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Sorumlu Yazar/ Corresponding Author:
Mehmet ÖZKAN,
ozkannmehmett@gmail.com

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APPLICATION FOR CARGO COMPANY SELECTION USING FUZZY AHP AND FUZZY EDAS METHODS

MEHMET ÖZKAN[1*]

[1] *Dr. Öğr. Üyesi, Yalova Üniversitesi, Mühendislik Fakültesi, ozkannmehmett@gmail.com*

ABSTRACT

Today, customer needs have increased the importance of applications in logistics and supply chain management. In this direction, the most appropriate delivery of products produced in different regions to consumers in different regions provides advantages in both competitiveness and customer satisfaction. For this reason, there is a multi-criteria decision-making process for selecting a cargo company to deliver orders to customers.

The study determines the most suitable cargo company to deliver the orders received by a business that sells both e-commerce and store sales. The model has four main criteria: delivery, quality, system adequacy and trust. In the decision process, a decision team of 5 people consisting of three responsible personnel and two academicians working in the field of logistics is formed. The fuzzy AHP method is used for the criteria weights, and the Fuzzy EDAS method is used for the cargo company selection. With the Fuzzy AHP method, it is concluded that the main criteria have equal importance level, the criterion with the highest importance is the criterion of responding to customer demands/complaints, the flexibility criterion has the lowest importance and the most suitable cargo company is B cargo company with the Fuzzy EDAS method.

Keywords: Logistics and Supply Chain Management, Fuzzy AHP, Fuzzy EDAS, Multi-Criteria Decision Making (MCDM)

BULANIK AHP VE BULANIK EDAS YÖNTEMLERİYLE KARGO FİRMASI SEÇİM UYGULAMASI

ÖZ

Günümüzde müşteri ihtiyaçları lojistik ve tedarik zinciri yönetimi alanında yapılan uygulamaların önemini arttırmıştır. Bu doğrultuda farklı bölgelerde üretilen ürünlerin farklı bölgelerdeki tüketicilere en uygun şekilde ulaştırılması hem rekabet gücü hem de müşteri memnuniyeti yönünden avantaj sağlamaktadır. Bu nedenle siparişlerin müşterilere ulaştırması için kargo firması seçimine yönelik çok kriterli karar verme süreci söz konusu olmaktadır.

Çalışma hem e-ticaret hem de mağaza satışı yapan bir işletmenin aldığı siparişleri müşterilerine ulaştıracak en uygun kargo firmasını belirlemektedir. Model teslimat, kalite, sistem yeterliliği ve güven olmak üzere dört ana kriterden oluşmaktadır. Karar sürecinde lojistik alanında çalışan üç sorumlu personel ve iki akademisyenden oluşan 5 kişilik karar takımı oluşturulmuştur. Kriter ağırlıkları için Bulanık AHP, kargo firması seçimi için Bulanık EDAS yöntemleri kullanılmıştır. Bulanık AHP yöntemi ile ana kriterlerin eşit önem düzeyine sahip olduğu, en yüksek öneme sahip kriterin müşteri taleplerine/şikayetlerine cevap verme kriteri olduğu, esneklik kriterinin en düşük öneme sahip olduğu ve Bulanık EDAS yöntemi ile en uygun kargo firmasının B kargo firması olduğu sonucuna ulaşılmıştır.

Anahtar Kelimeler: Lojistik ve Tedarik Zinciri Yönetimi, Bulanık AHP, Bulanık EDAS, Çok Kriterli Karar Verme (ÇKKV)

Introduction

Today, in line with people's increasing needs, large organizations are needed to deliver products with regional advantages or manufactured products to other regions. The concept of logistics, which covers the transportation, inventory, storage, material management, and packaging processes that are the basis of this organization, is also defined differently as providing resources such as products or services to the desired location at the desired time (Asoğlu & Eren, 2018). Implementing and monitoring these processes requires expertise due to the increase in the cargo volume to be processed. Therefore, it is not easy for producers and sellers to implement logistics processes within their organizations. For this reason, logistics is an outsourced service because it requires expertise and investment to share the risk.

Products sold over the internet are delivered to customers through cargo companies. For this reason, businesses that sell on the internet work in partnership with cargo transportation businesses. Moreover, strategic partnerships are made in the field of logistics in order to work for a long time (Nebati, 2024). At this point, it is important to determine the cargo business with which a strategic business partnership will be made.

In determining the cargo business, it is necessary to determine the features sought in the cargo business. Since a large number of criteria will be used in determining the cargo business, it is considered as a multi-criteria decision making problem (Sancar & Gül, 2024). For this reason, fuzzy AHP and fuzzy EDAS methods, among the multi-criteria decision-making methods, are used and integrated into the study. The fuzzy AHP method is applied for rating the criteria of the cargo business depending on the opinions of the decision team. The determined criteria weights are then included in the fuzzy EDAS method, and a recommendation is presented among alternative cargo businesses.

In the second part of this study, fuzzy numbers, fuzzy AHP, and fuzzy EDAS methods are explained by conducting a literature review. The third part constitutes the application of the study. A preference recommendation is made from alternative cargo companies depending on the criteria.

LITERATURE RESEARCH

The studies in the field of logistics and supply chain management are analyzed with the help of Google Scholar with the words "Cargo+selection". Some studies on cargo business selection have been conducted. However, it has been determined that the methods used in this study for selecting the cargo company that an enterprise will work with are not used together. For this reason, the method applied in this study is thought to guide the completion of the gap in this field, making it different from other studies.

Many studies using the BAHP method in different fields are found in the literature. However, in order to reduce the complexity, the closest studies encountered in the literature research are shown in the table with their explanations.

TABLE 1 | Literature Research Table

Authors	Subject
(Yücel & Ulutaş, 2009)	Numerical criteria are determined by surveying the cargo companies in Malatya. Using the ELECTRE method, it is tried to determine the location of the new store to be opened.
(Atmaca & Turğut , 2015)	Criteria for the selection of cargo companies operating in Turkey are examined. A field study is conducted, and the results are evaluated with SPSS Statistics 20 Program. At the end of the study, it is determined which criteria are important, and the appropriate cargo company is preferred.
(Uzun & Süer, 2015)	Factors affecting service quality in the cargo transportation sector have been determined. Depending on these factors, 3 alternative cargo companies' service quality is compared. AHP and TOPSIS are used as methods.
(Asoğlu & Eren, 2018)	The criteria that a company attaches importance to are created by experts, and the cargo company is selected using AHP, TOPSIS, and PROMETHEE methods.

