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Use of consistency index, expert prioritization and direct numerical inputs for generic fuzzy-AHP modeling: A process model for shipping asset management

Emrah Bulut [a,*], Okan Duru [b], Tuba Keçeci [b], Shigeru Yoshida [a]

[a] Department of Maritime Transportation Systems, Kobe University, Higashinada, 658-0022 Kobe, Japan
[b] Department of Maritime Transportation and Management Engineering, Istanbul Technical University, Tuzla 34940, Istanbul, Turkey

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ABSTRACT

The aim of this paper is to develop a generic version of the conventional fuzzy-analytic hierarchy process (FAHP) method and investigate the shipping asset management (SAM) problem in the dry bulk shipping market. The recent literature has various applications of the FAHP, but these studies lack consistency control, use identical decision support rather than weighted expert choices, and lack measurable criteria. The proposed model, generic fuzzy-AHP (here after GF-AHP), provides a standard control of consistency on the decision matrix for the expert group. GF-AHP also improves the capabilities of the FAHP by executing direct numerical inputs without expert consultation. In practical business, some of the criteria can be easily calculated and expert consultation is a redundant process. Therefore, GF-AHP presents how to transform such numerical inputs to a priority scale. Finally, expertise differences on the decision group are reflected in the GF-AHP process by an expert weighting algorithm.

1. Introduction

Design and improvement of decision support systems have great potential in the literature. Many decision processes are highly complicated and investigation of expert choice has several pitfalls since expert judgment is subject to bias. Such bias includes underestimation, optimism and limited capacity for concurrent analysis of multi-factor problems (Tversky & Kahneman, 2000). Difficulties of accurate decision support are also common in series choice problems. For instance, an investment decision has many dimensions ranging from the purchasing of an asset to the management and supply of subsequent processes. In such complicated cases, a series of decisions should be applied to all the components of purchase-to-operation. Use of expert decision systems deals with a multi-factor preference problem and inconsistency is important in terms of confidence in preferences. In the existing literature, many scholars present studies on the FAHP method, but none of them discuss whether the decision matrices are consistent (Chang, 1996; Kahraman, Cebeci, & Ruan, 2004; Kreng & Wu, 2007; Mikhailov & Tsvetinov, 2004). Saaty (1977, 1980) first suggested the classical AHP method and emphasized on consistency control. Because of the long and complicated content of a pairwise comparison survey, subjects may lose concentration with the result that their responses may just be a simulation of random choices or somewhat better than random selection. Therefore, the survey process of AHP is a crucial element of accurate decision support.

Ramanathan and Ganesh (1994) discussed the group preference aggregation problem and pointed out that expert from different backgrounds and levels of expertise may cause disparities among the group decision matrix. Therefore, aggregation of individual decision matrices is suggested through by weighting expert judgments with a normalized scale.

In many of the AHP studies, factors of decision are selected from intangible linguistic terms. Many preference problems have tangible and comparable aspects which can be directly investigated without expert aid. For example, financial analysis outcome is an important input of investment appraisal and results are readily comparable by ranking according to cost or benefit perception. The highest rate of return on investment directly indicates superiority due to financial perspective. Investigation of such problems without these tangible data may cause lack of generality and rationality.

The proposed model, GF-AHP, deals with problems mentioned in previous discussions and suggests improving expert system performance by classification of decision makers and use of numerical data with the ranking procedure of Saaty (2008). GF-AHP also proposes a control procedure for decision matrix consistency as it is particularly suggested by the initial study of Saaty and Vargas (1987). Although it is not used in existing FAHP studies, GF-AHP contributes to the literature by developing a centric consistency index (CCI) which is an extended version of the geometric consistency index (GCI). CCI is a detection tool for inconsistent expert

* Corresponding author. Tel.: +81 80 3866 1453; fax: +81 78 431 6259.
E-mail address: bltemrah@gmail.com (E. Bulut).

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consultation and over the boundaries of CCI; the decision support survey should be replaced with collecting new responses. Rethinking of preferences ensures an additional opportunity to increase consensus among the expert group (Saaty & Vargas, 1987).

The remainder of this paper is organized as follows: Section 2 briefly describes the ship investment. Section 3 states the methodology used in this paper to investigate the multi-strategy selection. Next, Section 4 presents empirical study, application and result. Finally, conclusion is the subject of the last Section 5.

2. Brief description of the ship investment

World merchandise trade is broadly based on seaborne transportation. Therefore, Maritime transportation is a critical part of global economics. Economic growth and increase of shipping services are parallel issues since most of the world's surface is covered by waterways. For example, the most important industrial product of the world, steel, is produced by two major raw materials, iron ore and coal. Both raw materials are mainly transferred from several exporting countries by merchant ships.

