A Consensus Model For Choosing The Best Bulkcarrier anoigeRl Shipbuilding

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Abstract: The BulkCarrier shipbuilding industry is marked by its global presence with ships being built in industrialized countries such as Japan, Europe, South Korea and China. The geographical distribution of new ship construction has show strong change starting from the original dominance of Europe to an increased role for Asian countries such as South Korea, Japan and China. The decision makers for strategic purchasing of marine companies greatly require an efficient, valid and fair tool to assist them in determining appropriate region to build from, which belongs to multi criteria Decision-Making problem. Most methodologies that deals with multi criteria Decision-Making even it deals with uncertainty problem need database to deal with the certainty portion, and it needs experts for more than one stage to give their opinions. In this paper, we present a consensus model for Group Decision-Making GDM problem with interval fuzzy preference relations to assist the decision maker to take the appropriate decision in short time under upset of data. We introduce an application example in choosing the best regional distribution of ship building market. The input data for this model were collected from expert persons, and the output is ranking of BulkCarrier shipbuilding region. The final rank of BulkCarrier shipbuilding region in year 2013 is China at the first then Europe , Japan and South Korea comes at the end.

Index Terms: Global market regional of BulkCarrier shipbuilding group decision-making; Consensus; interval fuzzy preference relation.

1. INTRODUCTION

A Century ago, BulkCarrier shipbuilding was dominated by Europe. In the 1950 this position was gradually taken over by Japan. At the early 1970 Japan and Europe still dominated the world market with a combined share of some 90%. In the early, 1970 South Korea entered the stage. China is only becoming a dominant player since the last 10 years [1],[2]. Selection of the suitable BulkCarrier shipbuilding region alternative for building new ship is one of the critical decision milestones in this situation, which takes a very hard search from decision makers and takes a lot of board of directors and Committees sessions, this may take more than one year. The main aim of this paper is to address a decision support system based on consensus model which deals with the experience of a group of expertise under linguistic interval fuzzy preferences relations [3] to address the previous object. Consensus model is used for many applications such as Advanced Practice Registered Nurse APRN, Regulation Licensure Accreditation Certification and Education, Seasonal Hurricane Prediction, and Molecular Packing of Type Collagen. Consensus model is based on two criteria to guide consensus process [4]:

1) *A consensus measure*, evaluates the agreement of all the experts, it is used to guide the consensus process until the final solution is achieved.
2) *A proximity measure* evaluates the agreement between the experts individual opinions and the group opinion. It is used to guide the group discussion in the consensus process.

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Both measures were computed on the three levels of representation of linguistic interval fuzzy preference relations: level of pair, level of alternative and level of relation. Then, automatic feedback mechanism was enabled to guide experts in the consensus reaching process and substitute the moderators activity. The paper is set out as follows. Section 2 is the process of data gathering .Section 3 is Group Decision-Making GDM problem based on linguistic interval fuzzy preference relations. Section 4 presents the consensus model. An imperial study is given in section 5. A discussion was illustrated in section 6, Finally, we conclude the work in section 7.

2. THE PROCESS OF DATA GATHERING

The data source in the Consensus Group Decision Making methodology took from expert persons, so the excellence select of the expert is a very critical step in this situation. Honorably three senior decision-makers were invited, two of them are experts of commercial strategic purchasing in National Navigation Company since 1981. National Navigation Company is considered the largest shipping Egyptian company specialized in shipping dry cargo among the world's largest ports. It is also responsible of conducting regular liner lines for vessels owned or chartered for shipping general cargo among ports in Northern and Western Europe, the Adriatic, the Black Sea, and the Mediterranean Sea. The first expert is the Head of the commercial department and he worked in the shipping area for over twenty years and in that time has represented Egypt at a range of international organizations, second expert is the head of marine department of the same company and he is worked in the marine area since 1981 till now and he was engaged in a range of research and consultancy activities, including commodity studies, shipping market analysis, computer modeling and data processing in "Arab Academy for Science, Technology & Maritime Transport "one of The league of Arab States Specialized Organizations. The third expert from Maritime Transport Sector MTS , Appointed Director of Business Development, responsible for Corporate Planning, capital expenditure, financial forecasting and statistical services within Egyptian Shipyards. A gathering data form was designed to collects their opinion as follows:

