Integrating Approach For Multi Criteria Decision Making (Case Study: Ranking For Bulk Carrier Shipbuilding Region)

Mohammed Rizk Awad, Prof. Dr. Taymoor Nazmy, Prof. Dr. Ismael Amr Ismael

Abstract: Investing in the bulk carrier market constitutes risky investment due to the volatility of the bulk carrier earning rates. Ship-owners invariably take several quotations before making an order for building a new ship. Shipbuilding process has indeed swung upwards or downwards depending upon the number of shipyards competing for a given volume of orders, and the shipyard region. The decision makers for strategic purchasing greatly require an efficient, valid and fair tool to assist them in determining the best region to build from forthwith. In this paper, we concentrated a suitable shipbuilding Dry-cargo Bulk Carrier region for decision makers, which belongs to Multi-Criteria Decision Making and attempted to uncover the benefit of using integrated Fuzzy set theory with AHP methodology to decrease the influence of decision maker's subjective preference, and control the uncertain and imprecise variations during evaluation process. The degree of confidence and risk index are also joined, so that decision makers can adjust them to match real context. Finally, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was applied to the final rank of alternatives. The data were collected from "Clarksons Research Studies" (CRS) for quantitative variable which provides a statistical and research service to Clarkson brokers, their clients and the shipping world in general. Four decisions makers in marine strategic purchasing were invited and asked to give the qualitative variables (intangible criteria). Another methodology was employed for the same object called Consensus Group Decision Making (CGDM), with addition of threshold to simplify the process iteration of the methodology and it gives the same rank [21]. The advantages of FAHP is mainly depends of tangible criteria that have accurate values and intangible criteria which Fuzzy theory was used to deals with, compared with the CGDM that mainly depends of experts that may be high risk and have confidence degree of their opinions.

Index Terms: Decision Support System, Fuzzy AHP, TOPSIS.

1. INTRODUCTION

Development in the shipping industry, including all its fields and activities during the past years of the last century lead to the maximization of its role in serving the world trade, and the international trade played an influential role in the progress and growth in the shipping industry. Countries paid more attention to this industry as it deserves, it is considered one of the most important pillars of economy affecting foreign trade. The complexity of this industry and its dependence on world economic conditions require a wealth of knowledge and skills in order to cope with day-to-day operations and events that keep routine away. This complexity and skills requirement make ship-owners some of the most respected investors in the world that can flourish in almost anything they do besides shipping [1]. Commercial fleets considered one of the elements of the shipping industry and it reflects its development.

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The it became an important link in the chain of this industry due to its development, complexity and multiplicity of its activities, and through which foreign trade at the local and global levels are deliberated. The better region to make an order for new ship building is a critical decision and it must be an accurate decision, decision makers need efficient tools to assist them for this decision. Decision making problem is classified to three classes: Multi-criteria decision making (MCDM), which is an important branch of decision-making problem classification. It deals with the decision problems under the presence of a number of decision criteria. The second classification is Multi Object Decision Making MODM tries to optimize more than one objective function subject to a set of constraints. At least, the obtained solution is the most efficient one and it is not possible to improve the performance of an objective function without decreasing the performance of one other objective function. However, in Multi Expert Decision Making (MEDM), there is more than one expert to take their opinions [4],[5]. The analytic hierarchy process (AHP) method is used for MCDM extensively and has been successfully applied to many practical decision-making. Saaty [20] in the University of Pottsburgh creates this method. The AHP provides the relative ease but theoretically strong multi-criteria methodology for evaluating alternatives. It enables decision makers to use a simple hierarchy structure to deal with a complicated problem and to evaluate quantitative data in a systematic methodology under conflicting multi-criteria. After that, many scholars successively present all kinds of relative researches. Chang[6],[7],[16] Introduce new triangular fuzzy approach for handling fuzzy AHP. This approach use triangular fuzzy numbers for pair-wise comparison scale of fuzzy AHP, and use the extent analysis methods for the synthetic value of the pair-wise comparison. Zhu[10] , Chang [13],[16] further discuss about extent analysis method and applications of fuzzy. They prove the basic theory of the triangular fuzzy number, and improve the formulation of comparing the triangular fuzzy number's size. Deng [12] Present a simple and straightforward fuzzy pair-wise comparisons methods, thinking of the degree of confidence, the degree of similarity and the risk index, for handling qualitative multi-criteria analysis problems. Weck [17] propose the extended fuzzy AHP for modular product design complemented with a case example to validate its feasibility in a real company. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is proposed by Chen and Hwang [12], [13]and. It is the principal techniques for MCDM problems. Although TOPSIS is based on a simple and intuitive concept, it enables consistent and systematic aggregation of the criteria. TOPSIS defines two kinds of solutions (1) the ideal solution, and (2) the negative ideal solution. The ideal solution is regarded as the maximal benefits solution, it consists of the all-best values of criteria, on the contrary, the negative ideal solution is treated as the minimal benefits solution, and it is composed of the all worst values of criteria. TOPSIS defines solutions as the points, which are nearest to the ideal point and farthest from the negative ideal solution at the same time. In this concept, during the process of alternative selection, the optimal alternative is closest to the ideal solution and farther from the negative ideal solution. We briefly present some of the research literature related for selection problem. A work titled "Application of an Integrated Model with MCDM and IPA to Evaluate the Service Quality of Transshipment Port" [2] solves complex decision-making problems in the marine transportation environment, such as the evaluation of service quality and the location choice of ports. An integrated model with multiple-criteria decision making (MCDM) and importance-performance analysis (IPA) is presented in that paper, and then, applied to solve the problem of service quality evaluation of transshipment port. The MCDM approach can be used to deal with both quantitative data and qualitative ratings simultaneously. Although the work deals with quantitative and qualitative variables but it lakes with the degree with confidence and risk. Another work titled "A fuzzy ANP approach to shipyard location selection" [3] to select the best shipyard location. The author use analytical network method to select the best region, but the work didn’t deal with qualitative criteria. This paper employee a fuzzy analytical hierarchy methodology to deal with Bulk carrier region selection problem, and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [4] was applied to the final rank of alternatives. The organization of our work is as follows. (2) Regional distribution of BulkCarrier shipbuilding. (3) Implemented technique for multi criteria decision making. (4) Experimental Results. (5) Conclusion.

