Decision Making for Company Acquisition by ELECTRE Method

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***Abstract*— Growth in economy together with globalization makes global companies and investment holdings more active in international markets. This activity involves a certain level of risk as payback period of investments are very critical and correct decision on selection of companies to be invested determines success of top management of investors and also creditors. As management requires solid techniques and methods for selection of correct candidate to be invested, application of decision making methods will contribute to this process and reduce the possibility of wrong investments. In this article an investment group's local acquisition opportunities are evaluated by ELECTRE (Elimination et choix traduisant la realite) method. In this case there are four alternatives that are accepting same price and other contractual requirements. This paper lists six important criteria that have influence on local acquisition alternatives' selection in Turkey according to references: Financial performance, accreditations and authorizations, Administrative and accounting, technical infrastructure, staff expertise and experience, customer portfolio. AHP (Analytical Hierarchy Process) have been used to evaluate the criteria and then ELECTRE method is used for ranking the alternatives.**

Keywords*—Company Acquisition, AHP, ELECTRE*

1. Introduction

Decision making is always critical for managers when leading their organizations. During decision making process there are a lot of constraints to be considered which may sometimes conflict each other. Process of decision making covers broad perspective to take into account, costs, benefits, long and midterm results, investments etc. In this aspect criteria are in our hand and decision making process becomes a Multicriteria Decision Making Process.

Global economy forces companies for organic growth by their daily activities and investment on their current work. However one of the other opportunities for growth is acquisition of other companies in the same or similar field of activity. These acquisitions transfer assets as well as significant customer portfolios at once to the new owner and mostly a win-win situation. Global company provides know-how, capital, international network and new business areas whereas acquired company brings local access to clients, flexibility and information about local legal procedures and business practices. Foreign direct investment in this perspective also a win for the local economy and is a good opportunity for capital and technical know-how transfer to local market. It is acceptable that all these above benefits is only possible with a correct match of both parties which requires correct decision making. This decision making process depends on facts and objective criteria. This objectivity is also required for creditors, which is one of the important stakeholders.

Experts have made various researches on this issue and have established many models for effective decision making. Below are some methods briefly explained:

Analytic hierarchy process (AHP) is a technique for analysing complex decisions, based on mathematics and psychology [1]. AHP is a multicriteria decision making technique that can help express the general decision operation by decomposing a complicated problem into a multilevel hierarchical structure of objective, evaluation criteria and decision alternatives [2]. AHP performs pairwise comparisons to derive relative importance of the variable in each level of

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the hierarchy and / or appraises the alternatives in the lowest level of the hierarchy in order to make the best decision among alternatives. AHP is a effective decision making method especially when subjectivity exists and it is very suitable to solve problems where the decision criteria can be organized in a hierarchical way into sub-criteria [3, 4]

The VIKOR method is a originally developed by Serafim Opricovic to solve decision making problems with conflicting criteria, assuming that compromise is acceptable for resolution, the decision maker wants a solution that is the closest to the ideal, and the alternatives are evaluated according to all established criteria. VIKOR sorts alternatives and determines the solution named compromise that is the closest to the ideal [5].

The preference ranking organization method for enrichment of evaluations and its descriptive complement geometrical analysis for interactive aid are better known as the PROMETHEE and GAIA methods. Based on mathematics and sociology, the PROMETHEE and GAIA method was developed at the beginning of the 1980s and has been extensively studied since then. It has particular application in decision making, and is used around the world in a wide variety of decision scenarios, in fields such as management, supply chain and healthcare [6, 7].

ELECTRE method is the core of this article and origins of ELECTRE methods go back to 1965 at the European consultancy company SEMA. At that time, a research team from SEMA worked on a concrete, multicriteria, real-world problem regarding decisions dealing with the development of new activities in companies [8, 9].

ELECTRE method is developed as a result of Bernard Roy's decision making works in 1968 ELECTRE stands for "ELimination Et Choix Traduisant la Realite. ELECTRE method is converting a quantitative solution to more verbal result. ELECTRE depends on comparision of pairs in set of alternatives[10].

This study proposes a combined MCDM framework for a Company Acquisition problem. AHP method is used to weighting of decision criteria and ELECTRE is applied to determine the best alternative for investment.

