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Using the AHP-ELECTREIII integrated method in a competitive profile matrix

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Abstract. In this paper, the competitive profile matrix (CPM) method, which identifies firm's major competitors and its particular strengths and weaknesses in relation to a sample firm's strategic position, is adopted by the concept Multiple-Attribute Decision Making (MADM).Hence, an integrated approach which employs analytic hierarchy process (AHP) and ELECTREIII together, is proposed for the CPM method. The AHP method is used to determine the weights of factors and while ECTREIII is employed to determine the priorities of the competitors. ELECTREIII method takesinto defining of indifference, preference and veto threshold for the factors, determinedby the decision-makers.

Keywords:ELECTREIII, AHP,Competitive Profile Matrix

1. Introduction

If an enterprise wants to stand up in fierce market competition, should useStrategic management. The strategicmanagement process consists of three stages: strategy formulation, strategy implementation, and strategy evaluation [6].

"The competitive profile matrix (CPM) identifies firm's major competitors and its particular strengths and weaknesses in relation to a sample firm's strategic position"[5].A CPM creates a powerful visual catch point, it conveys information regarding your competitive advantage and basis for your company's strategic and is a useful tool to communicate those attribute and show how the competition is addressing them [2].

Unfortunately, any attention hasn't been given obviously in literature for application of multi criteria decision making (MADM) in CPM problem. But some studies in literature have that discussed about methods of quantified analysis in strategic management.Garfiet al proposed Multi-criteria analysis (MCA) tools for using in strategic environmental assessment (SEA) procedures. In this study is used AHP for the comparison of alternatives and monitoring[7].

A review of the related literature also indicates that most attentions have been given to application quantitative and decision analysis methods in SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. [10]used Analytic Hierarchy Process (AHP) to determined priorities for the factors included in SWOT analysis and AHP with SWOT have been integrated to improve the quantitative information basis of strategic planning process. [5]Presented a quantified SWOT analytical method that uses a multi-layer scheme to simplify complicated problems.

In CPM method following shortcomings is inevitable: (1) the rating for key factors measured subjectively and assigns numbers between 1 and 4. (2) Non-uniformity may occur when the key factors' weights are assigning subjectively by the evaluation group without a consistency test [4].[2] Avoiding assigning duplicate rating on any row in a CPM method.According to its above-mentioned structure, an AHP-ELECTREII aggregated method provide to improving the usability CPM analysis. In this paper, the AHP method is used to analyze the structure of the CPM method and determine the weights of factors and while ECTREIII is employed to determine the priorities of the competitors. The weights obtained from AHP are included in CPM methods by using them in ELECTREIII computations and the competitors' priorities.

This paper is divided into four sections. In Section "Principles of AHP and ELECTREIII methods" briefly describes the two proposed methodologies. In Section "Proposed AHP-ELECTREIII integrated approach", proposedAHP–ELECTREIII integrated approach for CPM method is presented and the stages of the proposed approach and steps are determined in detail.. In Section "Conclusions and future research", conclusions and future research areas are discussed.

2. Method

2.1. The AHP method

The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities. In the literature, AHP has been widely used in solving many complicated decision-making problems[3].

The first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex MCDM problem into a hierarchy of interrelatedcriteria and decision alternatives. With the AHP,in a hierarchical structure, the objectives, criteria and alternatives are arranged similar to a family tree. A hierarchy has at least three levels: in the top level is placed overall goal of the problem, multiple criteria that define alternatives in the middle, and in the bottom level is placed decision alternatives [1].

Let C = {Cj | j = 1, 2, . . . , n} be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in an (n × n) evaluation matrix A in which every element aij(i, j = 1, 2, . . . , n) is the quotient of weights of the criteria, as shown in Eq. 1:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}, \quad a_{ii} = 1, a_{ji} = {}^{1}/_{a_{ij}}\ , a_{ij} \neq 0 \qquad (1)$$

At the last step, each matrix is normalized and be found the relative weights. The relative weights are given by the right eigenvector (w) corresponding to the largest eigenvalue (λ max), as:

$$\mathrm{A_w} = \lambda_{\mathrm{max}}\mathrm{w} \qquad (2)$$

If the pairwise comparisons are completely consistent, the matrix A has rank 1 and$\lambda_{\mathrm{max}} = 1$. In this case, weights can be obtained by normalizing any of the rows or columns of A[13].

