Selection of Logistics Centre Location via ELECTRE Method: A Case Study in Turkey

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Abstract

The aim of this study is determining the appropriate facility location through one of the multiple-criteria decision making methods addressing the selection of location in Western Black Sea. In parallel with this aim, firstly the regional commercial analysis was performed and then detailed facility location analysis was carried out by selecting the appropriate region. This analysis was realized via ELECTRE method. After determining 11 logistics factors that affect the facility location, these were ranked and transformed with ELECTRE method. In consequence of this analysis that was carried out through this method, the optimal facility location was determined as Caycuma county of Zonguldak city among six alternative regions.

Keywords: logistics centre; location problem; multiple-criteria decision analysis; ELECTRE method

1. Introduction

Western Black Sea plays an essential role in the increasing foreign trade volume of Turkey. The increasing mobility in the market requires logistic support for the region as well. The only structure to provide this support is a logistics centre. Logistics centre is a professional facility that offers services such as storage, cold storage, handling, clearance, accommodation, reassembly, disassembly, quality control and social facilities for logistics companies that carry on national and international logistic activities. The facility location should be selected optimally because of high investment costs and static facility feature of these centres that offers the benefits of cost, quality, coordination and optimization for companies. Many methods are used for this. These methods are separated as mathematical, simulation, financial and multi-criteria decision making methods. The multi-criteria decision making methods, where hierarchy is taken into consideration, are AHP, TOPSIS, Fuzzy TOPSIS, ELECTRE and Fuzzy AHP (Eleren 2006).

The aim of this study is recognizing the need for logistics centre in Western Black Sea region, which takes an important place in Black Sea commerce network of Turkey with its import-export density, and determining the optimal facility location with regards to this need. Within the scope of the study, Duzce, Karabuk, Zonguldak, Kastamonu, Bartin and Bolu cities of Western Black Sea were analysed according to harbour oriented foreign trade volume and it was tried to determine the most appropriate city for the facility location.

An evaluation was carried out according to criteria of closeness to harbour and airport, distance to residential areas, accessibility to labour, environment security, accessibility to highways and linking roads, substructure, traffic density, air pollution, building site – permit, regional incentive for the optimal selection of facility location and the datum obtained was analysed through ELECTRE method.

The logistics centre to be established in Western Black Sea will be connected to Filyos project with its integrable structure and will both provide required logistics support and eliminate local traffic problems. When viewed from this aspect, it is thought that the logistics work would provide a solution for city logistics in micro size and fill the void in logistics network of Turkey in macro size, provide high employment opportunity and develop the studies in the field of logistics.

2. Logistics Centres

Logistics derived from the word "logisticos", which means "ability to calculation" in Greek. With the first one in the field of military, several definitions of logistics were made; however the best definition of logistic activities was made by Logistics Governing Council in 1991. According to that definition; it is a part of the supply chain, which controls the planning and implementation of the two-way movement of services and information flow efficiently and storage of materials within the supply chain from the point where the products are produced to the consumption point, the place of end use, for satisfying the needs of customers (Hafeez, et al. 2013).

Rising as a need in the field of military, logistic activities developed in parallel with industrialisation and became a strategic solution for companies along with increasing international trade. Logistic activity offered some returns such as quality, low cost and low fault risk to customers in the result of professionalization and became a competition factor. However, the coordination of logistic activities got difficult with the concentration of international trade. As a solution for this problem, the first logistics centre was established in 1960s. After the logistics centre established in Paris France, logistics centres started to be established in Italy, Germany, Belgium, Holland and America as well (Ballis and Mavrotas 2007).

The increasing population in recent years affected the logistics sector substantially. Many logistics companies to be situated in city centres affects them negatively with regards to time, cost and customer satisfaction. On the purpose of reducing this effect, city logistics concept was developed, which provides an integration of current resources for solving the problems arising from increasing population and vehicle traffic in urban areas (Tseng, Yue and Taylor 2005). When considered with regards to city logistics, which is one of the modern logistics concepts, the logistics centres established in cities with high rates of population/area provide effective solutions for the problems of inner city freight shipment and life quality arising from traffic jam (Ballis 2006). Providing multidimensional benefit, these centres are special areas involving both national and international transportation, logistics and physical distribution activities conducted by several operators (Eryürük, Kalaoğlu and Baskak 2012). Within these areas, there are service areas like customhouse, post office / communication service / bus services, areas like park and loading-unloading operations, silos, storage, cold storage, railway rebroadcasting station, quarantine, packaging facilities, restaurants, cafes, car wash and fuelling stations (Europlatforms Eeig 2004).

3. Logistics Centre Analysis in Western Black Sea

As the number of logistics centres increased rapidly with the developing industry in the USA and Europe, the delay in Turkey"s investments to logistics sector brought 45 international freight companies together and the first and only international logistics centre of Turkey, Ankara Logistics Base, was founded in 2004. Besides this logistics centre, which was established with its shareholders" own resources, there are 13 logistics centres under construction with finished project designs and 6 logistics centres that were put into service in Turkey (See Fig. 1). These centres are Usak, Eskisehir (Hasanbey), Samsun (Gelemen), Izmit (Kosekoy), Denizli (Kaklik) and Halkali logistics centres.