Studies related to the ELECTRE method are available in the literature. In the study of Karacasu and Yayla [11], ELECTRE is used as a decision making model for evaluation of transportation investments for urban city transport. ELECTRE method is applied by Norese [12] to localisation of waste-treatment plants. This approach is used by Bari and Leung [13] to network selection in a heterogeneous wireless network environment. Company location criteria have been evaluated by the ELECTRE method using in determining optimal location choice. ELECTRE is considered as a tool for shipping company. By means of these analyses, the location of the new branch of the shipping company was determined in the study of Yücel and Ulutaş [14].

Afshari et al. [15] consider a real application of personnel selection with using the opinion of experts by one of the group decision making model, ELECTRE method. Study has applied seven criteria for choosing the suitable one amongst five personnel and also ranking them. Computer systems are selected by ELECTRE and Fuzzy AHP methods in the study Ertuğrul and Karakaşoğlu [10].

Rouyendegh and Erol [16] studied ELECTRE method by fuzzy numbers to select the best project among alternatives. ELECTRE is used for determination of the optimal location among three location alternatives for a textile company to be established in Turkey [17]. Chatterjee et al. [18] present a comprehensive solution to automated inspection device selection problems using ELECTRE method.

2. AHP Method

The AHP is an effective decision making method to solve multi-dimensional and complex problems. AHP performs pairwise comparison matrices to decompose and solve a multiple criteria decision making problems with different and conflicting criteria. AHP method is based on three main principles: structure of the model; comparative judgment of the criteria and/or alternatives; synthesis of the priorities [19].

Steps of the AHP method as follows [20, 21, 22]:

Step 1: Developing the hierarchical structure.

A decision problem is structured as a hierarchy.

With the AHP, the goal, decision criteria and alternatives are arranged in a hierarchical structure similar to a family tree [23, 24].

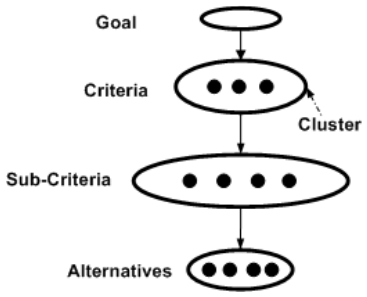

Figure 1. Hierarchical structure of AHP

Step 2: Perform the pairwise comparisons.

In this step, comparison matrices are formed and pairwise comparisons are conducted. Decision criteria are compared in the corresponding level using fundamental comparison scale. The table below shows the comparison scale used by AHP.

Table 1. The fundamental scale for pairwise comparison

Intensity of importance	Explanation
1	Two activities or criteria contribute equally to the objective
3	Experience and judgement slightly favor one over another
5	Experience and judgment strongly favor one over another
7	An activity or criteria is strongly favored and its dominance is demonstrated in practice
9	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	When compromise is needed

This pairwise comparison can be shown by a square and reciprocal matrix, (see Eq. (1)). The result of the pairwise comparison on *n* criteria can be summarized in an (*n* x *n*) evaluation matrix.

$$A=\left(a_{ij}\right)_{nxn}=\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ a_{n1} & a_{n2} & . & a_{nn} \end{bmatrix} \quad (1)$$

Step 3: Calculating the relative importance weights.

In the last step, each matrix is normalized and perform calculations to check consistency. Via normalization, the normalized weight vectors and priority of criteria can be obtained.

The number 0.1 is the accepted upper limit for consistency ratio (CR) [25]. The CR is calculated as the ratio of the consistency index (CI) and the random index (RI). The CI and CR can be computed with the use of following equations:

$$CI=\frac{\lambda_{\max}-n}{n-1} \quad (2)$$

$$CR=\frac{CI}{RI} \quad (3)$$

Table 2. Random index [20]

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
R	0.0	0.0	0.5	0.9	1.1	1.2	1.3	1.4

3. ELECTRE Method

The ELimination Et Choix Traduisant la REalit´e (elimination and choice expressing reality) methods, abbreviated to as ELECTRE, belong to the outranking methods [26]. Steps of ELECTRE method are given below [27, 28, 29, 30, 31]:

Step 1: Preparation of Decision Matrix

In decision matrix columns will give you the criteria (n) and rows will state the alternatives (m). This will be standard matrix for determining the grounds of the process.