Shipping services are classified as either dry cargo shipments or wet cargo shipments. Dry cargoes are carried by dry bulk carriers; container ships, etc., while wet cargoes are transferred by tanker ships. The concern of the present paper is the dry bulk shipping industry and sample projects are selected from the dry bulk shipping assets. According to potential cargo sizes, routes and service capabilities, dry bulk carriers are classified by their tonnage capacities. Tonnage classes are usually divided as follows: Capesize bulker (over 80,000 deadweight-DWT), Panamax bulker (around 80,000–60,000 DWT), Handymax bulker (60,000–45,000 DWT) and Handysize bulker (45,000–10,000 DWT). Sample projects are selected from Panamax and Handymax size assets. The reason for this selection is based on convenience of data collection, interactions of similar cargoes (competitiveness exists at some degree), and closeness of asset prices among others.

Purchase of a shipping asset can be performed by a new building contract or a second hand alternative. A new building option has a long delivery procedure and prices will be higher. Conversely, a second hand ship can be purchased in a reasonable term with cheaper prices. Differences between prices and delivery dates compose the main concern of the asset selection problem in the shipping industry.

When a ship owner purchases a merchant ship, management of the fleet is another problematic point of the asset management process. The owner may prefer to manage the fleet by himself; management outsourcing is another option. An experienced investor may choose to manage his fleet by senior managers of the corporation or if the investor is an entrepreneur, management outsourcing can be a reasonable solution. Depending on the size of the fleet, it may be feasible to establish management at the headquarters or through third party management companies. Selection of a management service provider is another focus of the present research.

Once corporate decides if part of the management task will be outsourced or if the enterprise will take on full management responsibility of shipping asset, then some additional critical selection problems exist in the shipping business. One of them is the pattern of crew nationality on board. Nowadays, various crew agencies provide a manning pool that includes native workers or foreigners. Due to the cost of manning, quality of on board services etc., nationality pattern selection is inserted in the entire process of the SAM problem.

By the mentioned definitions, the SAM problem is identified in three major steps (Fig. 1). First, particulars of the shipping asset will be defined by an expert aided process. Second, a management service provider will be selected. Finally, nationality patterns of the crew should be designated. Moreover, if the commercial management of the shipping asset is expected to be supplied by corporate itself, then chartering characteristics must be decided between the spot trading and period trading alternatives.

3. Methodology

3.1. Fuzzy sets and triangular fuzzy numbers

The fuzzy set theory is developed to cope with the extraction of the principal outcome from a variety of information distantly and roughly (Zadeh, 1965). It is an effective instrument for modeling in the lack of comprehensive and accurate information. The fuzzy set theory is particularly applied in complex business, finance and management problems. A triangular fuzzy number is a particular fuzzy set $\tilde{A}$, and its membership function $\mu_{\tilde{A}}(x)$ is a continuous linear function.

Definition 1. Let X be universe of discourse, $\tilde{A}$ is a fuzzy subset of X such that for all $x \in X$. $\mu_{\tilde{A}}(x) \in [0,1]$ which is assigned to stand for the membership of x to $\tilde{A}$, and $\mu_{\tilde{A}}(x)$ is called the membership function of fuzzy set $\tilde{A}$.

Definition 2. A fuzzy number $\tilde{A}$ is a convex and normalized fuzzy set of $X \subseteq \mathbb{R}$.

Definition 3. A triangular fuzzy number is defined by its basic particulars which is:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \leqslant x < m, \\ 1, & x = m, \\ (u-x)/(u-m), & m < x \leqslant u, \\ 0, & u < x. \end{cases} \tag{1}$$

where l and u correspond to the lower and upper bounds of the fuzzy number $\tilde{A}$, respectively, and m is the midpoint. The triangular fuzzy number is indicated as $\tilde{A} = (l, m, u)$. Arithmetic operations between fuzzy numbers or a fuzzy number and crisp number are defined in Zadeh (1965) by standard fuzzy arithmetic operations.

3.2. Fuzzy AHP

In order to overcome the deficiency of the fuzziness during decision making, the fuzzy analytical hierarchy process (FAHP) was developed for solving the decision making problems. Laarhoven and Pedrycz (1983) have evolved AHP into the FAHP by adapting the triangular fuzzy number of the fuzzy set theory into the pairwise comparison matrix of the AHP.

Many scholars proposed FAHP methods for various decision making problems. Leung and Cao (2000) propose a fuzzy consistency definition with consideration of a tolerance deviation. The fuzzy ratios of relative importance are formulated as constraints on the membership values of the local priorities. The fuzzy local and global weights are determined via the extension principle. The alternatives are ranked on the basis of the global weights by application of max–min set ranking method. Buckley (1985) determined trapezoidal fuzzy numbers to express the priorities of comparison ratios. Chang (1996) used triangular fuzzy membership value for pairwise comparison and introduced a new approach for handling FAHP named "extent synthesis analysis". Lee, Pham, and Zhang (1999) review the basic ideas behind the AHP and introduce the concept of comparison interval and propose a