2. THE REGIONAL DISTRIPUTION OF BULKCARRIER SHIPBUILDING

Thirty-one countries have a merchant shipbuilding industry. In year 2000, using compensated gross tons as a measure. Compensated Gross Tonnage (CGT) is an indicator of the amount of work that is necessary to build a given ship and is calculated by multiplying the tonnage of a ship by a coefficient, which is determined according to type and size of a particular ship. The market leader was Japan, which produced 38% of world shipbuilding output. However, South Korea was catching up fast and accounted for 35% of world production in CGT. Another 10% of the output was produced by Eastern and Western Europe, spread over twenty countries, most of which produced only 200,000-300,000 cgt of ships each yard.. The remaining production concentrated in the Far East and South America [20]. Shipbuilding capacity can be divided into the following four areas:

Japan: Maintains a dominant position in the world shipbuilding industry, with output of 6.3 million cgt in 2000 accounting for 38% of the world total.

South Korea: The country made the decision to enter the shipbuilding market in the early 1970s, initially by the construction of the shipyard. During the 1980 South Korea shipbuilding output increased steadily, reaching 5.7 million cgt, whilst shipbuilding employment is estimated to have increased from 40,000 in 1976 to around 50,000. Because of this expansion and the country's low production costs, South Korea has increasingly taken the role of price leader in the world shipbuilding market.

W. Europe: In 2000, the EEC had a market share of 10% producing 1.6 m cgt. Germany accounted for almost one-third of the total output. Denmark, Italy and Spain each had produce 1-200,000 cgt per annum. Other Europe includes Finland, and the various E European yards.

China: Although having shipyard since the 1940s, China is only becoming a dominant player since the last 10 years. The countries economic boom together with the strategic choice to develop having industry activities has led to a strong increase in global market share.

3. IMPLEMENTED TECHNIQUE FOR MULTI-CRITERIA DECISION MAKING

An approach based on AHP was proposed to deal with Bulk carrier shipbuilding region selection which belongs to MCDM problem. However, during decision-making process of the AHP, the input information, which contains the decision maker's subjective judgments, results in uncertain and imprecise relations between criteria and alternatives. These subjective preferences and uncertain and imprecise variations will cause large influences towards the evaluation results. The combination of Fuzzy logic with original AHP method overcomes the foregoing difficulties. We also take into account the potential risk of decision-making and degree of confidence. Finally, we apply a ranking method, TOPSIS. Fuzzy AHP methodology is consists of the following process.

3.1. Assumptions and Notations

In order to facilitate the pair-wise comparison, all elements are represented by triangular Fuzzy number. We define triangular fuzzy number for fuzzy judgment matrix decision process in table1. [17]

Table 1. The membership function of fuzzy number

Fuzzy	Membership function	
$\tilde{1}$	(1,1,3)	
$\tilde{x}$	(x-2,x,x+2)	for
$\tilde{9}$	(7,9,9)	

We define five-scales, the membership function of the triangular fuzzy number $\tilde{x}$ shown in figure1.

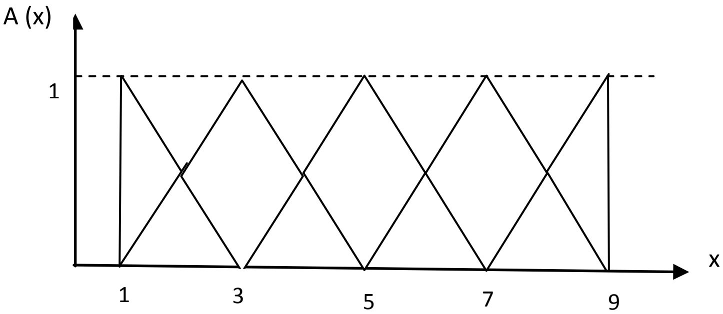


Figure 1. Triangular fuzzy ratio scales

During executing fuzzy judgment matrix process, these triangular fuzzy number 1,3,5,7,9 respectively represent the linguistic term with meaning of "v.poor","poor","ordinary","excellent", and "v.excellent" as table 2.

Table 2. Linguistic term and its fuzzy ratio

Linguistic	Fuzzy ration
Very poor	$\tilde{1}$
Poor	$\tilde{3}$
Ordinary	$\tilde{5}$
Excellent	$\tilde{7}$
Very excellent	$\tilde{9}$

The notifications used are listed below:

A_i: An alternative i or a supplier i , i =1,2,……n,

c_j : a criterion *j*, *j*= 1,2,………..m,

C_{jk} : a sub-criterion *jk* under a criteria *j, K=1,2,…..*q,

D_p : a decision maker of strategic purchasing *p, p=*

$\tilde{G}_{ijkp}$: a grade of alternative *i* with respect to sub-criterion *jk.*

$\tilde{G}_{ij}$: score of alternative *i* with respect to a criterion *j.*

$\tilde{a}_{ij}$: judgment score of alternative *i* with respect to a criterion *j.*

b_{jep} : a score , which a decision maker p evaluates the relative importance between criterion *j* and criterion *e* , *e* = 1,2,…….,m,