$$A_{ij}=\begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} \quad (4)$$

Step 2: Calculation of the normalized decision matrix

Decision matrix will be normalized by below formula and will give us normalized decision matrix

$$x_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{n} r_{ij}^{2}}} \qquad i = 1,2,\ldots\ldots m \quad j = 1,2,\ldots\ldots n \tag{5}$$

for cost parameters other than benefit following formula is used

$$x_{ij} = \frac{\frac{1}{r_{ij}}}{\sqrt{\sum_{i=1}^{m}\left(\frac{1}{r_{ij}}\right)^{2}}} \qquad i = 1,2,\ldots\ldots m \quad j = 1,2,\ldots\ldots n \tag{6}$$

Based on this calculation normalized decision matrix (X) is given as;

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1n} \\ x_{21} & x_{22} & \ldots & x_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix} \tag{7}$$

Step 3: Calculate the weighted normalized decision matrix

Weight determined by AHP process above will be multiplied by the normalized matrix and weighted normalized matrix is now available.

$$v_{ij} = w_j . x_{ij} \tag{8}$$

As it can be seen, the matrix W is a diagonal matrix which values of its main diameter is W and rest values are zero.

$$W = \begin{bmatrix} w_1 & \ldots & 0 \\ \vdots & w_2 & \ldots \\ 0 & \ldots & w_n \end{bmatrix} \tag{9}$$

Step 4: Determine the concordance and discordance sets

Net weighted normalized matrix data is compared for every pair and results are evaluated as below: If alternative is better than or equal to other element of pair it is considered under concordance set and defined by C.

$$C(p,q) = \{j, \quad v_{pj} \geq v_{qj}\} \tag{10}$$

If alternative is worse than the other element of the pair for relevant criteria it is considered under discordance set and defined by D

$$D(p,q) = \{j, \quad v_{pj} < v_{qj}\} \tag{11}$$

Step 5: Calculate the concordance matrix

Concordance matrix is the matrix generated by adding the values of weights of Concordance set elements.

$$C_{pq} = \sum_{j^*} w_{j^*} \tag{12}$$

Step 6: Calculate the discordance matrix

Discordance matrix is prepared by dividing discordance set members values to total value of whole set.

$$D_{pq} = \frac{\left(\sum_{j^0} \left| v_{pj^0} - v_{qj^0} \right|\right)}{\left(\sum_{j} \left| v_{pj} - v_{qj} \right|\right)} \tag{13}$$

Step 7: Make calculations of advantage

Averages of concordance and discordance values are taken. In the Concordance matrix any C_{pq} value bigger than or equal to C average it is stated as Yes. In the discordance matrix any value less than or equal to D average is stated as No.

Step 8: Calculate net concordance and discordance matrix

Net concordance and discordance values are calculated to make the ranking amongst alternatives. Not always C and D ranks gives the same in this case you may have more than one best alternatives and should prepare the final rank based on this data.

$$C_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{kp} \quad (14)$$

$$D_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{kp} \quad (15)$$

4. Implementation of Proposed Combined Method

A European investment company will make an acquisition in Turkey. During this acquisition they will be evaluating four companies by following parameters and criteria:

Financial performance: Financial performance of the alternative will be determined based on EBITDA X7 and will be supported by other parameters as goodwill. Other parameters will also consider cash flow, account receivables, account payables, bad debtors etc.

Accreditations and authorizations: Investor company is also in conformity assessment field and accreditation like ISO 17021, ISO 17025, ISO 17020, authorities like notified body status are very important for business continuity.

Accreditations will also provide services to be provided worldwide as they are international recognized.

Administrative and accounting: Administrative issues like internal accounting, third party auditing, tax office relations and any penalties are also considered as criteria. Transparent accounting system is very important for creditors. International financial auditors will be checking the eligibility based on company books.

Technical infrastructure: Company field of service requires laboratory infrastructure, technical equipment like mobile electrical testing, NDT equipment etc. Calibration and maintenance of this laboratories and equipment is an asset.

Staff expertise and experience: Conformity assessment services require experts on various fields and standards. These standards will support the product safety legislation and experts should be available based on education, training and work experience.

