks due to their size, complexity, and the large number of external and internal actors involved. Consequently, there is a lack of suitable ERP maintenance standards or methodologies that define the best way to manage the process. [9]

Accordingly, this paper assesses the effects of risks on the success of ERP maintenance through a systematic approach similar to that proposed elsewhere. With this in mind, we identify risks to ERP maintenance success. Moreover, we specify which goals must be reached so that ERP maintenance will be considered successful. Finally, we create a Fuzzy Cognitive Map (FCM) to forecast risk effects on ERP maintenance goals and simulate distinct scenarios. This tool may help ERP maintenance managers assess existing risks in their projects.

The structure of the paper is as follows:

Section 2 presents a literature review of ERP maintenance and risk.

Section 3 presents the fundamentals of FCM. Moreover, this section presents key aspects of the tool, such as its dynamic behavior and how it achieves a consensual result.

Section 4 describes the process for building an FCM to model risk in ERP maintenance.

Section 5 studies the impacts of both highly controllable and poorly controllable risks on ERP maintenance goals. For this purpose, we define two scenarios and simulate them using the FCM.

Finally, Section 6 offers conclusions and describes possible future research lines.

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II. BACKGROUND

A. ERP Maintenance

An ERP system can be defined as a single software system to support the complete integration of information from all functional areas of a company by means of a single database that is accessible through a unified interface and channel of communication [10]. The ERP life cycle begins when top management decides to install the software. Following this decision, numerous tasks are carried out to implement the system. However, the ERP life cycle is not finished as soon as the application is operative and the ERP implementation stage has been concluded. At that moment, ERP enters into the post implementation stage which continues until its retirement. During the post implementation stage, adopter companies use their ERPs and try to obtain a return on investment in a short time. In addition, they continuously carry out activities to improve their systems.

The companies thus seek to maximize ERP value [11] to achieve a competitive advantage over their competitors. In this way, they stabilize their systems, synthesize business process improvements, integrate complementary applications, and achieve value from their use of the ERP. For the ERP post implementation phase to be successful, ERP maintenance is key [12]. ERP maintenance includes all those activities executed from the time the system is operative until it is withdrawn. This includes matching the system to business strategies, goals, structure, and organizational processes so that the ERP responds to requests, corrects mistakes, and prevents future problems. We can define ERP maintenance success in terms of compliance of time limits, budgets constrains, and demanded requirements, provided that:. The ERP system is not damaged. Users are satisfied with the ERP. The ERP is perfectly fit to the company and its environment.

A successful maintenance of ERP improves the system and information quality and, consequently, enhances capabilities and effectiveness of system users, organizational results, and capabilities. Hence, if ERP maintenance process is successful, these will improve ERP performance, increasing system adoption success. If the adopter firm fails to perform this maintenance, the system will not perform well. The ERP will not fulfill initial expectations. Moreover, daily business activities may be hindered. The ERP project might even become a failure that severely impacts company stability. Therefore, ERP maintenance is critical to the success of ERP adoption. In spite of this, the majority of ERP publications focus on the implementation stage. However, in the last decade, ERP post implementation stage studies have arisen in the literature,.

In the literature, various papers propose models to support ERP maintenance management [10], [13], [14] , other research concerns those aspects that influence ERP benefits after the implementation phase. In the same line, another study proposed taxonomy to classify maintenance requests depending on the business benefits that they help reach [8]. Critical factors for a successful ERP upgrade and maintenance have even been identified. Nevertheless, managers must also know which are the goals or desired results in the project. In spite of this, no single research study has identified ERP maintenance goals. These goals have to be reached to consider the ERP maintenance outcomes successful. In addition, these reflect manager insights into maintenance performance. Hence, this knowledge would help manage the process better. For this reason, identifying the goals for ERP maintenance was one aim of our research.

B. Risk with ERP Maintenance

ERP maintenance is a large-scale, unstructured, and highly complex undertaking [15], [16]. In some cases, it even requires the use of unfamiliar technologies and tools.

