A Methodology to Improve the Decision-Making Process: Integration of System Dynamics Models and Decision Theory With TRIZ

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ABSTRACT

The modeling approach is relevant to support the decision-making process. Modeling requires a structured approach, knowledge and specific analytical skills in order to obtain an appropriate representation of the situation under analysis. Nevertheless, creating a good representation of the reality is not a simple task; it is not trivial to choose an analysis approach since most of decision-makers could have partial lacks information during the different stages of the modeling process. Considering this, we propose a methodology to support the decision-making process by using a novel structured integration of different quantitative and qualitative tools, such as system dynamics, decision theory and the theory of inventive problem solving (TRIZ), in order to simplify the modeling process in complex analysis. A case study attempts to illustrate the application of the methodology in a real problem situation, related to the analysis of disasters within the boundaries of Valparaíso City, specifically fires.

KEYWORDS

Chile, Decision-Making, Model, System-Dynamics, TRIZ

INTRODUCTION

Modeling of complex systems is important to decrease the risk in decision making (Cardona & Hurtado, 2000). Modeling in practice combines the experience of analysts which seeks to represent reality through the use of variables that are important in the case to be modeled (Flores, 2013). On one hand, modeling must deliver results that support the decision-making process (Flores, 2013). On the other hand, the modeling should be as objective as possible in order to reduce the uncertainty of the situation to be analyzed (Pena de Ladaga & Berger, 2006).

In practice, the situation to be modeled and the representation of its variables is based mainly on the experience of the analysts on the context under study. This process of analysis requires considerable knowledge and, above all, an active participation of experts who seek the causal relationship between

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the variables that affect the model (Flores, 2013). In other words, the analyst requires a lot of experience and detailed knowledge about the subject (Flores, 2013). Under this logic, models of system dynamics seek standardization of the modeling process by creating predefined structures which can generate modeling scenarios in a simpler way (Braun, 2002; Bulla, 2013). Consequently, under this type of analysis, analysts are forced to create models, which may not be fully representative of reality, limiting their use in practice. On the other hand, if the analyst does not have the necessary experience on the subject, he may discard and/or omit variables that are relevant in modeling.

Under the limitation above-mentioned and from a problem-based perspective, OTSM-TRIZ presents different tools for both modeling and analyzing in order to present the problematic situation in the most realistic and plausible way. The objective of OTSM-TRIZ, specifically of the Network of Problems (NoP), is to represent the causal-reality, looking for the associated problems in a situation, in addition to looking for solutions that allow undertaking the situation in conflict. The approach proposed by the NoP allows raising the analysis of the situation more efficiently (Savransky, 2000). From the point of view of the scenario analysis, the limitations of the OTSM-TRIZ are based on the difficulty of evaluating the effects of the solutions created in the model over time; consequently, the process of analysis and evaluation in OTSM-TRIZ is considered practically separated from the generation of solutions, which discontinues the process of analysis.

In this paper, a systematic and structured methodology that allows modeling and evaluating the resolution of a complex situation is proposed. The methodology combines the logic of OTSM-TRIZ and system dynamics, which allows generating a more holistic, complete and structured analysis process. In other words, this article proposes a combination of system dynamics and OTSM-TRIZ which allows obtaining a more holistic understanding of a future situation, given certain influencing variables by combination of real data and experts’ knowledge by using decision theory. The main advantage of the proposed methodology is explaining complex scenarios within a system of multiple variables where both qualitative and quantitative analysis are required to better understand a specific situation over time.

The methodology consists of six structured steps which are considered as an operational algorithm that the analyst must follow during the analysis process. To validate the proposed integration, a case study is presented in a real context in the city of Valparaiso, and it is related to the analysis of catastrophes, such as fires in the city.

**STATE-OF-ART**

The proposal combines three well-known methods: i) System dynamics, which corresponds to generic structures that allow facing and modeling management issues, ii) OTSM-TRIZ, which offers a structured approach based on problems and solutions represented by causal diagrams of the main problems to be solved; and iii) decision theory, which allows to combine partial quantitative and qualitative data to create scenario analysis, improving the overall decision making process. This combination enables to streamline the process of representing problematic situations to be modeled.

**System Dynamics Modeling**

Modeling is essential to represent reality, allowing understanding, analyzing and concluding about a situation (Jablonka, 2007). There are different approaches to modeling and analyzing situations. On the one hand, regression analysis allows combining variables and finding causal relationships between variables, which helps to understand the dependence between variables. Some of the most commonly used approaches are linear regressions, multivariate analysis and structural equations (Brandmaie et al., 2007). This type of analysis requires quantities of data to effectively validate the relationship between variables. On the other hand, stochastic and probabilistic models allow evaluating situations under a certain probabilistic scenario, which determines their validity according to the number of events and their probability of occurrence in practice (Canavos & Medal, 1987). From another point
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