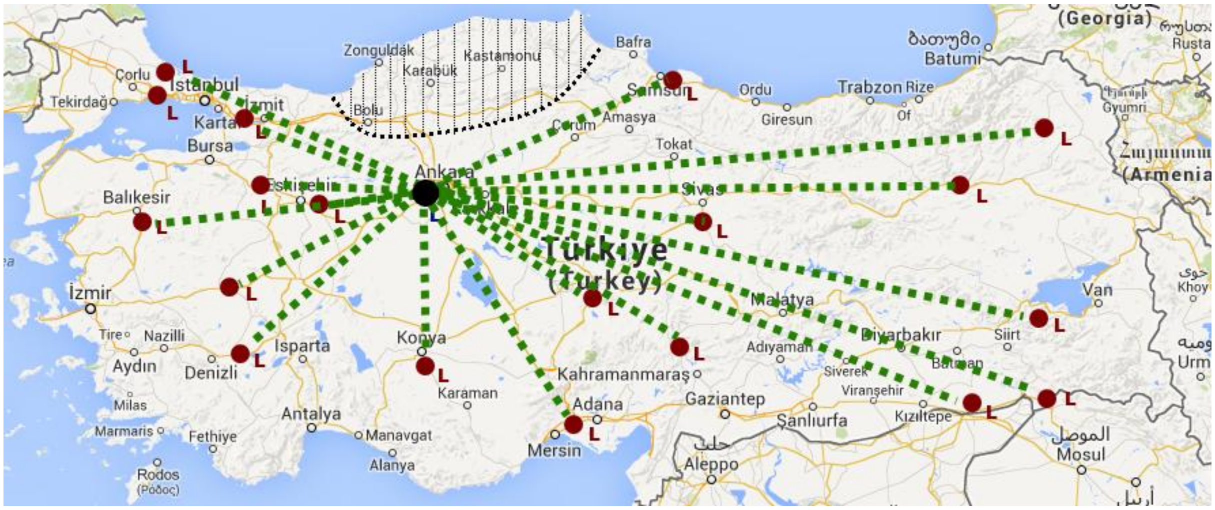

Figure 1: Logistics Network of Turkey

In Figure 1, there are locations of 19 logistics centres in Turkey. The logistics network of Turkey takes shape, when these locations are connected to each other via Ankara connection point. However, the Western Black Sea region stays out of this network.

When the entire Black Sea region is examined, it is seen that there is only one logistics centre. While Central Black Sea and Eastern Black Sea are connected to each other with coastal roads, there is not such a connection between Western and Central Black Sea regions because of geographic barriers. So, it is impossible to carry the logistic mobility of Western Black Sea to Samsun. And its dispatch from internal regions increases the transportation costs. And it is possible to transfer the logistic mobility to Marmara region; however, considering the density of the harbours in Marmara region, this will both increase the current density and slow down the logistic activities. Considering all these factors and the trading volume of Western Black Sea region, the most rational decision is founding a logistics centre in the region. The logistics centre to be founded will not only support foreign trade in the region, but also relieve the logistics density in Marmara region and constitute a dispatching point in northwest for the import-export flow from Ankara, Kastamonu, Bolu, Cankiri, Eskisehir, Kayseri and Kirikkale in the hinterland to Black Sea countries.

3.1. Harbour Oriented Foreign Trade Analysis in Western Black Sea

Duzce, Karabuk, Zonguldak, Kastamonu, Bartin and Bolu cities are located in Western Black Sea region. And the cities that have coast to Black Sea in the region are Duzce, Zonguldak, Bartin and Kastamonu. The foreign trade datum[*] relating to the region was given in Table 1.

Table 1: Foreign Trade Analysis of the Harbours in the Cities of Western Black Sea

	Harbour Name	Foreign Trade Volume		Ship/Rig Number Arrival	Ship/Rig Number Departer
		Import	Export		
Duzce	Akçakoca Harbour	-	-	-	-
Karabuk	-	-	-	-	-
Zonguldak	Zonguldak Harbour	594.331.882 $	95.483.456 $	541 Ship / 15878 Rig	529 Ship / 17588 Rig
	Erdemir Harbour	1.134.376.652 $	312.356.649 $	423 Ship / 170 Rig	293 Ship / 109 Rig
Kastamonu	Inebolu Harbour	-	-	-	-
Bartin	Bartin Harbour	-	-	-	-
Bolu	-	-	-	-	-

[*] These data consists of the trade volume realized between January and October months of the year 2013.

When Table 1 is analysed, it is seen the only city in Western Black Sea region, in the harbour of which foreign trade is plied actively, is Zonguldak. In this city, there are two harbours, which are Zonguldak and Erdemir harbours. Zonguldak Harbour, one of these harbours, is located in the city centre and Erdemir Harbour is in Eregli County. When import and export figures are analysed, it is seen that Erdemir Harbour had bigger foreign trade volume comparing to Zonguldak Harbour; however considering the rig mobility in harbours, it is seen that total rig mobility in Zonguldak Harbour was 33466 and this figure was 279 in Erdemir Harbour. The reason of this inverse relationship is the difference of foreign trade materials in two harbours. While iron and steel products and their derivatives are imported in Erdemir Harbour; plaster, fibreglass, plastic wainscot cement and iron and steel derivatives are exported. And while fresh fruits and vegetables, ceramic, sanitary ware and dry bulk trailer are importedin Zonguldak Harbour; timber, lumber, hard coal, manganese and steel roll are exported. When two harbours are compared, it is seen that the economic values of the materials subjected to foreign trade in Erdemir Harbour are higher than the ones in Zonguldak Harbour. Although the material values of these materials are high, their logistic mobility is very low. Therefore, when considered from the logistics point of view, foreign trade to be intensively made through RO-RO ships brings the logistics need of Zonguldak Harbour into the forefront.