Therefore, risk management becomes a crucial process to ensure ERP adoption success. Risk management must be fully integrated into the project. This involves identifying, evaluating, treating, monitoring, and controlling the existing risk factors. In this way, the literature provides numerous methods, checklists, analytical frameworks, risk assessment tools, and risk response strategies to help project managers to handle risk factors more effectively. These studies mainly focus on classic software projects. However, different risks affect ERP project success because classic software projects and ERP projects are not similar [8], [10]. The ERP maintenance projects' complexity is greater than other software maintenance projects. This is due to the size of ERP systems, the high number applications connected to them, the high number of actors involved, and the continuous changes performed in the applications during the implementation and post implementation stage. Moreover, the maintenance tasks carried out throughout the software maintenance life cycle model are different. This has encouraged the appearance of ERP project risk studies in the literature. However, these studies focus on the implementation stage. Various research efforts have identified risk in the context of ERP projects. Sumner identified, described, and categorized the risk factors associated with ERP implementation. Moreover, Sumner also marked which risks are unique in ERP projects. Aloini et al. also identified the risk factors in addition to their effects.

Poba-Nzaou et al. described a method to minimize risks associated with ERP adoption in small and medium-sized firms. Scott and Vessey created a risk factor model based on the implementation case studies of Dow Corning Incorporated and Fox Meyer Drug Corporation. Zafeiropoulos et al. proposed an application for risk management in the implementation of an ERP system. By contrast, post implementation stage risk research is scarce in the literature. In fact, we could only find two articles [18], [19].

Risks affect ERP maintenance success and managers should handle them effectively to avoid failures and increase the likelihood of project success,. In this way, they should begin identifying and assessing ERP maintenance risks. But, which risks will impact on ERP maintenance goals? How will these impact ERP maintenance goals and the rest of the risks? To help managers to answer the previous questions and cover a gap in the literature, identifying and assessing the risks effects on ERP maintenance success was the main objective of our study. This is a wider area of interest, and we focus on building a tool called FCM for forecasting the joint impact of risks on ERP maintenance goals. In the following section, we present FCMs and explain important issues about this technique.

III. FUZZY COGNITIVE MAPS

Cognitive Maps (CM) [19] and, later, FCM [20] have been applied in such diverse fields as medicine [21], computer science [22], simulation and prediction [23], and other domains,. These have emerged as tools for modeling and studying the behavior of complex systems.

The FCM technique specifically describes a cognitive map model with two significant characteristics. First, causal relationships between nodes have different intensities, represented by fuzzy numbers. A fuzzy number is a quantity whose value is uncertain, rather than exact. It can be thought of as a function whose domain is usually the interval between 0 and 1 (or -1 and 1), inclusive [24]. Each numerical value in the interval represents the degree of membership in a fuzzy set, where 0 is nonmember ship and 1 represents full membership. The second characteristic is that the system is dynamic— it evolves with time. The system involves feedback, and a change in a concept node may affect other concept nodes, which in turn can impact the node initiating the change. Feedback plays a prominent role in FCMs by propagating causal influences along complicated pathways.

In contrast, FCMs are capable of dealing with uncertainly using procedure such as human reasoning. An evolved FCM even includes grayness as a measure of uncertainty. Stochastic models (e.g., correlation or regression analysis) treat uncertainty in terms of the variance. These models represent the relationship between a dependent factor and one or more independent factors.

FCMs show the behavior of a system in terms of concepts; each concept represents an entity, a variable, or a characteristic of the system [25]. The variable state evolves depending on the fuzzy weight values assigned to the feedback links between variables. Therefore, FCMs support the analysis of the evolution of a scenario at successive times and the evaluation of alternatives by applying a complementary analysis.

FCMs are directed graph with cycles that allow the analysis of the evolution of a scenario at successive iterations. Moreover, Bayesian belief networks also deal with uncertainties, although in probabilistic terms. For this reason, this tool requires the conversion of continuous variables to discrete distributions, which is not needed in FCMs.

We consider that FCMs are more suitable mechanism for modeling them due the nonlinear nature of ERP maintenance risks and its relationships. Moreover, it is considered an excellent tool for representing complex system when data lack.

In the present study, we build an FCM to model the factors that can lead to critical failure in ERP maintenance projects and the relationships between them.

IV. PROPOSED FCM CONSTRUCTION TO MODEL RISK IMPACT ON ERP MAINTENANCE SUCCESS

The aim of this study was to create an FCM for predicting the effect of risks on the goals for ERP maintenance. Toward this end, we carried out to the following steps.

A. STEP 1:

Selecting the Experts to build the FCM, advice was sought from two panels of experts. The quality of the panels was of paramount importance for us. In this paper, multiple choices were explored to select the respondents.

