# Critical Review

A Publication of Society for Mathematics of Uncertainty

Volume X, 2015



Publisher:

Center for Mathematics of Uncertainty
Creighton University

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# Contents

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# Neutrosophic cognitive maps for modeling project portfolio interdependencies

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## Abstract

Interdependency modeling and analysis have commonly been ignored in project portfolio management. In this work, we proposed a new method for modeling project portfolio interdependencies, and specially risks interdependencies, using neutrosophic logic and neutrosophic cognitive maps. This proposal has many advantages for dealing with indeterminacy making easy the elicitation of knowledge from experts. An illustrative example is presented to demonstrate the applicability of the proposed method.

## Keywords

Neutrosophic logic, Neutrosophic cognitive maps, Risk interdependencies, Project portfolio interdependencies.

## 1 Introduction

A portfolio of project is a group of project that share resources creating relation among them of complementarity, incompatibility or synergy [1]. The interdependency modeling and analysis have commonly been ignored in project portfolio management [2].

In an international survey only 38.6 % of responders understand this element [2]. Cost increasing, the lack of benefits exploitation [3] and the incorrect selection of projects [4] are among the consequences. In this work a proposal for modeling project portfolio risk interdependencies neutrosophic cognitive maps (NCM) [11] is developed.

This paper is structured as follows: Section 2 reviews some important concepts about neutrosophic cognitive maps and risks interdependencies modeling. In Section 3, we present a framework for modeling interdependencies in project portfolio risks. Section 4 shows an illustrative example. The paper ends with conclusions and further work recommendations in Section 5.

## 2 Neutrosophic cognitive maps and risks interdependencies

A fuzzy cognitive maps (FCM) [5] are fuzzy graph structures for representing causal knowledge. FCM have been applied to diverse areas such as decision support and com-plex systems analysis [6]. Furthermore multiples extensions have been developed such as fuzzy grey cognitive maps [7], interval fuzzy cognitive maps [8], Intuitionistic fuzzy cognitive maps [9] and linguistic 2-tuple fuzzy cognitive maps [10].

Neutrosophic cognitive maps (NCM) were created by Vasantha & Smarandache [11] as an extension of the Fuzzy Cognitive Maps (FCMs) in which indeterminacy is included using neutrosophic logic. Neutrosophic logic is a logic in which each proposition is esti-mated to have the percentage of truth in a subset T, the percentage of indeterminacy in a subset I, and the percentage of falsity in a subset F [12].

There are five types of project portfolio interdependencies: benefit, risk, outcome, schedule and resources [13]. Risks have a positive or negative correlation with others provoking risk diversification or amplification effects. In this work project portfolio risk interdependencies are modeled using neutrosophic logic to include indeterminacy.

## 3 Modeling project portfolio interdependencies

Our aim is develop framework for modeling project portfolio and its interrelation based NCM. The model consists of the following phases (graphically, *Figure 1*):


*Figure 1.* A Framework project portfolio risk interdependencies.

### Identifying risks

The first step is the identification of risks. Risks are identified initially at project level. A portfolio risk breakdown structure with interdependencies is obtained. An example for a risk breakdown structure applicable to IT portfolios with interdependencies is shown in [13].

### NCM development

The weight of the relationship among from given risk $R_i$ to risk $R_j$ is represented by means of neutrosophic logic. Additionally static analysis for selecting the most important risks could be developed [14].

## 4 Illustrative example

Five risks $R = (r_1, \ldots, r_5)$ are identified at portfolio level (*Table 2*).

*Table 1.* Portfolio risks

| Node | Description |
|---|---|
| $\mathbf{R_1}$ | Project 1 Technical feasibility |
| $\mathbf{R_2}$ | Project 1 Timely completion |
| $\mathbf{R_3}$ | Project 2 Timely completion |
| $\mathbf{R_4}$ | Project 2 Code quality |
| $\mathbf{R_5}$ | Project 3 Timely completion |
| $\mathbf{R_6}$ | Project 3 Cultural acceptance |

Later, the expert provides the following interrelations (*Figure 2*):

$$W = \begin{matrix} 0 & 0 & 0.75 & 0 & 0 & 0 \\ 0 & 0 & 0.3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & I & 0 & 0 & 0 \\ 0 & 0 & 0.5 & I & 0 & 0 \end{matrix}$$

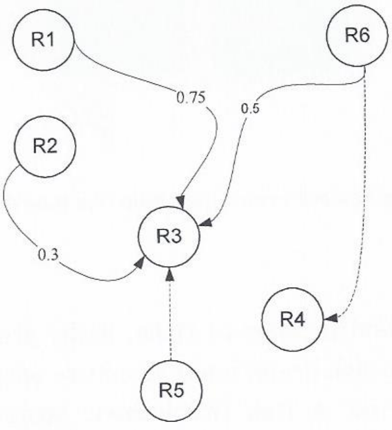


*Figure 2.* Neutrosophic cognitive map representing risks interdependencies.

In this example, the technical feasibility of project #1 (technical risk) could severely affect the timely completion of projects #2. Also, if no consistent tooling is used, and the agile development approach (project #3) is not culturally accepted, projects #2 are more likely to experience quality issues and time delay. Indeterminacy is introduced in project #3 risks interrelation with other risks of project #2.

## 5 Conclusion

This paper proposes a new framework to model interdependencies in project portfolio. NCM representation model is used for modeling relation among risks.

Building NCM follows an approach more similar to human reasoning introducing indeterminacy in relations. An illustrative example showed the applicability of the proposal. Further works will concentrate on two objectives: developing a consensus model, and extending the model to other areas of project portfolio interdependencies modeling.

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