Fuzzy Cognitive Maps-Based IT Projects Risks Scenarios

Jose L. Salmeron

Abstract. Firms have spent billions of dollars in IT projects. Therefore, IT risk management is a critical issue. According to this context, the applied efforts to look for the correct IT implementation should be accompanied by mechanisms for managing the implementation risks. The goal is to reduce the risk of implementation failure. This paper analyzes IT projects implementation risks and the relationships between using an innovative soft computing technique called Fuzzy Cognitive Map. Through this proposal, it is possible to observe which the most relevant risks are, and, above all, which have a greater impact on the IT projects. Finally, three what-if analyses are done.

1 Introduction

Most real-life decision-making processes are dynamic. Critical decisions in business areas as manufacturing, sales, marketing, finance, and other domains require multiple and interrelated time-constrained decisions within strongly uncertain and so complex environments.

Information Technology (IT) projects have certain features that make them slightly different from other engineering projects. These include increased complexity and higher rates of project failure. Improving general knowledge about IT projects and IT risks specially can make it easier to implement and to increase the success rates.

This paper is structured in six sections. In the second section, IT projects risks fundamentals are presented. Next, in the third section, the author explains a decision support technique called Fuzzy Cognitive Maps (FCM). In the fourth section an experimental analysis about IT projects risks is done. In the fifth section, FCM-based what-if scenarios are designed. Then, in the last section the conclusions are exposed.

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2 IT Projects Risks

IT can enhance database access, analytical power, and the communication capacity of decision makers. It is based on the premise that more and better quality information will result in reduced uncertainty and complexity in decision-making (Ritchie and Brindley, 2001). As noted, most approaches to decision making often revolve around the assumptions that alternative courses of action (future scenarios) can be established, the outcome of choosing an alternative is known, or is at least calculable.

Several issues measure IT projects success: to be deployed on time, to budget, and meeting the specifications. Literature confirms that a few of those projects were finished on time, and within the estimated budget (Saleh and Alshawi, 2005).

It seems clear that the criteria mentioned (delivered on time, to budget and meeting the specification) are not enough to guarantee the success of an IT project avoiding their risks. An IT project could be implemented on time, within cost forecasts and according the specifications, but if it is not useful to the users, not liked by the sponsors and does not increase the efficiency of the company, that IT project is not a success. Therefore, there is a need to identify what the critical risks influencing IT projects success are and the relationships between them.

In order to begin to assess the risks involved within major IT projects it is necessary first to understand them.

Large IT projects are inherently risky undertakings. Yet the literature (Griffiths, 1995) suggests that risks factors are strongly underplayed and underassessed. Management challenges are compounded when technological innovation integral to a project is a factor. This is specifically the case in large (IT) projects. Indeed a range of studies show that the IT component adds a different dimension of risk which all too often can tip the balance towards project failure, rather than towards project success.

IT risk management is a critical process in any effective IT project (Cuellar and Gallivan, 2006; Rodriguez-Repiso et al., 2007). Risk management in IT ones is needed according to the high risk and cost of those projects (Hakim and Hakim, 2010). It causes huge loss for companies. In fact, risks are intrinsic to any IT project and risk taking is a necessary component of any process of decision-making (Cadle and Yeate, 2001). Poor risk management often leads IT projects to failure.

However, before we can develop meaningful risk management strategies, however, we must identify these risks and the relationships between them. Risk is the occurrence of an event that has consequences for, or impacts on, IT projects (Kliem and Ludin, 2000). The risk may halt from the nature of the work, from the resources available, from the contractual relationship, or from social issues with impact over the project (Cadle and Yeate, 2001).

So, if it is not possible to eradicate risks altogether; it must certainly be possible to manage IT projects in a way that identify the risks and plans methods of mitigate them if they occur (Cadle and Yeate, 2001). Risk identification, valuation and assessment are therefore the fundamental basis to support the entire risk management process. This paper proposes the use of Fuzzy Cognitive Maps for risks analysis in IT projects.

3 Fuzzy Cognitive Maps

This paper applies a soft computing technique called Fuzzy Cognitive Map (FCM) in IT projects risks management. The FCM process is an innovative and flexible technique (Bueno and Salmeron, 2008) for modelling human knowledge. In addition, FCM provide excellent mechanisms to develop forecasting exercises, specially what-if analysis.