Customer portfolio and marketing: Customer portfolio and marketing efforts are important for business continuity. This will support the company after acquisition for smooth transition and improved performance.

4.1 Determination of Criteria Weights by using AHP method

For determination of weights for criteria AHP method is used. The AHP methodology first necessitates the pairwise comparisons of the criteria and the sub-criteria by the decision makers in order to determine their weights. By implementation of this method following weights are determined with respect to criteria.

Table 3. Priority weights of evaluation criteria

Selection Criteria	Weight
Financial performance	0.32
Accreditations and authorizations	0.14
Administrative and accounting	0.05
Technical infrastructure	0.11
Staff expertise and experience	0.10
Customer portfolio and marketing	0.28

4.2 Application of ELECTRE Method

At this step, the ELECTRE method is applied for obtaining the ranking list of company alternatives.

The consensus evaluation values for four alternatives are given in Table 4.

Table 4. Consensus evaluation scores for alternatives

		Alternatives				
Criteria	**Scale**	**A1**	**A2**	**A3**	**A4**	**W**
Financial performance	As it is	1000	1050	950	900	0.32
Accreditations and authorizations	1-10	10	7	8	6	0.14
Administrative and accounting	1-10	6	8	7	9	0.05
Technical infrastructure	1-10	9	7	7	8	0.11
Staff expertise and experience	1-10	8	9	8	7	0.10
Customer portfolio and marketing	As it is	4800	4200	3200	2500	0.28

In the next step; normalized decision matrix and weighted decision matrix are constructed.

Table 5. Normalized Decision Matrix

Criteria	**A1**	**A2**	**A3**	**A4**
Financial performance	0.51	0.54	0.49	0.46
Accreditations and authorizations	0.63	0.44	0.51	0.38
Administrative and accounting	0.40	0.53	0.46	0.59
Technical infrastructure	0.58	0.45	0.45	0.51
Staff expertise and experience	0.50	0.56	0.50	0.44
Customer portfolio and marketing	0.63	0.56	0.42	0.33

Table 6. Weighted Decision Matrix

Criteria	**A1**	**A2**	**A3**	**A4**
Financial performance	0.16	0.17	0.16	0.15
Accreditations and authorizations	0.09	0.06	0.07	0.05
Administrative and accounting	0.02	0.03	0.02	0.03
Technical infrastructure	0.06	0.05	0.05	0.06
Staff expertise and experience	0.05	0.06	0.05	0.04
Customer portfolio and marketing	0.18	0.16	0.12	0.09

With respect to equations 10 and 11, concordance and discordance sets can be ascertained as follows:

Table 7. Concordance and Discordance Sets

C (1,2)	(2,4,6)	**D (1,2)**	(1,3,5)
C (1,3)	(1,2,4,5,6)	**D (1,3)**	(3)
C (1,4)	(1,2,4,5,6)	**D (1,4)**	(3)
C (2,1)	(1,3,5)	**D (2,1)**	(2,4,6)
C (2,3)	(1,3,4,5,6)	**D (2,3)**	(2)
C (2,4)	(1,2,5,6)	**D (2,4)**	(3,4)
C (3,1)	(3,4)	**D (3,1)**	(1,2,5,6)
C (3,2)	(2,4,5)	**D (3,2)**	(1,3,6)
C (3,4)	(1,2,5,6)	**D (3,4)**	(3,4)
C (4,1)	(3)	**D (4,1)**	(1,2,4,5,6)
C (4,2)	(3,4)	**D (4,2)**	(1,2,5,6)
C (4,3)	(3,4)	**D (4,3)**	(1,2,5,6)

Table 8. Concordance and Discordance Indexes

C (1,2)	0.53	**D (1,2)**	0.25
C (1,3)	0.95	**D (1,3)**	0.03
C (1,4)	0.95	**D (1,4)**	0.06
C (2,1)	0.47	**D (2,1)**	0.75
C (2,3)	0.86	**D (2,3)**	0.12
C (2,4)	0.84	**D (2,4)**	0.03
C (3,1)	0.16	**D (3,1)**	0.83
C (3,2)	0.36	**D (3,2)**	0.79
C (3,4)	0.85	**D (3,4)**	0.09
C (4,1)	0.05	**D (4,1)**	0.94
C (4,2)	0.16	**D (4,2)**	0.91
C (4,3)	0.16	**D (4,3)**	0.81
TOTAL C	6.34	**TOTAL D**	5.62
C (Average)	0.53	**D (Average)**	0.47

Comparison table depicted in Table 9.