3.1.1. Logistics Centre Analysis in Zonguldak

Zonguldak has a great importance by virtue of taking part in the maritime commerce carried out by Turkey with Black Sea countries, having a substructure that enables the use of four transportation modes of logistics (land route, railway, seaway and airway) and being situated in a short distance of 119 km to Ankara-Istanbul highway. In parallel with the increase of foreign trade volume in the region, the substructure and support works are continuing as well. On the latest developed projects is Filyos Harbour. This harbour will activate Karabuk-Bartin-Zonguldak commercial ties further and provide a better continuation of maritime and logistics activities with its features. However, the establishment of a new harbour in the region is not enough for a higher trade volume. The establishment of a logistics centre to provide a logistic mobility in Zonguldak region, where an important part of foreign trade is plied by RO-RO ships, is just as essential as Filyos Harbour.

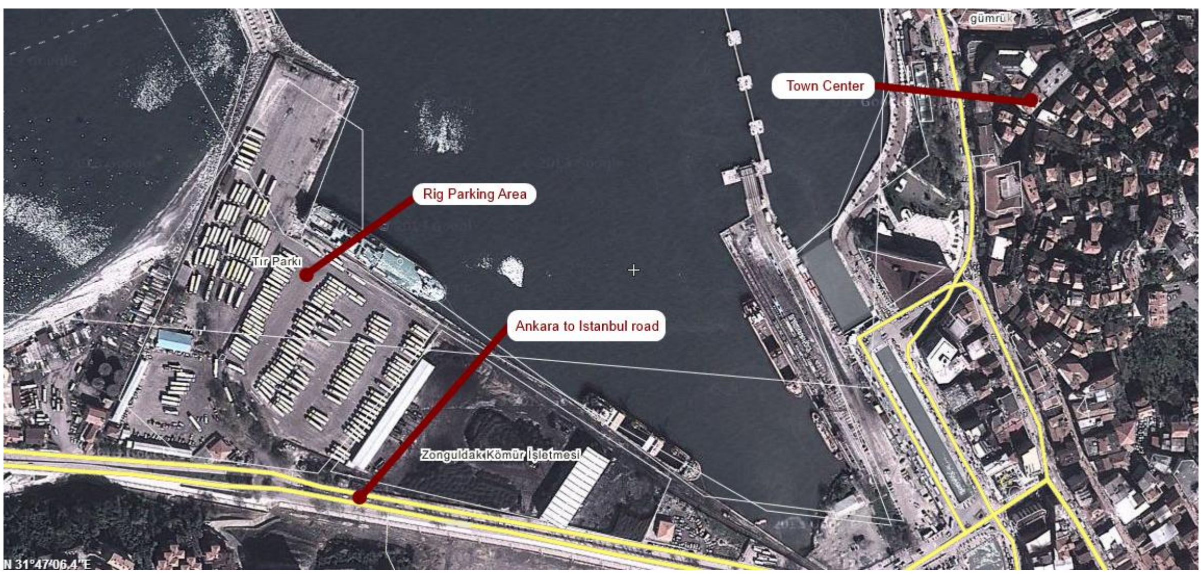

Figure 2: Zonguldak Harbour

When the position (See Figure 2) and services of Zonguldak Harbour are analysed, it is seen that the substructure of the current rig park was not sufficient, there was no basis to meet the food and accommodation needs of drivers and logistics staff who has to stay in harbour, and the needs of logistics vehicles such as repair-maintenance and parking lot, and so rigs closed the through road of Ankara-Istanbul and caused traffic density and prevented people from strolling around the recreational areas on the seaside (See Figure 3).

Figure 3: Rig Parking Area - 6 October 2013

Alternative routes do not exist because of the geographical reasons and urban planning cannot be done due to lack of land, and therefore the intensity of foreign trade in Zonguldak affects people"s lives directly. In the city that is subjected to land constraint because of the increase in inner city traffic density and the air pollution, the solution of the factors that cause such cases is only possible with the city logistics. When viewed from this aspect, a logistics centre to be established in the region will both decrease the traffic density and soften the effects of shipping delays experienced due to climatic reasons. Units to be contained by the logistics centre, such as storage, cold storage, entrepot, care services, accommodation facilities, handling equipments, security systems and clearance will enable logistic activities to be carried out more coordinately. Besides, it will be a common market for both companies and customers by gathering transport companies and warehouses under the same roof, which are situated in the city disorganizedly. However, for the implementation and sustainability of this logistic process successfully, the selection of the establishment site of the logistics centre is all important. Logistics centres, which are untransferable investments are established within the frame of long termed plans and need high capital structures. Such a sizable investment should be made by analysing both the regional and logistic factors. Designed prudentially with a right position, a logistics centre will increase the foreign trade activities in the region and be an optimisation centre for logistic activities.

4. Logistics Centre Establishment Location Selection

Having long term characteristic and enabling the company go into operation with a strategic investment decision that affects its competitive power; the establishment site (Üreten 2005) is defined as the optimum place, where the company will realize its main functions like procurement, production, storage and distribution and attain its economic goals related to these functions (Çınar 2010).