TABLE 1
PREFERENCE FORM

	BulkCarrier region comparison			
	Expert Name:	…………………………………………………………		
	Current position:	…………………………………………………………		
	Kindly put your preference depending on the following keys			
	Impossible	Extremely Unlikely	Very Low Chance	Small Chance
	It may	Meaningful Chance	Most Likely	Extremely likely
	Certain			
	South Korea	**China**	**Japan**	**Europe**
South Korea	(0,0)	(……,…….)	(……,…..)	(……,…..)
China		(0,0)	(……,…….)	(……,…..)
Japan			(0,0)	(……,…..)
Europe				(0,0)

Table 1 shows the used form for gathering the data from the experts, Nine preference linguistic variable[4] are used by experts to determine their preferences , an attention was given for simplicity and clearance in designing the preference table, the remaining preference under the diagonal was deduced from the input preference.

3. THE GDM PROBLEM BASED ON INTERVAL FUZZY PREFERENCE RELATIONS

In this section we briefly describe the GDM problem based on interval Fuzzy preference relations and the resolution process used to obtain the solution set of alternative [5].

a. The Group Decision-Making Problem

Let X = {x_1, x_2, . . . , x_n}(n ≥2) be a finite set of alternatives to be evaluated by a finite set of experts, E = {e_1,e_2, . . . ,e_m}(m ≥ 2). The Group Decision-Making process consists to find the best alternative according to the expert's preferences {P^1, P^2 ,…., P^m }. In a usual GDM problem we assume that the experts provide their preferences on X by means of the fuzzy preference relations, $P^k \subset X \times X$ with membership function

$\mu_{pk} : X \times X \rightarrow S$, Where $\mu_{pk}(x_i, x_j) = P_{ij}^k$ denotes the preference degree of the alternative X_i over X_j .

Let S = { S_0, . . . , S_T}, where each label S_i represents a possible value for a linguistic real variable. We use the following nine linguistic label set, see table2, with their respective associated semantics to express the preferences as table2:

TABLE 2
NINE PREFERENCE LINGUISTIC VARIABLE

S_8	*C*	Certain
S_7	*EL*	Extremely likely
S_6	*ML*	Most Likely
S_5	*MC*	Meaningful Chance
S_4	*IM*	It may
S_3	*SC*	Small Chance
S_2	*VLC*	Very Low Chance
S_1	*EU*	Extremely Unlikely
S_0	*I*	Impossible

b. Resolution Method of the Group Decision-Making Problem

Resolution method is the process used to obtain the solution set of alternatives, it consists of two phases: Consensus phase if the experts express their individual preferences by means of the interval fuzzy preference relation, and selection phase which composed by two procedures [6], [7]: 1) Aggregation and 2) exploitation.

Aggregation phase

In this phase, a collective linguistic interval fuzzy preference relation is obtained by means of the aggregation of all individual linguistic interval fuzzy preference relations. Such that $P_{ij}^k = S_i$ then $P_{ji}^k = S_{T-i}$ .The collective relation called U would be as, $U = (U_{ij})$ for *i,j=1,…………,n* with $U_{ij} = \left[\min_k (p_{ij}^{k-}), \max_k (p_{ij}^{k+})\right]$ For *k =1,.., n.*

Exploitation phase

This phase transforms the global and collective information about the alternatives into a global ranking of them, and then we choose the set of solution alternatives for each alternative x_i we could calculate its dominance degree px_i from the collective linguistic interval fuzzy preference relation as:

$px_i = \sum_{\substack{j=1 \\ j \neq i}}^{n} \left(s(p_{ij}^-) + s(p_{ij}^+)\right)$, Where p_{ij}^- and p_{ij}^+ is the preference of (x_i, x_j)respectively. In such a way, we obtain a classification of the alternatives, if $px_i > px_j$ then xi is preferable to x_j.

4. CONSENSUS MODEL

In this section, we present a consensus model defined for GDM problem assuming that the experts express their preferences by means of the linguistic interval fuzzy preference relations, this model presents the following main characteristics [8]:

1. It is based on two soft consensus criteria: a consensus measure and a proximity measure.
2. It incorporates a feedback mechanism that generates recommendation to the experts on how to change the interval Fuzzy preference relations in the consensus process.