$\tilde{b}_{je}$: a comprehensive score, which the relative importance between criterion *j* and criterion *e* with triangular fuzzy numbers,

$\tilde{w}_{je}$: a weight with respect to a specific criterion,

$\tilde{h}_{ij}$: The fuzzy performance score, which alternative *i* corresponds to criterion *j* with triangular fuzzy numbers,

α : The decision makers' degree of confidence when they subjectively evaluate alternative scores and criteria weights for this problem, $0 \le \alpha \le 1$,

β : The risk index. The decision makers perceive the degree of risk about product characteristics in the related market $0 \le \beta \le 1$

$h^{\alpha}_{ij\beta_{ij}}$: The crisp performance score of each alternative *i* with respect to criterion *j* under α degree of confidence

$h^{\alpha+}_{j\beta_{ij}}$ and $h^{\alpha-}_{j\beta_{ij}}$: the best and the worst crisp performance

$S^{\alpha+}_{j\beta_{ij}}$ and $S^{\alpha-}_{j\beta_{ij}}$: the distance between $h^{\alpha}_{ij\beta_{ij}}$ of alternative *i* with respect to all criteria and all the ideal solutions and all the negative ideal solutions, respectively,

$R^{\alpha}_{i\beta_{ij}}$: The final performance score, which contains α degree of confidence about their evaluations and viewpoint of risk level β for alternative *i*,

3.2. Fuzzy Judgment Matrix

At this stage, the main missions include (a) formulate the decision problem as a MCDM problem and construct a hierarchical structure for the problem, and (b) build Fuzzy Judgment matrix

3.2.1. construct hierarchical structure

Firstly, we must clearly define problem's specification for its multi-criteria perspectives and identify what criteria and sub-criteria we concern about, and how many potential alternatives there are. These questions can be fairly answered by the questionnaires or experts' suggestions after setting up all elements of the problem. The problem is decomposed into a hierarchical structure as figure 2.

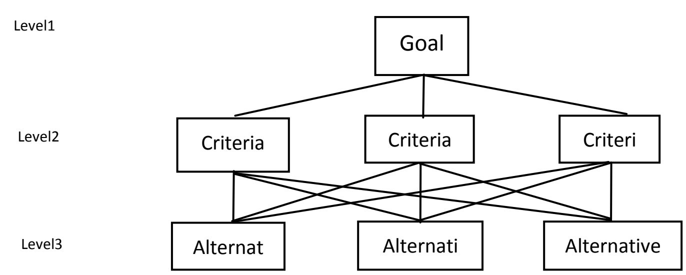


Figure2. General architecture of the

3.2.2. Obtain the Fuzzy judgment matrix

All scores $(\tilde{G}_{ij})$ derived and form a decision matrix like Eq (1).

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{array} \begin{array}{c} \begin{matrix} C_1 & C_2 & \cdots & C_m \end{matrix} \\ \begin{bmatrix} \tilde{G}_{11} & \tilde{G}_{12} & \cdots & \tilde{G}_{1m} \\ \tilde{G}_{21} & \tilde{G}_{22} & \cdots & \tilde{G}_{2m} \\ \cdots & \cdots & \ddots & \cdots \\ \tilde{G}_{n1} & \tilde{G}_{n2} & \cdots & \tilde{G}_{nm} \end{bmatrix} \end{array} \quad (1)$$

$$\tilde{a}_{ij} = \frac{\tilde{G}_{ij}}{\sqrt{\sum_{i=1}^{n}(\tilde{G}_{ij})^2}}, j = 1,2,.......m \quad (2)$$

The formulation of normalization is present by Chen and Hwang [11]. Each criterion (c_j) in Eq. (1) is normalized by using Eq. (2). A Fuzzy judgment matrix (A) is attained as Eq. (3) after normalizing.

$$A = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1m} \\ A_2 & \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nm} \end{matrix} \quad (3)$$

3.3. Fuzzy Performance Matrix

It can be attained by multiplying the Fuzzy judgment matrix by the corresponding Fuzzy weight vector, it can be reached via two tasks: (a) determine the fuzzy weight vector and (b) make a synthesis.

3.3.1. Determine the Fuzzy Weight Vector

We reach a group decision based on AHP with triangular Fuzzy number to improve original pair-wise comparison.
Firstly, let each decision maker (D_p) individually carry out pair-wise comparison by using Saaty's scale number from 1-9 in Table 1 for all criteria as Eq.(4)

$$D_p = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{b}_{11p} & \tilde{b}_{12p} & \cdots & \tilde{b}_{1mp} \\ A_2 & \tilde{b}_{21p} & \tilde{b}_{22p} & \cdots & \tilde{b}_{2mp} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{b}_{m1p} & \tilde{b}_{m2p} & \cdots & \tilde{b}_{mmp} \end{matrix} \; p = 1,2,.....t \quad (4)$$

$$b_{jep} = \begin{cases} b_{ejp}^{-1} & \text{If } j \neq e \\ 1 & \text{If } j = e \end{cases} \quad \text{J= 1,2,….m} \quad \text{e= 1,2,…m}$$

Where a score (b_{jep}) represents a decision maker (D_p) measures the relative importance by using Satty's scale 1-9 between each criterion. Then, a comprehensive pair-wise comparison matrix (D) is built by integrating all decision makers' grades (b_{jep}) through Eq. (5) – (9) as:

$$L_{je} = \min(b_{jep}), \text{p=1, 2,..t} \quad \text{j= 1,2,..m} \quad \text{e= 1,2,..m} \quad (5)$$

$$M_{je} = \frac{\sum_{p=1}^{t} b_{jep}}{p}, \text{ p=1, 2,.t j= 1,2,..m e= 1,2,..m} \quad (6)$$

$$U_{je} = \max(U_{jep}), \text{p=1, 2,.t j= 1,2,..m e= 1,2,..m} \quad (7)$$

$$\tilde{b}_{je} = (L_{je}, M_{je}, U_{je}) \text{ j=1,2,..m} \quad \text{e= 1,2,……..m} \quad (8)$$

where a comprehensive score ($\tilde{b}_{je}$) represents the relative importance among each criterion with triangular fuzzy numbers.