TABLE 1 (Devamı) | Literature Research Table

Authors	Subject
(Deste & Savaşkan, 2020)	A model consisting of 8 criteria and 5 different alternatives is used to select 3rd Party Logistics Service Providers for e-commerce businesses. The application is realized with the VIKOR method.
(Yürüyen & Ulutaş , 2020)	In order to select a third-party logistics service provider for a factory producing military vehicles and equipment in Ankara, the criteria are weighted with the Fuzzy AHP method. In the last stage, The Fuzzy EDAS method is applied using these weight values, and a decision is made.
(Diken & Çalık, 2022)	The aim is to develop a decision model for the selection of 3PL companies. Criteria and alternatives are evaluated using the AHP and TOPSIS methods. The accuracy of the decision model is checked with expert opinions.
(Nebati, 2024)	The important criteria of the enterprises that benefit from cargo transportation are determined by the ANP method. Then, the most appropriate cargo company is selected by using the CODAS (Combinative Distance-based Assessment) method.

Analytic Hierarchy Process (AHP) is a subjective method based on expert opinions to determine the weights of criteria in the decision model (Onat & Kaçtıoğlu, 2020). EDAS (The Evaluation based on Distance from Average Solution) is a method that enables evaluation between alternatives (Kas Bayrakdaroğlu & Kundakcı, 2019). For a better decision result by eliminating the subjectivity in both methods, fuzzy numbers are used in the AHP and EDAS methods when obtaining expert opinions. There are some studies in the literature on the integration of the methods applied in the study. These studies are explained to increase the whole methodology's reliability. The studies mentioned;

Panchal et al. (2021), the study has selected the best sustainable oil for a cleaner and environmentally friendly production system in a small-scale foundry industry in Agra, India. Performance, quality, and cost are identified as the most important criteria. Jatropha, vegetable oil, karanja oil, and light diesel oil are considered alternatives. Fuzzy Analytic Hierarchy Process (FAHP) has been used to calculate the criteria weights, while Fuzzy TOPSIS (FTOPSIS) and Fuzzy EDAS (FEDAS) methods are preferred to evaluate the alternatives. Light diesel oil is found to be the best oil based on the evaluation criteria. Sensitivity analysis (SA) is applied to determine the accuracy of the proposed decision model. Out of the twelve experiments of the sensitivity analysis, light diesel oil retained the highest score in nine of them.

Karatop et al. (2021), in this study, he has been presented a decision methodology for making optimum investment decisions in the renewable energy sector in Turkey. Five renewable energies, namely hydroelectricity, solar energy, wind energy, geothermal energy, and biomass energy, are identified as alternatives. Fuzzy AHP and Fuzzy EDAS are determined as the solution methods of the study. The importance weights of renewable energy alternatives are calculated using the fuzzy AHP method. The best alternatives have been determined by comparing the results of the fuzzy EDAS method. It is determined that Turkey should focus on hydroelectricity and wind energy in renewable energy investments.

Yel et al. (2022), the study aimed to identify projects based on technical and managerial criteria, taking into account the skills of the development teams actively involved in the project. The weights of the criteria are determined using the fuzzy AHP method. Fuzzy EDAS and WASPAS methods are then used to rank the projects and IT teams as alternatives. As a result of the application, statistical information about errors after software development is accessed.

Sancar & Gül (2023), in his study, he is aimed to determine the most suitable printing machine for machine park investment in a newspaper printing plant. Fuzzy AHP is used to determine the importance weights of the criteria, and Fuzzy EDAS methods are used to evaluate the alternatives in terms of the criteria. Cost, efficiency, and flexibility criteria have been determined with expert opinions and literature research. Four different printing machines suitable for the process and budget are selected as alternatives. As a result of the Fuzzy AHP method, the cost criterion is determined to be the most important criterion. As a result of the fuzzy EDAS method used in evaluating alternatives, it has been determined that machine A2 is the most suitable.

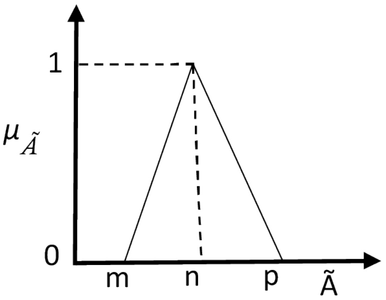
Karipoğlu et al. (2023), in this study, a Geographic Information System (GIS)-based site selection for a hybrid offshore wind and solar power plant is applied. Fuzzy AHP (FAHP) is used to evaluate multiple criteria affecting the location of potential hybrid power plants and Fuzzy EDAS (FEDAS) method is used to determine the most suitable areas. Among the evaluation criteria, it has been found that the technical criteria has a priority weight of 0.60, and the weight of the social criteria is approximately 0.07. Among the sub-criteria, the wind speed criterion has the highest priority weight, while the distance to the port and visibility criteria have the highest priority weights under the main economic and social criteria. Region 2 (A-2) is the best alternative for hybrid offshore power plants among the identified alternatives.

Fuzzy numbers are explained in the next section, and fuzzy AHP and fuzzy EDAS methods are explained in the following sections.

I. Fuzzy Numbers

The first study on fuzzy numbers used in multi-criteria decision-making methods was conducted by Zadeh (Zadeh, 1965). Fuzzy set theory envisages the mathematical description of events that are desired to be explained under the lack of information and uncertainties in real life. Triangular fuzzy numbers are the most widely used in the literature.

FIGURE 1 | Ã Fuzzy Number



$\tilde{A}$, A triangle fuzzy number,

$$\tilde{A} = (m, n, p) \tag{1}$$

It is expressed as follows. Here, m is the lower bound and p is the upper bound of the weight of the criterion affecting the decision maker's decision. Between the lower and upper bound, n is the midpoint that gives the highest value of the decision maker's membership function. The fuzzy number in (1) is defined in (2) as $\mu_{\tilde{A}}(x): R \rightarrow [0,1]$.

$$\mu_M(x) = \begin{cases} \dfrac{x-m}{n-m}, & m \le x \le n \\ \dfrac{p-x}{p-n}, & n \le x \le p \\ 0, & otherwise \end{cases} \tag{2}$$

Arithmetic operations for fuzzy numbers $\tilde{A}_1 = (m_1, n_1, p_1)$ and fuzzy numbers $\tilde{A}_2 = (m_2, n_2, p_2)$ and fuzzy numbers are performed as in the following equations (Chang, 1996).