The establishment location selection is an activity that comprises three stages of selecting the region where the company will be established, determining a specific area in the region and selecting the land where the factory will be established (Korkut, Doğan and Bekar 2011). And this activity evaluates in itself the factors of employee quality, labor cost, facility cost, substructure development, customer intimacy and intimacy to other companies (Ravet 2012).

The establishment location selection is a part of hierarchic planning process for the logistics companies (Lu and Bostel 2007). While the optimal establishment location selection in the logistics sector decreases transportation costs, it increases the job performance, competitive capacity and profitability of companies (Thai and Grewal 2005). Moreover, it decreases the traffic density in urban areas arising from freight shipment (Awasthi, Chauhan and Goyal 2011).

Several methods are used in the establishment location selection . Some of these methods are intuitional and others are statistical and mathematical. Some methods that are used or could be used in the evaluation of the establishment site are Analytic Hierarchy Process (AHP), Delphi Method, Weighting Method, ELECTRE Method, Mathematical Programming Methods, Multipurpose Mathematical Methods, Artificial Intelligence Methods and Genetic Algorithms (Elgün 2011). Events and objects are defined according to the collective effects of multivariate readings through these multiple criteria decision making methods (Aydın, Öznehir and Akçalı 2009).

By this means, the decision making mechanism can be kept under control and it can be reached to a decision in cases of multiple and contradictory criteria as easy and fast as possible (Ertuğrul and Karakaşoğlu 2010).

There are various studies in different disciplines where multi-criteria decision making methods are used. Rinner and Raubal (2004) used OWA (ordered weighted averaging) method in a study they carried out in the field of geography and analysed the location based decision support. Linares and Romero (2000) used AHP (analytic hierarchy process) method for the solution of electricity planning problems in their study they carried out in Spain. Similarly, Ho, Higson and Dey (2007) used AHP (analytic hierarchy process) method in a study they carried out and worked on the subject of resource allocation in higher education. Janic and Reggiani (2002) used SAW (simple additive weighting), TOPSIS and AHP (analytic hierarchy process) methods for the study they carried out in the subject of selecting a new central airport in Europe. Lu, Wang and Mao (2010) evaluated safe software products by using ELECTRE TRI method in their study.

4.1. ELECTRE Method

Decision makers can include numerous quantitative and qualitative criteria into the decision making process through ELECTRE, which is one of the optimisation oriented mathematical programming methods; weight the criteria in line with objective, defined the optimal alternative by collecting these weightings (Kuru and Akın 2012).

ELECTRE Method was developed firstly by Benayoun, Roy et al. Firstly presented ELECTRE I, conformity-nonconformity or upper-rating methods became different with regards to the preference structures they contained, whether they are using weight data or not and the results (outputs) they revealed and were named as ELECTRE II, III, IV and ELECTRE TRI. These methods use mainly the upper rating relation and end up with the selection of an element (choice), classification of alternatives as “acceptable”, “unacceptable” etc. and rating the alternatives for the significant elements of an A alternatives set (Bouyssou 2001). By force of this method, it is started from an inception table. Columns are separated into choices (alternatives) and lines are separated into criteria in such a this table. On the other hand, each criterion is weighted in a way to reveal the importance they bore comparing to others. In the second stage, conformity and nonconformity matrices are formed, which enable the comparison of alternatives. And in the third stage, these two tables are combined in the final evaluation table according to the threshold values defined for the conformity and nonconformity matrices and the optimal alternative is determined (Daşdemir and Güngör 2002).

8 mathematical steps are followed in the implementation of ELECTRE I method. These steps were given below respectively (Çelik and Ustasüleyman 2014);

Step 1: Formation of Decision Matrix (A)

Decision points that will be ranked according to their supremacies take part in the lines and the evaluation factors to be used in decision making take part in the columns of the decision matrix. A matrix is the inception matrix formed by the decision maker. Decision matrix is showed as follows:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

m gives the number of decision points and n gives the number of evaluation factor in A_{ij} matrix.

Step 2: Formation of Standard Decision Matrix (X)

Standard decision matrix is calculated by using the elements of A matrix and the formula below.

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

The X matrix is obtained as follows in the result of the calculations:

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

Step 3: Formation of weighted Standard Decision Matrix (Y)

Weights of the evaluation factors may be different for decision maker. Y matrix is calculated for reflecting this weight differences to ELECTRE solution. Decision maker should firstly determined the weights of the evaluation factors (w_i) and the addition of these weights should be one ($\sum_{i=1}^{n} w_i = 1$).

Then the elements in each of the columns of X matrix are multiplied with the relevant w_i value and Y matrix is constituted. The Y matrix is shown below:

$$Y_{ij} = \begin{bmatrix} w_1 x_{11} & w_2 x_{12} & \dots & w_n x_{1n} \\ w_1 x_{21} & w_2 x_{22} & \dots & w_n x_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ w_1 x_{m1} & w_2 x_{m2} & \dots & w_n x_{mn} \end{bmatrix}$$

Step 4: Determination of Conformity (C_{kl}) and Nonconformity (D_{kl}) Sets

It is got out of Y matrix for conformity sets to be determined, the decision points are compared to one another with regards to evaluation factors and the sets are defined by means of the relation shown in the formula below. The formula is mainly depended on the comparison of the magnitudes of line elements comparing to each other:

$C_{kl} = \{j, y_{kj} \geq y_{lj}\}$ A nonconformity set (D_{kl}) corresponds to each conformity set (C_{kl}) in ELECTRE method. The number of conformity sets is as much as the number nonconformity sets. Elements of nonconformity set consist of *j* values that do not belong to the relevant conformity set.