Cognitive maps (Axelrod, 1976) and, after, Fuzzy Cognitive Maps (Kosko, 1986), have emerged as tools for representing and studying the behaviour of systems and people. Cognitive maps are a set of nodes linked by edges. The nodes represent concepts relevant to a given domain. The causal links between these concepts are represented by the edges, which are oriented to show the direction of influence. The other attribute of an edge is its sign, which can be positive (a promoting effect) or negative (an inhibitory effect).

The main goal of building a cognitive map (or FCM) around a problem is to be able to predict the outcome by letting the relevant issues interact with one another.

FCMs were proposed as an extension of cognitive maps. The FCM technique was proposed by Kosko (1986) to describe a cognitive map model with two significant characteristics. The first one, 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), including both (Xirogiannis and Glykas, 2007). Each numerical value in the interval is the grade of membership to the set, where 0 represents the smallest possible grade, and 1 is the largest possible grade.

The second one, the system is dynamic, that is, it evolves with time. It involves feedback, where the effect of change in a concept node may affect other concept nodes, which in turn can affect the node initiating the change.

After an inference process, the FCM reaches either one of two states following a number of iterations. It settles down to a fixed pattern of node values, the so-called hidden pattern or fixed-point attractor. Alternatively, it keeps cycling between several fixed states, known as a limit cycle. Using a continuous transformation function, a third possibility known as a chaotic attractor exists. This occurs when, instead of stabilizing, the FCM continues to produce different results (known as state-vector values) for each cycle. Feedback plays a prominent role in FCMs by propagating causal influences in complicated pathways.

FCMs have been applied in such different fields as medicine (Georgopoulos et al., 2003; Papageorgiou et al., 2006a), computer science (Kim and Lee, 1998; Konar and Chakraborty, 2005; Osei-Bryson, 2004; Stach et al., 2005), IT projects success (Rodriguez-Repiso et al., 2007), and other domains (Kang et al., 2004; Lee and Han, 2000; Rai and Kim, 2002; Xirogiannis et al., 2008). As yet, there have been few attempts at applying FCMs as real-world tools for supporting decisions (Salmeron, 2009) within real business environments. In addition, FCMs have been used in simulation and prediction projects (Fu, 1991).

Moreover, FCM provide an intuitive, yet precise way of expressing concepts and reasoning about them at their natural level of abstraction. By transforming decision modelling into causal graphs, decision makers with no technical background can understand all of the components in a given situation. In addition, with a FCM, it is possible to identify and consider the most relevant factor that seems to affect the expected target variable.

3.1 Fuzzy Cognitive Map Fundamentals

The FCM nodes (x_i) would represent such concepts as costs, sales, tool selection, investment, or marketing strategy, to name a few. Figure 1 shows an example of an FCM model.

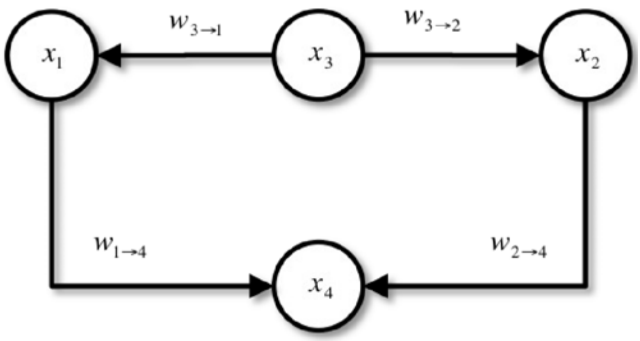

Fig. 1 Fuzzy Cognitive Map example

The relationships between nodes are represented by directed edges. An edge linking two nodes models the influence of the causal variable on the effect variable (Xirogiannis and Glykas, 2004). Since FCMs are hybrid methods (Xirogiannis and Glykas, 2008) mixing fuzzy logic (Zadeh, 1965, Bellman and Zadeh, 1970) and neural networks (Kosko, 1992), each cause is assessed by its intensity $w_{i\to j} \in [0,1]$, where i is the pre-synaptic (causal) node and j the post-synaptic (effect node) one.

