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Multiple Criteria Decision Making on selecting new laminate factory: the case of Turkey

Donošenje odluke o izboru lokacije za novu tvornicu laminata na temelju više kriterija: primjer Turske

Prethodno priopćenje • Preliminary report

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ABSTRACT • Multiple Criteria Decision Making (MCDM) method has used by many decision makers in site selection for many production facilities. This study is indented to demonstrate the application of Electre Technique as an MCDM tool for the selection of decorative laminate factory site. The criteria used to rank alternatives were economic factors including raw material resource, transporting possibilities, market possibilities, operation cost, government policies, establishment cost, suppliers and environmental factors including international economical organizations, military and strategically factors, foreign trade, environmental policy, regional development policy, infrastructure, local service capacity, skilled labor capacity, climatic and natural conditions. The technique was used to select the most suitable factory site among five different alternatives. Corlu was determined as the best place for a new laminate factory site.

Key words: Multiple Criteria Decision Making, Electre Technique, laminate industry, selection of factory site

SAŽETAK • Metoda za donošenje odluke na temelju više kriterija vrlo često se primjenjuje za izbor najboljeg mjesta za gradnju proizvodnih pogona. U ovom se radu obrađuje primjena metode nazvane Electre (Elimination et Choix Traduisant La Realité, opisane u odjeljku Metode), koja služi za donošenje odluke na temelju analize više kriterija o izboru mjesta za gradnju pogona za proizvodnju laminata. Kriteriji primjenjeni za rangiranje mogućih mjesta jesu ekonomski čimbenici koji uključuju sirovinske resurse, transportne mogućnosti, tržišne mogućnosti, operacijske troškove, vladine mjere i poticaje, troškove izgradnje pogona, dobavljače i čimbenike vezane uz zaštitu okoliša, koji uključuju i međuna-rodne ekonomske organizacije, vojne i strateške čimbenike, inozemno tržište, zaštitu okoliša, regionalnu razvojnu aktivnost, infrastrukturu, lokalne uslužne kapacitete, kvalificiranu stručnu radnu snagu, klimatske i prirodne uvjete. Metoda je primjenjena pri izboru najboljeg mjesta za gradnju tvornice od pet mogućih mjesta. Mjesto Corlu određeno je kao najbolje za gradnju tvornice za proizvodnju laminata.

Key words: donošenje odluke na temelju više kriterija, metoda Electre, industrija laminata, izbor mjesta za gradnju tvornice

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1 INTRODUCTION

1 UVOD

Recently decorative laminate production has increased worldwide since the breakthrough of the use of laminated products in wood and furniture industry. One of the advantages of laminate as a synthetic surface covering material is its availability and uniformity in color and design when compared to wood coverings. Nearly half of the laminate manufacturing has been materialized in Europe since 1995. Italy and Germany are the leading countries in the sphere of distribution of laminate manufacturing in Europe with laminate production of 90 and 71 million m², respectively. However, Turkey's laminate production is limited to 4 million m² per year. Since the laminate production in Turkey does not meet the consumers' demands the country imports 7.5 million m² of laminate each year from several countries. The anticipated increase in the import and production stabilization have led laminate materials to become interesting for investments.

The factory site is a geographic location where the companies' main production takes place. For an industrial company, the factory site is supposed to be the most suitable place for carrying out the basic activities like supplying, manufacturing, storing, distributing, as well as for achieving economical aims. In other words, the site is an important factor in manufacturing at the lowest cost and with the highest profit. As shown in Figure 1, the factors affecting the selection of the factory site can be classified into the group: Economical Factors and Environmental Factors (Barutcugil, 1998; Erkut and Baskak, 1997; Ilhan and Burdurlu, 1991; Kobu, 1999).

These factors to be considered in selecting a factory site make the company work properly under certain conditions for a long time. A site that initially seems to be ideal may become inappropriate in time if one or more of the factors are neglected. Since the importance of factors differ from each other and vary from one site to another, the site of each establishment should be evaluated according to its own conditions (Demir and Gumusoglu, 1994; Kurtoglu and Tanritanir, 1991; Kurtoglu and Tanritanir, 1995; Mucuk, 1985; Rockstroh, 1981; Roy, 1968; Tumer, 1978; Tanritanir, 1989).