$$A_1 \oplus \tilde{A}_2 = (m_1 + m_2, n_1 + n_2, p_1 + p_2) \tag{3}$$

$$A_1 \ominus \tilde{A}_2 = (m_1 - p_2, n_1 - n_2, p_1 - m_2) \tag{4}$$

$$\tilde{A}_1 \odot \tilde{A}_2 = (m_1 m_2, n_1 n_2, p_1 p_2) \tag{5}$$

$$\tilde{A}_1 \oslash \tilde{A}_2 = (m_1 / p_2, n_1 / n_2, p_1 / m_2) \tag{6}$$

$$\lambda \odot \tilde{A}_1 = (\lambda m_1, \lambda n_1, \lambda p_1) \tag{7}$$

$$\tilde{A}_1^{-1} = (1/p_1, 1/n_1, 1/m_1) \tag{8}$$

The center of gravity method is generally preferred for stabilizing the triangular fuzzy number Ã=(l,m,u) and Equation 9 is used in the calculation (Gao ve diğerleri, 2020; Yılmaz & Atan, 2021).

$$k(\tilde{A}) = \frac{m+n+p}{3} \tag{9}$$

Equation 10 is used to determine the average distance of a triangular fuzzy number depending on its center of gravity (Yılmaz & Atan, 2021).

$$\psi(\tilde{A}) = \begin{cases} \tilde{A}, & k(\tilde{A}) > 0 \\ \tilde{0}, & k(\tilde{A}) \le 0 \end{cases} \tag{10}$$

$\tilde{0}=(0,0,0)$ Here it is in the form

II. Fuzzy AHP Method

The AHP method, which is widely used in research using multi-criteria decision-making methods, was developed by Thomas L. Saaty (Şengül et al., 2012). AHP is based on the principle that the decision maker evaluates all available alternatives according to all the criteria belonging to them and makes pairwise comparisons of the importance of the relative criteria (Ertunç & Çay, 2020). An importance scale consisting of 1, 3, 5, 7 and 9 absolute values is used in the evaluation process.

Fuzzy AHP method is based on the integration of fuzzy numbers into the AHP method. Different fuzzy AHP approaches are used in the literature. Among these approaches, Buckley (1985) developed the method in which evaluation is made based on qualitative and quantitative criteria and trapezoidal fuzzy numbers are used (Onat & Kaçtıoğlu, 2020). The other fuzzy AHP approach used in the study is the "Extended Analysis Method" in which triangular fuzzy numbers are used and synthetic order values are analyzed (Chang, 1996).

The steps of the fuzzy AHP Extended Analysis Method used in the application part of the research are shown starting from step 3.

Step 1. The linguistic scale in Table 1 is used to transform the decision makers' pairwise comparison evaluations for alternatives and criteria into triangular fuzzy numbers.

TABLE 2 | Fuzzy AHP Criteria Comparison Scale

Fuzzy Number	Linguistic Expressions	Triangular Fuzzy Number Scale
9	Perfect	(8,9,10)
8	Absolutely.	(7,8,9)
7	Very good	(6,7,8)
6	Pretty good	(5,6,7)
5	Good.	(4,5,6)
4	Preferable	(3,4,5)
3	Not bad	(2,3,4)
2	Less advantageous	(1,2,3)
1	Equally important	(1,1,1)

Source: *(Singh et al., 2018)*

Step 2. As a result of the decision team members' comparison of alternatives and criteria, geometric averages are taken using Equation 11 (Sancar & Gül, 2024) to create the combined decision matrix.

$$l_{ij} = \left(\prod_{k=1}^{K} l_{ijk} \right)^{\frac{1}{k}}, m_{ij} = \left(\prod_{k=1}^{K} m_{ijk} \right)^{\frac{1}{k}}, u_{ij} = \left(\prod_{k=1}^{K} u_{ijk} \right)^{\frac{1}{k}} \tag{11}$$

Step 3. After taking the geometric mean of the answers of the decision makers, the Fuzzy AHP Order Analysis Method (Chang, 1996) is applied. The application in question is made by comparing the analysis results of the values corresponding to the x-axis of the intersection points of the triangular numbers.

Step 3a. $X=\{x_1,x_2,...,x_n\}$ is the object set and $U=\{u_1,u_2,..., u_m\}$ is the target set. The extended analysis method is applied to each object cluster element and each target cluster element. As a result, n extended analysis values of the form $M_{gi}^1, M_{gi}^2, \ldots, M_{gi}^m$ (i=1, 2, … , n) and m fuzzy numbers M_{gi}^j (j=1,2,3…,m) are obtained.

Step 3b. $M_{gi}^{1}, M_{gi}^{2}, \ldots, M_{gi}^{m}$ denote the extended analysis values of its objects for m objectives. Equation 13 is then applied for the fuzzy synthetic extended value (order value) of object i.

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{i=1}^{n} m_j, \sum_{j=1}^{m} u_j\right) \quad (12)$$

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \odot \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (13)$$

Equation 14 shows the -first power of the sum of the total n fuzzy numbers $\sum_{j=1}^{m} M_{gi}^{j}$ for each criterion. In other words, it means adding the values of l, m and u in each column and taking the inverse.

$$A^{-1} = \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right) \quad (14)$$

Step 4. The next steps are followed by comparing the order value S_i calculated for each element.

Step 4a. The probability value of the fuzzy numbers $M_1=(l_1,m_1,u_1)$ and $M_2=(l_2,m_2,u_2)$ is calculated as in equation 15.

$$V(M_1 \geq M_2) = \sup_{x \geq y}\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \quad (15)$$

$$V(M_1 \geq M_2) = 1, \quad if \quad m_1 \geq m_2 \quad (16)$$

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \quad (17)$$

Using equations 16 and 17 above, the probability values $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ are calculated.

Step 4b. Equation 18 is used to calculate the degree of superiority of a fuzzy number over k fuzzy numbers.

$$V(M \geq M_1, M_2, \ldots, M_k) = minV(M \geq M_i), \quad i = 1,2,\ldots,k \quad (18)$$

$$d'(A_i) = minV(S_i \geq S_k), \quad k = 1,2,\ldots,n \quad (19)$$

$$W' = \left(d'(A_1), d'(A_2), \ldots d'(A_n)\right)^T \quad (20)$$

Step 4c. Finally, the weight vector in Equation 20 is normalized to calculate the normalized weight vector in Equation 21, which is not a fuzzy number.

$$W = \left(d(A_1), d(A_2), \ldots d(A_n)\right)^T \quad (21)$$

III. Fuzzy EDAS Method

The Evaluation based on Distance from Average Solution (EDAS) method is an approach proposed by (Keshavarz Grohabaee et al., 2015). The EDAS method has been used in the multi-criteria inventory classification problem as an alternative to ABC analysis and aims to make the best alternative decision based on the average solution based on the normalization technique (Torkayesh et al., 2023).