An adjacency matrix A represents the Figure 1 FCM nodes connectivity. FCMs measure the intensity of the causal relation between two factors and if no causal relation exists it is denoted by 0 in the adjacency matrix.

$$A = \begin{pmatrix} 0 & 0 & 0 & w_{1\to4} \\ 0 & 0 & 0 & w_{2\to4} \\ w_{3\to1} & w_{3\to2} & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

The high level FCM building process is summarized in Fig. 2.

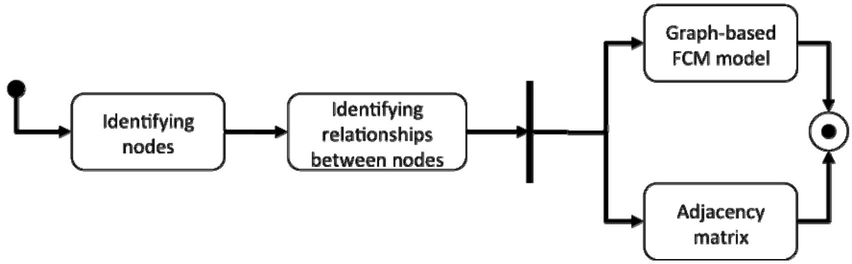

Fig. 2 FCM building process

FCMs are dynamical systems (Xirogiannis et al., 2008) involving feedback, where the effect of change in a node may affect other nodes, which in turn can affect the node initiating the change. The analysis begins with the design of the initial vector state ($\vec{C}_0$), which represents the initial value of each variable or concept (node). The initial vector state with n nodes is denoted as

$$\vec{C}_0 = \left(C_0^{[1]} \quad C_0^{[2]} \quad \ldots \quad C_0^{[n]}\right)$$

where $C_0^{[i]}$ is the initial value of the i concept.

The new values of the nodes are computed in an iterative vector-matrix multiplication process with an activation function, which is used to map monotonically the node value into a normalized range [0,1]. The sigmoid is the most used function (Bueno and Salmeron, 2009) when the concept (node) value maps in the range [0,1]. The vector state $\vec{C}_{(t+1)}$ at the instant $t+1$ would be

$$\begin{aligned}
\vec{C}_{(t+1)} &= S\left[\vec{C}_t \times A\right] \\
&= S\left[\vec{C}_t A\right] \\
&= S\left[\left(\vec{C}_t A^{[1]} \quad \vec{C}_t A^{[2]} \quad \ldots \quad \vec{C}_t A^{[n]}\right)\right] \\
&= \left(S\left(\vec{C}_t A^{[1]}\right) \quad S\left(\vec{C}_t A^{[2]}\right) \quad \ldots \quad S\left(\vec{C}_t A^{[n]}\right)\right) \\
&= \left(C_{(t+1)}^{[1]} \quad C_{(t+1)}^{[2]} \quad \ldots \quad C_{(t+1)}^{[n]}\right)
\end{aligned}$$

where $\vec{C}_t$ is the vector state at the t instant, $C_t^{[i]}$ is the value of the i concept at the t instant, $S[x]$ is the sigmoid function and A the adjacency matrix. The state is changing along the process.

The component i of the vector state $\vec{C}_{(t+1)}$ at the instant $t+1$ would be

$$C_{(t+1)}^{[i]} = \frac{1}{\left(1 + e^{-l \times \vec{C}_t A^{[i]}}\right)}$$

where λ is the constant for function slope (degree of fuzzification). The FCM designer has to specify the lambda value. For large values of lambda (e.g. $\lambda \geq 10$) the sigmoid approximates a discrete function that maps its results to interval (0,1), for smaller values of lambda (e.g. $\lambda = 1$) the sigmoid approximates a linear function, while values of lambda closer to 5 provides a good degree of fuzzification in [0,1] interval (Bueno and Salmeron, 2009; Grant and Osei-Bryson, 2005).