2 MATERIALS AND METHODS 2 MATERIJALI I METODE

2.1 Materials

2.1 Materijali

In this study, five alternative factory sites for laminate production were evaluated by the Electre Technique. In the determination of the alternative sites, distance to the market, raw material resources and transportation possibilities were considered. The alternative factory sites were weighted and scored by the experts, the staff from a laminate factory, a laminate seller, and the academic staff of Istanbul University.

2.2 Methods 2.2 Metode

There are various application areas in Multiple Criteria Decision Making (MCDM) approach to multiple conflicts. The Electre Technique is one of the methods that converts the qualitative data to quantitative data. The word "Electre" is the acronym for "Elimination et Choix Traduisant La Realité" (Roy, 1968; Turker, 1989; Erkut and Baskak, 1997). This technique can easily be applied to any problem that is national or international with its dynamic characteristics. In order to obtain the best results by this method, the problem should be defined clearly, factors affecting the problem should be determined, and alternatives should be defined by the experts weighting and scoring the factors.

The Electre Technique, similarly as other multiple criteria approaches, follows the steps described below for the solution (Roy, 1968; Durmusoglu, 1994; Erkut and Baskak, 1997; Turker, 1989; Wild, 1987):

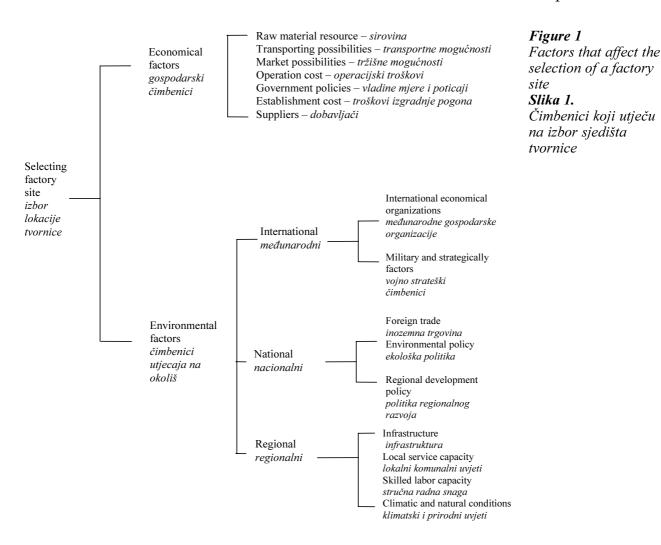
- 1. Defining the alternatives about the problems
- 2. Defining the important factors for the problem
- 3. Evaluating the alternatives due to the factors
- 4. Solution.

3 RESULTS AND DISCUSSION 3 REZULTATI I RASPRAVA

3.1 Definition of the alternatives 3.1 Definicija alternativa

In this study, the sites in Gebze, Corlu, Izmir, Kayesri, and Duzce were deemed to be the best alternatives based on meeting the increasing demands for laminate products.

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3.2 Definition of the factors 3.2 Definicija čimbenika

The factors that affect the selection of the factory site for a laminate factory were defined as follow: Economical Factors, international and regional factors from Environmental Factors (Figure 1). These factors were then subdivided into raw material resources, market possibilities, transporting possibilities, establishment cost, operation cost, government policies, suppliers, infrastructure, public society, skilled labor capacity, energy and pollution.

3.3 Evaluation of the alternatives based on the factors

3.3 Procjena alternativa s obzirom na čimbenike

3.3.1 Weighting the factors 3.3.1 Pridjeljivanje **težina** čimbenicima

One of the crucial points of Electre Technique is weighting the factors. The experts ranked the factors according to their importance by "weighting" each factor. In this study, the weighting values ranged from 1 to 8.

3.3.2 Defining the scales 3.3.2 Definiranje ljestvica

In this step, each factor was scored according to its weight. The critical point during scoring is to keep the class width of the high weight scale wider compared to the low weight scale. The aim of this is to treat the low weighted factor unjustly compared to the high weighted one. The weights and scales of this study are given in Table 1.

3.3.3 Scoring the factors

3.3.3 Bodovanje čimbenika

In this step, the alternatives were scored among each other and defined by concordance and discordance matrixes. The scoring table formed by the experts is given in Table 2. These qualitative scores converted to the quantitative scores by the weights and scales are shown in Table 3.