Step 5: Formation of Conformity (C) and Nonconformity Matrices (D)

It is benefited from conformity sets for the formation of conformity matrix (C). C matrix is *mxm* dimensional and it does not take value for $k = l$. The elements of C matrix are calculated by means of the relationship shown in the formula below.

$$c_{kl} = \sum_{j \in C_{kl}} w_j$$

And the elements of nonconformity matrix (D) are calculated by means of the formula below:

$$d_{kl} = \frac{\max\limits_{j \in D_{kl}} |y_{kj} - y_{lj}|}{\max\limits_{j} |y_{kj} - y_{lj}|}$$

D matrix is also mxm dimensional and it does not take value for $k = l$. The D matrix is shown below:

$$D = \begin{bmatrix} - & d_{12} & d_{13} & \ldots & d_{1m} \\ d_{21} & - & d_{23} & \ldots & d_{2m} \\ . & & & & . \\ . & & & & . \\ . & & & & . \\ d_{m1} & d_{m2} & d_{m3} & \ldots & - \end{bmatrix}$$

Step 6: Formation of Conformity Supremacy (F) and Nonconformity Supremacy (G) Matrices

Conformity supremacy matrix (F) is mxm dimensional and the elements of the matrix is obtained by the comparison of conformity threshold value ($\underline{c}$) with the elements of conformity matrix (c_{kl}). Conformity threshold value ($\underline{c}$) is obtained by means of the formula below:

$$\underline{c} = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} c_{kl}$$

m in the formula shows the number of decision points. More clearly, the $\underline{c}$ value is equal to the multiplying of $\frac{1}{m(m-1)}$ and the total of the elements that form the C matrix.

The elements of F matrix (f_{kl}), take the value of either 1 or 0 and there is no value on the diagonal of the matrix due to it showed the same decision points. If $c_{kl} \geq \underline{c} \Rightarrow f_{kl} = 1$, and if $c_{kl} < \underline{c} \Rightarrow f_{kl} = 0$.

Nonconformity supremacy matrix (G) is also mxm dimensional and it is constituted similarly to F matrix. The nonconformity threshold value ($\underline{d}$) is obtained by means of the formula below:

$$\underline{d} = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl}$$

The element of the G matrix (g_{kl}) also take the values of either 1 or 0 values and there is no value on the diagonal of the matrix due to it showed the same decision points. If $d_{kl} \geq \underline{d} \Rightarrow g_{kl} = 1$, and if $d_{kl} < \underline{d} \Rightarrow g_{kl} = 0$.

Step 7: Formation of Total Dominance Matrix (E)

The elements of the total dominance matrix (E) are equal to mutual multiplying of (e_{kl}) f_{kl} and g_{kl} elements. Here, the E matrix is *mxm* dimensional depending upon the F and G matrices and again comprise of 1 or 0 values.

Step 8: Defining the Importance Order of the Decision Points

The lines and columns of the E matrix show the decision points. 0 and 1 values in the lines are analysed and absolute dominance is found and the importance order of the decision points is defined.

4.2. Implementation of the Method

Factors affecting the location selection , which are needed for the implementation of ELECTRE Method and the alternative establishment sites, were determined by considering the import-export traffic and the logistic factors in Zonguldak.

The factors affecting the location selection were determined as closeness to harbour, closeness to airport, distance to residential areas, accessibility to labour, environmental safety, accessibility to highways and linking roads, substructure, traffic density, air pollution, building area-permit and regional incentive. And the establishment site alternatives were determined as Caycuma, Merkez, Kozlu, Kilimli, Alaplı and Devrek. And Eregli County was not considered as an alternative; because, despite the fact that Erdemir Harbour has bigger foreign trade volume than Zonguldak Harbour, it has much lesser logistic activities.

After the determination of factors and alternative establishment sites, a questionnaire was formed intended to the definition of factor weights and it was implemented though face-to-face survey method with 55 people. Data providers were requested giving points to 11 factors from 1 to 5 by basing on the logistics sector in the questionnaire and their weighted points were calculated by analysing the data obtained (See Table 2).

Table 2: Factor Weights

Factor No	Factor Name		Factor Weight
1	Closeness to Harbour	w_1	*0,0846*
2	Closeness to Airport	w_2	*0,1016*
3	Distance to Residential Areas	w_3	*0,0991*
4	Accessibility to Labour	w_4	*0,0817*
5	Environmental Safety	w_5	*0,1137*
6	Accessibility to Highways and Linking Roads	w_6	*0,1036*
7	Substructure	w_7	*0,0982*
8	Traffic Density	w_8	*0,0739*
9	Air Pollution	w_9	*0,0627*
10	Building Site and Permit	w_{10}	*0,0798*
11	Regional Incentive	w_{11}	*0,1013*

After the determination of factor weights, the beginning matrix, in other words the decision matrix (A), which is needed for the 1st step of ELECTRE Method, was given below (See Table 3).