4.1. Consensus and proximity measures

Consensus indicators were calculated in the following steps [9]:

1) We calculate the consensus relations of each expert e_k, called C_k, with respect to the collective preference relations as:

$$\left(\left|\left(s\left(p_{ij}^{k-}\right)-\left(p_{ij}^{-}\right)\right)\right|+\left|\left(s\left(p_{ij}^{k+}\right)-\left(p_{ij}^{+}\right)\right)\right|\right)/T \quad \text{For } i, j=1,\ldots,n$$

2) We define the linguistic global consensus degree LCD as,

$$LCD=\left(1-\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m}C_{ij}^{k}/\left(\left(n^2-n\right)m\right)\right)\times 100\%$$

3) We calculate the proximity measures. First, we calculate the expert proximity relations, called F^k, with respect to collective preference relation U as

$$F^k=\left(F_{ij}^{k}\right) \quad \text{with,}$$
$$F_{ij}^{k}=\left(s\left(p_{ij}^{k}\right)-\left(p_{ij}\right),\left(p_{ij}^{k+}\right)-s\left(p_{ij}\right)\right)=\left(f_{ij}^{k},f_{ij}^{k+}\right)$$
$$\text{For } ij=1,\ldots,n \text{ and } p_{ij}=\left(p_{ij}^{-}+p_{ij}^{+}\right)/2$$

4) Then we define the proximity measure PM of the expert e_k on a preference P_{ij} as

$$PM_{ij}^{k}=\left(\left|f_{ij}^{k}\right|+\left|f_{ij}^{k+}\right|\right)/2T$$

5) Then, we define the proximity measure of the expert e^k in an alternative x^i as

$$PM_{i}^{k}=\sum_{\substack{i=1\\ j\neq 1}}^{n}PM_{ij}^{k}/n-1$$

6) Then, we define the global proximity measure of the expert e^k as

$$PM^{k}=\sum_{i=1}^{n}PM_{i}^{k}/n$$

4.2. Moderator / Feedback process

Feedback mechanism was applied to guide the change of the expert's opinions with use proximity matrix F^k. Usually, the feedback process is carried out in two phase [10], identification phase and recommendation phase.

1) Identification phase, necessary to compare global consensus degree CD and a consensus threshold A, previously fixed. Then, if CD > A or CD = A the consensus process will stop, on the other hand, if CD < A, new consensus round must be applied.
2) Recommendation phase. In this phase, we recommend expert changes of their preference according to some rules to change the opinions, we define the following rules:
   a) If $\left(p_{ij}^{k-}-p_{ij}\right)=f_{ij}^{k+}\rangle 0$ then expert e_k should decrease the assessment associated to the pair of alternatives $\left(x_i,x_j\right)$.
   b) If $\left(p_{ij}^{k+}-p_{ij}\right)=f_{ij}^{k+}\langle 0$ then expert e_k should increase the assessment associated to the pair of alternatives $\left(x_i,x_j\right)$.
   c) If $f_{ij}^{k-}\langle 0\langle f_{ij}^{k+}$ then expert e_k should increase p_{ij}^{k-} and decrease p_{ij}^{k+} in the assessments associated to the pair of alternatives $\left(x_i,x_j\right)$.

5. An empirical study

Three expert E_1, E_2 and E_3 who want to find the best BulkCarrier shipbuilding region. Let us use the nine linguistic labels set $\{S_0,\ldots,S_8\}$ defined in (Herrera et al., 1996a). Suppose that they have four possible BulkCarrier shipbuilding region (South Korea = X_1, China = X_2, Japan = X_3, Europe = X_4) and provide preference on them using the following interval fuzzy preference relations.