FCM inference process finishes when the stability is reached. The final vector state shows the effect of the change in the value of each node in the FCM. After the inference process, the FCM reaches either one of three states following a number of iterations. It settles down to a fixed pattern of node values, the so-called hidden pattern or fixed-point attractor. Alternatively, the state could to keep cycling between several fixed states, known as a limit cycle. With a continuous function, a third possibility would be a chaotic attractor. This occurs when, instead of stabilizing, the FCM continues to produce different results (state vector values) for each cycle. In this case, the technique is not able to offer a useful outcome for risks analysis.

3.2 Experts' Consensus in FCM

Various methodologies could be used in order to reach a consensus among the experts in FCM (Bryson et al., 1997; Bueno and Salmeron, 2008). Delphi is a well-known methodology used to structure the experts' communication process to reach a consensus regarding a complex problem (Dalkey and Helmer, 1963; Linstone and Turoff, 1975). One of the main features of the Delphi study is when the experts receive feedback reports; they have the opportunity of changing their own opinion based on this feedback (Dalkey and Helmer, 1963).

The Augmented FCM approach (Dickerson and Kosko, 1994; Salmeron, 2009) does not need that experts change slightly their former opinions for consensus. It is needed within Delphi methodology (Cho et al., 2002). The augmented adjacency matrix is built adding the adjacency matrix of each expert (Kosko, 1996).

The Augmented FCM approach combines additively FCM matrices of each expert. The outcoming Augmented includes the union of the causal nodes for all the experts. If an expert's FCM does not include a specific concept then those rows and columns in adjacency matrix are all zero. The resulting augmented matrix is computed by

$$A^{Aug} = \Sigma_{i=1}^{n} A_i$$

where n is the number of experts and A_i is the adjacency FCM matrix for i expert.

4 Experimental Analysis

The experiment is focused on IT projects implementation risks and its relationships. IT projects have certain features that make them different from other projects. These include increased complexity and higher chances of project failures (Rodriguez-Repiso et al., 2007). To increase the chances of these projects to be successful, it is necessary to identify and control the critical risks influencing them. Risk control is needed according to the high risks and costs of IT projects.

According to Kwak and Stoddard (2004), a critical point is that some IT practitioners perceive risk management as extra work. Usually, risk management processes are the first element to be removed from the project tasks when the project schedule slips. For that reason, practitioners' involvement in risk management (e.g.: building FCM models) is so interesting.

4.1 Expert Panel

With the purpose of determining the group of risks in IT projects, as well as the relationships between them, advice was taken from a panel of experts. The number of experts selected is found to be within the recommended range. Experts suggest a range of 10 to 18 to be a fit number for each panel of experts (Okoli and Pawlowski, 2004). Anyway, the optimal number of experts depends of the study itself. In our case, ten participants composed the expert panel.

These experts had formed or form part of an IT implementation team or is working as IT manager, both with more than ten years of experience. They belonged to both the public and private sectors from Europe (6) and USA (4). This team composition guarantees the experts who are finally chosen having thorough profound IT knowledge.

The main selection criterion considered was recognized knowledge in domain topic, absence of conflicts of interest and geographic diversity. All conditions were respected. In addition, respondents were not chosen just because they are easily accessible.

4.2 Building the Model

The experts suggest fifteen ERP projects critical risks. The node description and its relationships are detailed in Table 1 and the graphical model in Fig. 3. The Augmented FCM approach has been used for building consensus.

The FCM graphical model is shown in Figure 4. Note that it is complex to take into account all these concepts at the same time even for experts. IT projects managers gain understanding of the problem in the FCM building process and then they can simulate different initial situations. For those reasons, FCM is a useful tool for IT projects managers.