Table 3: Decision Matrix (A)

$$A=\begin{bmatrix} 263 & 175 & 88 & 173 & 164 & 188 & 173 & 85 & 68 & 58 & 153 \\ 125 & 239 & 220 & 135 & 255 & 217 & 224 & 169 & 151 & 210 & 160 \\ 135 & 125 & 153 & 150 & 169 & 162 & 164 & 123 & 97 & 146 & 157 \\ 95 & 119 & 135 & 108 & 132 & 133 & 104 & 86 & 75 & 118 & 148 \\ 78 & 139 & 162 & 96 & 154 & 135 & 113 & 112 & 87 & 115 & 150 \\ 74 & 128 & 144 & 82 & 161 & 108 & 116 & 98 & 93 & 80 & 154 \end{bmatrix}$$

The standard decision matrix (X), which is formed in the result of the recalculation of the elements of decision matrix in Table 3 by using the normalization formula, was given in the table below (See Table 4).

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \quad \text{For instance for } X_{11}; \quad X_{11} = \frac{263}{\sqrt{263^2 + 125^2 + 135^2 + 95^2 + 78^2 + 74^2}}$$

Table 4: Standard Decision Matrix (X)

$$X=\begin{bmatrix} 0,7481 & 0,4471 & 0,2644 & 0,5519 & 0,4284 & 0,4756 & 0,4558 & 0,2997 & 0,2807 & 0,1813 & 0,4063 \\ 0,3555 & 0,6105 & 0,3606 & 0,4307 & 0,4049 & 0,5490 & 0,5902 & 0,5958 & 0,6234 & 0,6565 & 0,4249 \\ 0,3840 & 0,3193 & 0,4597 & 0,4785 & 0,4415 & 0,4098 & 0,4321 & 0,4336 & 0,4004 & 0,4564 & 0,4170 \\ 0,2702 & 0,3040 & 0,4056 & 0,3445 & 0,3448 & 0,3365 & 0,2740 & 0,3032 & 0,3096 & 0,3689 & 0,3931 \\ 0,2219 & 0,3551 & 0,4868 & 0,3063 & 0,4023 & 0,3415 & 0,2977 & 0,3948 & 0,3592 & 0,3595 & 0,3984 \\ 0,2105 & 0,3270 & 0,4327 & 0,2616 & 0,4206 & 0,2732 & 0,3056 & 0,3455 & 0,3839 & 0,2501 & 0,4090 \end{bmatrix}$$

The weighted standard decision matrix (Y), which was obtained in the result of the distribution of weights of these 11 factors on the standard decision matrix, was given in the table below (See Table 5).

By taking the rule of $\sum_{i=1}^{n} w_i = 1$ into consideration, for $W_1 \times X_{11}$; Y_{11} = 0,0846 x 0,7481

Table 5: Weighted Standard Decision Matrix (Y)

Y=

0,0633	0,0454	0,0262	0,0451	0,0487	0,0493	0,0448	0,0221	0,0176	0,0145	0,0411
0,0301	0,0620	0,0357	0,0352	0,0460	0,0568	0,0579	0,0440	0,0391	0,0524	0,0430
0,0325	0,0324	0,0455	0,0391	0,0502	0,0424	0,0424	0,0320	0,0251	0,0364	0,0422
0,0228	0,0309	0,0402	0,0282	0,0392	0,0348	0,0269	0,0224	0,0194	0,0295	0,0398
0,0188	0,0361	0,0482	0,0250	0,0457	0,0354	0,0292	0,0292	0,0225	0,0287	0,0403
0,0178	0,0332	0,0429	0,0214	0,0478	0,0283	0,0300	0,0255	0,0241	0,0200	0,0414

After the calculation of weighted standard decision matrix, the next step is the formation of conformity and nonconformity sets. In pairwise comparisons, A_p alternative is opt to A_q in A_p and A_q (1,2,....,*m and* $p \neq q$) conformity set. In that case, A_q takes part in nonconformity set. Accordingly, the conformity and nonconformity sets were given in Table 6.

