

# Chapter 3

## Fuzzy Analytic Hierarchy Process and Its Application to E-Marketplace Selection

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### ABSTRACT

*Making decisions is a part of daily life. The nature of decision-making includes multiple and usually conflicting criteria. Multi Criteria Decision-Making (MCDM) problems are handled under two main headings: Multi Attribute Decision Making (MADM) and Multi Objective Decision Making (MODM). Analytic Hierarchy Process (AHP) is a widely used multi-criteria decision making approach and has successfully been applied to many practical problems. Traditional AHP requires exact or crisp judgments (numbers). However, due to the complexity and uncertainty involved in real world decision problems, decision makers might be more reluctant to provide crisp judgments than fuzzy ones. Furthermore, even when people use the same words, individual judgments of events are invariably subjective, and the interpretations that they attach to the same words may differ. This is why fuzzy numbers and fuzzy sets have been introduced to characterize linguistic variables. Here, the authors overview the most known fuzzy AHP approaches and their application, and they present a case study to select an e-marketplace for a firm, which produces and sells electronic parts of computers in Turkey.*

### 1. INTRODUCTION

Making decision is a part of human daily life. The nature of decision-making includes multiple and usually conflicting criteria. Multi Criteria Decision-Making (MCDM) problems handled

under two main headings: Multi Attribute Decision-Making (MADM) and Multi Objective Decision-Making (MODM).

AHP is a widely used multi-criteria decision making approach and has successfully been applied to many practical problems. In spite of its

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popularity, this method is often criticized for its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the DM's perceptions to exact numbers. Traditional AHP requires exact or crisp judgments (numbers). However, due to the complexity and uncertainty involved in real world decision problems, decision makers might be more reluctant to provide crisp judgments than fuzzy ones. Furthermore, even when people use the same words, individual judgments of events are invariably subjective, and the interpretations that they attach to the same words may differ. Moreover, even if the meaning of a word is well defined (e.g., the linguistic comparison labels in the standard AHP questionnaire responses), the boundary criterion that determines whether an object does or does not belong to the set defined by that word is often fuzzy or vague. This is why fuzzy numbers and fuzzy sets have been introduced to characterize linguistic variables. A linguistic variable is a variable whose values are not numbers but words or sentences from a natural or artificial language. Linguistic variables are used to represent the imprecise nature of human cognition when we try to translate people's opinions into spatial data. The preferences in AHP are essentially human judgments based on human perceptions (this is especially true for intangibles), so fuzzy approaches allow for a more accurate description of the decision-making process (Chen, Tzeng & Ding, 2008; Tiryaki & Ahlatcioglu, 2009). A number of methods have been developed to handle fuzzy AHP.

## **2. LITERATURE REVIEW FOR FUZZY AHP**

In the literature, there are several approaches for fuzzy AHP, which were proposed by various authors. Van Laarhoven and Pedrycz proposed the first method of Fuzzy AHP (Van Laarhoven & Pedrycz, 1983). They used to the Lootsma's

logarithmic least square method to derive fuzzy weights and fuzzy performance scores. In this method, triangular fuzzy numbers expressed the elements in the reciprocal matrix. Multiple decision makers' judgments can also be modeled in the reciprocal matrix and the method is valid when decision maker does not express his/her comparison ratios. In spite of that, Buckley used trapezoidal numbers to determine fuzzy comparison ratios (Buckley, 1985). He criticized Laarhoven and Pedrycz's method since there is not always a solution to the linear equations and this method is valid for only triangular fuzzy numbers. In their article (Boender, de Graan & Lootsma, 1989), they pointed out an error in the Laarhoven and Pedrycz's method and showed how it can be corrected. Saaty's AHP has been extended to the fuzzy environment in (Ruoning & Xiaoyan, 1992). Ruoning and Xiaoyan employed step-form fuzzy numbers and fuzzified another procedure, which they claim is the same as Saaty's original method for crisp perfectly consistent, positive, reciprocal matrices to calculate the fuzzy weights. However, In their article (Buckley, Feuring & Hayashi, 2001), they criticized their paper as the matrices are usually not perfectly consistent only reasonably consistent, so this procedure will produce different weights compared to Saaty's original method, for crisp data. In their article (Mohanty & Singh, 1994), they introduced a procedure for solving an AHP problem under fuzzy environment. This paper used fuzzy relational equations to model fuzzy AHP problem. A new and general decision making method has been proposed for evaluating weapon systems using fuzzy AHP based on entropy weight in (Mon, Cheng & Lin, 1994). A new algorithm for evaluating weapon systems by AHP based on fuzzy scales, which is a multi-criteria decision-making approach in fuzzy environment has been proposed in (Cheng & Mon, 1994). They used the triangular fuzzy number to build the judgment matrices and through the pair wise comparison technique. Wang, Kerre and

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