Table 1 Nodes and outgoing edges

Node source	Description	Weights of outgoing edges
x_1	Wrong IT tools selection	$w_{1\to 2} = 0.4$
		$w_{1\to 3} = 0.8$
		$w_{1\to 4} = 0.4$
		$w_{1\to 6} = 0.6$
		$w_{1\to 8} = 0.2$
		$w_{1\to 12} = 0.7$
		$w_{1\to 13} = 0.6$
x_2	IT software releases unstability	$w_{2\to 3} = 0.7$
		$w_{2\to 6} = 0.5$
		$w_{2\to 7} = 0.2$
		$w_{2\to 8} = 0.3$
		$w_{2\to 11} = 0.6$
		$w_{2\to 12} = 0.7$
x_3	Complex IT integration within current infrastructure	$w_{3\to 8} = 0.8$
		$w_{3\to 13} = 0.3$
x_4	Unrealistic expectations	$w_{4\to 5} = 0.6$
		$w_{4\to 6} = 0.4$
		$w_{4\to 9} = 0.1$
x_5	Low Top management support	No outgoing edges
x_6	Low users' involvement	$w_{6\to 11} = 0.2$
		$w_{6\to 13} = 0.6$
x_7	Inadequate consulting services	$w_{7\to 1} = 0.8$
		$w_{7\to 8} = 0.9$
		$w_{7\to 9} = 0.6$
		$w_{7\to 11} = 0.7$
		$w_{7\to 13} = 0.8$
x_8	High costs	$w_{8\to 4} = 0.7$
		$w_{8\to 5} = 0.8$
x_9	Wrong IT project management	$w_{9\to 3} = 0.3$
		$w_{9\to 5} = 0.5$

Table 1 (*continued*)

		$w_{9\to6} = 0.4$
		$w_{9\to8} = 0.4$
		$w_{9\to11} = 0.3$
x_{10}	High reliability requirements	$w_{10\to8} = 0.4$
x_{11}	Wrong legacy systems management	$w_{11\to3} = 0.7$
x_{12}	IT security issues	$w_{12\to5} = 0.2$
x_{13}	Low Performance	$w_{13\to5} = 0.3$

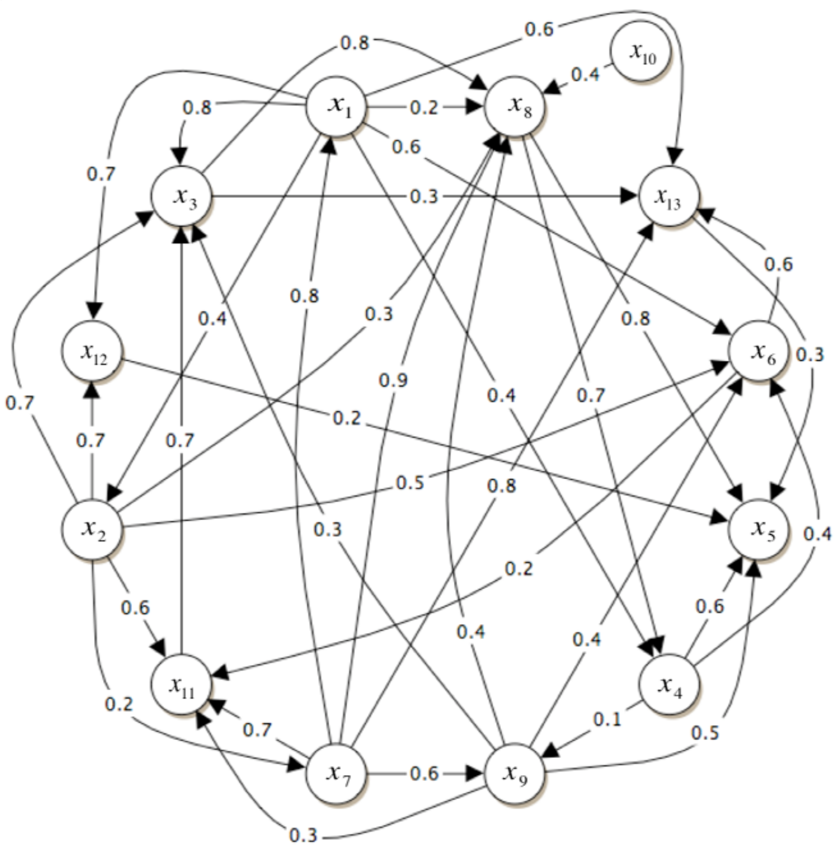

Fig. 3 IT projects risks Fuzzy Cognitive Map

5 FCM-Based Scenarios

It is possible to develop what-if analysis (scenarios) using different initial vector states. With the intention of observing the evolution of several initial scenarios, each analysis begins with the definition of an initial vector ($\vec{C}_0$), which represents a proposed initial situation or scenario. It means that it would start a specific IT project, but one o several risks are known before.