Table 6: Conformity and Nonconformity Sets

Conformity Sets	***Nonconformity Sets***
C (1,2) = {1,4,5}	D (1,2) = {2,3,6,7,8,9,10,11}
C (1,3) = {1,2,4,6,7}	D (1,3) = {3,5,8,9,10,11}
C (1,4) = {1,2,4,5,6,7,11}	D (1,4) = {3,8,9,10}
C (1,5) = {1,2,4,5,6,7,11}	D (1,5) = {3,8,9,10}
C (1,6) = {1,2,4,5,6,7}	D (1,6) = {3,8,9,10,11}
C (2,1) = {2,3,6,7,8,9,10,11}	D (2,1) = {1,4,5}
C (2,3) = {2,6,7,8,9,10,11}	D (2,3) = {1,3,4,5}
C (2,4) = {1,2,4,5,6,7,8,9,10,11}	D (2,4) = {3}
C (2,5) = {1,2,4,5,6,7,8,9,10,11}	D (2,5) = {3}
C (2,6) = {1,2,4,6,7,8,9,10,11}	D (2,6) = {3,5}
C (3,1) = {3,5,8,9,10,11}	D (3,1) = {1,2,4,6,7}
C (3,2) = {1,3,4,5}	D (3,2) = {2,6,7,8,9,10,11}
C (3,4) = {1,2,3,4,5,6,7,8,9,10,11}	D (3,4) = {-}
C (3,5) = {1,4,5,6,7,8,9,10,11}	D (3,5) = {2,3}
C (3,6) = {1,3,4,5,6,7,8,9,10,11}	D (3,6) = {2}
C (4,1) = {3,8,9,10}	D (4,1) = {1,2,4,5,6,7,11}
C (4,2) = {3}	D (4,2) = {1,2,4,5,6,7,8,9,10,11}
C (4,3) = {-}	D (4,3) = {1,2,3,4,5,6,7,8,9,10,11}
C (4,5) = {1,4,10}	D (4,5) = {2,3,5,6,7,8,9,11}
C (4,6) = {1,4,6,10}	D (4,6) = {2,3,5,7,8,9,10,11}
C (5,1) = {3,8,9,10}	D (5,1) = {1,2,4,5,6,7,11}
C (5,2) = {3}	D (5,2) = {1,2,4,5,6,7,8,9,10,11}
C (5,3) = {2,3}	D (5,3) = {1,4,5,6,7,8,9,10,11}
C (5,4) = {2,3,5,6,7,8,9,11}	D (5,4) = {1,4,10}
C (5,6) = {1,2,3,4,6,8,10}	D (5,6) = {5,7,9,11}
C (6,1) = {3,8,9,10,11}	D (6,1) = {1,2,4,5,6,7}
C (6,2) = {3,5}	D (6,2) = {1,2,4,6,7,8,9,10,11}
C (6,3) = {2}	D (6,3) = {1,3,4,5,6,7,8,9,10,11}
C (6,4) = {2,3,5,7,8,9,11}	D (6,4) = {1,4,6,10}
C (6,5) = {5,7,9,11}	D (6,5) = {1,2,3,4,6,8,10}

The next step after forming the conformity and nonconformity sets is the calculations of conformity matrix (C) and nonconformity matrix (D). The calculated conformity and nonconformity sets were given below (See Table 7 and 8).

For instance, for C_{12}; $c_{kl} = \sum_{j \in C_{kl}} w_j$ formula is implemented $C_{12} = (w_1 + w_4 + w_5)$

Table 7. Conformity Matrix (C)

C=

—	0,2799	0,4696	0,6845	0,6845	0,5832
0,7201	—	0,6210	0,9009	0,9009	0,7873
0,5304	0,3790	—	1,0000	0,7994	0,8984
0,3155	0,0991	0,0000	—	0,2461	0,3497
0,3155	0,0991	0,2006	0,7539	—	0,6242
0,4168	0,2127	0,1016	0,6503	0,3758	—

$d_{kl} = \dfrac{\max_{j \in D_{kl}} |y_{kj} - y_{lj}|}{\max_{j} |y_{kj} - y_{lj}|}$ formula is implemented and the example of D_{12} calculation as follows;

$$D_{12} = \frac{\max\{0{,}0166;\ 0{,}0095;\ 0{,}0076;\ 0{,}0132;\ 0{,}0219;\ 0{,}0215;\ 0{,}0379;\ 0{,}0019\}}{\max\{0{,}0332;\ 0{,}0166;\ 0{,}0095;\ 0{,}0099;\ 0{,}0239;\ 0{,}0076;\ 0{,}0132;\ 0{,}0219;\ 0{,}0215;\ 0{,}0379;\ 0{,}0019\}}$$

Table 8: Nonconformity Matrix (D)

D=

—	1,0000	0,7143	0,3713	0,4944	0,3670
0,8760	—	0,7635	0,1393	0,4355	0,7623
1,0000	1,0000	—	0,0000	0,2553	0,0452
1,0000	1,0000	1,0000	—	1,0000	1,0000
1,0000	1,0000	1,0000	0,5125	—	1,0000
1,0000	1,0000	1,0000	1,0000	1,0000	—

The step after the calculation of conformity and nonconformity matrices is the calculation of conformity supremacy and nonconformity supremacy matrices. For this, conformity and nonconformity threshold values are needed. Formulas below are used in the calculation of these values.

$$\underline{c} = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} c_{kl} \quad C_{treshold} = \frac{1}{6(6-1)}(2{,}7017+3{,}9303+3{,}6072+1{,}0103+1{,}9933+1{,}7572)$$

$$\underline{d} = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} d_{kl} \quad D_{treshold} = \frac{1}{6(6-1)}(2{,}9470+2{,}9767+2{,}3005+5{,}0000+4{,}5125+5{,}0000)$$

In the result of these calculations the values were found as $C_{treshold}$= 0,5091, $D_{treshold}$=0,8741. Accordingly the comparison result of $C_{treshold}$ value and conformity matrix elements were given in Table 9.

Table 9: Conformity Supremacy Matrix (F)

F=

—	0	0	1	1	1
1	—	1	1	1	1
1	0	—	1	1	1
0	0	0	—	0	0
0	0	0	1	—	1
0	0	0	1	0	—

The result the comparison of $D_{treshold}$ value and nonconformity matrix elements was given in Table 10.

Table 10: Nonconformity Supremacy Matrix (G)

$$G=\begin{bmatrix} — & 1 & 0 & 0 & 0 & 0 \\ 1 & — & 1 & 0 & 0 & 1 \\ 1 & 1 & — & 0 & 0 & 0 \\ 1 & 1 & 1 & — & 1 & 1 \\ 1 & 1 & 1 & 0 & — & 1 \\ 1 & 1 & 1 & 1 & 1 & — \end{bmatrix}$$

After finding F Conformity Supremacy and G Nonconformity Supremacy matrices the total dominance matrix should be found for the determination of the importance order of decision points. The total dominance matrix (E), which is obtained with the multiplication of the lines and columns of F and G matrices, was given below (See Table 11).