$$D = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{b}_{11} & \tilde{b}_{12} & \cdots & \tilde{b}_{1m} \\ A_2 & \tilde{b}_{21} & \tilde{b}_{22} & \cdots & \tilde{b}_{2m} \\ . & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{b}_{m1} & \tilde{b}_{m2} & \cdots & \tilde{b}_{mm} \end{matrix} \; p = 1,2,.....t \quad (9)$$

An equation is determined to calculate relative weight between all criteria as below

$$\tilde{w}_j = \frac{\sum_{e=1}^{m} \tilde{b}_{je}}{\sum_{j=1}^{m}\sum_{e=1}^{m} \tilde{b}_{je}}, \text{j=1,2,…..m} \quad \text{e=1,2,…..m} \quad (10)$$

Each criterion weight ($\tilde{w}_j$) is sequentially solved by Eq.(10) . These criteria weights collectively make up a fuzzy weight vector (W) as Eq.(11).

$$W = (\tilde{w}_1, \tilde{w}_2, ...,\tilde{w}_m) \quad (11)$$

3.3.2. Synthesize

We individually take each criteria weight ($\tilde{w}_j$) to multiply each corresponding criteria (c_j) in the Fuzzy judgment matrix as Eq. (12), where the Fuzzy h_{ij} denotes the Fuzzy performance score.

$$H = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{w}_1\tilde{a}_{11} & \tilde{w}_2\tilde{a}_{12} & \cdots & \tilde{w}_m\tilde{a}_{1m} \\ A_2 & \tilde{w}_1\tilde{a}_{21} & \tilde{w}_2\tilde{a}_{22} & \cdots & \tilde{w}_m\tilde{a}_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{w}_1\tilde{a}_{n1} & \tilde{w}_2\tilde{a}_{n2} & \cdots & \tilde{w}_m\tilde{a}_{nm} \end{matrix} = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{h}_{11} & \tilde{h}_{12} & \cdots & \tilde{h}_{1m} \\ A_2 & \tilde{h}_{21} & \tilde{h}_{22} & \cdots & \tilde{h}_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{h}_{n1} & \tilde{h}_{n2} & \cdots & \tilde{h}_{nm} \end{matrix} \quad (12)$$

3.4. Crisp Performance Matrix

Deng (1999) [8] initially joins the decision maker's degree of confidence and the risk issue to his proposal model. The target will discuss about the way of defuzzification is executed by the interval performance matrix.

3.4.1. Determine the interval performance Matrix

Each Fuzzy performance score ($\tilde{h}_{ij}$) is joined α-cut to respectively form an interval $[\overset{\alpha}{h}_{ijl}, \overset{\alpha}{h}_{ijr}]$ as figure 3. $\overset{\alpha}{h}_{ijl}, \overset{\alpha}{h}_{ijr}$ Can be found out by extending as Eq. (13) and Eq. (14)

$$\overset{\alpha}{h}_{ijl} = L_{ij} + \alpha(M_{ij} - L_{ij}) \quad (13)$$

$$\overset{\alpha}{h}_{ijr} = U_{ij} - \alpha(U_{ij} - M_{ij}) \quad (14)$$

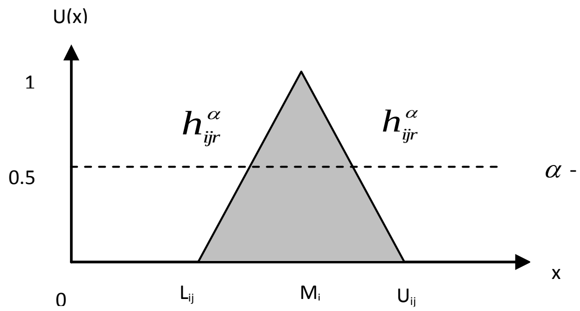


Figure 3. α -cut on each fuzzy

Where h_{ijl}^{α} *and* h_{ijr}^{α} respectively denote the left point and right point of using the triangular after using α-cut further, the overall interval performance matrix (H^{α}) with α value can be determined.

3.4.2. Risk and Defuzzification

The risk index is also applied to be a defuzzifier here, defuzzification is implemented by joining the risk index to produce crisp numbers, and the crisp performance matrix $(H^{\alpha}{}_{B})$ is calculated (15) and (16).

$$h_{ij\beta}{}^{\alpha} = \beta h_{ijl}{}^{\alpha} + (1-\beta) h_{ijr}{}^{\alpha} \quad , 0 \le \alpha \le 1 \quad 0 \le \beta \le 1 \qquad (15)$$

$$H_{\beta}^{\alpha} = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ A_1 & \tilde{h}_{11\beta}^{\alpha} & \tilde{h}_{12\beta}^{\alpha} & \cdots & \tilde{h}_{1m\beta}^{\alpha} \\ A_2 & \tilde{h}_{12\beta}^{\alpha} & \tilde{h}_{22\beta}^{\alpha} & \cdots & \tilde{h}_{2m\beta}^{\alpha} \\ . & \vdots & \vdots & \ddots & \vdots \\ A_n & \tilde{h}_{n1\beta}^{\alpha} & \tilde{h}_{n2\beta}^{\alpha} & \cdots & \tilde{h}_{nm\beta}^{\alpha} \end{matrix} \qquad (16)$$

Where $h_{ij\beta}{}^{\alpha}$ denotes the crisp performance score which each alternative (A_i) corresponds to all criteria (c_j) under α degree of confidence and β risk level.

