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USING THE ELECTRE II METHOD TO APPLY AND ANALYZE THE DIFFERENTIATION THEORY

Wen-Chih HUANG
Associate Professor
Dept. of Harbor and River Engineering,
National Taiwan Ocean University.
P.O.BOX. 7-107.
Keelung, Taiwan
FAX: + 886-2-24635153
E-mail: huangwc@mail.ntou.edu.tw

Chien-Hua CHEN
Doctor Student
Dept. of Harbor and River Engineering,
National Taiwan Ocean University.
No.6, Lane 656, Road Jungjheng,
Keelung, Taiwan
FAX: + 886-2-24295179
E-mail: kl037@mail.klcg.gov.tw

Abstract: The ELECTRE evaluation method is widely recognized for high-performance policy analysis involving both qualitative and quantitative criteria. However, a critical advantage of this evaluation method is its capacity to pinpoint the exact needs of a decision maker and suggest an appropriate evaluation approach. The discordance indices of modified ELECTRE evaluation method are used to explain the significance of modified evaluation standards. The ELECTRE II evaluation method, applied to case simulation, helps analyze the potential effects triggered by the absolute value of the maximum differentiated performance and the absolute value of the sum of differentiated performance under two discordance index evaluation standards. In general, using the ELECTRE evaluation method in the absence of a differentiation process may produce results opposite to those desired by a decision maker. In addition to discussing the above phenomena, the author attempts to explain the policy-making process using a case study of land redevelopment in Heping Harbor Zone**,** Keelung, Taiwan, ROC

Keywords: ELECTRE, Evaluation Method, Policy Analysis.

1. INTRODUCTION

With the rapid changes in living environment experienced in recent decades, many cities have placed increasing expectations on land redevelopment to help ease urban planning problems. However, a high priority should be given to a restructuring of the decision-making processes employed during the formulation and execution of redevelopment decisions. These processes demand consideration of complex, multi-faceted issues and, therefore, typically incorporate both qualitative and quantitative evaluation criteria. ELECTRE is a widely recognized evaluation method with a strong performance track record that can be employed to facilitate decision-making activities which incorporate both qualitative and quantitative criteria. However, ELECTRE evaluation method as currently used uses different evaluation standards for different purposes. Therefore, accurately defining decision maker needs and choosing appropriate evaluation methods represent issues of ongoing concern for scholars involved in the mechanics of this evaluation method. In general, using ELECTRE evaluation method in the absence of the differentiation process could produce results opposite to those desired by a decision maker. Therefore, in order to make correct, informed decisions, it is important that decision makers have access to complete information and thoroughly understand various alternatives. The discordance index evaluation benchmarks of the modified ELECTRE evaluation method in this study are used to explain the significance of modified evaluation standards. ELECTRE II evaluation method is applied to case simulation. The possible effect triggered by the absolute value of the maximum differentiated performance and the absolute value of the sum of differentiated performance is analyzed under the two discordance index evaluation standards. The following illustrate how the established evaluation method has been applied to the case study on land redevelopment in Heping Harbor Zone**,** Keelung, Taiwan, R**OC**

2. REVIEW OF LITERATURE

The outranking method, part of the multi-criteria decision-aid (MCDA), was introduced in 1966 when three French scholars (i.e. Benayoun, Roy and Sussmann) initiated ELECTRE (Elimination Et (and) Choice Translating Reality) evaluation method. Then, scholars and study groups made some important efforts to move this method forward and published worldwide a number of articles involving similar theories and their applications. Firstly, the evaluation method is required to establish preference relation, i.e. outranking relation, and then make consistent exploration and analysis in support of decision makers. ELECTRE I is one of the earliest multi-criteria evaluation method developed among outranking methods. The major purpose of this evaluation method is to select a desirable alternative that meets both the demands of concordance preference above many evaluation benchmarks and of discordance preference under any optional benchmark. The ELECTRE I evaluation method generally included three concepts; namely the concordance index, discordance index and threshold value. ELECTRE II evaluation method, developed by scholars Roy and Bertier (1971), represented the improvement and promotion of ELECTRE I. The concordance index and discordance index in ELECTRE II incorporate two extreme opposite relationships, i.e. strong relationship (R_S) and weak relationship (R_W), whereby strong-ranking and weak-ranking are deduced to obtain the final ranking.