Fuzzy EDAS method has been proposed by applying EDAS method and fuzzy set approach together (Kas Bayrakdaroğlu & Kundakcı, 2019). This study applies the approach in which triangular fuzzy numbers are integrated into the EDAS method. The steps of the applied fuzzy EDAS method are explained below respectively.

TABLE 3 | Fuzzy EDAS Criteria Comparison Scale

Linguistic Expression	Triangular Fuzzy Numbers
Very High	(7,9,9)
High	(5,7,9)
Middle	(3,5,7)
Low	(1,3,5)
Very Low	(1,1,3)

Source: *(Lee et al., 2010)*

Step 1. The answers given by the decision team are transformed into triangular fuzzy numbers with the help of Table 3.

Step 2. With the answers transformed into triangular fuzzy numbers, a combined decision matrix is created with the help of equation 22.

$$\tilde{X} = \left[\tilde{X}_{ij}\right]_{mxn} \quad (22)$$

$$\tilde{X}_{ij} = \left(\prod_{k=1}^{k} X_{ij}^{p}\right)^{\frac{1}{k}} \quad (23)$$

Where $\tilde{X}_{ij}^{p}$ is the performance value of criterion i *(1≤i≤m)* for alternative j *(1≤j≤n)* by p *(1≤p≤k)* decision maker. The responses of these decision makers are combined by taking the geometric meaning.

Step 3. For the average solution matrix or vector, the average of the alternatives for each criterion is taken. The value $\tilde{av}_i$ in equation 24 is the average performance value of the alternatives for each criterion.

$$AV = \left[\tilde{av}_i\right]_{1xn} \quad (24)$$

$$\tilde{av}_i = \frac{\sum_{i=1}^{m} \tilde{X}_{ij}}{m} \quad (25)$$

Step 4. Set K represents the set of benefit-type criteria, and set L represents the set of cost-type criteria. Here, positive distances from the mean and negative distances from the mean are calculated using equations 26 and 27.

Positive distance value from the mean, PDA= $\left[\tilde{pda}_{ij}\right]_{mxn}$

Negative distance value from the mean, NDA= $\left[\tilde{nda}_{ij}\right]_{mxn}$

$$\tilde{pda}_{ij} = \begin{cases} \dfrac{\psi(\tilde{X}_{ij} \ominus \tilde{av}_j)}{k(\tilde{av}_j)}, & if\ j \in K \\ \dfrac{\psi(\tilde{av}_j \ominus \tilde{X}_{ij})}{k(\tilde{av}_j)}, & if\ j \in L \end{cases} \quad (26)$$

$$\tilde{nda}_{ij} = \begin{cases} \dfrac{\psi(\tilde{av}_j \ominus \tilde{X}_{ij})}{k(\tilde{av}_j)}, & if\ j \in K \\ \dfrac{\psi(\tilde{X}_{ij} \ominus \tilde{av}_j)}{k(\tilde{av}_j)}, & if\ j \in L \end{cases} \quad (27)$$

Step 5. Weighted positive and negative distance values are calculated for each alternative.

$$\tilde{sp}_i = \sum_{j=1}^{n} (\tilde{w}_j \otimes \tilde{pda}_{ij}) \quad (28)$$

$$\tilde{sn}_i = \sum_{j=1}^{n} (\tilde{w}_j \otimes \tilde{nda}_{ij}) \quad (29)$$

The w_j values in Equations 28 and 29 are the weight values calculated by the fuzzy AHP method.

Step 6. The calculated $\tilde{sp}_i$ and $\tilde{sn}_i$ values are normalized using equations 30 and 31.

$$\tilde{nsp}_i = \frac{\tilde{sp}_i}{max_i(\tilde{sp}_i)} \quad (30)$$

$$\tilde{nsn}_i = 1 - \frac{\tilde{sn}_i}{max_i(\tilde{sn}_i)} \quad (31)$$

Step 7.1. The fuzzy evaluation performance value $\tilde{as}_i$ for each alternative is calculated using equation 32.

$$\tilde{as}_i = 1 - \frac{\tilde{nsp}_i \otimes \tilde{nsn}_i}{2} \quad (32)$$

Step 7.2. The calculated fuzzy number performance values $\left(\tilde{as}_i\left(as_i^l, as_i^m, as_i^u\right)\right)$ of the alternatives are converted into non-fuzzy values by being stabilized with equation 32. Clarification of triangular fuzzy numbers is generally done by the center of gravity method (Gao ve diğerleri, 2020)

$$as_i = \frac{as_i^l \oplus as_i^m \oplus as_i^u}{3} \quad (33)$$

The calculated as_i values of the alternatives are not fuzzy numbers. The alternative with the highest value is preferred.

CARGO BUSINESS SELECTION APPLICATION

I. Purpose of the Study

It is aimed to make the most appropriate selection from alternative cargo companies for the order delivery of an enterprise that sells electronic materials both in the store and through e-commerce. In this direction, at the end of the application, the preference score of each alternative cargo company will be determined. The cargo company with the highest preference score will be recommended as the most appropriate choice.

II. Assumptions and Limitations of the Study

Ethics committee permission for this study is obtained with the decision of Yalova University Ethics Committees Coordinatorship dated 05/02/2025 and numbered 2024/282. It is accepted that 2 academicians and 3 business managers participating in the study responded to the evaluation forms independently based on their knowledge and experience.

In order to ensure the reliability of the results of the study, a sensitive approach was taken in the process of determining the decision team. For this reason, in order to ensure familiarity and conceptual mastery in the evaluation of the criteria, attention was paid to the fact that the managers and academicians participating in the evaluation were working or working in the fields of logistics and supply chain management. In addition, to ensure the experience condition in the comparison of the criteria, the decision team was determined within the conditions of having at least 10 years of experience in academia or the sector. The information about the decision team members is shown in Table 4.