3.4.3. Ranking Using TOPSIS

Some methods for ranking MCDM problem have been suggested such as TOPSIS, Electre, Promethee, and Voke. We choose TOPSIS method to carry out final ranking, because it not only provides the adequate ability for ranking alternatives in simple mathematical formula according to the relative performance of the candidate alternatives but also bases on the theoretical methodology. In TOPSIS, the ideal solution $(h_{j\beta}{}^{\alpha+})$ is defined as the best crisp performance score result across all alternatives on a criterion in Eq. (17)

$$h_{j\beta}{}^{\alpha+} = \{(\max h_{ij\beta}^{\alpha} \mid j \in J), (\min h_{ij\beta}^{\alpha} \mid j \in J), i = 1,2,..n\} \qquad (17)$$

On the contrary, the negative ideal solution $(h_{j\beta}{}^{\alpha-})$ is determined as the worst crisp performance score result across all alternatives on criteria, Eq. (18)

$$h_{j\beta}{}^{\alpha-} = \{(\min h_{ij\beta}^{\alpha} \mid j \in J), (\max h_{ij\beta}^{\alpha} \mid j \in J), i = 1,2,...n\} \qquad (18)$$

After determining the ideal solution and negative ideal solution the distance between ideal solution and negative ideal solution for each alternative is respectively calculated by Eq.(19),(20)

$$S_{i\beta}^{\alpha+} = \sqrt{\sum_{j=1}^{m} (h_{ij\beta}^{\alpha} - h_{j\beta}^{\alpha+})^2} \quad \text{i= 1,2,….,n} \qquad (19)$$

$$S_{i\beta}^{\alpha-} = \sqrt{\sum_{j=1}^{m} (h_{ij\beta}^{\alpha} - h_{j\beta}^{\alpha-})^2} \quad \text{i= 1,2,….,n} \qquad (20)$$

Where $S_{i\beta}^{\alpha+}$ and $S_{i\beta}^{\alpha-}$ represent the distance between the crisp performance scores $(h_{ij\beta}^{\alpha}, j = 1,2,\ldots.m)$ of an alternative (A_i) with respect to all criteria (c_j , j=1, 2,…m) and all the ideal solutions $(h_{ij\beta}^{\alpha-}, j = 1,2,\ldots.m)$ respectively. A prior alternative has a longer distance to the negative ideal solution and shorter distance to the ideal solution for each alternative can be formulated as Eq. (21)

$$R_{i\beta}^{\alpha} = \frac{S_{i\beta}^{\alpha-}}{S_{i\beta}^{\alpha+} + S_{i\beta}^{\alpha-}}, i = 1,2,\ldots., n \qquad (21)$$

Where $R_{i\beta}^{\alpha}$ denote a final performance score, which contains the decision makers' α degree of confidence about their evaluations and viewpoint of risk level β for each alternative. The larger final performance score $R_{i\beta}^{\alpha}$ expresses the prior alternative.

4. EXPERIMENTAL RESULTS

The main leader Bulk Carrier shipbuilding regions are Europe, Japan, South Korea, and china, symbolic A, B, C, and D respectively. The following are the steps of FAHP and TOPSIS to rank these shipbuilding regions.

4.1. Data Description

In the domain of multi-criteria supplier selection problem, a lot of criteria have been discussed. These criteria fall into two kinds: tangible criteria (quantitative variables) such that "number of enterprise in each region" and intangible criteria (qualitative variables) such that "ambidexterity strategy". The data were collected from "Clarksons Research Studies" (CRS)[23] for quantitative variable which provides a statistical and research service to Clarkson brokers, their clients and the shipping world in general. Four decisions makers in marine strategic purchasing were invited and asked to give the qualitative variables (intangible criteria): two senior persons from the commercial department in National Navigation Company, one representative from maritime training institutions, and one representative from Misr maritime transportation company.

4.1.1. Set up criteria for supplier selection

From shipbuilding market and from the experts of this field the researcher deduced concluded the following criteria that oriented shipbuilding region. The selected criteria divided into two categories: firstly, tangible criteria, which represent the quantitative variable and we are keen to gather them from the same source as possible to maintain the, quality reliability of the data: secondly, intangible criteria, which represent the qualitative variable and the researcher gets their data from experts. See table 3.

Table 3 Bulk carrier Shipbuilding Criteria

No.	Criteria	Definition	type
1	Employment	Number of person employed in each region	tangible
2	Companies	Number of enterprises in each region	tangible
3	Value added at factor cost	Refers to "extra" feature(s) of an item of interest (product, service, person etc.)	tangible
4	Production	Production value	tangible
5	CGT	Capital Gain Tax	tangible
6	Specialization (or segmentation)	Strategy is used in specialized markets in which firms gain more advantage through innovation rather than efficiency	intangible
7	Differentiation strategy	Aims for a broad market in which customers are willing to pay premium for the brand or technology	intangible
8	Low cost strategy	Aims for standardized mass products with large economies of scale	intangible
9	Ambidexterity strategy	Combines both differentiate and low cost strategy to have efficient product for current customers and innovate to serve future customers	intangible

This study aims to select the best shipbuilding region from the following for regions **Japan**, **South Korea**, **Europe** and **China**. We can consider the hierarchy structure as follows from which can facilitate us to handle the problem. The goal is illustrate in level one, at the next level seven major criteria are generated, in addition three candidate supplier are located at the lowest level. Hierarchy structure is illustrated in figure 4, from which can facilitate us to handle the problem the goal is illustrate in level one, at the next level nine major criteria are generated, in addition four candidate regions are located at the lowest level.