The literature confirms that ELECTRE evaluation method is widely considered as an effective and efficient decision aid with a broad range of applications covering policy-making with regard to the use of urban land and planning investments, transport facilities, environmental protection programs, among others. Thanks to the concerted efforts of many scholars in this field, evaluation methods most frequently referred to include ELECTRE I, ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE IS and ELECTRE A. Despite the numerous versions of the ELECTRE evaluation method, how to select the method most relevant to a particular problem is a key problem for analysts and policy makers. Thus, updating the ELECTRE benchmark to provide the most pertinent response to different issues is crucial. Otherwise, the resulting recommendations are likely to define an objective that falls below policy maker expectations.

3. OVERVIEW OF EVALUATION METHODS

Some examples of ELECTRE II evaluation methods are introduced below:
A represents the aggregate obtained from n feasible alternatives $\left(A_1, A_2, ...A_n\right)$, i.e.

$$A = \left\{A_i \middle| i = 1,2,...,n\right\}$$

I represents the aggregate obtained from m evaluation criteria $(C_1, C_2, ..., C_m)$, i.e.

$$I = \{C_j \mid j = 1,2,...,m\}$$

Assuming there are identified weights of m evaluation criteria, with W representing the aggregate of m weights $(W_1, W_2, ..., W_m)$, i.e.

$$W = \{W_j \mid j = 1,2,...,m\}$$

The performance value of feasible alternative A_i under evaluation criterion C_j is represented by $g_j(A_i)$ With regard to two optional alternatives A_h and A_k, m evaluation criteria are classified into three categories when $g_j(A_h)$ and $g_j(A_k)$ are compared under every criterion C_j:

$$I^+ = \{C_j \mid g_j(A_h) > g_j(A_k)\}$$
$$I^= = \{C_j \mid g_j(A_h) = g_j(A_k)\}$$
$$I^- = \{C_j \mid g_j(A_h) < g_j(A_k)\}$$

I^+ is represented by the aggregate in case the evaluation criterion for the performance value of alternative A_h is better than for alternative A_k, with its weight W^+ shown below:

$$W^+ = \sum_{j \in I^+} W_j$$

$I^=$ is represented by the aggregate in case the evaluation criterion for the performance value of alternative A_h is the same as that for alternative A_k, with its weight $W^=$ shown below:

$$W^= = \sum_{j \in I^=} W_j$$

I^- is represented by the aggregate in case the evaluation criterion for the performance value of alternative A_h is inferior to that for alternative A_k, with its weight W^- shown below:

$$W^- = \sum_{j \in I^-} W_j$$

3.1 Establishment of Concordance Index:

The following models, such as W^+, $W^+ + W^=$ and $W^+ + \frac{1}{2}W^=$ shall be applied as the numerator in the concordance index. Meanwhile, decision makers may opt to choose the numerator as their evaluation standard. The denominator is $W^+ + W^= + W^-$. In this paper, the W^+ model is used as the numerator. Thus, the evaluation standard for the concordance index shall be based upon the weight ratio (the weight of performance value of alternative A_h better than of A_k, in relation to the weight sum). Two optional alternatives A_h and A_k are compared with concordance index $C(h,k)$ defined below:

$$C(h,k)=\frac{W^{+}}{W^{+}+W^{=}+W^{-}} \quad ,\forall h,k;h\neq k$$

To compare alternative A_h with alternative A_k, the concordance index can be calculated by totaling the weight of the performance value of alternative A_h in criterion j better than that of alternative A_k in criterion j. The result is then divided by the weight sum of all criteria. In addition, with respect to $C(h,k)=\sum_{j\in I^{+}} W_{j} / \sum_{j\in I} W_j$, if $\sum_{J\in i} W_j = 1$, the above-specified formula can be represented by $C(h,k)=\sum_{j\in I^{+}} W_j$, so $0\leq C(h,k)\leq 1$.