It should be noted that theconsistency of the pairwise comparison judgments is shows quality of the output of the AHP. The consistency is defined by the relation between the entries of A: $\mathrm{a_{ij}} \times \mathrm{a_{jk}} = \mathrm{a_{ik}}$. The consistency index (CI) is

$$\mathrm{CI} = ((\lambda\_\mathrm{max} - \mathrm{n})) \;/\; ((\mathrm{n} - 1)\;) \qquad (3)$$

Using the final consistency ratio (CR) can conclude whether the evaluations are sufficiently consistent. The CR is calculated as the ratio of the CI and the random index (RI), as indicated in Eq. 4.

$$\mathrm{CR} = \mathrm{CI} \;/\; \mathrm{RI} \qquad (4)$$

The number 0.1 is the accepted upper limit for CR. If the final consistency ratio exceeds this value, the evaluation procedure has to be repeated to improve consistency.

2.2. The ELECTRE III method

The ELECTRE III method is based on two phases. First, Construction of the outranking relation between pairs of alternatives. This results in an outranking matrix. The second phase consists producing a partial pre-orderbased onoutranking relation, [7].

2.2.1. Concordance and discordance indexes

In concordance index(Eq. (8))if C equal 1 indicates the full strengthof the assertion and C=0 indicate the assertion is false. Likewise,indiscordance index (Eq.(10)) if $\mathrm{Z_i(B)} - \mathrm{Z_i(A)}$, foreach criterion i, is higher than the vote threshold $\mathrm{v_i}$, it is indicates A can't outrank B. The concordance and discordance indices for each criterion i are defined following as, respectively:

$$C(A,B) = \sum_{i=1}^{n} W_i C_i(A,B) \qquad (8)$$

$$C_i(A,B) = \begin{cases} 1 & \text{if } Z_i(B) - Z_i(A) \le q_i \\ \frac{P_i(Z_i(A)) + Z_i(A) - Z_i(B)}{P_i(Z_i(A)) - q_i(Z_i(B))} & \text{if} q_i < Z_i(B) - Z_i(A) < p_i \\ 0 & \text{if } Z_i(B) - Z_i(A) \ge p_i \end{cases} \qquad (9)$$

$$D_i(A,B) = \begin{cases} 0 & \text{if } Z_i(B) - Z_i(A) \le P_i \\ \frac{Z_i(B) - [Z_i(A) + p_i]}{v_i - p_i} & \text{if } P_i < Z_i(B) - Z_i(A) < v_i \\ 1 & \text{if } Z_i(B) - Z_i(A) \ge v_i \end{cases} \qquad (10)$$

Here,

W_i: weight of the criterion i

n: number of criteria

$z_i(X)$: Performances of the alternative X as regards to the criterion i

q_i: Indifference threshold for the criterion i

p_i: Preference threshold of the alternative on the criterion i

Then calculation the concordance (Eq. (8)) and discordance indices (Eq. (10)), the degree of credibility (Eq. (11)) is provided and according to that indicates whether the outranking hypothesis is true or not.

$$S(A,B) = \begin{cases} C(A,B) & \text{if} D_i(A,B) \le C(A,B) \forall i \\ C(A,B).\Pi_{i \in J(A,B)} \frac{(1 - D_i(A,B))}{(1 - C(A,B))} & \text{otherwise} \end{cases} \qquad (11)$$

Where J (A, B) is the set of criteria for which$D_i(A,B) > C(A,B)$.

Then, the degrees of credibility are gathered in a credibility matrix[9].

2.2.2. Distillation procedures

This algorithm for ranking all alternativesyields two pre-orders. The first pre-order is obtainedwith a descending distillation and second is obtained with an ascending distillation. In ascending distillation, selecting the worst-rated alternatives initially and finishingwith the best. The seconddistillation uses the same process but on the original set of alternativesselecting first the best rated options, and finishing with the assignment of the worst (descending distillation).

For the distillation, the condition needed to state that an alternative Ais preferred toB is defined as follow: an alternativeA is preferred toB if thedegree of credibility of “A outranks B” is higher than a threshold $\lambda_2$andsignificantly higher than the degree of credibility “B outranks A” (Eq. (12)).

$$S(A,B) > \lambda_2 \text{ AND } S(A,B) - S(B,A) > S(\lambda_0) (12)$$

Where λ_2 is the largest credibility index, which is just below the cutofflevel λ_1 as follows:

$$\lambda_2 = \max_{\{S(A,B) \le \lambda_1\}} S(A,B) \qquad \forall \{A,B\} \in G \qquad (13)$$

where G is the set of alternatives. λ_1 is the following cut-off level:

$$\lambda_1 = \lambda_0 - s(\lambda_0) (14)$$

Where λ_0 is the highest degree of credibility in the following credibilitymatrix:

$$\lambda_0 = \max_{A,B \in G} S(A,B) \qquad (15)$$

And $s(\lambda_0)$ is the following discrimination threshold[11]:

$$(\lambda_0) = \alpha + \beta.\lambda_0 (16)$$

We use α=0.3 and β=−0.15 because the two values are recommendedvalues from[12].