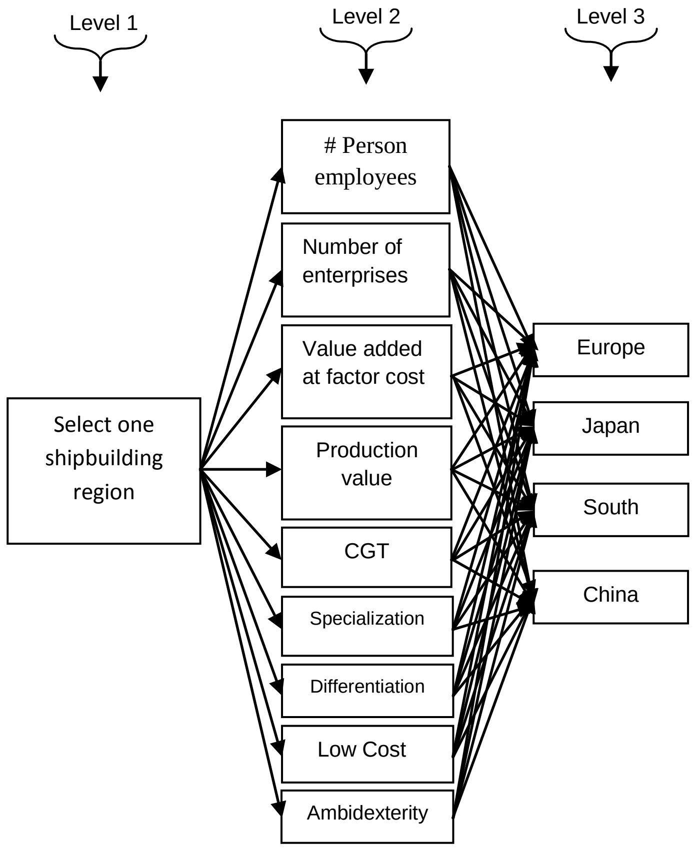


Figure 4 A Hierarchy Structure of shipbuilding model

4.1.2. Measure the Tangible Criteria

Concerning tangible criteria, real and quantitative historical data are collected about four regions in Table 4. The researcher marks the Europe region by variable A, Japan region by variable B, South Korea region By variable C, and China by variable D.

Table 4: True value of each region with respect to all tangible criteria

Region	# person empl-oyees	Number of enterprises	Value added at factor cost	Prod-uction value	CGT
A(	265800	10824	10.827	42.861	4.8
B(	109000	1632	4344	17669	9.7
C(	162703	1628	6.894	36.12	14.5
D(	440000	1242	12187	42679	9.0

Source: Europe (Eurostat), Japan (OECD STAN), South Korea (KOSHIPA, Shin & Hassink, OECD STAN), China (CANSI); CESA for CGT values, 2009.

Four decision-making persons in marine strategic purchasing were seek, two seniors work in the commercial department in National Navigation Company, and one is representative from maritime training institutions, finally the other representative is from Misr Maritime Transportation Company. They gave information and opinions about the interval values for each criterion. Table 5 is designed to express the interval values of each fuzzy region with respect to tangible criteria.

Table 5: Interval values of fuzzy rations with respect to each criterion

	# person employees	Number of enterprises	Value added at factor cost	Production value	CGT
1	<=50000	>=1000	<=4000	<=10000	<=4
3	50000 ~100000	1000 ~2000	4000 ~6000	10000 ~20000	4 ~ 6
5	100000 ~150000	2000 ~3000	6000 ~8000	20000 ~30000	6 ~ 8
7	150000 ~200000	3000 ~4000	8000 ~10000	30000 ~40000	8 ~ 10
9	>=200000	>=4000	>=10000	>=40000	>=10

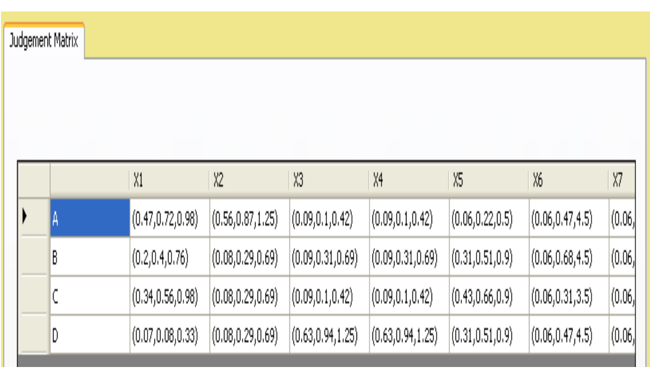
4.1.3. Measure the Intangible Criteria
Intangible criteria cannot be quantified, consequently the four experts D1, D2, D3 and D4 were asked to categorize the intangible criteria into Fuzzy number for each region .Table 6 shows the grades outcome of the expert's opinion.

Table 6: Grades for decision makers for intangible criteria

	Specialization				Low cost				ambidexterity				Low cost leader			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
A	9	7	9	7	5	7	3	5	5	3	7	3	3	5	3	7
B	5	7	5	7	9	7	9	9	5	7	3	7	7	5	5	7
C	3	5	7	5	7	5	9	5	9	7	7	9	7	5	7	7
D	3	3	5	7	9	7	5	9	5	7	3	3	9	9	7	9

A program is developed with C sharp to handle the calculation with the FAHP steps with unlimited number of alternative and any number of experts.

4.2. Calculate the Fuzzy judgment matrix
The fuzzy judgment matrix can be built as below from equation 1 and equation 2. See figure 5.