3.2 Establishment of Discordance Index:

Under evaluation criterion C_j, the discordance index $d_j(h,k)$ of feasible alternative A_h is not better than that of alternative A_k, showing that selection of alternative A_h other than better alternative A_k will likely result in the dissatisfaction of decision makers to a considerable extent. In this dissertation, the initial discordance index $d_j(h,k)$ of ELECTRE II evaluation model is defined below:

$$d_j(h,k)=\left|\frac{g_j(A_h)-g_j(A_k)}{\max\limits_{j\in I^{-}}\left(g_j(A_h),\theta_j\right)}\right| \quad , \quad \forall h,k;h\neq k$$

In the above equation, $d_j(h,k)$ refers to the differentiation percentage of plans A_h and A_k under evaluation criterion C_j. Besides, θ_j refers to the R-degree parameter used by a decision maker for criteria j to represent the degree of attention paid by the decision maker to criteria j. In other words, decision makers can express their preference for criteria reflecting differing levels of significance. If m criteria are evaluated concurrently, the feasible plan A_h is not superior to plan A_k of the discordance index $d_m(h,k)$, which is defined as the maximum value of discordance index $d_j(h,k)$ under m criteria, then

$$d_m(h,k)=\max\left(d_j(h,k)\right)$$

Since the denominator of $d_j(h,k)$ is determined by θ_j and $g_j(A_h)$, there is no guarantee that $d_m(h,k)$ is between 0 and 1. Therefore, the following equation does not satisfy:

$$0\leq d_m(h,k)\leq 1 \quad \forall h,k;h\neq k$$

In this dissertation, $d_S(h,k)$ is used to represent the discordance index with benchmarks of the absolute value of the sum of differentiated performance and modified as below:

$$d_S(h,k) = \sum_{j \in I^-} d_j(h,k)$$

Similarly, there is no guarantee that $d_S(h,k)$ is between 0 and 1, thus, the following equation does not satisfy:

$$0 \le d_S(h,k) \le 1 \quad \forall h,k; h \ne k$$

3.3 Establishment of Strong Outranking and Weak Outranking Relationship:

Two elements are used to establish the outranking relationship value for ELECTRE II : strong outranking relationship (R_S) and weak outranking relationship (R_W). According to the definition of R_S and R_W, policy makers must determine different concordance index levels and discordance index reducible level. It is assumed that p^*, p^0 and p^- are represented by three degressive concordance levels, respectively, and meet the following conditions:

$$0 \le p^- \le p^0 \le p^* \le 1$$

Additionally, q^0 and q^* are represented by two degressive discordance levels, and meet the following conditions:

$$0 < q^0 < q^* < 1$$

After decision maker identify concordance and discordance levels, it is possible to establish value for the strong outranking relationship (R_S) and weak outranking relationship (R_W), calculate strong ranking V' and weak ranking V'' values, and finally, determine the average ranking $\overline{V}$ for final ranking result.

4. COMPARATIVE ANALYSIS

ELECTRE evaluation method allows qualitative and quantitative criteria to be handled simultaneously. The existing discordance index evaluation benchmark always uses the absolute value of the maximum differentiated performance as the evaluation standard. This study proposes another benchmark, namely the absolute value of the sum of differentiated performance as the evaluation standard. In fact, those two evaluation standards represent different decision-making approaches, based on whether a decision maker focuses on discrepancies in the most important criteria or in the overall criteria, respectively. In general, using of ELECTRE evaluation methods, without the differentiation process, may produce a result that is opposite that targeted by the decision maker. The following explains this concept. This example involves six-criteria evaluation analysis. The normalization performance of three alternatives is shown as follows:

