HIERARCHICAL COMPROMISE MODEL FOR GROUP DECISION MAKING: A CASE OF PORTS SITING

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abstract: This paper offers a hierarchical compromise model (HCM) for multiple criteria group decision making problems. A practice application of the HCM to the case of international container transhipment center ports siting in South China is Specified, which includes 4 ports, 8 interest groups and 35 criteria. The research comes to the conclusion that not only the optimal compromise soltion but also the optimum deggree of that solution can be obtained by means of the HCM. The latter is just the outstanding merit of the HCM compared with traditional methods.

1. INTRODUCTION

It is well known that in China the reform of the economic system has brought up a great vitality in every aspect of the country, also in the development of ports. Now, in some coastal areas specially in the coastland of South China, the mechanism of market compete is playing an important role in port operation and investment decision, because there are many differences among ports in the management systems, the given economical policy conditions and the way to raise developing funds besides the differences in port scales and natural conditions. It has become more and more important and necessary, in making any decision about port project investment, to consider the direct effects on the benefit of port enterprises, cargo—owners and ship companies, the indirect effects on the other respects of social development, such as the urban planning, regional industrial estate developing, land and coastline resources utilizaion, employment supply, environmental pollution control and so on, and the interactionbetween a new project and existing facilities, between a new project and existing facilities. As it is often necessary to make a trade—off or compromise choice from among many conflicting objectives, criteria and benefit being concerned with various interest groups, port developing decision makings of this kind are the typical problems of multiple criteria group decision making (MCGDM), and unfortunately, traditional individual decision making methods often fail to deal with the complicate MCGDM situations. In this paper, a hierarchical compromise model (HCM) for group decision making with an application to the problem of international container transhipment center ports siting in South China is specified, which includes 4 ports, 8 interest groups and 35 criteria. The research comes to the conclusion that not only the optimal compromise solution (OCS) but also the optimum degree of that solution can be obtained by means of the HCM.

2. SITING PROBLEM

The problem can be described as follows: a decision about container transhipment center port locaion must be made by the government under the situation that there are some ports possible to be taken as the alternatives in the coastland of South China, But the estimation or opinions of the alternatives from different interest groups relative to the decision making are different and even conflicting, and as the will of each interest group is one of the most important decisive factors, only such a choice, which has taken the standpoints of all the interest groups into account as fully as possible, and furthermore, reduces the degree of dissension to the minimum, or in other words, makes the consistency of opinions be the maximum, is the optimal compromise result and can be taken by decision maker(s).

On the basis of analyzing the status quo and prospects of South China international container transportation system, 4 ports in the same seaboard are taken as the alternatives of container transhipment center in light of the fundamental functions with which a transhipment center should be provided. Here the ports can be separated with the notations of P1, P2, P3 and P4.

In this siting case, the interest groups may roughly be classified into three types: (i) those of the port authorities or port enterprise managers concerned with one of four alternative ports, (ii) those of the port users such as cargo—owners, ship companies, etc. , (iii) those of the government departments or competent organizations to be responsible for investing, planning, examining, approving and so on. According to the classification, opinions from 8 main interest groups are taken into account. The interest groups are separated with the notations of G1, G2, G3, G4, G5, G6, G7 and G8.

To define a set of proper criteria is the key to any decision making problems and also to the siting problem. Taking account of their importance and comparative characteristics, the criteria including 6 essential conditions and 29 sub—conditions belong respectively with the essential conditions are established and denoted Ei, i=1,2,···,6 and Ci,i=1,2,···,29 respectively (see Fig. 1). Figure 1 shows the hierarchical structure of the port siting problem.