In each sub-set, When B outranks A, B and A is given the score +1 and -1, respectively. For each alternative, to give the final qualification score, the individual strengths and weakness are summed together [11].

2.2.3. Final ranking

The final ranking is obtained through the combination of the two pre-orders and ranking matrix. There are four possible cases:

I. If A outranks B in both distillations or A outranks B in one distillation and has the same ranking in the other distillation then A is better strategic position than B: A P+ B.

II. If outranks B in one distillation but B outranks A in the other distillation then point of view strategic position, A is incomparable to B: A R B.

III. If in both distillations, A and B has the same ranking then A and B have same strategic position: A I B.

IV. If Boutranks A in both distillations or Boutranks Ain one distillation and has the same rank in the other distillation then A is worst strategic position than B: A P− B.

The final ranking is obtained by adding the number of P+.

3. Proposed AHP-ELECTREIII integrated approach

The proposed model for the CPM problem, the integrated approach composed of AHP and ELECTRE III methods consist of three basic stage: (1) Data gathering, (2) AHP computations, (3) evaluation of firm's competitors with ELECTRE III and determination of the final rank. In the first stage, alternative firm's major competitors and the critical success factors which will be used in their evaluation are determined and approved by decision-making team.

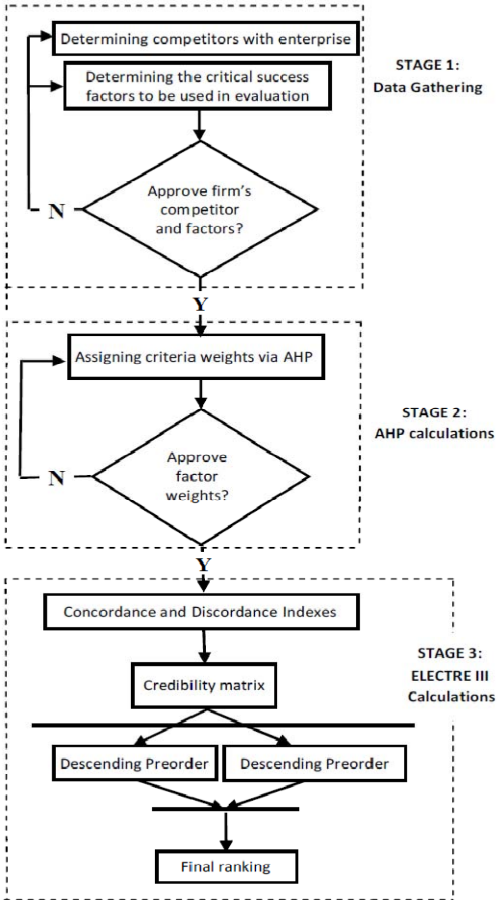

Fig. 1 Schematic representation of the process proposed for aircraft engine selection

After the approval of competitors and factors, factors used in CPM problem are assigned weights using AHP in the second stage. In this phase, pairwise comparison matrices are formed to determine the criteria weights. To determine the values of the elements of pairwise comparison matrices, the each expert from decision-making team make individual evaluations. Computing the geometric mean of the values obtained from individual evaluations, a final pairwise comparison matrix on which there is a consensus is found. The weights of the critical success factors are calculated based on this final comparison matrix. In the last step of this phase, calculated weights of the factors are approved bydecision making team.Ranking firms are determined by using ELECTRE III method in the third stage. Firstly, firms are pairwise compared (A, B).in this step, the concordance and discordance indexes for all of pairwise firms is calculated. After calculation of concordance and discordance indexes, the degrees of credibility are constructed and gathered in the credibility matrix. In the second step, from the credibility matrix, descending and ascending distillation pre-orders are obtained that be used to rank the firms. In the last step, the final ranking is obtained through the combination of the two pre-orders. The results from the partial pre-orders are aggregated into the ranking matrix. Schematic representation of the proposed approach is presented in Fig. 1.

4. Conclusion

In this paper, a decision approach is provided for competitive profileproblem.ELECTREIII and AHP compound decision making methods have been used in proposed approach. With its above-mentioned structure, little attention has been given to the use of these methods as an integrated approach and the proposed approach differs from the present literature. AHP is used to assign weights to the factor to be used in CPM, while ECTREIII is employed to determine the priorities of the alternatives. The weights obtained from AHP are included in competitive profileprocess by using them in ELECTREIII computations and the competitors priorities are determined based on these weights.

The strengths of this approach over the existing methodscan be explained as follows. ELECTREIII method takesinto defining of indifference, preference andveto threshold for the factors, determinedby the decision-makers.

5. References

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