Table 1			
Position		Average of experience in ERP maintenance	
Project Leaders	43.3%	1-5 years	10%
Consultants	16.7%	6-10 years	46.7%
Analysts	6.7%	Above 10 years	23.3%
Programmer	3.3%t	Not Reported	20.0%
others	13.3%		
Not Reported	16.7%		

Table 1 shows the profile of consulted experts. The main selection criterion was profound knowledge and experience in ERP maintenance and/or software risk management and absence of conflicts of interest. Over 70 percent of them had more than five years of experience in ERP maintenance. In order to build an accurate FCM which faithfully represents ERP maintenance reality, we formed heterogeneous panels. A heterogeneous group is understood to be a group of people with the same knowledge, but on a different social or professional scale, which describes our experts' panels. Moreover, the experts were not chosen just because they were easily accessible. All conditions were respected. All experts' opinions were considered to be of the same importance. The optimal number of experts is quite difficult to establish, and no study has been conclusive with respect to this number. The optimal panel size depends on the characteristics of the research itself.

B. STEP 2:

Identifying Preliminary Nodes - The FCM features two types of node. First, there are nodes that represent the risk factors that affect ERP maintenance processes. Other nodes represent the goals for ERP maintenance. The criteria used to select papers were:

1. "Risk Management" in the title, abstract, or keywords.
2. One of the following expressions in the title, abstract, or as a keyword: "IT/IS Project," "Software Project," "Software Maintenance," or "ERP."
3. The study must identify the risks clearly.
4. The time horizon was not limited.

Thus, all target studies were collected and reviewed. Different risk factors were identified from 8 papers [26], [27], [28], [29], [30], [31], [32], [33], [41]. However, not all of these risks affect ERP maintenance success. We found that many studies identified the same or similar risk factors. Accordingly, we carefully analyzed and removed duplicates and eliminated any risks that do not impact ERP maintenance. In addition, risks were renamed and adapted to match the scope of our study. We ultimately generated 15 risks nodes from the critical literature review.

We found seven maintenance goals in our literature review [34], [35], [36], [37], [38], [39], [40], [41]. These represent conditions that must concur in ERP maintenance contexts at the level of process performance, system performance, and user satisfaction to consider the ERP adoption successful.

Given the absence of research on risk factors and goals for ERP maintenance, it is possible that relevant preliminary nodes were not identified during the critical literature review. Accordingly, we consulted the participating experts in the first panel. They checked the preliminary nodes and made helpful comments

Moreover, some experts added further risk factors and goals. So there are 15 nodes and 7 maintenance goals.

Table2

FCM Nodes

ID	Node	Literature Review / Personal Interaction
R1	Changing Processes	LR
R2	Unstable organizational environment	LR
R3	Non Cooperation of managers/ employees	LR
R4	Miscommunication and misunderstanding of the requirements	LR
R5	Conflicting ERP requirements	LR
R6	Inadequate requirements prioritization	LR
R7	Conflict and non cooperation between ERP maintenance team members	LR
R8	Team members lack skills/knowledge.	LR
R9	Team members not committed motivated	LR
R10	Inadequately trained ERP team members	LR
R11	Short/poor and no documentation at all	LR
R12	The quality of code	LR
R13	Poor establishment of standard procedure/processes and methods	LR
R14	Inappropriate IT infrastructure	LR
R15	Procedure to manage requests is not properly defined.	

TABLE 3. Maintenance Goals

G1	ERP system functionally is maintained and enhanced	PI
G2	Complexity is controlled	PI
G3	Maintenance cost is not over budgeted	PI
G4	Maintenance time is not over budgeted	PI
G5	User are more or equally satisfied with the system	PI
G6	ERP is implemented in all business functions	PI
G7	ERP is properly fitted in the environment of the firm.	PI

C. STEP 3: Building the FCMs

FCMs are normally built by experts who have experience and sound knowledge in this regard. They offer specific knowledge in designing the FCM model (nodes, intensity, and signs of the edges). Different methods can be used to build FCMs.

We sent the preliminary list of nodes to the experts in the second panel. This list was only a guide for them. Experts could include the nodes they considered appropriate regardless of whether these were in the list or not. Experts individually used this list and added further nodes to build their FCMs. The experts specifically identified the nodes and the relationships between them. Thus, we obtained an adjacency matrix describing each expert's opinion. We eventually created the augmented matrix by aggregating the adjacency matrix of each expert. This aggregation process depends on whether there are common nodes between the FCMs.

The final FCM consists of 15 risk nodes and 7 maintenance goals nodes.

Tables 2 and 3 summarize the nodes and indicate where each was identified. As expected, the previous literature did not include all of the risks that affect ERP maintenance success.