In this experiment the author uses three initial vectors state, each one have some risks activated. Each initial vector state interacts with the adjacency matrix A^{Aug} as detailed before.

5.1 Scenario A

Globalization has led companies to engage in IT projects that are critical to their survival. In order to succeed, companies must finish IT projects on time and within budget, and meet specifications while managing project risks. While large amounts of resources are dedicated to selecting and designing IT projects, it remains of critical importance that projects be adequately managed if they are to achieve their performance objectives (Raymond and Bergeron, 2008; Holland and Light, 1999).

On the other hand, consulting services can be one of the most difficult kinds of services to acquire. The acquirement process required for these services can involve major investments in time, money, and people with no assurance of a successful outcome (Mitchell, 1994). Anyway, one key to a successful IT project implementation is to maintain an effective and smooth consulting process, specially in IT projects as Enterprise Resource Planning systems (Bueno and Salmeron, 2008).

All the risks (nodes) in the initial vector $\vec{C}_0^A$ are not activated at the initial time in the A scenario, but “Wrong IT project management” and “Inadequate consulting services”. This scenario is related with an IT project where the external side has been wrong selected.

$$\vec{C}_0^A = (0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0) \xrightarrow{n \text{ iterations}}$$

$$\vec{C}_n^A = (.77 \quad .54 \quad .98 \quad .90 \quad .97 \quad .96 \quad .71 \quad .98 \quad .66 \quad 0 \quad .96 \quad .92 \quad .96)$$

Regarding to the results, the stable vector shows as the initial activated risks have a strong influence over the remainder risks. Findings confirm the critical role of project management and external consultants in IT projects. It is coherent with the importance of project management and consulting services in IT projects. According to this, one critical factor to a successful IT implementation is to maintain an effective and smooth consulting process and an effective IT project management.

Higher impacts are got over “Complex IT integration within current infrastructure” (0.98), “Unrealistic expectations” (0.90), “Low top management support” (0.97), “Low users’ involvement” (0.96), “High costs” (0.98), “Wrong legacy system management” (0.98) and “Wrong legacy systems management” (0.96), “IT security issue” (0.92) and “Low performance” (0.96).

5.2 Scenario B

All the risks (nodes) in the initial vector $\vec{C}_0^B$ are not activated at the initial time, but “Low top management support” and “Low users’ involvement”. This scenario is related with an IT project where the internal side is not supporting enough the IT project.

Top management mission in IT projects is to promote the project. Their mission is not focused on the daily activity of development and implementation process, but on supporting the IT system with his/her authority and influence over the rest of the firm. Literature claims that top management support is a critical factor of IT projects success (Bingi et al., 1999; Umble et al., 2003). Without this support, IT may not be implemented optimally and returns on IT investments can be reduced.

User involvement refers to participation in IT projects implementation processes by target users representatives. In a deeply approach, user's involvement is defined (Barki and Hartwick, 1989; Lin and Shao, 2000) as a mental or psychological state of users toward the system and its development process.

It is generally accepted that IT users' involvement is important and necessary, as the lack of their involvement may represent a serious problem for the final system. IT implementation could represent a threat to users’ perceptions of control over their own work. User involvement restores or enhances perceived control through participating the whole project plan (Zhang et al., 2005).

$$\vec{C}_0^B = (0 \quad 0 \quad 0 \quad 0 \quad 1 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0) \xrightarrow{n \text{ iterations}}$$
$$\vec{C}_n^B = (0 \quad 0 \quad .24 \quad .45 \quad .79 \quad .34 \quad 0 \quad .42 \quad .07 \quad 0 \quad .15 \quad 0 \quad .62)$$

The final stable vector shows as the initial activated risks have the stronger influence over “Low performance” (0.62). It shows that if top management support and users’ involvement are low, the final IT system will get low performance.

Despite the difficulties in explaining the contribution of IT investments to organizational performance, it is a critical issue for companies (Li and Yen, 1999). IT allows companies to obtain, process, store and exchange information. Nevertheless, the presence of IT neither guarantees performance increases.