Table 9. Comparisons

C (p,q)	**C (p,q)≥ C_{ave}**	**D (p,q)**	**D (p,q) ≤ D_{ave}**	**A_p → A_q**
C (1,2)	YES	**D (1,2)**	YES	1→2
C (1,3)	YES	**D (1,3)**	YES	1→3
C (1,4)	YES	**D (1,4)**	YES	1→4
C (2,1)	NO	**D (2,1)**	NO	NO
C (2,3)	YES	**D (2,3)**	YES	2→3
C (2,4)	YES	**D (2,4)**	YES	2→4
C (3,1)	NO	**D (3,1)**	NO	NO
C (3,2)	NO	**D (3,2)**	NO	NO
C (3,4)	YES	**D (3,4)**	YES	3→4
C (4,1)	NO	**D (4,1)**	NO	NO
C (4,2)	NO	**D (4,2)**	NO	NO
C (4,3)	NO	**D (4,3)**	NO	NO
TOTAL C	6.34	**TOTAL D**	5.62	
C (AVE)	0.53	**D (AVE)**	0.47	

5. Results

As seen in Figure 2, Alternative 1 has no incoming arrows and stated to be the best alternative amongst others.

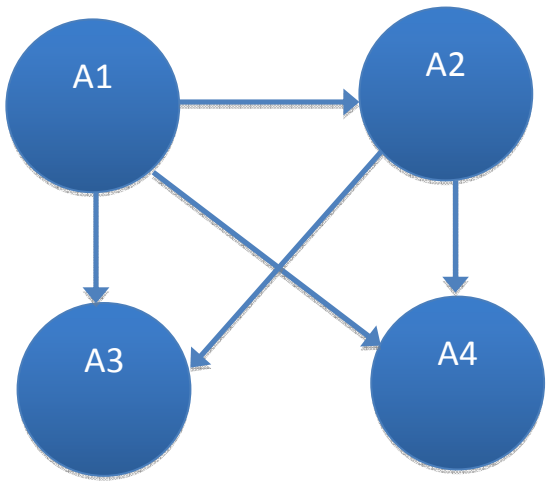

Figure 2. Outranking graph

Final step is calculation of net concordance and discordance matrix to determine ranking amongst alternatives

Sample calculation is given below:

$C_1 = (C_{12}+C_{13}+C_{14}) - (C_{21}+C_{31}+C_{41}) = 1.75$

$D_1 = (D_{12}+D_{13}+D_{14}) - (D_{21}+D_{31}+D_{41}) = -2.18$

By repeating above calculation for all C and D below table is prepared. This table will be sorted from largest to smallest for C and smallest to largest for D and results are given below:

Table 10. C and D Values for Alternatives

		Rank			Rank
C1	1.75	**1**	**D1**	-2.18	**1**
C2	1.12	**2**	**D2**	-1.05	**2**
C3	-0.6	**3**	**D3**	0.75	**3**
C4	-2.27	**4**	**D4**	2.48	**4**

After sorting it is determined that both C and D comparison gives same rank between alternatives. When these ranks are not the same table should be evaluated as required and final rank will be determined. This study hereby states A1 alternative to be selected by international investment group to be acquired in Turkey.

6. Conclusions

Investors do not have many chances to find resources for acquisitions. Responsible team for investment processes is liable to creditors, board of directors, stakeholders of the investor as well as invested company. Correct decision on the investment and perfect fit of the invested company will make all parties comfortable. Using solid methods and decision making tools as presented in this article will provide the correct basis for whole process. Finding correct candidates, shortlisting better fits and final decision making will be much robust with the suggested techniques.

This study proposes a combined MCDM framework for company selection problem. Two MCDM techniques, namely AHP and ELECTRE were combined to evaluate criteria set and alternatives. An empirical case study is also used to exemplify the methodology. Future research could improve the using fuzzy logic framework with different multicriteria decision making methods to more effectively analyze cases having uncertainty.

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