$$e_1=\begin{pmatrix} - & [SC,SC] & [I,SC] & [VLC,SC] \\ [MC,MC] & - & [MC,C] & [IM,MC] \\ [MC,C] & [I,SC] & - & [VLC,SC] \\ [MC,ML] & [SC,IM] & [MC,ML] & - \end{pmatrix}$$

$$e_2=\begin{pmatrix} - & [SC,MC] & [VLC,SC] & [I,VLC] \\ [SC,MC] & - & [MC,ML] & [MC,EL] \\ [MC,ML] & [VLC,SC] & - & [EU,SC] \\ [ML,C] & [EU,SC] & [MC,EL] & - \end{pmatrix}$$

$$e_3=\begin{pmatrix} - & [IM,ML] & [IM,MC] & [MC,ML] \\ [VLC,IM] & - & [SC,IM] & [ML,C] \\ [SC,IM] & [IM,MC] & - & [IM,IM] \\ [VLC,ISC] & [I,VLC] & [IM,IM] & - \end{pmatrix}$$

Then we obtain the following collective linguistic interval Fuzzy, with membership function,

$$U=\begin{pmatrix} - & [3,6] & [0,5] & [0,6] \\ [2,5] & - & [3,8] & [4,8] \\ [3,8] & [0,5] & - & [1,4] \\ [2,8] & [0,4] & [4,7] & - \end{pmatrix}$$

When we applied the nine linguistic labels set defined we obtain the linguistic membership function as follows:

$$U=\begin{pmatrix} - & [SC,ML] & [I,MC] & [I,ML] \\ [VLC,MC] & - & [SC,C] & [IM,C] \\ [SC,C] & [I,MC] & - & [EU,IM] \\ [VLC,C] & [I,IM] & [IM,EL] & - \end{pmatrix}$$

Now, we calculate the consensus relations of each expert

$$C^1=\begin{pmatrix} - & 0.375 & 0.250 & 0.625 \\ 0.375 & - & 0.250 & 0.375 \\ 0.250 & 0.250 & - & 0.250 \\ 0.625 & 0.375 & 0.250 & - \end{pmatrix}$$

$$C^2=\begin{pmatrix} - & 0.125 & 0.500 & 0.500 \\ 0.125 & - & 0.5 & 0.250 \\ 0.500 & 0.500 & - & 0.125 \\ 0.500 & 0.250 & 0.125 & - \end{pmatrix}$$

$$C^3=\begin{pmatrix} - & 0.125 & 0.500 & 0.625 \\ 0.125 & - & 0.500 & 0.250 \\ 0.500 & 0.500 & - & 0.375 \\ 0.625 & 0.250 & 0.375 & - \end{pmatrix}$$

Therefore, consensus degrees on the preference P_{ij} are

$$CD=\begin{pmatrix} - & 0.792 & 0.583 & 0.417 \\ 0.792 & - & 0.583 & 0.708 \\ 0.583 & 0.583 & - & 0.750 \\ 0.417 & 0.708 & 0.750 & - \end{pmatrix}$$

$$LCD=1-\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m}C_{ij}^{k}}{\left(\left(n^2-n\right)m\right)}$$

$$LCD=1-\frac{4.25+4.00+4.75}{\left(\left(4^2-4\right)\times 3\right)}=0.639$$

The global consensus degree is LCD = 0.639 or LCD = 63.9% if we fix a consensus threshold

$$A=\frac{E_i}{X_i}=\frac{3}{4}=0.75=75\%,$$

then it seems unacceptable to finish the Decision-Making process. Therefore, we have to calculate the first process of feedback to reach the threshold value, then F_i^k for each expert as follows:

$$F^1=\begin{pmatrix} - & [-1.5,-1.5] & [-2.5,0.5] & [-1,0] \\ [1.5,-0.5] & - & [-0.5,2.5] & [-2,-1] \\ [-0.5,2.5] & [-2.5,0.5] & - & [-0.5,0.5] \\ [-0.5,1.0] & [1,2] & [-0.5,0.5] & - \end{pmatrix}$$

$$F^2=\begin{pmatrix} - & [-1.5,0.5] & [-0.5,0.5] & [-3,-1] \\ [-0.5,5.5] & - & [-0.5,0.5] & [-1,1] \\ [-0.5,0.5] & [-0.5,0.5] & - & [-1.5,0.5] \\ [1,3] & [-1.0,1.0] & [-0.5,1.5] & - \end{pmatrix}$$

$$F^3=\begin{pmatrix} - & [-0.5,1.5] & [1.5,2.5] & [2,3] \\ [-1.5,0.5] & - & [-2.5,-1.5] & [0,2] \\ [-2.5,-1.5] & [1.5,2.5] & - & [1.5,1.5] \\ [-3.0,-2.0] & [-2,0] & [-1.5,-1.5] & - \end{pmatrix}$$