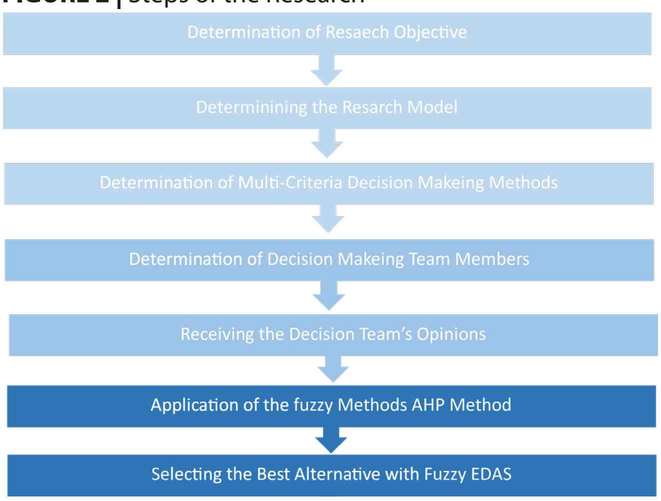
TABLE 4 | Information on Members of the Decision Team

Decision Team Member	Workspace	Experience	Education Status
Academician A	Logistics and Supply Chain Management	More than 20 years	PhD
Academician B	Logistics and Supply Chain Management	More than 10 years	PhD
Expert A	Warehouse Supervisor	More than 15 years	Bachelor's
Expert B	Logistics and Transportation Officer	More than 10 years	Bachelor's
Expert C	Warehouse staff	More than 10 years	Bachelor's

III. Application

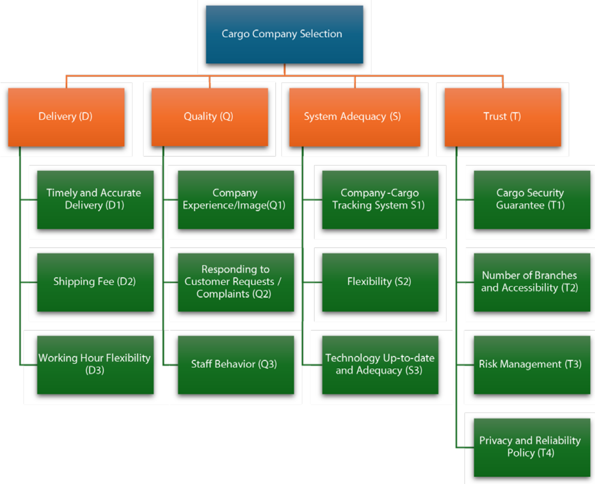
In order to prevent any incomplete implementation and errors in the research process, the implementation steps to be followed are determined as shown in the figure.

FIGURE 2 | Steps of the Research



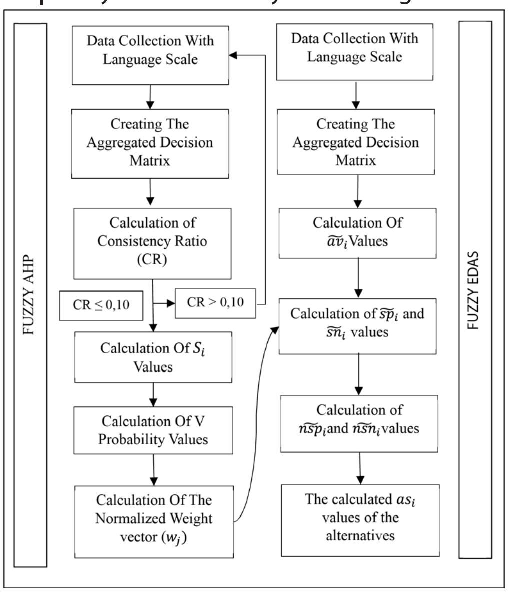
The main criteria and sub-criteria used in the research are shown in Figure 2. The main criteria are delivery, quality, system adequacy, and trust. Under the main delivery criterion, there are sub-criteria of on-time and accurate delivery, shipping cost, and flexibility of operation. Similarly, under the main criterion of quality, there are sub-criteria of company experience/image, responsiveness to customer demands/complaints and staff behavior; under the main criterion of system adequacy, there are sub-criteria of company-cargo tracking system, flexibility, technology update and adequacy; and finally, under the main criterion of trust, there are sub-criteria of cargo security assurance, number of branches and accessibility, risk management, confidentiality and reliability policy. In total, 4 main criteria and 13 sub-criteria are used.

FIGURE 3 | Research Model (Nebati, 2024)



Depending on these criteria, four cargo companies operating in Turkey and known in the sector are determined by taking the opinion of the experts participating in the study. In order to prevent negative understandings that may arise in the form of comparing cargo companies with each other, A, B, C, and D are coded as cargo companies in the study.

FIGURE 4 | Fuzzy AHP and Fuzzy EDAS Integration



IV. Fuzzy AHP Application

Step 1. The decision team members performed the comparison of the main criteria and sub-criteria using the language scale in Table 2. A total of 5 pairwise comparison matrices were created, to which 5 decision team members responded.

To determine the consistency of the Fuzzy AHP method, Kwong and Bai (2013) converted fuzzy numbers into crisp values. This conversion is performed using equation 34 (Kwong & Bai, 2013). The crisp value of $\tilde{M}=(m,n,p)$ fuzzy number A is calculated using equation 24.

$$M\_crisp = (m + 4n + p) / 6 \quad (34)$$

Equations 35 and 36 are used to calculate the consistency ratio of the matrices created by calculating Crisp values.

$$CI = (\lambda_{max} - n) / (n-1) \quad (35)$$

$$CR = \frac{CI}{RI} \quad (36)$$

Here, λ_{max} is the largest eigenvalue in the comparison matrix. The consistency index (CI) depends on the value of λ_{max}, and n is the size of the pairwise comparison matrix. The random index (RI) value in Table 5 depends on the size of the pairwise comparison matrix.

TABLE 5 | Randon Index (RI) (Kwong & Bai, 2013)

n	3	4	5	6	7	8	9
RI (n)	0,58	0,90	1,12	1,24	1,32	1,41	1,45

Table 6 illustrates the transformation of the combined decision matrix of the main criteria into a crisp matrix using Equation 34.

TABLE 6 | Combined Crisp Values Matrix for Main Criteria

	Delivery	Quality	System Adequacy	Trust
Delivery	1,000	0,615	2,051	1,651
Quality	1,642	1,000	2,672	2,299
System Adequacy	0,492	0,380	1,000	0,307
Trust	0,611	0,437	3,286	1,000

The largest eigenvalue (λ_{max}), of the matrix has been calculated to be 4,150. In the calculation, the RI value of the 4-dimensional matrix is taken as 0.90, as shown in Table 5. The consistency ratio (CR) value is then calculated using Equations 35 and 36.

$$CI = (\lambda_{max} - n) / (n - 1) = (4,150 - 4) / (4 - 1) = 0,050$$

$$CR = CI / RI = (0,050) / 0,90 = 0,06 \leq 0,10$$

Since the consistency ratio is less than 0.10, the combined decision matrix is determined as consistent. The consistency ratios of the decision matrices used are calculated similarly and shown in Table 7.

TABLE 7 | Consistency Ratios of Matrices (CR)

Matrice	CR
Main Criteria	0,06
Delivery	0,02
Quality	0,10
System Adequacy	0,02
Trust	0,06

The consistency ratio is first applied to the combined decision matrix of the main criteria and then to the combined decision matrix of the sub-criteria (Özkan, 2021). After the comparison matrices have been determined and verified to be consistent, step 2 is proceeded.

Step 2. The answers given by the decision team members are combined with the formula in equation 11. In this way, the combined matrices of the main criteria and sub-criteria are obtained. The matrices are shown in Table 8-12.

TABLE 8 | Combined Pairwise Comparison Matrix for Main Criteria

	D			Q			S			T		
D	0,33	0,33	0,33	0,28	0,33	0,40	0,28	0,33	0,38	0,28	0,33	0,39
Q	0,27	0,33	0,39	0,33	0,33	0,33	0,26	0,33	0,40	0,30	0,33	0,37
S	0,28	0,33	0,39	0,27	0,32	0,41	0,33	0,33	0,33	0,28	0,33	0,39
T	0,28	0,33	0,39	0,30	0,33	0,37	0,28	0,33	0,39	0,33	0,33	0,33

TABLE 9 | Combined Pairwise Comparison Matrix for "Delivery"

	D1			D2			D3		
D1	0,333	0,333	0,333	0,276	0,333	0,392	0,285	0,333	0,381
D2	0,279	0,327	0,394	0,333	0,333	0,333	0,262	0,335	0,403
D3	0,287	0,329	0,384	0,267	0,322	0,411	0,333	0,333	0,333

TABLE 10 | Combined Pairwise Comparison Matrix for "Quality"

	Q1			Q2			Q3		
Q1	1,00	1,00	1,00	0,27	0,32	0,39	1,31	1,57	1,88
Q2	2,57	3,09	3,65	1,00	1,00	1,00	1,54	1,83	2,11
Q3	0,53	0,64	0,76	0,47	0,55	0,65	1,00	1,00	1,00

TABLE 11 | Combined Pairwise Comparison Matrix for "System Adequacy"

	S1			S2			S3		
S1	1,00	1,00	1,00	2,66	3,39	4,46	1,58	2,05	2,43
S2	0,22	0,29	0,38	1,00	1,00	1,00	0,60	0,72	0,85
S3	0,41	0,49	0,63	1,18	1,40	1,66	1,00	1,00	1,00

TABLE 12 | Combined Pairwise Comparison Matrix for "Trust"

	T1			T2			T3			T4		
T1	1,00	1,00	1,00	2,30	2,67	2,99	0,91	1,10	1,34	1,05	1,23	1,48
T2	0,33	0,37	0,44	1,00	1,00	1,00	0,61	0,76	0,96	0,76	0,92	1,17
T3	0,74	0,91	1,10	1,04	1,31	1,64	1,00	1,00	1,00	0,40	0,49	0,61
T4	0,68	0,81	0,96	0,85	1,09	1,32	1,64	2,04	2,49	1,00	1,00	1,00

Step 3. Fuzzy order values of the main criteria and sub-criteria are calculated and shown in Table 13. Fuzzy order values are calculated by applying equation 12.

TABLE 13 | Fuzzy Order Values for Main and Sub-Criteria

	l	m	u
D	1,17	1,32	2,50
D1	0,89	1,00	1,89
D2	0,87	1,00	1,87
D3	0,89	0,98	1,87
Q	1,17	1,33	2,50
Q1	2,59	2,90	5,48
Q2	5,11	5,92	11,03
Q3	2,00	2,18	4,19

	l	m	u
S	1,16	1,32	2,48
S1	5,25	6,44	11,69
S2	1,83	2,01	3,84
S3	2,59	2,89	5,47
T	1,19	1,33	2,52
T1	5,25	5,99	11,25
T2	2,70	3,05	5,75
T3	3,18	3,71	6,90
T4	4,17	4,94	9,12

Step 4. Synthetic order values for the main criteria and sub-criteria are calculated using Equation 13. The calculated fuzzy numbers are shown in Table 14.

TABLE 14 | Synthetic Order Values for Main and Sub-Criteria

	l	m	u
D	0,12	0,25	0,53
D1	0,16	0,34	0,71
D2	0,16	0,33	0,70
D3	0,16	0,33	0,70
Q	0,12	0,25	0,53
Q1	0,12	0,26	0,56
Q2	0,25	0,54	1,14
Q3	0,10	0,20	0,43

	l	m	u
S	0,12	0,25	0,53
S1	0,25	0,57	1,21
S2	0,09	0,18	0,40
S3	0,12	0,25	0,57
T	0,12	0,25	0,54
T1	0,16	0,34	0,73
T2	0,08	0,17	0,38
T3	0,10	0,21	0,45
T4	0,13	0,28	0,60

Step 5. V probability values are calculated using equations 15, 16 and 17. Table 15 shows the probability values.

TABLE 15 | Table of Probability Values

	D	Q	S	T
D		1	1	1
Q	1		1	1
S	1	0,99		0,99
T	1	1	1	

	T1	T2	T3	T4
T1		1	1	1
T2	0,78		1	1
T3	0,63	0,86		095
T4	0,69	0,91	1	

	D1	D2	D3
D1		1	1
D2	1		1
D3	0,99	0,99	

	Q1	Q2	Q3
Q1		0,54	1
Q2	1		1
Q3	0,83	1	

	S1	S2	S3
S1		1	1
S2	0,27		0,78
S3	0,50	1	

Since the l_1-$u_2>0$ condition (Chang, 1996) emerged in the comparison of the fuzzy synthetic order values obtained from the combined comparison matrix of the main criteria and the combined comparison matrix of the "delivery" criterion, these two matrices are normalized and included in the calculation and presented in Table 8 and Table 9.

Step 6. Depending on the probability values of V, weight vectors are determined using equations 18, 19, and 20. The resulting weight vector is shown in Table 16.

TABLE 16 | Weight Vector Table

Wa′	0,25	0,25	0,25	0,25
Wd′	0,33	0,33	0,33	
Wq′	0,28	0,53	0,19	
Ws′	0,56	0,15	0,28	
Wt′	0,32	0,18	0,22	0,28

Step 7. In Table 16, the weight values in each row are normalized by dividing by the sum of the values in that row. After the operations performed, the normalized criteria weights are shown in Table 17.