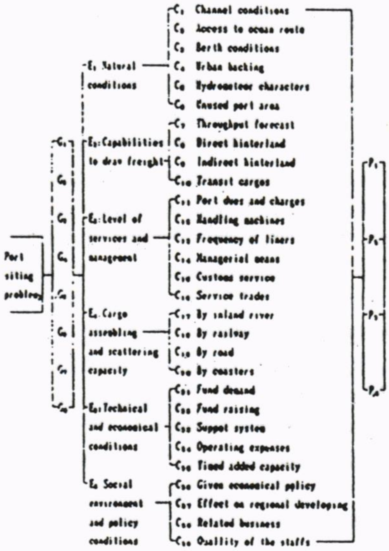

Fig.1. Structure of the port siting problem

3. HIERARCHICAL COMPROMISE MODEL

Being different from the general problems of multiple criteria decision making, the siting problem is three—dimensional decision making consisting of three sets of decision variables:

alternatives, criteria and interest groups. In order to deal with the complicate MCGDM problems of this kind, the HCM is introduced hereinafter.

Supposing there are m alternatives (A) chosen by n interest groups (G) in light of r criteria (C), without loss of generality, the MCGDM problem D can be mathematically defined as a set as follows:

$$D=(A,C,G)$$

where, $A=(A1,A2,\cdots,Ai,\cdots,Am)$,

$$C=(C1,C2,\cdots,Ck,\cdots,Cr)$$

and $G=(G1,G2,\cdots,Gj,\cdots,Gn)$. Clearly, all main original opinions can be given expression by means of a set of discrete points in three—dimensional space $A\times C\times G$ looking like a cube, as in Fig. 2. For example, the point s(i,j,k) in Fig. 2 denotes an estimation of alternative A i from interest group Gj in the light of criterion Ck.

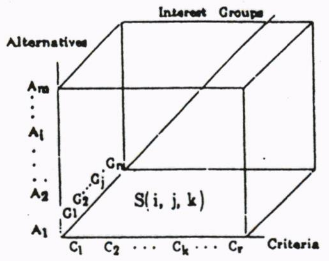

Fig. 2. Information space of the MCGDM

It is a pity that most conventional methods are designed only to process the information given in plane $A\times C$ and/or plane $A\times G$ but then lose sight of the information from plane $C\times G$, that is, the conventional methods usually take two sequential procedures of decision making: first to give an individual ranking of alternatives by each interest groups according to their own preference of criteria (criteria may or may not be the same to each interest group), which can be called the individual judgement, then to make a collective choice of alternatives on the basis of individual rankings in the light of a certain determinative rule, which can be called the group choice. In fact, by analyzing the individual judgement, it is not difficult to find that in many cases, the individuals involoved in decision making are of more subjective to rank the alter natives as souch rank is direct concerned in the benefit of themselves and the factor of self—regard would be unavoidable thereby, but then they are of more objective to estimate the importance of criteria as such estimation is mainly concerned in technical and economical factors, i. e. , the information obtained from plane $C\times G$ in Fig. 2 is of more objective relatively. If all the information derived from the three—dimensional space including the plane $C\times G$ can be processed by a proper way, for example, we can combine the individual judgement with the group choice purposively and this combination should be of flexible and hierarchical and be able to phase in information feedback, then, as a result of interchanging opinions or information between the individuals and the collective repeatedly, the compatibility, reliability and validity of the group decision making will increase undoubtedly. According to the above thoughts, the HCM, a new method, was designed and the general structure of the HCM is shown in Fig. 3. It is understood that the structure shown in Fig. 1 is particular just to the port siting problem.

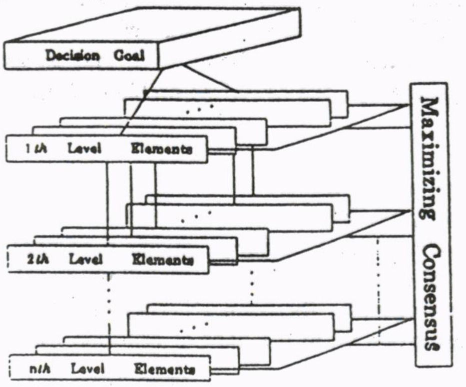

Fig. 3. General structure of the HCM

The most important notions inhered in the HCM are hierarchy and compromise. Hierarchy represents the model structure and compromise reveals the solution and result of the problem. Maybe the AHP developed by Saaty (1977) is the most well—known hierarchical model. According to Seaty, a model with hierarchical structure has many advantages and the most important of them is capable of simplifying a complicated decision making problem. Clearly, the principle of hierarchy is applicable not only to various individual decisions but also specially to various group decisions.