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Table 1		8	7	6	5	4	3	2	1
Definition of weights	Perfect - savršeno	10.0	9.5	9.0	8.5	8.0	7.5	7.0	6.5
and scales Tablica 1.	Very good – vrlo dobro	9.0	8.6	8.2	7.8	7.4	7.0	6.6	6.2
Definicija težina i	Good – dobro	8.0	7.7	7.4	7.1	6.8	6.5	6.2	5.9
ljestvica	Good enough – dovoljno dobro	7.0	6.8	6.6	6.4	6.2	6.0	5.8	5.6
	Good-average – prosječno dobro	6.0	5.9	5.8	5.7	5.6	5.5	5.4	5.3
	Average – prosječno	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Below average – ispod prosječno	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7
	Almost poor – gotovo slabo	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
	Poor – slabo	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.1
	Very poor – <i>vrlo</i> <i>slabo</i>	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8
	Insignificant – beznačajno	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5

Table 2

The scores given to the alternative factory sites by the experts **Tablica 2.** Bodovi koje su eksperti pridijelili mogućim lokacijama tvornica

	Gebze	Corlu	Izmir	Kayseri	Duzce	Weights
Raw material – sirovina	Very good	Very good	Good	Poor	Good	7
Market – tržište	Good	Good	Good	Very good	Average	8
Transport – transport	Perfect	Very good	Very good	Good	Good	7
Establishment cost – troškovi izgradnje pogona	Good	Very Good	Good	Good	Good	6
Operation cost operacijski troškovi	Good	Very Good	Good enough	Good	Good	6
Government policy – vladine mjere i poticaji	Good	Very Good	Average	Good	Good- average	5
Suppliers – dobavljači	Very good	Very good	Very good	Good	Good	5
Public Society – društvena zajednica	Very good	Very good	Very good	Good enough	Good	2
Climatic condition – klimatski uvjeti	Good	Good	Good	Good	Good enough	6
Infrastructure – infrastruktura	Perfect	Perfect	Perfect	Very good	Good	7
Technological conditions – <i>tehnološki uvjeti</i>	Perfect	Perfect	Very good	Very good	Good enough	4
Skilled labor – stručna radna snaga	Very good	Very good	Very good	Good	Good	3
Energy – energija	Very good	Very good	Very good	Very good	Good	5
Pollution - onečišćenje	Average	Good	Average	Very good	Very good	2
						Total = 73

Perfect - *savršeno*; Very good - *vrlo dobro*; Good - *dobro*; Good enough - *dovoljno dobro*; Goodaverage - *prosječno dobro*; Average - *prosječno*; Below average - *ispod prosječno*; Almost poor *gotovo slabo*; Poor - *slabo*; Very poor - *vrlo slabo*; Insignificant - *beznačajno*

3.3.4 Formation of concordance matrix

3.3.4 Formiranje matrice podudarnosti

Table 4 shows the concordance matrix indicating the dominance of the alternative

factory sites on each other by the help of the scores and weights of the factors. The dominated degrees are counted by comparing the alternative factory sites in pairs and adding the weights of the superior factors and dividing them by the total weight.

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	Gebze	Corlu	Izmir	Kayseri	Duzce	Weights
Raw material – sirovina	8.6	8.6	7.7	2.3	8.0	7
Market – tržište	8.0	8.0	8.0	9.0	5.0	8
Transport – <i>transport</i>	9.5	8.6	8.6	7.7	7.7	7
Establishment cost – troškovi izgradnje pogona	7.4	8.2	7.4	7.4	7.4	6
Operation cost operacijski troškovi	7.4	8.2	6.6	7.4	5.8	6
Government policy – vladine mjere i poticaji	7.1	7.8	5.0	7.1	7.1	5
Suppliers – dobavljači	7.8	7.8	7.8	7.1	7.1	5
Public society – društvena zajednica	6.6	6.6	6.6	5.8	5.8	2
Climatic condition – klimatski uvjeti	7.4	7.4	7.4	7.4	7.4	6
Infrastructure – infrastruktura	9.5	9.5	9.5	8.6	7.7	7
Technological conditions – <i>tehnološki uvjeti</i>	8.0	8.0	7.4	7.4	6.8	4
Skilled labor – stručna radna snaga	7.0	7.0	7.0	6.5	6.5	3
Energy – energija	7.8	7.8	7.8	7.8	7.1	5
Pollution - onečišćenje	5.0	6.2	5.0	6.6	6.6	2

Table 3Conversion ofqualitative scores toquantitative scores byweights and scalesTablica 3.Pretvorbakvalitativnih bodova ukvantitativne spomoću težina iljestvica