TABLE 17 | Normalized Criteria Weights

Main Criteria	Sub Criteria	Group Weight	Overall Weight
Delivery (D)	Accurate Delivery on Time (D1)	0,335	0,084
0,250	Shipping Fee (D2)	0,334	0,083
	Working Time Flexibility (D3)	0,332	0,083
Quality (Q)	Company Experience/Image (Q1)	0,284	0,071
0,251	Responding to Customers (Q2)	0,530	0,133
	Staff Behavior (Q3)	0,186	0,047
System Sufficiency (S)	Company Cargo Tracking System (S1)	0,563	0,140
0,249	Flexibility (S2)	0,154	0,038
	Technology Up-to-Date Enough (Q3)	0,283	0,070
Trust (T)	Cargo Security Coverage (T1)	0,319	0,080
0,250	Number of Branches and Accessibility (T2)	0,180	0,045
	Risk Management (T3)	0,221	0,055
	Privacy and Reliability Policy (T4)	0,280	0,070

For example, in Table 17, the weight of the delivery criterion is 0.25. The group weight of the sub-criteria of the main delivery criterion, the on-time delivery criterion, is 0.335. To calculate the overall weight value of the on-time delivery criterion, these two values are multiplied by each other to obtain a value of 0.084. The criteria obtained in this way will be used as a weight vector in the application of the Fuzzy EDAS method.

V. Fuzzy EDAS Application

Step 1. Using the language scale in Table-3, an opinion form is created to make a pairwise comparison of the criteria for each alternative. The team members are then asked to fill in this form. For example, for cargo company A, the sub-criteria of the main criteria of delivery, quality, system adequacy, and trust are compared among themselves.

The same application is made for cargo company A, which is made for cargo companies B, C, and D. This application is made to prevent the subjective approach of the decision team members and to obtain more reliable results. The decision matrix for Cargo Company A is created by taking the geometric mean of the answers given by the decision team members. An example is shown in Table 18. The decision matrix is created for other cargo companies.

TABLE 18 | Decision Matrix for A Cargo Company

Delivery	D1	D2	D3									
D1	1,00	1,00	1,00	1,52	2,55	3,57	1,00	1,52	2,37			
D2	0,28	0,39	0,66	1,00	1,00	1,00	1,40	1,86	2,49			
D3	0,42	0,66	1,00	0,40	0,54	0,72	1,00	1,00	1,00			
Quality	Q1	Q2	Q3									
Q1	1,00	1,00	1,00	1,15	1,55	2,00	0,57	0,74	0,94			
Q2	0,50	0,64	0,87	1,00	1,00	1,00	0,08	1,19	1,55			
Q3	1,06	1,35	1,74	0,80	0,96	1,25	1,52	1,00	1,00			
System Adequacy	S1	S2	S3									
S1	1,00	1,00	1,00	1,32	1,78	2,17	1,15	1,64	2,05			
S2	0,46	0,56	0,76	1,00	1,00	1,00	0,70	0,87	1,15			
S3	0,61	0,80	1,20	0,87	1,15	1,43	1,00	1,00	1,00			
Trust	T1	T2	T3	T4								
T1	1,00	1,00	1,00	1,15	1,55	2,00	1,64	2,4	3,06	0,76	0,92	1,08
T2	0,50	0,64	0,87	1,00	1,00	1,00	0,80	1,15	1,55	0,36	0,53	0,87
T3	0,33	0,42	0,61	0,64	0,87	1,25	1,00	1,00	1,00	0,76	0,92	1,20
T4	0,92	1,08	1,32	1,15	1,89	2,83	0,83	1,08	1,32	1,00	1,00	1,00

Step 2. The combined EDAS decision matrix in Table 19 is obtained by using Equations 22 and 23 in the decision matrices created by taking the geometric mean of the answers given by the decision team members of each cargo company.

TABLE 19 | Combined EDAS Decision Matrix

Criteria	A Cargo			B Cargo			C Cargo			D Cargo		
D1	1,15	1,57	2,04	1,30	1,64	2,00	1,20	1,54	1,87	1,37	1,73	2,04
D2	0,73	0,90	1,18	0,89	1,16	1,49	0,89	1,07	1,25	1,05	1,24	1,46
D3	0,55	0,71	0,89	0,42	0,53	0,69	0,53	0,61	0,75	0,43	0,49	0,58
Q1	0,87	1,05	1,24	0,74	0,82	0,95	0,86	1,13	1,48	0,91	1,11	1,31
Q2	0,74	0,92	1,11	1,03	1,23	1,42	0,76	0,97	1,23	0,85	0,97	1,14
Q3	1,09	1,09	1,29	0,87	0,99	1,11	0,77	0,91	1,08	0,80	0,92	1,08
S1	1,15	1,43	1,64	1,26	1,74	2,13	0,79	1,04	1,28	1,08	1,36	1,59
S2	0,69	0,79	0,95	0,63	0,80	1,09	0,75	0,89	1,15	0,73	0,81	0,93
S3	0,81	0,97	1,20	0,57	0,72	0,95	0,89	1,08	1,29	0,80	0,91	1,08
T1	1,09	1,36	1,61	0,92	1,27	1,69	0,99	1,34	1,67	0,84	1,01	1,22
T2	0,62	0,79	1,04	0,64	0,81	1,06	0,52	0,60	0,77	1,04	1,27	1,55
T3	0,63	0,76	0,98	0,58	0,73	0,93	0,61	0,73	0,99	0,83	0,96	1,13
T4	0,97	1,22	1,49	1,00	1,28	1,61	1,35	1,69	2,02	0,69	0,81	0,94

Step 3. The average solution matrix is obtained using Equations 24 and 25. The matrix is shown in Table 20.

TABLE 20 | Average Solution Matrix

Criteria		Avj		k(avj)
D1	1,26	1,62	1,98	1,62
D2	0,89	1,09	1,35	1,11
D3	0,48	0,58	0,73	0,60
Q1	0,85	1,03	1,25	1,04
Q2	0,85	1,02	1,22	1,03
Q3	0,88	0,98	1,14	1,00
S1	1,07	1,39	1,66	1,37
S2	0,70	0,82	1,03	0,85
S3	0,77	0,92	1,13	0,94
T1	0,96	1,24	1,55	1,25
T2	0,70	0,87	1,10	0,89
T3	0,66	0,80	1,00	0,82
T4	1,00	1,25	1,52	1,25

Step 4. Using Formulas 26 and 27, the matrix showing the positive (PDA) and negative (NDA) distance values is calculated. The calculated matrices are shown in Table 21 and Table 22.