The proximity measures PM for experts are:

$$PM_1^1=0.146 \quad PM_1^2=0.167 \quad PM_1^3=0.229$$
$$PM_2^1=0.167 \quad PM_2^2=0.146 \quad PM_2^3=0.167$$
$$PM_3^1=0.146 \quad PM_3^2=0.104 \quad PM_3^3=0.229$$
$$PM_4^1=0.104 \quad PM_4^2=0.000 \quad PM_4^3=0.208$$

And,

$$PM^1=0.141 \quad PM^2=0.104$$
$$PM^3=0.208$$

Applying the feedback mechanism:

In this phase, we recommend expert changes of their preferences according values to change the opinions depending of the recommendation phase as follows:

$$e_1=\begin{pmatrix} - & [IM,IM] & [EU,VLC] & [SC,SC] \\ [IM,ML] & - & [MC,EL] & [MC,ML] \\ [ML,EL] & [EU,VLC] & - & [SC,VLC] \\ [MC,MC] & [VLC,SC] & [ML,MC] & - \end{pmatrix}$$

$$e_2=\begin{pmatrix} - & [IM,IM] & [VLC,VLC] & [EU,SC] \\ [IM,IM] & - & [ML,MC] & [IM,ML] \\ [ML,MC] & [SC,VLC] & - & [VLC,VLC] \\ [MC,EL] & [VLC,VLC] & [ML,ML] & - \end{pmatrix}$$

$$e_3=\begin{pmatrix} - & [MC,MC] & [SC,IM] & [IM,MC] \\ [SC,SC] & - & [IM,MC] & [ML,EL] \\ [IM,MC] & [SC,IM] & - & [SC,SC] \\ [SC,IM] & [EU,VLC] & [MC,MC] & - \end{pmatrix}$$

Then, we obtain the following collective linguistic membership interval function preference relation:

$$U = \begin{pmatrix} - & [IM, MC] & [EU, IM] & [EU, MC] \\ [SC, ML] & - & [IM, EL] & [IM, EL] \\ [IM, EL] & [EU, IM] & - & [VLC, SC] \\ [SC, EL] & [EU, MC] & [MC, ML] & - \end{pmatrix}$$

The new calculation of the new consensus relations of each expert as follows:

$$C^1 = \begin{pmatrix} - & 0.125 & 0.250 & 0.500 \\ 0.125 & - & 0.250 & 0.125 \\ 0.250 & 0.250 & - & 0.250 \\ 0.500 & 0.375 & 0.250 & - \end{pmatrix}$$

$$C^2 = \begin{pmatrix} - & 0.125 & 0.500 & 0.250 \\ 0.375 & - & 0.500 & 0.250 \\ 0.500 & 0.500 & - & 0.125 \\ 0.250 & 0.250 & 0.125 & - \end{pmatrix}$$

$$C^3 = \begin{pmatrix} - & 0.125 & 0.250 & 0.375 \\ 0.375 & - & 0.250 & 0.125 \\ 0.250 & 0.250 & - & 0.125 \\ 0.500 & 0.125 & 0.125 & - \end{pmatrix}$$

Therefore, consensus degrees on the preference P_{ij}

$$CD = \begin{pmatrix} - & 0.875 & 0.667 & 0.625 \\ 0.708 & - & 0.667 & 0.833 \\ 0.667 & 0.667 & - & 0.833 \\ 0.625 & 0.833 & 0.833 & - \end{pmatrix}$$

$LCD = 1 - \frac{9.5}{36} = 0.736$ or,

$LCD = 73.6\%$

The global consensus degree *LCD* = 0.736 or *LCD* = 73.6% which is not acceptable with comparing of the threshold, so another feedback required. The second feedback were completed with the following LCD :

$LCD = 1 - \frac{8.89}{36} = 0.753$ or LCD = 75.3% which is acceptable ratio. From collective interval fuzzy preference relations matrix µ it is possible to obtain the following dominance degree