	Gebze	Corlu	Izmir	Kayseri	Duzce
Gebze	///////////////////////////////////////	0.904	0.603	0.521	0.233
Corlu	0.740	///////////////////////////////////////	0589	0.288	0.110
Izmir	0.973	1.000	///////////////////////////////////////	0.575	0.322
Kayseri	0.863	0.863	0.712	///////////////////////////////////////	0.590
Duzce	0.973	0.973	0.808	0.890	///////////////////////////////////////

	Gebze	Corlu	Izmir	Kayseri	Duzce
Gebze	///////////////////////////////////////	0.012	0.029	0.086	0.041
Corlu	0.016	///////////////////////////////////////	0.038	0.086	0.041
Izmir	0.000	0.000	///////////////////////////////////////	0.074	0.041
Kayseri	0.022	0.005	0.070	///////////////////////////////////////	0.055
Duzce	0.022	0.005	0.029	0.078	///////////////////////////////////////

	Gebze	Corlu	Izmir	Kayseri	Duzce
Gebze	///////////////////////////////////////	0.000	0.012	0.012	0.025
Corlu	0.011	///////////////////////////////////////	0.022	0.012	0.033
Izmir	0.000	0.000	///////////////////////////////////////	0.012	0.025
Kayseri	0.000	0.000	0.029	///////////////////////////////////////	0.022
Duzce	0.000	0.000	0.022	0.000	///////////////////////////////////////

Table 5 First discordance matrix **Tablica 5.** Prva matrica nepodudarnosti

Concordance matrix

Matrica podudarnosti

Table 4

Tablica 4.

Table 6 Second discordance matrix **Tablica 6.** Druga matrica nepodudarnosti

3.3.5 Formation of discordance matrix

3.3.5 Izrada matrice nepodudarnosti

There are two discordance matrixes in the Electre Technique: first discordance matrix shows the non-dominated degrees of the alternative factory sites with the help of the scores and weights of the factors. In this matrix, the alternatives are compared in pairs and the highest difference is proportioned to the total weight (Table 5). In the second discordance matrix, the alternatives are re-compared in pairs and the second highest difference is proportioned to the total weight (Table 6).

Table 7		Gebze	Corlu	Izmir	Kayseri	Duzce
Selection and decision	Gebze	///////////////////////////////////////	pq			
Tablica 7.	Corlu		///////////////////////////////////////			
Izbor i odluka	Izmir	pq	pq	///////////////////////////////////////		
	Kayseri	pq	pq		///////////////////////////////////////	
	Duzce	pa	na	n	n	///////////////////////////////////////

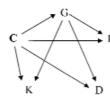
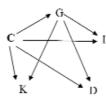


Table 8
Proof of the result
Tablica 8.
Dokaz rezultata

	Gebze	Corlu	Izmir	Kayseri	Duzce
Gebze	///////////////////////////////////////	pq			
Corlu		///////////////////////////////////////			
Izmir	pq	pq	///////////////////////////////////////		
Kayseri	pq	pq		///////////////////////////////////////	
Duzce	pq	pq	р	р	///////////////////////////////////////



3.4 Selection and decision 3.4 Izbor i odluka

After the selection of concordance and discordance matrixes, the threshold value was defined to select the factory site. There are two threshold values; the first threshold value is the preference threshold (p) which comes from the concordance matrix and it is a value close to 1.0. The second threshold value is the indifference threshold (q) which comes from the discordance matrix. In this study, with previously assumed threshold values p=0.808, q =0.012 the table would be as shown in (Table 7).

As shown in Table 7, the sites in Gebze, Izmir, Kayseri, and Duzce were eliminated and the site in Corlu remained. At this stage, the result needed a proof. In proving the result, "p" remained the same, but "q" was selected from the discordance matrix. Consequently, if p=0.808 and q=0.000, the table is as shown in Table 8. As a result Gebze, Izmir, Kayseri and Duzce are eliminated and Corlu remains as the best factory site. This proves the accuracy of the solution as well as of the used data.

4 CONCLUSION 4 ZAKLJUČAK

As a result of the evaluation of the

experts with the Electre Technique, Corlu was determined to be the best location for a new laminate factory site. When it is evaluated individually according to Economic and Environmental Factors, the obtained results differ considerably although based on the same Corlu's conditions. The method also provided the opportunity of ranking the site from superior to poor. The necessary data for the application of the method are prone to subjectivity because of the opinions of the experts. Therefore, different conditions and experts would most probably lead to different weights of the factor that affect the main aim, which could eventually result in a different decision.

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