Table 1: Data Sheet of Simple Case Normalization Performance

	c1	c2	c3	c4	c5	c6
a1	2	2	2	2	2	4
a2	3	3	3	3	3	1
a3	3	7	5	1	5	6

It is hypothesized that all three alternatives exceed the concordance index threshold and the denominators of discordance index $d_j(h,k)$ are the same (it is assumed that the decision maker preference value in the denominator of individual criteria is 1; In other words, θ_j =1 is the value of the denominator in each criterion). The absolute value of the maximum differentiated performance and the sum of differentiated performance are used to calculate the discordance index. The results are as follow:

a12= $\max(|2-3|,|2-3|,|2-3|,|2-3|,|2-3|,|2-3|) = \max(1,1,1,1,1) = 1$

a21= $\max(|1-4|) = \max(3) = 3$

a13= $\max(|2-3|,|2-7|,|2-5|,|2-5|,|4-6|) = \max(1,5,3,3,2) = 5$

a31= $\max(|1-2|) = \max(1) = 1$

a23= $\max(|3-7|,|3-5|,|3-5|,|1-6|) = \max(4,2,2,5) = 5$

a32= $\max(|1-3|) = \max(2) = 2$

Whereas, a12 and a21 are used as examples to explain the relationship based on a1 and a2. The result shows that a12< a21. In the screening process for discordance indices, a1 is superior to a2 (according to the screening principle of ELECTRE evaluation method, an alternative with smaller discordance index is more likely to become preferred alternative). Similarly, other results are compared, and the following conclusion is reached:

Whereas a3> a1> a2

Use of the absolute value of the sum of differentiated performance:

a12= $(|2-3|+|2-3|+|2-3|+|2-3|+|2-3|+|2-3|) = (1+1+1+1+1) = 5$

a21= $(|1-4|) = (3) = 3$

a13= $(|2-3|+|2-7|+|2-5|+|2-5|+|4-6|) = (1+5+3+3+2) = 14$

a31= $(|1-2|) = (1) = 1$

a23= $(|3-7|+|3-5|+|3-5|+|1-6|) = (4+2+2+5) = 13$

a32= $(|1-3|) = (2) = 2$

Similarly, other results are compared, and the following conclusion is reached:

Whereas, a3> a2> a1

The above result shows that the ranking result obtained by using the absolute value of the maximum differentiated performance is (a3> a1> a2), However, using the absolute value of the sum of differentiated performance gives a ranking result of (a3> a2> a1). The rankings for alternatives a1 and a2 trade places in the two results. Alternative a3 appears to be the optimal alternative under both evaluation benchmarks, yet, the relative difference between a3 and a1, as well as a3 and a2, has changed significantly. Using a1 and a3 as an illustrative example, the relative discrepancy in discordance indices for the two alternatives has increased from 4(a13 - a31 = 5 - 1= 4) to 13 (a13 - a31 = 14 - 1= 13). As seen, the discrepancy between the two evaluation benchmarks is significant. The discrepancy becomes even more significant with an increase in the number of evaluation criteria. In fact, the two evaluation benchmarks represent different meanings. The use of the absolute value of the maximum differentiated performance indicates the attention of decision maker is focused on the greatest utility discrepancy of performance on criterion, while the use of the absolute value of the sum of differentiated performance indicates he or she is focused on the utility accumulative discrepancy of performance on criterion. This study aims to explain the difference through actual simulation and clarify the concept through application and analysis of ELECTRE II evaluation method. The following are provided as illustrative examples.