$px_1 = 10$, $px_2 = 16$, $px_3 = 10.5$, $px_4 = 12.5$

So, these alternatives can be classified from highest to lowest preference: $X_2 \rangle X_4 \rangle X_3 \rangle X_1$

Which means ,

1. China
2. Europe
3. Japan
4. South Korea

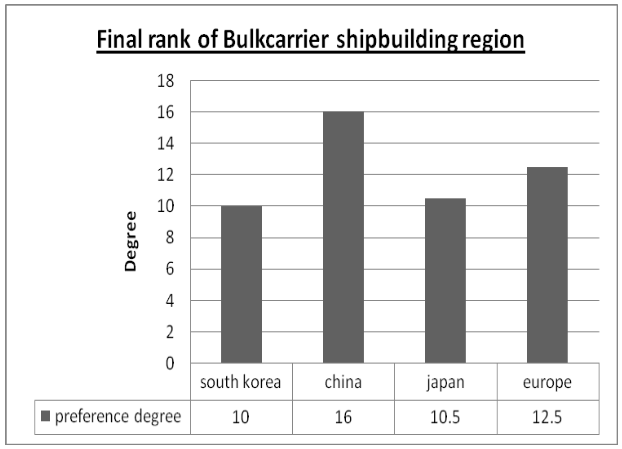

Figure 1: The rank of BulkCarrier shipbuilding region

As shown in the figure above, experts agreed that China ranks first in dry bulk shipbuilding, despite its late entry in the competition, but it entered and preceded Europe that was first and then took the second place after China, followed by Japan in the third place and finally North Korea came in the fourth place. Given the attention to the preceding schedule in Clarksons [11], the world's leading shipping services provider, is a dynamic organization at the forefront of change within the industry. More recently, the group has expanded its range of services so that it is now a fully integrated shipping services provider covering activities such as research and consultancy, shipping publications, shipping derivatives, shipping finance advice, shipping logistics and ship valuations.

TABLE 3

BULKCARRIER SHIPBUILDING ORDER BOOK FOR TOP REGION [11]

Region	Million.DWT
China	15.5
Greece	14.7
Japan	8.8
South Korea	4.8

From table 3, we can notice that although China has entered the competition area almost ten years ago, In 2012 it occupied the first rank with level of demand 15.5 million Dead Weight DWT with a fierce competition with Europe that occupied the second rank with level of demand 14.7 million DWT then Japan in the third rank with 8.8 million DWT and finally south Korea with million DWT. Notice that Dead Weight DWT refers to the carrying capacity of a vessel.

6. Discussion

The advantage of the Consensus Group Decision Making was illustrated as follows:

- It used in case of lacking of data in the domain of the problem.
- Not need a set of criteria related to the problem that may be not complete like the other models that deals with multi-criteria Decision-Making
- An experts opinion are closed to the selected criteria, they don't give their opinions as a global problems.
- Opinions of the expert persons were gathered only one time and feedback was processed automatically.
- It used a nine linguistic label set instead of five linguistic Saaty numbers, which gives the experts more flexibility to give their opinions.

We see that the main disadvantage of consensus model its dependency on the excellence selects of experts that gives their opinions, because an expert persons opinions is the kernel of the consensus model. Rank of BulkCarrier shipbuilding region had been solved by the same authors[12] using Fuzzy Analytical Hierarch process FAHP as a methodology which solve Multi-Criteria Decision-Making MCDM problem to find the rank of BulkCarrier shipbuilding region, FAHP gives the same output rank.

7. Conclusion

We concentrate on Group Decision-Making GDM in the Linguistic assessment for selecting excellent BulkCarrier shipbuilding regions. Our proposed methodology based on a consensus model to deal with Group Decision-Making with interval fuzzy preference relation. This model based on two consensus criteria, a consensus measures and proximity measures, in addition to feedback mechanism. We invited three experts to gather their preferences. Their attitudes and opinions played decisive roles for the outcome of the practical case. A simple and clearance form was design to perform this task. The final ranking of the BulkCarrier shipbuilding regions can be classified from highest to lower preference as follows:

1. China
2. Europe
3. Japan
4. South Korea.

Finally this work assists the decision making to take correct and accurate decision from a group of expert persons with a simple way in short time even if there are lot of distances between their opinions.

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