In addition, the FCM contains 105 edges, represented by the 22_22 matrix and shown in Table 4. The first column and row show the causal and effect nodes, respectively. The cells indicate the influence of one variable on another. All of the relationships between risks were positive. This means that values would change in the same direction. Moreover, the majority of connections between risks and maintenance goals were negative. When these risks increase, they negatively impact the relevant maintenance goals. However, the adjacency matrix also revealed positive impacts, In this example, the positive impact means that a continuing stream of requirement changes enhances ERP system functionality, although this risk negatively impacts other maintenance goals. Last, the graphical representation of the final FCM is not clear due to the large number of elements that compose it. For this reason, we did not include it in this paper.

D. STEP 4: Validation

The process of validation is essential in the modeling of complex systems. This provides insights on degree in which it represents the relevant aspects of the problem studied. FCM Nodes Designers should validate the model in two distinct moments. On one hand, the validation process should be embedded in the process of model building. This requires the active collaboration of the experts participating in the model process. On the other hand, the validation process should also be performed once the model building finished. To do so, designers can compare the model output with the real system data. There is no widely accepted strategy or method by scientific community for validating the models building. The suitability of the strategy selected depends on the availability of data on the phenomena, the real system, and model purpose. However, in the present study, we had neither available data nor reliable measures to evaluate with precision all concepts included in FCM. In fact, the validation of FCMs is complex and, many times, even impossible. This is due to the fact that FCMs are qualitative models that do not yield outputs directly measurable in the real world. In such a case, the designers should consult experts in the phenomena studied. If the experts are consulted during formulation of the model, the feedback obtained can be used to improve the performance of the model.

Hence, we began the validation during the building of the FCM. In this way, we have applied the modeling-validating process proposed in,, which has been applied in similar studies as. First, we sought to guarantee the FCM conceptual validity, that is, whether the theories and assumptions underlying in the conceptualization of the phenomena are correct and enough to represent it adequately. In doing so, experts in ERP maintenance replied to the following question: Is this research looking at the study of ERP maintenance risks from the appropriate perspective? The whole set of experts answered affirmatively. In addition, they approved the criteria adopted for conceptualizing the influence of risks on ERP maintenance goals. Subsequently, we elaborated a formal model.

V. SIMULATING SCENARIOS AND INTERPRETING RESULTS

The FCM models risk factors, ERP maintenance goals, and existing connections between them. Furthermore, this tool allows us to predict the impact of risk on maintenance goals by means of dynamic simulations of the FCM behavior over time. To perform this analysis, it is necessary to create “what-if” scenarios and to simulate them separately. We design two scenarios to study how strongly and weakly controllable risks influence ERP maintenance goals. Note that not all risks are controllable to the same degree by ERP maintenance managers.

TABLE 3 Adjacency Matrix

ID	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	G1	G2	G3	G4	G5	G6	G7
R1	0.0	0.0	0.055	0.06	0.14	0.33	0.025	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.0	0.0	0.0	-0.05	0.0	-0.08	0.0	0.0
R2	0.245	0.0	0.0	0.0	0.0	0.065	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.05	0.0	-0.05	0.0	0.0	0.0
R3	0.0	0.0	0.0	0.335	0.13	0.05	0.17	0.07	0.09	0.0	0.0	0.0	0.0	0.0	0.05	-0.05	-0.075	0.0	-0.05	0.0	0.0	-0.07
R4	0.0	0.0	0.0	0.0	0.235	0.055	0.585	0.245	0.0	0.06	0.0	0.0	0.0	0.0	0.0	-0.22	-0.075	0.0	0.0	-0.06	0.0	-0.17
R5	0.0	0.0	0.025	0	0.0	0.07	0.05	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-.025	0.0	0.0	0.0	0.0	0.0
R6	0.0	0.0	0.0	0.0	0.05	0.0	0.13	0.135	0.0	0.04	0.04	0.0	0.0	0.0	0.0	0.223	0.05	-0.1	0.0	-0.07	0.0	0.0
R7	0.0	0.0	0.025	0.0	0.0	0.0	0.0	0.37	0.0	0.0	0.06	0.0	0.0	0.0	0.0	-0.23	-0.19	-0.025	0.0	-0.025	-0.06	-0.3
R8	0.0	0.0	0.05	0.0	0.0	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.01	0.0	0.0	0.0	-0.09	-0.115
R9	0.0	0.0	0.075	0.0	0.0	0.0	0.11	0.185	0.0	0.33	0.18	0.16	0.195	0.075	0.195	-0.03	0.0	0.0	0.0	-0.18	-0.165	0.0
R10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.075	0.035	0.0	0.0	0.0	0.0	0.0	0.0	-0.05	0.0	0.0
R11	0.0	0.0	0.0	0.0	0.0	0.0	0.08	0.0	0.0	0.035	0.0	0.0	0.0	0.0	0.0	0.0	-0.08	-0.025	0.0	-0.025	-0.115	-0.17
R12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.15	0.0	0.255	0.175	0.0	0.0	-0.03	0.0	0.0	0.0	0.0	0.0
R13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.15	0.0	0.035	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	0.26	0.0	0.04	0.0	0.0	-0.08	0.0	0.0	-0.08	-0.05	-0.11
R15	0.0	0.0	0.05	0.0	0.04	0.0	0.07	0.0	0.0	0.0	0.155	0.0	0.0	0.0	0.0	0.0	0.0	-0.17	0.0	0.0	0.0	-0.035
G1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(Each cell shows one fuzzy weight. This represents the intensity of the relationship between two nodes.)