5. DESCRIPTION OF CASES

To ensure a successful detailed description, the evaluation method is designed for the case study of land use in Heping Harbor Zone, Keelung, Taiwan, ROC Located at eastern coast of Keelung Harbor, Heping Harbor Zone is always hired by Keelung main plant of China Shipbuilding Co., Ltd. Owing to poor performance in recent years, this company has no way but to downscale its organizational structure. Thus, the redevelopment of approx 36 hectares a land will play a key role in the redevelopment of remodeling of Keelung Harbor. There are six preliminary improvement alternatives according to collected information:
alternative one (recreational area): develop into a tourist recreational area
alternative two (value-added re-import logistics center): develop into a value-added re-import logistics center
alternative three (naval harbor+ shipyard): develop into a naval harbor while maintaining existing shipyard for military purpose
alternative four (container): develop into a container harbor
alternative five (shipyard): maintain existing shipyard without redevelopment
alternative six (naval harbor): develop into a naval harbor

In a bid to optimize the overall efficiency in favor of this harbor, the harbor authority has given overall consideration to these alternatives, and subsequently decided to focus on improving the overall competitiveness of Keelung Harbor and optimal utilization of Heping Harbor Zone. After the case study by experts and questionnaire investigation, it has decided to set its major objective of “improving overall competitiveness of Keelung Harbor and optimal utilization of Heping Harbor Zone“, and taken into account of the following factors, i.e. 1. regional and transportation feasibility, 2. economic and financial feasibility, 3. public interest compliance, 4. impact of environment, 5. policy and implementation feasibility, 6. performance of national defense. Furthermore, the harbor authority has finalized 18 evaluation criteria (12 qualitative criteria and 6 quantitative criteria), i.e. (1) convenience of external transportation, (2) room of requirement, (3) geographical location, (4) financial feasibility, (5) how to improve operation competitive edge of Keelung Harbor, (6) how to boost the integration efficiency of harbor and city, (7) governmental policies and development trend, (8)how to stimulate industrial development and job opportunities, (9) noise and air pollution, (10) impact upon ecology and scenery, (11) compatibility to cultural and historical relics, (12) difficulty of engineering technologies, (13) public willingness and cooperation, (14) coordination with relevant units, (15) feasibility of law compliance, (16) how to ensure overall safety of the harbor, (17) overall performance of combat capability, (18) how to ensure the safety of naval ships. The hierarchy of above-specified objectives and alternatives are shown in Fig.1.