Table 11: Total Dominance Matrix

$$E=\begin{bmatrix} — & 0 & 0 & 0 & 0 & 0 \\ 1 & — & 1 & 0 & 0 & 1 \\ 1 & 0 & — & 0 & 0 & 0 \\ 0 & 0 & 0 & — & 0 & 0 \\ 0 & 0 & 0 & 0 & — & 1 \\ 0 & 0 & 0 & 1 & 0 & — \end{bmatrix}$$

After finding the total dominance matrix, the last step of ELECTRE I method is the determination of importance order of decision points. For this, it is needed to compare the totals of the lines in E matrix with one another (See Table 12)

Table 12: Order of Importance

No	Place	Total Dominance Matrix						Total		Order of Importance
k_1	Centre	—	0	0	0	0	0	$\sum k_1$	0	3
k_2	**Caycuma**	**1**	**—**	**1**	**0**	**0**	**1**	$\sum k_2$	**3**	**1**
k_3	Kozlu	1	0	—	0	0	0	$\sum k_3$	1	2
k_4	Kilimli	0	0	0	—	0	0	$\sum k_4$	0	3
k_5	Alapli	0	0	0	0	—	1	$\sum k_5$	1	2
k_6	Devrek	0	0	0	1	0	—	$\sum k_6$	1	2

According to Table 12; the 2nd decision point predominates over the 1st, 3rd, 4th, 5th and the 6th decision points absolutely. Although the 3rd, 5th and the 6th decision points predominate over the 1st and 4th decision points, they do not predominate over each other. And the 1st and 4th decision points does not predominate over any decision points.

6. Conclusions

The aim of our study is determining the appropriate facility location through one of the multiple-criteria decision making methods addressing the selection of location in Western Black Sea. It was needed to determine the logistic oriented establishment location selection criteria and their weights in order to achieve the goal defined in this research. Alternative establishment site related data was collected by using need oriented questionnaire method. According to this data, 11 factors that affect the establishment location selection and ranged according to their weights. When factors are examined, it was determined that the factor with the highest weight was the environmental safety, and the factor with the lowest weight was the air pollution.

And when factor weights are evaluated in general, closenesses of weights to one another attract attention. Because of this closeness integrated the criteria of establishment location selection , it enabled the analysis to end up more realistic.

Data obtained within the scope of the analysis was analysed via ELECTRE method. In this analysis, decision matrix, standard decision matrix, weighted standard decision matrix, conformity and nonconformity sets, conformity matrix, nonconformity matrix, conformity supremacy matrix, nonconformity supremacy matrix, total dominance matrix were formed and prioritised. According to this prioritisation, the total dominance values were calculated as “3” for Caycuma, “1” for Alapli, “1” for Kozlu, “0” for Kilimli, “1” for Devrek and “0” for the city centre. According to these calculations, the absolute dominance grading was determined as Caycuma > Kozlu = Devrek = Alaplı > Kozlu > Kilimli = Centre.

In the result of the ELECTRE analysis performed for the selection of establishment site, the establishment of a logistics centre in Caycuma predominated over the other alternatives according to 11 factors. When factor weights are analysed, it was determined that the dominance of this county was directly associated with the factor of accessibility to highways and linking roads, closeness to airport and environmental safety. According to analysis results, the central region, where Zonguldak Harbour is located, could not predominate over any of the other regions. The reasons for this are harbour to be in the city centre, rig traffic to affect the city centre directly, closeness of residential areas to harbour, weak safety in logistics operations, nonbeing of support services like accommodation and park and the most importantly the harbour not to have a land sufficient for the project to be conducted.

According to the research result, the determination of the optimal establishment site as Caycuma County also supports Filyos Harbour project, which is one of the 5 biggest investment project of Turkey. With the construction of Filyos Harbour, two-way RO-RO and container ship traffic will increase in Odessa, Ilyichevsk, Izmail, Mariupol, Kostence, Varna, Burgaz, Novorossiysk, Tuapse, Batum and Poti harbours in the region. And considering the extensive railway network in the region, the logistics centre to be established will both set up a substructure for logistics activities increasing with combined transportation and be the administration point between the Western Black Sea and the Central Anatolia regions.

Proposals presented according to the results obtained from the research;

- The logistics centre will be positioned in Caycuma.
- Feasibility study should be carried out for Caycuma region.
- Filyos harbour project and the logistics centre should be integrated.
- The transportation to optimal establishment site should be supported by means of transport.
- Traffic planning should be done by performing urban logistics based analyses.
- Logistics centre area planning should be done by estimating the commercial growth trends.
- Air cargo transportation and logistics centre integration should be planned by activating the Caycuma airport.
- Plans should be done intended to integration of independent carrying agents and warehouses under a single transportation centre.
- Demand analysis and storage area design should be done in the logistics centre for the companies that take investment decision within the scope of Filyos Harbour project.
- Investment incentives should be increased in the region.
- In case of transferring the merchant ship traffic to Western Black Sea region by basing on the shipping and harbour capacity of Marmara region, the planning of possible domestic logistics distribution network and cost optimisation should be done.

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