In Scenario 1, we activate the risks that the professionals could less readily control. These risks arise through the actions of agents external to the project (i.e., ERP users, top management, consultants, and ERP vendors) or following changes in the organizational environment or strategy of the adopter firm.

In Scenario 2, we simulate the opposite case. We ascribe a value of 1 to the risks that ERP maintenance managers can most easily control. Risk factors derived from requirements, tools, procedures, standards, the ERP maintenance team, and the process management itself can be prevented by management.

VI. CONCLUSIONS, LIMITATIONS, AND FUTURE WORKS

Numerous risks threaten ERP systems maintenance [41]. These can severely impact ERP user satisfaction, the project outcome, performance, and fitting the system to the firm’s needs. To avoid failures, managers should handle these risks effectively by identifying and assessing the risks in their projects. In spite of this, the literature lacks studies on ERP maintenance which help managers in the risks management. In order to study ERP maintenance risks, we proposed an innovative tool called FCM. To do so, we used augmented FCM approach. This additive methodology allows to model faithfully the studied problem based on perceptions of experts on the phenomena. In this study, experts who have experience in ERP maintenance actively participated in the building and validation of the FCM. From a static perspective, the FCM created indicates the goals which have to be reached for considering successful ERP maintenance. This also represents the risks which threaten the achievement of these goals so that the causal connections exist between these elements. The final map shows that the risks identified are closely related and they negatively impact maintenance goals. From dynamic perspective, the FCM created predicts the joint effects of risks on the ERP maintenance goals. The results will help understand the influence of risks on ERP maintenance better. Consequently, the professionals may take more effective measures to treat or prevent existing risks. To prove the dynamic behavior of the new FCM, we created two what-if scenarios and simulated them. We specifically modeled the impact of strongly and weakly controllable risks on ERP maintenance goals.

Our results confirm that risks strongly affect ERP maintenance performance. Specifically, ERP user satisfaction was the goal that was most strongly affected by the risks. In contrast, ERP volatility was the least impacted goal. In addition, the findings, as a preliminary study, reveal that risks considered the most important are often not under the project manager's direct control. In fact, less controllable risks impact more strongly on maintenance goals than more controllable risks, although the differences are very small. Only ERP systems quality and functionality are more damaged by controllable risks. The comparison of the simulation's results also shows a direct relationship between the degree of control over a risk and the amount that risk is influenced by other risks. Therefore, risks that are less readily controllable by managers will be less impacted by other risks. From the academic point of view, the results of the research presented here are also relevant. This paper lays the groundwork for further studies because it is the first time that ERP maintenance risks and goals have been identified. However, this study, while significant, is not exempt from limitations. This is not empirical research. We simply built a tool (FCM) so that a practitioner can formally assess risks existing in ERP maintenance. The simulation of scenarios demonstrates applicability and usability of the proposed tool, this being the aim of the present paper. However, other scenarios could have been simulated. We invite researchers and practitioners to propose further possible scenarios. This research is focused in assessing the joint impact of risks on ERP maintenance goals. Nonetheless, ERP maintenance risks are still an under-researched topic with unsolved issues. So, it is necessary to undertake further research on the existing risks in ERP maintenance. To manage such risks most effectively, managers should know which risks are most important to ERP maintenance success. Therefore, research that answers this question is required. The development of techniques to predict the appearance of risks in ERP maintenance projects is also very worthwhile. Moreover, it would be interesting to know real problematic situations which have occurred during ERP maintenance. This will help to achieve better results in these complex projects.

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