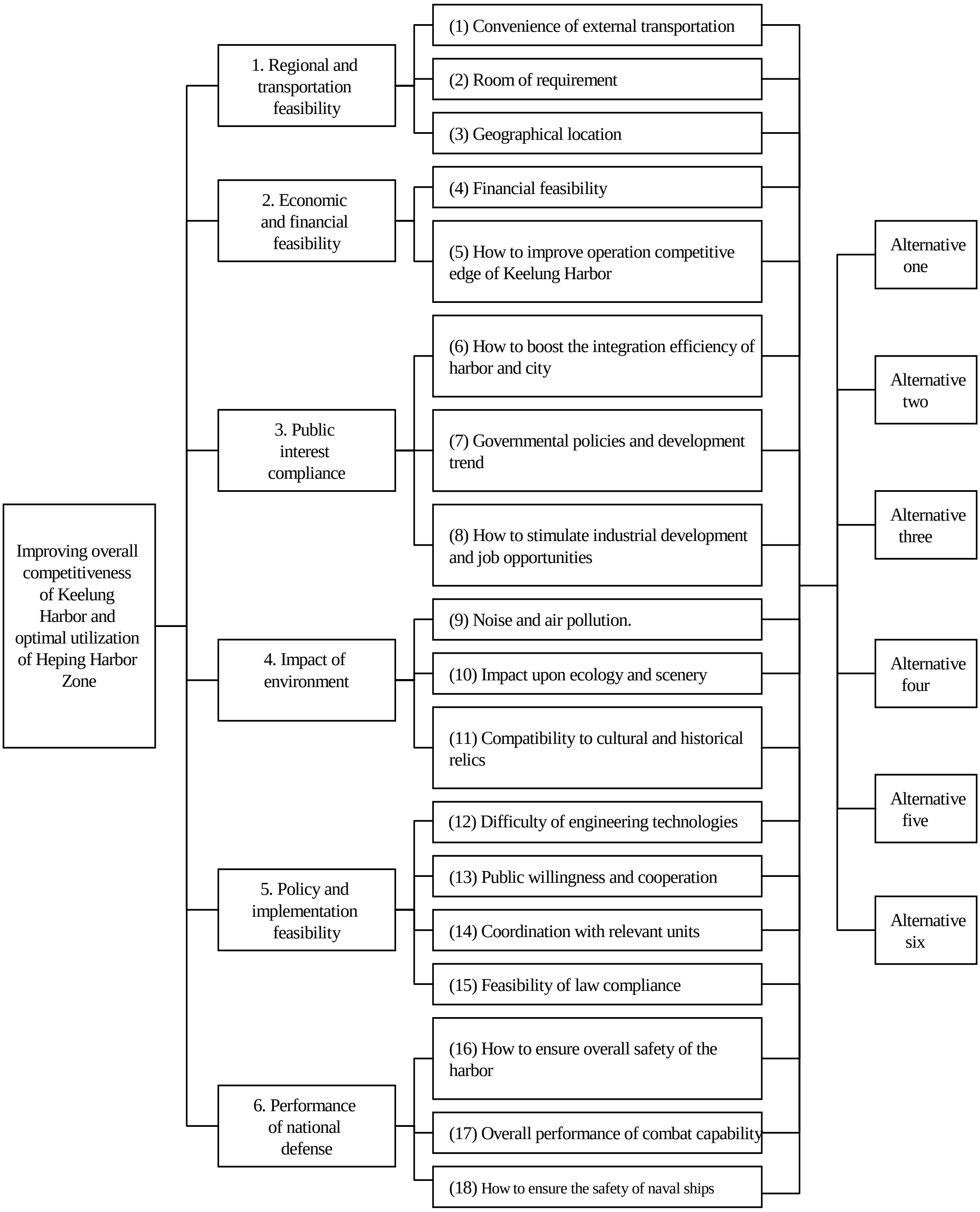

Figure 1: Hierarchy of Objectives and alternatives

The data of original performance values etc obtained in this case study are listed in Table 2 to Table 7:

Table 2: Data Sheet of Original Performance Value

Original Performance		c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
	a1	6	69.9	7	149	9	6	49.1	300	8	8	9	6	95.4	9	80.1	2	2	2
	a2	7	89.9	8	8	9	7	50.1	280	8	4	5	6	34.3	8	59.9	4	4	4
	a3	6	70.1	6	143	5	5	59.5	220	7	6	5	6	40.2	8	90.1	10	10	10
	a4	7	89.9	7	60	7	6	49.8	245	8	8	5	7	29.8	7	58.9	3	3	3
	a5	8	99.9	6	64	4	4	39.7	220	6	4	7	7	45.6	9	99.8	5	6	6
	a6	8	99.9	6	80	6	3	40.2	230	8	5	5	9	60.8	8	89.5	10	10	10

Table 3: Data Sheet of Normalization Performance Value

Normalization Performance		c1	c2	c3	c4	c5	c6	c7	c8	c9	c10	c11	c12	c13	c14	c15	c16	c17	c18
	a1	0.14	0.14	0.18	0.30	0.23	0.19	0.17	0.20	0.18	0.23	0.25	0.15	0.31	0.18	0.17	0.06	0.06	0.06
	a2	0.17	0.17	0.20	0.02	0.23	0.23	0.17	0.19	0.18	0.11	0.14	0.15	0.11	0.16	0.13	0.12	0.11	0.11
	a3	0.14	0.14	0.15	0.28	0.13	0.16	0.21	0.15	0.16	0.17	0.14	0.15	0.13	0.16	0.19	0.29	0.29	0.29
	a4	0.17	0.17	0.18	0.12	0.18	0.19	0.17	0.16	0.18	0.23	0.14	0.17	0.10	0.14	0.12	0.09	0.09	0.09
	a5	0.19	0.19	0.15	0.13	0.10	0.13	0.14	0.15	0.13	0.11	0.19	0.17	0.15	0.18	0.21	0.15	0.17	0.17
	a6	0.19	0.19	0.15	0.16	0.15	0.10	0.14	0.15	0.18	0.14	0.14	0.22	0.20	0.16	0.19	0.29	0.29	0.29