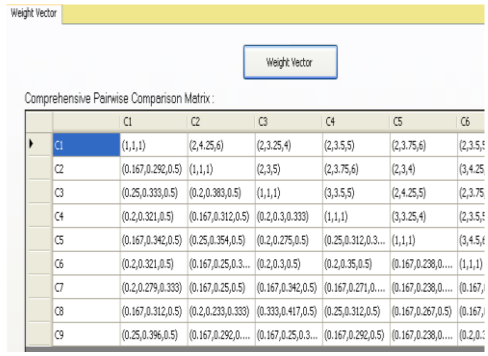
Judgement Matrix

	X1	X2	X3	X4	X5	X6	X7
A	(0.47,0.72,0.98)	(0.56,0.87,1.25)	(0.09,0.1,0.42)	(0.09,0.1,0.42)	(0.06,0.22,0.5)	(0.06,0.47,4.5)	(0.06,
B	(0.2,0.4,0.76)	(0.08,0.29,0.69)	(0.09,0.31,0.69)	(0.09,0.31,0.69)	(0.31,0.51,0.9)	(0.06,0.68,4.5)	(0.06,
C	(0.34,0.56,0.98)	(0.08,0.29,0.69)	(0.09,0.1,0.42)	(0.09,0.1,0.42)	(0.43,0.66,0.9)	(0.06,0.31,3.5)	(0.06,
D	(0.07,0.08,0.33)	(0.08,0.29,0.69)	(0.63,0.94,1.25)	(0.63,0.94,1.25)	(0.31,0.51,0.9)	(0.06,0.47,4.5)	(0.06,

Figure 5 Fuzzy judgment matrix

4.3. Fuzzy Performance Matrix
Relatives weights were joined of these criteria to measure the fuzzy judgment matrix, consequently, the weight vector must be calculated firstly. Afterward, fuzzy judgment matrix is multiplied by the corresponding fuzzy vector weight to obtain the fuzzy performance matrix.

4.3.1. Construct the Fuzzy weight vector
The group decision with the Analytical hierarch process is employed to convert into fuzzy form. The decision makers respectively compare relative importance between each criterion. The weight vector was reached by equation 4 to equation 10. See Figure 6.



Weight Vector

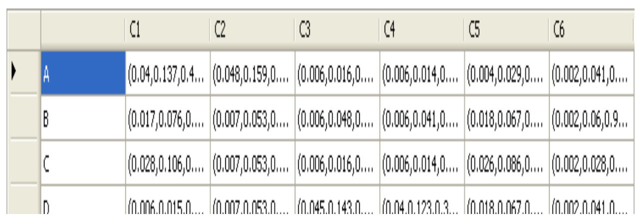
Weight Vector

Comprehensive Pairwise Comparison Matrix :

	C1	C2	C3	C4	C5	C6
C1	(1,1,1)	(2,4.25,6)	(2,3.25,4)	(2,3.5,5)	(2,3.75,6)	(2,3.5,5
C2	(0.167,0.292,0.5)	(1,1,1)	(2,3,5)	(2,3.75,6)	(2,3,4)	(3,4.25
C3	(0.25,0.333,0.5)	(0.2,0.383,0.5)	(1,1,1)	(3,3.5,5)	(2,4.25,5)	(2,3.75
C4	(0.2,0.321,0.5)	(0.167,0.312,0.5)	(0.2,0.3,0.333)	(1,1,1)	(3,3.25,4)	(2,3.5,5
C5	(0.167,0.342,0.5)	(0.25,0.354,0.5)	(0.2,0.275,0.5)	(0.25,0.312,0.3...	(1,1,1)	(3,4.5,6
C6	(0.2,0.321,0.5)	(0.167,0.25,0.3...	(0.2,0.3,0.5)	(0.2,0.35,0.5)	(0.167,0.238,0....	(1,1,1)
C7	(0.2,0.279,0.333)	(0.167,0.25,0.5)	(0.167,0.342,0.5)	(0.167,0.271,0....	(0.167,0.238,0....	(0.167,
C8	(0.167,0.312,0.5)	(0.2,0.233,0.333)	(0.333,0.417,0.5)	(0.25,0.312,0.5)	(0.167,0.267,0.5)	(0.167,
C9	(0.25,0.396,0.5)	(0.167,0.292,0....	(0.167,0.25,0.3...	(0.167,0.292,0.5)	(0.167,0.238,0....	(0.2,0.

Figure 6 fuzzy weight vectors

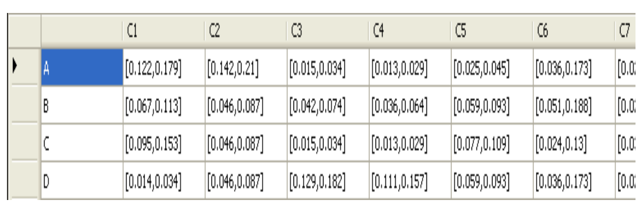
4.3.2. Fuzzy Performance matrix
Fuzzy weight vector and fuzzy judgment matrix were combined to construct the fuzzy performance matrix by using eq. 13 to eq. 16 see Figure 7.



	C1	C2	C3	C4	C5	C6
A	(0.04,0.137,0.4...	(0.048,0.159,0....	(0.006,0.016,0....	(0.006,0.014,0....	(0.004,0.029,0....	(0.002,0.041,0....
B	(0.017,0.076,0....	(0.007,0.053,0....	(0.006,0.048,0....	(0.006,0.041,0....	(0.018,0.067,0....	(0.002,0.06,0.9...
C	(0.028,0.106,0....	(0.007,0.053,0....	(0.006,0.016,0....	(0.006,0.014,0....	(0.026,0.086,0....	(0.002,0.028,0....
D	(0.006,0.015,0....	(0.007,0.053,0....	(0.045,0.143,0....	(0.04,0.123,0.3...	(0.018,0.067,0....	(0.002,0.041,0....