As any realistic problem of the MCGDM does not exist optimal solution in the sense of individual decision making, to facilitate a decision making group to seek out the OCS is the purpose of the HCM and that is just the distinction between the HCM and the AHP.

It should be pointed out that in order to search the OCS, the HCM takes advantage of the extended estimator ranking method (EER) which was developed by Fang (1993). The EER possesses two major merits out of the ordinary: one is suitable for dealing with both ordinal and cardinal ranking problems, another is capable of discovering both the OCS and the optimum degree corresponding to the solution in the sense of the value of consensus measure CB being at its maximal. Here, the consensus measure CB is a relative non—dimensional measure, which was put forward by Fang (1993) on the basis of improving upon the Cook—Seiford distance function method (Cook and Seiford, 1978), and can be used for judging the degree of consensus quantitatively. For instance, CB=1 is in correspondence with the perfect consensus, CB=0 is in correspondence with the extreme dissension.

Supposing some notations are defined as follow:

Aj=(aik)mxr —— the data matrix made up of m alternatives and r criteria according to the interest group Gj,

C0=(Cik)nxr —— the data matrix made up of n interest groups and r criteria,

C* —— the optimal compromise ranking of r criteria hinging upon the decision—making groups,

Aj* —— the ranking of m alternatives hinging upon the C* and the interest group Gj,

A* —— the OCS of the decision making problem, then, a sketchy flow chart of the HCM consisting of three hierarchy levels such as alternatives, Criteria and decision—making groups is shown in Fig. 4. Of course, the HCM is able to deal with more general problems which may consist of multiple hierarchy levels.

4. RESULT

By means of the HCM, the optimal compromise ranking and the weighted aggregative coefficients of 35 criteria concerned in the port siting problem were searched out, which corresponding to CB=0. 78. The rankings of 4 alternative ports given by 8 interest groups in light of the optimal compromise ranking of criteria and the final result (OCS), which corresponding to CB=0. 75, are shown in Table 1.

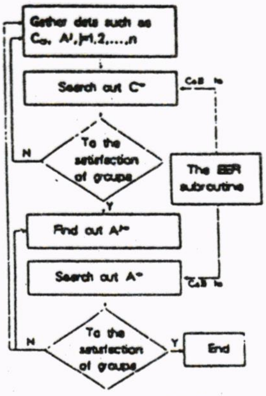

Fig. 4. Flow chart of the HCM

Table 1 The interim result and the final outcome

	Interim result								Final outcome	
	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Ranks	Weights
P_1	1	3	1	1	2	2	3	1	1	0: 39
P_2	2	2	2	2	1	3	2	2	2	0. 29
P_3	3	1	3	3	3	1	4	3	3	0. 19
P_4	4	4	4	4	4	4	1	4	4	0. 13

5. CONCLUSION

Compared with traditional methods such as the AHP, the result coming from the HCM has been shown in practice application to be more objective, reasonable and easily accepted by each interest group, and so to facilitate the implementation of the final decision. Now an initial software of the HCM has been designed and the general applied software is being perfected. It is our belief that the HCM may be applicable not only to siting problems but also to traffic demand forecast, investment projects choice and the other group decision making problems in the social economical and political fields.

REFERENCES

Cook, W. C. , and L. M. Seiford (1978). Priority ranking and consensus formation **Management Science**, Vol. 24, No. 16, pp. 1721—1732.

Fang, R. (1993). Multiple criteria group decision making; theory, methods and applications. Ph. D. Dissertation, Northern Jiaotong University, Beijing.

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. **J. of Math. Psych.** , Vol. 15, pp. 234—281.