5.3 Scenario C

All the risks in the initial vector $\vec{C}_0^C$ are not activated at the initial time, but “Complex IT integration within current infrastructure” and “Wrong IT tools selection”. This scenario represents an organization with high technical complexity that it fails selecting the IT tools. Effectively integrating the new IT tools in the previous technology infrastructure is not always an easy task. Anyway, it will be more complex if the selected tool is wrong.

$$\vec{C}_0^C = (1 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0) \xrightarrow{n \text{ iterations}}$$
$$\vec{C}_n^C = (.77 \quad .54 \quad .98 \quad .90 \quad .97 \quad .96 \quad .71 \quad .98 \quad .66 \quad 0 \quad .96 \quad .92 \quad .96)$$

The stable vector $\vec{C}_n^C$ shows as the initial activated risks have a strong influence over the whole model, specially on “Low Top management support” (0.97), “Low users’ involvement” (0.96), “High costs” (0.98), “Wrong legacy systems management” (0.96) and “Low performance” (0.96). Obviously, more complexity implies more risks as results suggest.

The findings are reasonable, because a more complex integration would generate more costs. The increasing budget decrease the top management support and it would has an impact over the users’ involvement. As a result, the system would get a lower performance (Berlin et al., 2009).

6 Conclusions

Companies have spent billions of dollars in IT projects. Therefore, IT risk management is a critical issue. According to this context, IT projects risk management is a relevant issue. To address it and improve scientific background around requires solid methodologies. In this sense, this paper proposes the use of Fuzzy Cognitive Maps for IT projects risk management.

An experimental analysis with three initial scenarios was designed. Each scenario analysis begins with the definition of the initial situation. It means that it would start a specific IT project, but one o several risks are known before. The FCM evolution generates the final situation for each scenario.

6.1 Relevance of the Proposal

The author' proposal offers some advantages in comparison with others similar tools. This paper proposes an innovative and flexible technique called Fuzzy Cognitive Maps to IT risks scenarios. It can be adapted to a wide range of problems, specially in knowledge intensive environments. This flexibility allows this model to be turned into a useful and innovative tool.

Firstly, FCM technique allows the defining of relationships between concepts. Through this characteristic, decisional models that are more reliable for interrelated environments are defined.

Secondly, FCM is able to quantify the influence of the relationships between concepts. Through this attribute, a better support in complex decisions can be reached. Finally, with this FCM model it is possible to develop a what-if analysis with the purpose of describing possible scenarios.

FCM application was used to analyze IT projects risks and interesting findings were extracted. Three risks initial scenarios were simulated and their impact over the model have been detailed. Through this proposal, one can observe which the most relevant risks are, and, above all, which have a greater impact on the IT projects. It allows using FCM as a simulation tool, where the initial risk situation suggests the future problems in IT projects implementation.

6.2 Limitations

However, this research possesses as its main limitation the experts' knowledge dependency. An FCM is based on experts' knowledge. Accumulated experiences are integrated within FCM structure. According to this, experts' selection needs to be extremely solid. Anyway, the opinions of one expert are never completely accurate and always contain some level of subjectivity.

The author highlights the reduced number of experts consulted in spite of it being among the recommended limits.

Consensus is other limitation. The Augmented FCM approach does not need that experts change slightly their former opinions, as others ones (Delphi). The current proposal applies Augmented matrices for reaching consensus, but it is not possible to know if the outlier has the right opinion.

6.3 Future Work

The author considers that the methodology applied in this paper has allowed successfully reaching the desired aim of this research. In this way, the author believes that its application is possible in other equally relevant decision-making process and that occur in the stages of pre-implementation, implementation and, even, maintenance of IT projects.

Moreover, Fuzzy Cognitive Maps are not a close research topic. More research about FCM building, learning and application is needed. Specially, the author is going to make efforts towards building FCM.

Finally, our findings highlight the necessity of continuing with research about this topic. Specifically, we could start future work based on these findings. First, we are interested in analyzing how some factors that influence the technological complexity, such as design, affordance, integrated search functionality and friendly interface, affect the behavioral intention to use an ERP system. Second, we consider that it would be interesting to develop future research to analyze IT projects after completing an implementation.

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