Table 4: Data Sheet of Criteria Weights

W	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	w11	w12	w13	w14	w15	w16	w17	w18
weight=	0.04	0.04	0.06	0.02	0.21	0.03	0.03	0.10	0.02	0.12	0.18	0.01	0.02	0.04	0.02	0.02	0.02	0.02

Table 5: Data Sheet of Concordance Index

Concordance Index		a1	a2	a3	a4	a5	a6
	a1	-	0.509	0.805	0.583	0.802	0.818
	a2	0.258	-	0.492	0.572	0.452	0.432
	a3	0.15	0.289	-	0.194	0.5	0.234
	a4	0.178	0.163	0.634	-	0.583	0.563
	a5	0.165	0.42	0.338	0.409	-	0.26
	a6	0.165	0.34	0.435	0.245	0.608	-

Abbreviations A.V.M.D.P. and A.V.S.D.P. represent the benchmarks “absolute value of the maximum differentiated performance” and “absolute value of the sum of differentiated performance.

Table 6: Data Sheet of Discordance Index of the Absolute Value of the Maximum Differentiation Performance

A.V.M.D.P. Discordance Index		a1	a2	a3	a4	a5	a6
	a1	-	0.059	0.235	0.038	0.114	0.235
	a2	0.28	-	0.268	0.114	0.111	0.177
	a3	0.18	0.1	-	0.057	0.057	0.073
	a4	0.214	0.05	0.206	-	0.086	0.206
	a5	0.169	0.125	0.157	0.114	-	0.147
	a6	0.137	0.129	0.125	0.097	0.056	-

Table 7: Data Sheet of Discordance Index of the Absolute Value of the Sum of Differentiated Performance:

A.V.S.D.P. Discordance Index		a1	a2	a3	a4	a5	a6
	a1	-	0.296	0.75	0.176	0.488	0.891
	a2	0.781	-	0.959	0.242	0.519	0.955
	a3	0.614	0.339	-	0.29	0.243	0.277
	a4	0.674	0.255	0.924	-	0.515	0.923
	a5	0.846	0.392	0.738	0.375	-	0.637
	a6	0.742	0.322	0.286	0.276	0.13	-

Additionally, the relevant parameters in this paper include:
To achieve the same base for comparative purpose, the preference of decision maker on each criterion is set to 1. In other words, θ_j=1 (since the performance after normalization is less than 1, the denominator of $d_j(h,k)$ is guaranteed to be 1 after screened with $\max_{j \in I^-}\left(g_j(A_h), \theta_j\right)$.

p^-=0.5 p^0=0.55 p^*=0.6

q^0 (discordance index threshold value)=0.15

Additionally, q^* (discordance index threshold value) = 0.20, 0.25, 0.30, 0.35, 0.40 is applied for comparative analysis of sensitivity

Table 8: Data Sheet of Final Ranking of Alternatives

		A.V.M.D.P.	A.V.S.D.P.
q^*=0.20	V'	1,3,6—2—4—5	1,2,3,6—4,5
	V''	1—2—4,6—3,5	1,6—2,3,4,5
	$\overline{V}$	1—2,6—3—4—5	1,6—2,3—4,5
q^*=0.25	V'	1—2—4—3,6—5	1,2,3,6—4,5
	V''	1—2—4—6—3,5	1,2,6—3,4,5
	$\overline{V}$	1—2—4—6—3—5	1,2,6—3—4,5
q^*=0.30	V'	1—2—4—3,6—5	1,3,6—2,5—4
	V''	1—2—4—6—3,5	1—2,6—3,4,5
	$\overline{V}$	1—2—4—6—3—5	1—6—2,3—5—4
q^*=0.35	V'	1—2—4—3,6—5	1,3,6—2,5—4
	V''	1—2—4—6—3,5	1—2,6—3,4,5
	$\overline{V}$	1—2—4—6—3—5	1—6—2,3—5—4
q^*=0.40	V'	1—2—4—3,6—5	1,3,6—2,5—4
	V''	1—2—4—6—3,5	1—2,6—3,4,5
	$\overline{V}$	1—2—4—6—3—5	1—6—2,3—5—4

