# Fuzzy Logic Approach in Risk Assessment

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## INTRODUCTION

As an intuitively subjective and ambiguous notion, risk requires a detailed and attentive study, though. Since risk involves the events likely to occur in the future, risk assessment is an area where uncertainty is prevalent. Therefore, making use of experience, previous statistics and prediction ability is crucial in risk studies. The field of risk management is enriched with new techniques and methodologies, which serve the purposes of discovering more data, reducing subjectivity through more quantitative models and building flexible systems conducive to be updated with the obtained data. One of these new tools is fuzzy logic representing the uncertainty and to study with imprecise and uncertain knowledge.

This paper discusses the application of fuzzy logic to risk assessment process as an alternative to the traditional models due to its similarity to human reasoning and its accuracy in interpreting uncertainty. A fuzzy logic-based algorithm is developed for the purposes of enhancing risk assessment accuracy. Impact and likelihood factors, which are fundamental elements of risk, measured by the fuzzy logic-based approach. Beyond the impact and likelihood values, the factors directly effecting impact and likelihood also considered in this study and these factors included in fuzzy operations, in order to reduce subjectivity and increase precision.

In this study, an approach is explained for risk assessment. The aim of this approach is providing insight as a powerful alternative to traditional methods. A comparison between the risk values measured by the new model and those measured by the classical model supports the view that using fuzzy logic in risk assessment helps to produce more effective outcomes.

## BACKGROUND

The concept of fuzzy logic was first introduced in 1965 by Prof. Lotfi A. Zadeh who developed Lukasiewicz's multivalued logic to set theory and created what he called fuzzy sets – sets whose elements belong to it in different degrees. At the start, fuzzy logic was a theoretical concept with little practical application. In the 1970's, Prof. Edrahim Mamdani of Queen Mary College, London, built the first fuzzy system, a steam-engine controller, and he later designed the first fuzzy traffic lights. His work led to an extensive development of fuzzy control applications and products (Cirstea, Dinu, McCormick & Khor, 2002, pp. 113-114).

Bellman and Zadeh (1970) developed an initial general theory on decision making in fuzzy environment which include three basic concepts as fuzzy goals, fuzzy constraints and fuzzy decisions. It is concluded that the proposed theory is generally has advantages according to the traditional probability theory.

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Tah and Carr (1999) claimed that the current risk management techniques mostly based on the operational research techniques developed in 1960s and usually had failed to meet the needs of project managers. They introduced a fuzzy risk analysis model for a construction project to eliminate the past studies' concentration on particular risks and proposed a model which have a generic and generally practicable representation.

The development of fuzzy set theory to fuzzy technology during the first half of the 1990s has been very fast. More than 16,000 publications have appeared since 1965. Most of them have advanced the theory in many areas. Quite a number of these publications describe, however, applications of fuzzy set theory to existing methodology or to real problems. In addition, the transition from fuzzy set theory to fuzzy technology has been achieved by providing numerous software and hardware tools that considerably improve the design of fuzzy systems and make them more applicable in practice (Zimmerman, 2001, p. xxi).

Hajiha, Roodposhti and Askary (2009) provided a risk assessment approach conducted on the basis of fuzzy logic for audit risk, inherent risk and control risk. The results are compared to a real case and the accuracy level of the results is discovered to be relatively higher.

Keropyan and Gil-Lafuente (2011) place the emphasis on the importance of the ability of making right decisions and provide examples of use of fuzzy logic in selection of the decision-making styles within the scope of strategic management.

A. Pesic, D. Pesic and Tepavcevic (2012) proposed fuzzy logic as an innovative strategic management instrument to identify internal risks and to eliminate some of the restrictions imposed by the classical methods.

Nunes and Marques (2012) developed a fuzzy logic-based model for using in risk assessment of work accidents and occupational diseases and discussed the superiority of the fuzzy logic over the classical methods arguing that it allows a more comprehensive evaluation of risks and combination of both subjective and objective criteria.

Dainiene and Dagiliene (2013) calculated the sustainability of the business by using fuzzy logic and the competence of the business was shown experimentally. In the study, the operational value of the business is calculated on the basis of the financial and non-financial data.

Shang and Hossen (2013) provided evidence for the possible use of fuzzy logic as a decision-making system. The study supports the view that fuzzy logic may also be used in complex risk systems along with the other risk models such as decision trees and artificial neural network.

All of the studies that have been investigated support the view that the use of fuzzy logic as a decision-making system in strategic management has a number of advantages particularly in situations where there is a high level of unclarity.

## USING FUZZY LOGIC TO IDENTIFY THE LEVEL OF RISK

### General Information on Fuzzy Logic

The concept in question is that of a fuzzy set, that is, a "class" with a continuum of grades of membership. As will be seen in the sequel, the notion of a fuzzy set provides a convenient point of departure for the construction of a conceptual framework which parallels in many respects the framework used in the case of ordinary sets, but is more general than the latter and, potentially, may prove to have much wider scope of aplicability, particularly in the fields of pattern classification and information processing. Essentially, such a framework provides a natural way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables (Zadeh, 1965, p. 339).

In short, fuzzy set is a set where the members of the universal set have appointed values between the closed range of 0-1 and their membership status and membership degrees can be identified by these appointed values. The following should be taken into consideration while forming fuzzy sets: