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A Decision Support Model Suggestion for Logistics Support Unit in Risky Environment

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Abstract. Storage facilities have an important role for uninterrupted product/service flow and ensuring continuity in supply chains. Criteria, which will be taken into account for the location of this facilities, and criteria values, can alter in accordance with private or public sector and risk environment as well. Besides logistics costs, transportation opportunities and proximity to the customers, risk based criteria such as terror, sabotage, air strikes, and natural disasters play an important role in order to select facility location. During production flow, Logistics Support Bases (LSB) are the military facilities, which affect firstly operation process positively or negatively and secondly result of the operations, serve in the risk environment. In a specific environment, selection of LSB becomes a Multi-Criteria Decision Making (MCDM) problem for the decision maker. This study aims to determine qualifications which will be used to select the best suitable location of LSB; define the importance value of selected qualifications via DEMATEL method, and select the best location of LSB between alternative places. DEMATEL has used in the determination of criteria values and then VIKOR method has used to select the most appropriate location for LSB in the risk environment.
Keywords. Logistics support unit, Risk, Facility location, Multi-criteria decision making, DEMATEL, VIKOR.
JEL. D81**,** R53, C40, C44, D70.

1. Introduction

Supply Chain distribution network design decisions are important investment decisions which were taken in strategic level. Indeed, these decisions are important since they influence the organization structure in the long run. In the distribution network design, many answers are obtained for questions including where the facilities will be located (i.e. factory, supply center and warehouses) how the products will be delivered to customers, which products will be produced and where, from which facilities the customers will purchase products and take services, how level of stock will be kept in the facilities. Cost efficiency and high level of profit is targeted for the created distribution network performance.

The facility location is one of the most important factors on increasing the performance and efficiency of a distribution network since the fact that the investment costs of the established facilities are very high. The established facilities are expected to offer services to customers efficiently. Factories, warehouses, distribution centers, industries sites could be given examples of

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industrial areas for these facilities on the other hand, school, hospital, library, military facilities, logistics support units, police centers, governor and municipalities service building could be cited for public organizations and institutions.

Facility location is a field of operation research which focuses on determining a new facility selection or location for the purposes of optimizing (to maximize or to minimize) at least one purpose function (cost, profit, income, distance, service level, waiting time, coverage area and market shares) in terms of some facilities (Farahani et al., 2010). Facility location selection decisions are strategic decisions which have important influence on increasing the organization performance and include many different amount of purposes including increasing the profit, decreasing the costs, reaching the maximum amount of customers, shortening the delivery time, responding the customer needs fast, increasing the amount of customers and their satisfaction levels.

For the facility location, which used to be selected through simple mathematical processes as comparing only cost or profit analyses in the past, better results could be obtained through developed decision making models today. Facility location problems, which target to make a selection among alternative locations, are included into Multiple Criteria Decision Making (MCDM) models methods beside of mathematical models since it is also a decision making problem.

Selection of the best location for facilities is a difficult problem to solve today. The difficulty of a real problem is stemmed from the fact that many factors and criteria should be taken into account and there are many limitations in those kinds of problems. In the literature review, it could be seen that facility location selection has a wide area, and especially in the recent years, there could be found many studies in which more real life conditions were reflected into the problem (i.e. criterion and limitations), and different kinds of mathematical models and methods are used alone or together.

The aim of this study is to provide solution suggestion for Logistics Support Unit (LSU) location selection problem which offer services in risky environment. LSUs are logistics facilities which offer supply and maintenance support to customers as they are established by public institutions as a distribution center in risky environment. The convenient location selection for these kinds of facilities is very important due to deliver the emergent products to the customers on time, to make efficient distribution and to provide moral support. These kinds of problems could include different qualitative and quantitative criteria like facility location problems. However, the criteria used in facility location selection problems for risky environment could be different from the criteria used for normal facility selection problems. Because, the decision makers put more emphasis on risky based criteria or solution of the problem. For the solution suggestion, DEMATEL and VIKOR methods are utilized together. DEMATEL method is used to determine the criteria priority weights and VIKOR methods used since the used criteria are contradictory, and conflicting with other criteria, there are more than one decision makers and to be able to obtain a solution suggestion in consensus.

The sections of the study are as follows: a literature review for the classification of the facility location selection and multiple criteria facility selection problems and the criteria used in these problems are given in the second section. Summary information is provided about DEMATEL and VIKOR methods in the third section. A numerical case is provided in the fourth section in which the suggested methods are implemented. The conclusion comments and suggestions for the future research studies are offered in the fifth section.

2. Literature Review

Facility location selection models have been studied in different ways for centuries. Although the concepts in the models changed; three main specifications are kept unchanged as a space which shows measurement system, customers whose locations are known in the system and the facilities of which the locations must be determined depending on the certain purpose functions (Revelle et al., 2008). In the historical development of location selection theory which is a classic science area, some experts argue that the beginning of this study area goes back to the early of 17th century with the studies conducted by Pierre de Fermat, Evagelistica Torricelli (student of Galileo) and Batiste Cavallieri. The purpose of Pierre de Fermat problem is to find the fourth point which will be established as the shortest distance as depending on the given three points in a plane (Smith et al., 2009).

It could be seen that the studies in the related literature are categorized according to various factors including problem's purpose function, static/dynamic structure, discrete/continuous structure, location space, process amount, flexible or stable structure of the demand, the amount of periods, whether it is a classic or combined/ vehicle rotating problem, whether it is limited capacity or not, type and amount of facility, type and amount of products, and cost or profit based establishment.

Arabani and Farahani categorized all facility location problems into two categories as static and dynamic facility location problems. The study which is conducted for facility location problems' classification is provided in Figure-1 (Arabani & Farahani, 2012). MCDM problems are also facility location selection problem which target to optimize more than one objective. These problems are categorized as multi objectives and multiple attributes. Generally, in the related terminology, the concept of MCDM is used for Multiple Criteria Decision Making (MCDM) or Multiple Attribute Decision Making (MADM) interchangeably.

Multiple attribute facility location selection problems are established through quantitative and qualitative criteria which are used to select the best alternative among the possible alternatives. In these problems, the alternative locations must be evaluated depending on the established criteria by decision makers. Generally the criteria have different weight values. In these kinds of problems, different solution methods could be utilized. Each method has some superiority over others.

There is not only one solution method to be used in determining the most convenient location for Multiple Attribute Decision Making (MADM) facility location selection problems in the literature. In the solutions of these problems; many different MADM methods including Analytical Hierarchy Process (AHP), Analytic Network Process (ANP), Elimination Et Choix Traduisant La Réalité (ELECTRE), Technique For Order Preference By Similarity To Ideal Solution (TOPSIS), Multi-Attribute Utility Theory (MAUT), VIsekriterijumska Optimizacija Kompromisno Resenje (VIKOR), and Stochastic Multicriteria Acceptability Analysis (SMAA) are used.

Tzeng et al. considered five dimensions (economic, transportation, competition commercial area and environment) and eleven criteria (rent cost, transportation cost, convenient of mass transportation, parking capacity, pedestrian volume, number of competitors, intensity of competitors, size of commercial area, extent of public facility, convenience for garbage disposal and sewage capacity) for a restaurant location selection problem and used AHP method for evaluation of four alternatives. Additionally, VIKOR technic, which is a consensus based technic, was used to determine the consistency scales for criteria weights (Tzeng et al., 2002). Aras et al. used AHP method to determine the best location for wind observation station in a university campus (Aras et al., 2004). In order to determine the location of hospital which would be established in Tahran, Vahidnia et al. used Geographic Information System (GIS) and fuzzy AHP method together (Vahidnia et al., 2009).

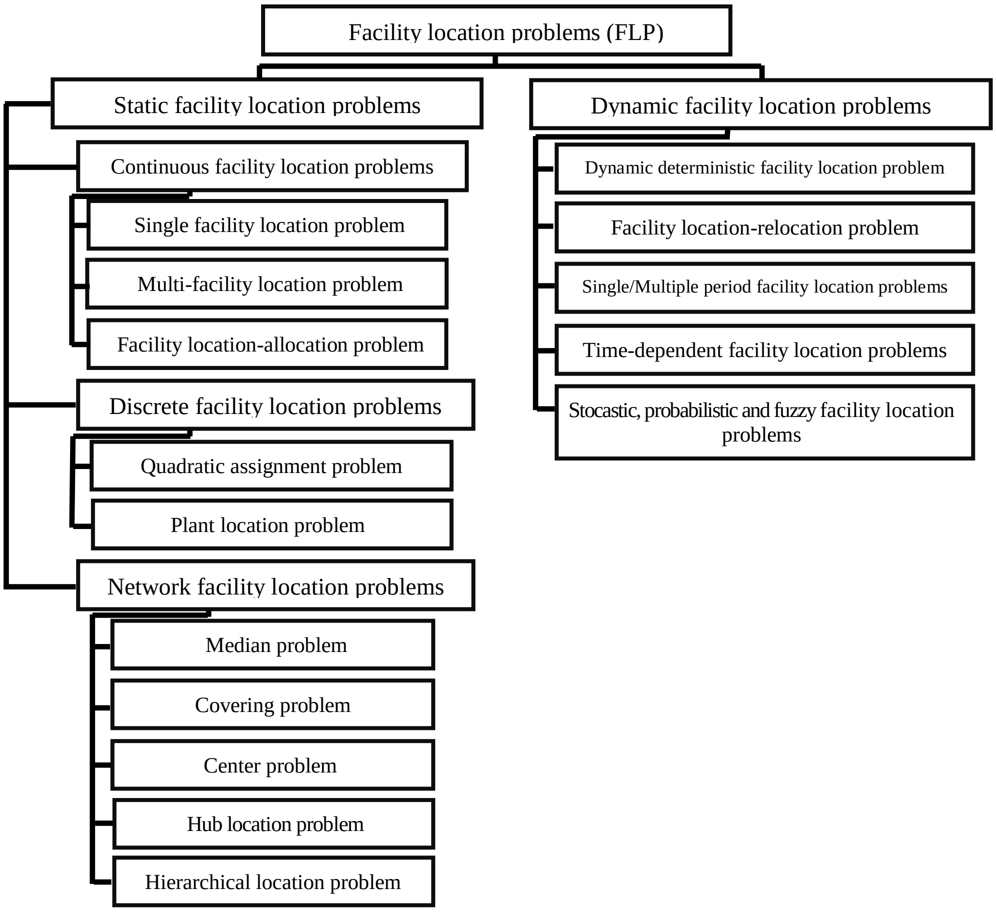

Figure 1: The Classification of Facility Location Problem

Chan and Chung developed a model in which genetic algorithm and AHP methods are used as combined for a distribution network problems solution (four manufacturing facilities, four warehouses, ten customers) within supply chain management (Chan & Chung, 2004). Fernandez and Ruiz suggested a three level hierarchical decision process which had geographic specifications in each phase; for an industrial park location selection problem. They utilized AHP method for solution of this problem (Fernandez & Ruiz, 2009). Guneri et al. used fuzzy ANP method for the problem of shipyard location selection. Yalova was chosen as the most convenient location for shipyard location among four alternative cities, as İzmir, Yalova, Yumurtalık and Samsun (Güneri et al., 2009).

Kuo suggested a hybrid model for international distribution center location selection problem. In the suggested model, DEMATEL model was used to establish the hierarchic/network structure of the criteria, AHP and ANP models were used to determine the criteria weights and a new fuzzy MCDM method was used to limit the alternatives (Kuo, 2011). Awasthi et al. used fuzzy TOPSIS method for a city distribution center location selection belongs to a logistic firm. Three decision makers were determined for the location selection model and they evaluated three alternatives determined through the eight criteria (Awasthi et al., 2011). Özdağoğlu used a fuzzy ANP method in which a hierarchic structure, established through main and sub-criteria, and the interaction among the criteria were also taken into account for facility location selection belong to a catering services firm in Istanbul. The criteria, which were important on selection of the best alternative location, were evaluated and the conducted sensitivity analysis was presented in the study conclusion (Özdağoğlu, 2011). Ertuğrul and Karakaşoğlu used fuzzy AHP and fuzzy TOPSIS method separately for facility location selection problem belong to a textile company which offered services in home textile in Turkey; and they implemented the analyses as comparing the differences and similarities of the results of these two methods (Ertuğrul & Karakaşoğlu, 2008).

Doerner et al. proposed a multi objective decision model which considered tsunami natural disease risk to determine the location of public facilities (school) as distanced form the coasts. In the model, coverage, risk and costs were considered in order as objective functions. Additionally, the obtained results were compared with heuristic method (Doerner et al., 2009). The criteria used in facility location selection problems in the related studies in the literature between 1994 and 2014 were given in Table-1.

Table 1. *The criteria used in the studies conducted between 1994-2014*

CRITERIA	AUTHOR AND YEAR		
Political Subjects and regulations *(Related communities' thoughts, country precautions, public regulations)*	Badri (1999) Kahraman et al. (2003) Canbolat et al. (2007) Viswanadham & Kameshwaran (2007)	Chou et al. (2008) Tabari et al. (2008) Ertuğrul & Karakaşoğlu (2008)	Shen & Yu (2009) Wadhwa et al. (2009)
Competition *(Competitive environment, the amount of competitors)*	Badri (1999) Tzeng et al. (2002)	Kahraman et al. (2003) Chou et al. (2008)	Önüt et al. (2010) Özdağoğlu (2011)
Economy related criteria and values *(The labor force opportunity, job opportunity, value of money, job climate)*	Guimaraes Pareira et al. (1994) Badri (1999) Kahraman et al. (2003) Norese (2006) Yong (2006) Canbolat et al. (2007)	Viswanadham & Kameshwaran (2007) Chou et al. (2008) Ertuğrul & Karakaşoğlu (2008) Tabari et al. (2008) Tuzkaya et al. (2008)	Fernandes & Ruiz (2009) Shen & Yu (2009) Wadhwa et al. (2009) Ashrafzadeh (2012) Ağdaş et al. (2014)
Population density	Tzeng et al. (2002) Lahdelma et al.(2002)	Norese (2006) Canbolat et al. (2007)	Önüt et al. (2010)
Capacity and magnitude *(Growth and spreading opportunity, flexibility)*	Tzeng et al. (2002) Norese (2006)	Tuzkaya et al. (2008) Önüt et al. (2010)	Awasthi et al. (2011) Ashrafzadeh (2012)
Proximity/ Distance *(Proximity to market-customer-supplier-source, distance from prohibited-dangerous-undesired facilities and natural diseases regions)*	GuimaraesPareira et al. (1994) Norese (2006) Viswanadham & Kameshwaran (2007)	Ertuğrul & Karakaşoğlu (2008) Tuzkaya et al. (2008) Kuo (2011)	Awasthi et al. (2011) Özdağoğlu (2011) Ashrafzadeh (2012) Ağdaş et al. (2014)
Suitability *(Cultural, social, technical, to field usage, to natural threats, traffic system, infrastructure, standard of living)*	Barda et al. (1990) Aras et al. (2004) Norese (2006)	Viswanadham & Kameshwaran (2007) Canbolat et al. (2007) Ertuğrul & Karakaşoğlu (2008)	Chou et al. (2008) Awasthi et al. (2011) Kuo (2011) Ağdaş et al. (2014)
Other criteria *(Attractiveness, the level of demand, operation ability)*	Önüt et al. (2010) Awasthi et al. (2011)	Özdağoğlu (2011) Kuo (2011)	Ağdaş et al. (2014)

3. Methods

3.1. DEMATEL Method

The Decision Making Trial and Evaluation Laboratory (DEMATEL) Method is developed to reveal the relationship between the criteria and to define applicable solutions for the problem groups which are complex and conflicting. (Aksakal & Dağdeviren, 2010). In DEMATEL method, n criteria which affect each other and h decision makers/expert groups who evaluate the criteria must be present. After determining the decision maker group and criteria; evaluations could be implemented as following the below mentioned phases:

Phase 1: Determining Initial Direct Relation Matrix and Finding the Average direct Relationship Matrix

Direct relationship matrix is determined by decision makers/expert group by comparing criteria (Ehrgott et al., 2010).

Table 2. DEMATEL Method Comparison Scale (Shieh et al., 2010)

Nominal Value	Definition
0	Ineffective
1	Less Effective
2	Medium Effective
3	Highly Effective

The decision makers/expert groups are asked to express their opinion about the direct influence between any two criteria by an integer score ranging from 0, 1, 2, 3 and 4 shown as in Table 2. As above stated; n*n sized matrix is called direct relationship matrix. Each (i,j) element in this matrix shows the direct relationship from criterion i to criterion j (Çınar, 2013). One evaluation matrice is expected from each expert or decision maker. H relationship matrix is obtained.

The average of the obtained direct relationship matrixes are calculated through Equation 1 and average direct relationship matrix (X) is established. This is the group decision at the same time.

$$a_{ij} = \frac{1}{H}\sum_{n=1}^{H} x_{ij}^{n} \tag{1}$$

Phase 2: Obtaining Normalized Direct Relation Matrix:

Normalized direct relationship matrix (C) is established as using equation 2 and equation 3. a_{ij} elements are written instead of x_{ij} elements; the max values from the sums of row and column are determined and the average direct relationship matrix is divided with this value (Ehrgott et al.,2010).

$$s = maks\ (maks\ \sum_{j=1}^{n} x_{ij}\ , maks\ \sum_{i=1}^{n} x_{ij}) \tag{2}$$

$$C = \frac{X}{s} \tag{3}$$

Phase 3: Finding total relation fuzzy matrix:

$$\lim_{H\to\infty} c + c^2 + c^3 + \cdots \ldots c^H \tag{4}$$

$$\mathrm{F} = \mathrm{C} + \mathrm{C}^2 + \mathrm{C}^3 + \cdots \ldots \ldots . + \mathrm{C}^{\mathrm{H}} = \mathrm{C}(\mathrm{I} - \mathrm{C})^{-1} \tag{5}$$

Here, I represents the unit matrix with size of n*n while C represents the decreasing indirect effects.

Phase 4: Finding causer and receiver groups:

Depending on the matrix (F) which is found in step 3; the sum of its row of; D_i shows the sum of direct and indirect effects which are sent to other criteria by i criterion. Column sum R_i shows the sum of effects coming from other criteria of the same criterion. Index of D_i + Ri, which is obtained as sums of rows and columns for each criterion, shows the sum of the value of effect which are received and submitted; on the other hand the value of $D_i - R_i$ shows the net effect which is produced by i factor for the system. The positive value shows that i-th criterion is “net causer” while negative value shows that i-th criterion is “net receiver”. The value of $D_i + R_i$ shows the degree of i-th criterion in the total system (Çınar, 2013).

The values of $D_i + R_i$ shows the importance degrees of criteria while the values of $D_i - R_i$ divide the criteria into two groups as causer and receiver. Generally, the negative values of $D_i - R_i$ represent the receiver group while positive values represent the causer group (Tzeng & Huang. 2011:265).

Phase 5: Determining the Criteria Weights:

The weights are determined as using Equation 6.

$$w_i = \sqrt{[(D_i + R_i)]^2 + [(D_i - R_i)]^2} \qquad W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \tag{6}$$

3.2. VIKOR Method

VIKOR method, which was developed as an easily applicable technic for MADM problems, was firstly introduced by Opricovic in 1988. VIKOR method was developed for multiple criteria optimization of complex systems. This method focuses on ordering the alternatives in the set of alternatives for complex criteria and then is used to select one alternative. T was also introduced as multiple criteria decision making ordering index which depends on the measurement of “the proximity to the ideal solution” (Opricovic & Tzeng, 2004). The application phases of VIKOR method are shown below:

1. Phase: Determining the best (f_i^*) and the worst (f_i^-) values for each criterion. If the criterion function represents a benefit, equation 7 is used.

$$f_i^* = \max_j f_{ij} \; f_i^- = \min_j f_{ij} \qquad i = 1,2, \dots n \tag{7}$$

2. Phase: Calculating the average group utility S_j and maximum regret value R_j. (equation 8 and 9) $j = 1,2, \dots m$

$$S_j = \sum_{i=1}^{n} w_i (f_i^* - f_{ij})/(f_i^* - f_i^-) \tag{8}$$
$$R_j = \max_i [w_i (f_i^* - f_{ij})/(f_i^* - f_i^-)] \tag{9}$$

w_i represents the importance value of i criterion. The sum of all criteria weights must be equal to 1.

3. Phase: Q_j values of all alternatives are calculated with equation 10.

$$Q_j = v(S_j - S^*)/(S^- - S^*) + (1 - v)(R_j - R^*)/(R^- - R^*) \tag{10}$$
$$S^* = \min_i S_i \; , \; S^- = \max_i S_i$$
$$R^* = \min_i R_i \; , \; R^- = \max_i R_i$$

Here, the value of S^* shows the maximum majority rule or minimum value of S_j as being the maximum group utility, while the value of R^* shows the minimum value of R_i as being minimum regrets of the people which have different opinions. Therefore, Q_j index which depends on both the group utility and minimum individual regrets of the people who share different ideas are obtained. Additionally, the value of v shows the importance of the strategy which provids the maximum goup utility. When the value of v is greater than 0.5 ($v > 0.5$), it is interpreted as the decision maker is prone to maximum group utility (consensus) on the other hand, if the value of v is equal to 0.5, it shows that decision maker is prone to the minimum regret decision of the opposite idea sharers. For the consensus solution, the value of v =0.5 is used (Opricovic & Tzeng, 2007).

4. Phase: Ranking the values of S, R, and Q from the smallest to the greatest value and obtaining the order within the alternatives. The obtained results are ranked from smallest to the greatest and an ordering list is established.

5. Phase: If the two conditions below are applied, the alternative which orders the best according to Q (minimum) value is suggested as a' consensus solution.

1st condition (C_1) Acceptable advantage:

$Q(a'') - Q(a') \geq DQ,\ \ DQ = \frac{1}{m-1}\ (DQ = 0.25\ if\ m \leq 4\quad)\quad a'' =,$ 2th alternative, m show the amount of alternative.

2nd condition (C_2) Acceptable stability in decision making: The best alternative $Q(a')$ must also be the best in the values of $S(a')$ and/ or $R(a')$. If the first condition (C_1) is not met and if $Q\left(a^{(m)}\right) - Q(a') \leq DQ$, then $a^{(m)}$ and a' are the same consensus solutions. Therefore, a' does not have superior advantage and the consensus solutions $a', a'', \ldots\ a^{(m)}$ are the same. If the second condition (C_2) is not accepted, the consistency on decision making is missing although a' has superior advantage. Then consensus a' and a'' alternatives are the same.

4. Case study

The success of logistic activities which are performed by the organizations in peace and war environments depends on the accurate, uninterrupted and fast flow of supply materials. In sustaining of this flow, the subject of facility location selection is an important criterion besides factors like supply, keeping inventory, stock control, warehouse, using information systems. The appropriate location of facilities provides economic supply at the same time. In this study; a temporary logistics support unit location problem for public organization is handled.

A Country in which the organization is located is bothered with the civil war and disorder in the neighboring country in the south land border. A country took decision of taking some precautions toward the border regions for the purposes of giving rapid reaction against the possible threats which might come from B country. In the coverage of the precautions to be taken, A country located its units on the short distance locations to border region in a permanent period in case of possible attack condition which may happened by neighboring country. However, some delays were experienced in terms of logistics since of these relocation plans. In this context, they decided to open a permanent LSU to support the units. The organization has six alternative lands. The criteria which will be used in the location selection for LSU are determined by decision makers according to the literature and among the ones which have risk specifications. The importance value of the selected criteria is presented in Table-3; the importance weights are calculated with DEMATEL method in the direction of 5 experts' ideas.

a. Distance to the Risk Region (km.): The distance of the facility from the neighboring country's gun systems' effective coverage.

b. Region's Risk Value: Shows the risk degree which are evaluated as focusing on the amount of terror, sabotage and attack incidents of the region which the Logistic Support Unit will be established on. The statistics of the incident amount which were experienced in the past years were considered. This value is determined among scale values as 1 risky – 5 riskless. The distribution center is expected to be established on the region which has the smallest degree of risk.

The representation is as follows;

- Risk_1 degree: incident amount 80 and over,
- Risk_2 degree: incident amount between 60 - 79,
- Risk_3 degree: incident amount between 40 - 59,
- Risk_4 degree: incident amount between 20 - 39,
- Risk_5 degree: incident amount between 19 and less.

c. Proximity to Transportation Opportunities (km.): The total distance of the region on which the Logistic Support Unit will be established to the different transportation points (highway, railway and helicopter pad)

d. Concealing Opportunity: To have forest area and plant cover which eliminates the visibility of the facility against the air raid and the wideness which enables the spreading. Logistics planners score the regions ranging from 1 to 100. The highest value represents the region which has the best hiding opportunities.

e. Distance to Supporting Units (km.): The total distance of the facility to supporting units.

f. Logistic costs: It covers the investment, infrastructure, transportation operating, storage, maintenance, prevention and relocating costs of the facility.

Table 3. *Criteria values for alternative locations*

Alternative Locations	Criterion_1 Distance to the Risk Region (km)	Criterion _2 Region's Risk Value (1-5)	Criterion _3 Proximity to Transport. Opportunitie s (km)	Criterion _4 Hiding Opportunity (1-100)	Criterion _5 Distance to Supporting Units (km)	Criterion _6 Logistic costs (100.000 TL)
M Point	178	2	13,41	70	42	180
N Point	169	2	14,25	80	54	145
O Point	161	3	13,22	70	26	160
D Point	143	3	14,80	80	36	150
E Point	182	1	14,36	70	44	230
F Point	163	2	15,55	90	37	170

Decision makers evaluate the criteria by their own opinions according to Table-2, the decision makers' evaluation matrix is transformed into initial direct relation matrix, the sum of the decision makers' matrix is founded and the average is calculated. Average Direct Relationship Matrix in Table-4 is obtained.

Table 4. *Average Direct Relationship Matrix (X)*

Criterion_1	Criterion_2	Criterion_3	Criterion_4	Criterion_5	Criterion_6
0.000	2.800	2.000	2.000	0.800	2.600
1.200	0.000	1.400	1.200	1.200	0.200
1.600	2.200	0.000	1.600	2.400	1.000
1.600	1.400	1.600	0.000	1.600	1.400
1.800	1.000	1.000	0.400	0.000	3.000
0.600	0.800	0.400	1.000	0.800	0.000

By using Equation 2 and Equation 3; Normalized Direct Relationship Matrix Table-5 is obtained.

Table 5. *Normalized Direct Relationship Matrix (C)*

Criterion_1	Criterion_2	Criterion_3	Criterion_4	Criterion_5	Criterion_6
0.000	0.933	0.667	0.667	0.267	0.867
0.400	0.000	0.467	0.400	0.400	0.067
0.533	0.733	0.000	0.533	0.800	0.333
0.533	0.467	0.533	0.000	0.533	0.467
0.600	0.333	0.333	0.133	0.000	1.000
0.200	0.267	0.133	0.333	0.267	0.000

Total Relationship Matrix is obtained by using Equation 5.

Table 6. *Total Relationship Matrix (F)*

Criterion_1	Criterion_2	Criterion_3	Criterion_4	Criterion_5	Criterion_6
0.000	-0.243	-0.163	-0.151	-0.119	-0.340
-0.075	0.000	-0.061	-0.074	-0.075	-0.030
-0.154	-0.232	0.000	-0.159	-0.148	-0.156
-0.128	-0.165	-0.117	0.000	-0.129	-0.160
-0.098	-0.111	-0.091	-0.041	0.000	0.052
-0.030	-0.048	-0.024	-0.024	-0.033	0.000

Sum of the columns provide the Di index and sum of the rows provide Ri index. As seen in Table-6 the value of Di – Ri, the most effect is produced by Criterion-2 with the value of 0.485 and the most affected criterion is Criterion-1 with the value of -0.532. Criteria importance degrees are calculated by using Equation 6 and provided in Table-6.

Table 6. *Importance Degrees*

	Di	Ri	Di + Ri	Di - Ri	CRITERIA IMPORTANCE DEGREES
Criterion-1	-1.017	-0.485	-1.502	-0.532	0.225
Criterion-2	-0.315	-0.800	-1.114	0.485	0.171
Criterion-3	-0.848	-0.456	-1.304	-0.391	0.192
Criterion-4	-0.699	-0.449	-1.148	-0.250	0.166
Criterion-5	-0.291	-0.503	-0.794	0.213	0.116
Criterion-6	-0.159	-0.635	-0.794	0.476	0.130

Then, the best value (f_i^*) and the worst value (f_i^-) of all decision alternatives are calculated in coverage of each criterion and provided in Table-7.

Table 7. *f*and f values regarding to alternative locations*

CRITERIA	f*	f-
Distance to the Risk Region (km)	143	182
Region's Risk Value	3	1
Proximity to Transportation Opportunities (km)	13,22	15,55
Concealing Opportunity	90	70
Distance to Supporting Units (km)	26	54
Logistic costs (100.000 TL)	145	230

S and R values of each alternative are calculated through Equation 8 and 9. These values are presented in Table-8.

Table 8. *S and R values regarding to alternative locations*

	M Point	N Point	O Point	D Point	E Point	F Point
S_i	0,589	0,519	0,293	0,262	0,861	0,477
R_j	0,202	0,150	0,166	0,130	0,225	0,192

Q values are calculated through Equation 10 and presented in Table-9.

Table 9. *Q values regarding to alternative locations*

Q_j	0,651	0,319	0,214	0,000	1,000	0,505

All values of alternatives (S, R and Q) are ranked from the smallest value to the greatest value. These values are provided in Table-10.

Table 10. Q, *S and R values regarding to alternative locations*

	Qj		Sj		Rj
D Point	*0,000*	*D Point*	*0,262*	*D Point*	*0,130*
O Point	0,214	O Point	0,293	N Point	0,150
N Point	0,319	F Point	0,477	O Point	0,166
F Point	0,505	N Point	0,519	F Point	0,192
M Point	0,651	M Point	0,589	M Point	0,202
E Point	1,000	E Point	0,861	E Point	0,225

In the decision model in which DEMATEL and VIKOR methods are used together, D Point is the best alternative in terms of Q, S and R values for LSU location selection. Therefore, D Point is selected as the most convenient location according to the determined risk criteria.

5. Conclusion

MCDM methods are solution approaches which can be used to consider and evaluate both qualitative and quantitative criteria at the same time. DEMATEL method is a technic which was especially developed to reveal the relationship between the criteria and to define applicable solutions between complex and conflicting criteria. VIKOR method is a decision support tool which makes selection among alternatives in a decision making problem, which has conflicting criteria, and makes ordering, and provides consensus solution suggestion. In a real problem which has a large number of decision makers, VIKOR method offers a consensus based solution suggestion.

In this study, the most convenient location selection problem is analyzed for a LSU which is planned to be opened in a risky environment, criteria importance weights are determined by 5 expert decision makers, DEMATEL and VIKOR methods are used together, a decision support model is established and solution suggestion is provided. As a result of the decision support model which is established with this combined method, the alternative locations are ordered and D Point is selected as the most convenient location for LSU.

As a result, the LSU location location (D Point) which is selected among the determined alternatives in the quantitative table is presented to the organization. The studies could be conducted for bigger location problems as setting mathematical models, increasing criteria amount and using different MCDM methods for these kinds of problems and different fuzzy values could be offered to decision makers for them to express themselves better.

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