V' represents a strong ranking, V'' a weak ranking and $\overline{V}$ by final ranking. As shown in the raking example 1,3,6—2—4—5 alternatives 1,3,6 is placed at the first sequential ranking, alternative 2 at the second, alternative 4 at the third, alternative 5 at the fourth. Thus, the above table shows various ranking result possibilities for alternatives under different threshold values of q^*.

The result shows that alternative 1 is the priority alternative as the discordance index evaluation benchmark for both A.V.M.D.P. and A.V.S.D.P. However, when the decision maker prefers to have more than one alternative to be taken into consideration, the alternatives after the first one vary greatly. Take the second "best" one in sequence as an example: given an A.V.M.D.P. of $q^* \geq 0.25$, alternative 2 is the only choice; given an A.V.S.D.P. of $q^* \geq 0.30$, alternative 6 is the only choice. Take the third one in sequence for example: given an A.V.M.D.P. of $q^* \geq 0.25$, alternative 4 is the best choice; given an A.V.S.D.P. of $q^* \geq 0.20$, alternative 4 is the worse alternative. The two evaluation benchmarks reflect different decision maker judgment and needs criteria. Therefore, if decision makers choose the discrepancy of overall criteria as the screening benchmark for evaluation alternatives, and the A.V.M.D.P. evaluation benchmark is still used, the screening results would lead to serious errors.

6. CONCLUSIONS AND SUGGESTIONS

How to select an appropriate evaluation model is a popular topic in this field. The evaluation method is widely used after being integrated with fuzzy concept and has achieved positive and beneficial results. This study analyzed the possible effect triggered by the absolute value of the maximum differentiated performance and the absolute value of the sum of differentiated performance under two discordance index evaluation standards, in order to stress the importance of understanding decision maker needs and selecting an appropriate evaluation method. To facilitate more accurate use of LECTRE evaluation method, the following conclusions and suggestions are proposed for reference for future researches.

6.1 Conclusions:

1. During the application of ELECTRE evaluation method, due attentions shall be paid to change the evaluation benchmark if practicable; Not doing so may cause the selected alternatives to run counter to practical demands.

2. It is required to duly change the concept of evaluation benchmark if practicable, which shall be incorporated into other ELECTRE evaluation methods.

3. In terms of evaluation criteria, the absolute value of the maximum differentiated performance used as the discordance index in this study is suited for focusing on discrepancies in important single criteria. The absolute value of the sum of differentiated performance is suited to highlight discrepancies within the overall criteria.

4. If the evaluation method is used concurrently with the fuzzy concept. The designed fuzzy membership function will influence evaluation results. Therefore, the fuzzy membership function may be properly designed if needed.

6.2 Suggestions:

1. The definition and calculation benchmarks of concordance index and discordance index are important elements underlying this evaluation method. Meanwhile, many scholars have made relevant studies from different perspectives in order to provide more rational utilization of ELECTRE evaluation method. So, it is recommended that this topic be the subject of investigation in future research.

2. ELECTRE evaluation method can be applied in parallel with other evaluation methods owing to getting only partial ranking. However, it requires closer attention to the advantages and disadvantages of the combination of various evaluation methods, as well as their differences.

3. As the weightings used in ELECTRE evaluation method is usually obtained beforehand, the calculation method used to determine weightings exerts great impact upon the final ranking. Therefore, particular attention shall be placed on weighting methodology when using ELECTRE evaluation method.

4. Appling ELECTRE evaluation method in concert with fuzzy concept permits greater research depth. This suggests the need for additional research into how to use fuzzy

concept to resolve possible disadvantages associated with the original non-fuzzy evaluation method.

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