Figure 7 The Performance matrix

4.4. Calculate Crisp Performance matrix
During the supplier selection process, some unobvious factors which usually are ignored may deeply affect the decision results.



	C1	C2	C3	C4	C5	C6	C7
A	[0.122,0.179]	[0.142,0.21]	[0.015,0.034]	[0.013,0.029]	[0.025,0.045]	[0.036,0.173]	[0.0
B	[0.067,0.113]	[0.046,0.087]	[0.042,0.074]	[0.036,0.064]	[0.059,0.093]	[0.051,0.188]	[0.0
C	[0.095,0.153]	[0.046,0.087]	[0.015,0.034]	[0.013,0.029]	[0.077,0.109]	[0.024,0.13]	[0.0
D	[0.014,0.034]	[0.046,0.087]	[0.129,0.182]	[0.111,0.157]	[0.059,0.093]	[0.036,0.173]	[0.0

Figure 8 crisp performance matrixes

The decision makers' degree of confidence and risk issue are brought up during defuzzification process see figure 8. The value of α indicates the decision makers' degree of confidence in their subjective evaluations concerning alternative scores and criteria weight. The higher α value expresses the higher degree of confidence and the closer to the possible value of the triangular fuzzy numbers. Here, four decision makers of strategic selecting region consider they have commanded enough information, Knowledge and data to overcome uncertainty in their evaluations for this selection problem, so they set up α=0.85 (average). On the other hand the potential decision-making risk issues encompass the region selection problems within a supply chain. In our proposed approach, we allow the decision makers' of strategic purchasing to adjust risk index β along BulkCarrier shipbuilding regional selection problem.

4.5. Final Rank Supplier program output

Risk performance matrix is shown in figure 9, the final ranking part shows that the best rank of the region is (D, A, B, C) that (china, Europe, Japan, South, Korea)

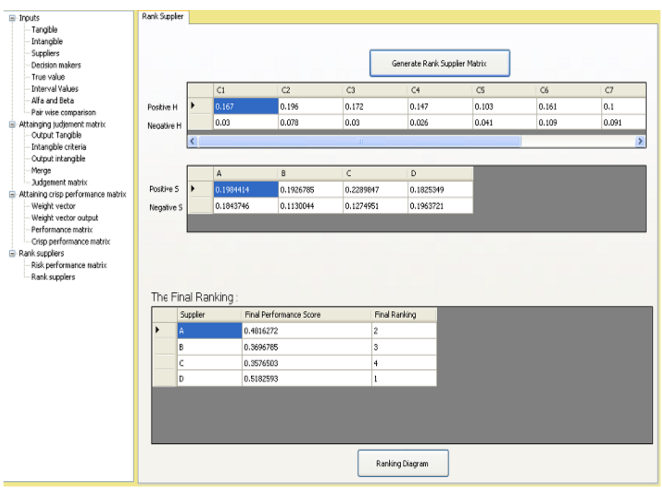


Figure 9 Rank suppliers matrix

depending on the previous criteria. The candidate region is ranked by their final performance score Under α= 0.85 and β = 0.2. Region china and Europe are obviously more outstanding than Japan and South Korea. Thus, the decision makers of strategic purchasing of BulkCarrier can build from china as the best region that has the best rank.

5. CONCLUSION

Decision makers must concurrently evaluate multiple criteria to select the suitable Bulk carrier shipbuilding region. In practice, it is usually lack of a valid tool to support them. Based on literature review, we find the characteristics of environmental effect problem which belongs to multi criteria decision making problem, and understand the AHP, fuzzy set theory, and TOPSIS methods. Under these techniques and concepts, a decision support system was developed that can resolve MCDM on suitable BulkCarrier shipbuilding region problem and achieve a consistent attitude toward decision-making. Bulk carrier shipbuilding region problem was evaluated, with dealing with the properties of uncertainty, imprecision and subjective in decision makers, a lot of criteria have been discussed. These criteria fall into two kinds: tangible criteria (quantitative variables) such that "number of enterprise in each region" and intangible criteria (qualitative variables) such that "ambidexterity strategy". The data were collected from "Clarksons Research Studies" (CRS) for quantitative variable which provides a statistical and research service to Clarkson brokers, their clients and the shipping world in general. Four decisions makers in marine strategic purchasing were invited and asked to give the qualitative variables (intangible criteria): two senior persons from the commercial department in National Navigation Company, one representative from maritime training institutions, and one representative from Misr Maritime Transportation Company. As a result of the subjective elements of the decision maker are decreased substantially, the uncertain and imprecise variations of the evaluation process are controlled adequately, the decision maker's the degree of confidence and risk factor are joined, so our approach can not only solve the complex bulk carrier shipbuilding region problems effectively, but also can be applied in MCDM problems in general. Nine criteria are determined five of them are tangible criteria and the four remaining are intangible criteria. The employment of Fuzzy set theory, which deals with the properties of uncertainty, imprecision and subjective in decision-maker, to overcome these weaknesses, the criteria are separated into tangible and intangible criteria. Specific membership function was constructed of each criterion for quantitative data. Additionally, the use of strength Deng's method define the decision makers' degree of confidence and risk issue in depth. Finally, a sound ranking method "TOPSIS", helps decision makers choose optimal alternative that has the relative closeness to the ideal solution. The final ranking model for the BulkCarrier shipbuilding regions ended as follows: 1. China , 2. Europe 3. Japan and 4. South Korea. The researcher employ another methodology deals with MCDM problem called Consensus Group Decision Making CGDM[21] the work titled "A Consensus Model For Choosing The Best Bulk carrier Regional Shipbuilding", and The two models, Fuzzy Analytical Hierarchy Process and Consensus Group Decision Making, achieved the same results of shipbuilding region ranking.

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