TABLE 21 | Positive Distance (PDA) Matrix

	A Cargo			B Cargo			C Cargo			D Cargo		
D1	-0,52	-0,03	0,48	-0,42	0,01	0,46	-0,48	-0,05	0,38	-0,38	0,07	0,48
D2	-0,55	-0,17	0,26	-0,41	0,06	0,54	-0,41	-0,02	0,33	-0,27	0,13	0,52
D3	-0,29	0,21	0,69	-0,51	-0,09	0,34	-0,33	0,04	0,45	-0,50	-0,16	0,16
Q1	-0,36	0,02	0,38	-0,49	-0,20	0,11	-0,37	0,10	0,61	-0,32	0,08	0,45
Q2	-0,47	-0,10	0,25	-0,19	0,20	0,56	-0,45	-0,05	0,37	-0,36	-0,05	0,28
Q3	-0,06	0,11	0,41	-0,27	0,01	0,23	-0,37	-0,07	0,20	-0,35	-0,06	0,20
S1	-0,37	0,03	0,42	-0,29	0,25	0,77	-0,63	-0,26	0,15	-0,43	-0,03	0,38
S2	-0,41	-0,04	0,30	-0,48	-0,02	0,47	-0,34	0,08	0,53	-0,36	-0,02	0,27
S3	-0,34	0,06	0,46	-0,60	-0,21	0,20	-0,26	0,17	0,56	-0,36	-0,01	0,34
T1	-0,36	0,09	0,52	-0,50	0,02	0,58	-0,45	0,07	0,57	-0,56	-0,19	0,20
T2	-0,55	-0,09	0,38	-0,53	-0,07	0,40	-0,66	-0,30	0,08	-0,07	0,45	0,95
T3	-0,45	-0,04	0,38	-0,51	-0,08	0,32	-0,48	-0,08	0,39	-0,21	0,20	0,57
T4	-0,44	-0,02	0,39	-0,41	0,03	0,49	-0,13	0,35	0,81	-0,66	-0,35	-0,05

TABLE 22 | Negative Distance (NDA) Matrix

	A Cargo			B Cargo			C Cargo			D Cargo		
D1	-0,48	0,03	-0,48	-0,46	-0,01	0,42	-0,38	0,05	0,38	-0,48	-0,07	0,38
D2	-0,26	0,17	-0,57	-0,54	-0,06	0,41	-0,33	0,02	0,27	-0,52	-0,13	0,27
D3	-0,69	-0,21	0,34	-0,34	0,09	0,51	-0,45	-0,04	0,50	-0,16	0,16	0,50
Q1	-0,38	-0,02	-0,45	-0,11	0,20	0,49	-0,61	-0,10	0,32	-0,45	-0,08	0,32
Q2	-0,25	0,10	-0,58	-0,56	-0,20	0,19	-0,37	0,05	0,36	-0,28	0,05	0,36
Q3	-0,41	-0,11	-0,47	-0,23	-0,01	0,27	-0,20	0,07	0,35	-0,20	0,06	0,35
S1	-0,42	-0,03	-0,47	-0,77	-0,25	0,29	-0,15	0,26	0,43	-0,38	0,03	0,43
S2	-0,30	0,04	-0,46	-0,47	0,02	0,48	-0,53	-0,08	0,36	-0,27	0,02	0,36
S3	-0,46	-0,06	-0,33	-0,20	0,21	0,60	-0,56	-0,17	0,36	-0,34	0,01	0,36
T1	-0,52	-0,09	-0,36	-0,58	-0,02	0,50	-0,57	-0,07	0,56	-0,20	0,19	0,56
T2	-0,38	0,09	-0,36	-0,40	0,07	0,53	-0,08	0,30	0,07	-0,95	-0,45	0,07
T3	-0,38	0,04	-0,34	-0,32	0,08	0,51	-0,39	0,08	0,21	-0,57	-0,20	0,21
T4	-0,39	0,02	-0,49	-0,49	-0,03	0,41	-0,81	-0,35	0,66	0,05	0,35	0,66

Step 5. Weighted positive ($\tilde{sp}_i$) and negative ($\tilde{sn}_i$) distance values are calculated with Formulas 26 and 27. The general criteria weights w_j obtained by fuzzy AHP application and shown in Table 16 are used in the calculation. The values obtained are shown in Table 17.
The general criteria weights (w_j) obtained by fuzzy AHP application and shown in Table 17 are used in calculation. The obtained values are shown in Table 23.

TABLE 23 | Weighted Distance Matrix

		$\tilde{sn}_i$			$\tilde{sp}_i$	
A Cargo	-0,4062	-0,0007	0,4078	-0,408	0,001	-0,395
B Cargo	-0,4261	0,0266	0,4598	-0,460	-0,027	0,406
C Cargo	-0,4261	-0,0132	0,4069	-0,407	0,013	0,388
D Cargo	-0,3875	-0,0127	0,3510	-0,351	0,013	0,388

Step 6. The values obtained with the weighted distance matrix are normalized using equations 30 and 31. The calculated normalized positive ($\tilde{nsp}_i$) and negative ($\tilde{nsn}_i$) distance values are shown in Table 24.

TABLE 24 | Normalized Weighted Distance Matrix

		$\tilde{nsp}_i$			$\tilde{nsn}_i$	
A Cargo	-2,22	0,56	3,30	0,00	0,12	-0,37
B Cargo	-2,86	1,01	4,86	-1,70	0,68	3,02
C Cargo	-1,83	0,78	3,41	-2,28	0,89	2,99
D Cargo	-1,30	0,76	2,66	-2,41	1,00	4,42

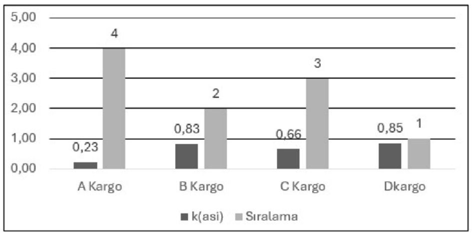
Step 7. Finally, the fuzzy evaluation performance value ($\tilde{as}_i$) for each alternative is calculated using Equation 32 and the fuzzy numbers are stabilized using Equation 33. The alternatives are ranked based on the calculated values. Related calculation results are shown in Table 25.

TABLE 25 | EDAS Evaluation Results

		$\tilde{as}_i$		as_i	Ranking
A Cargo	-1,11	0,34	1,46	0,23	4
**B Cargo	-2,28	0,84	3,94	0,83	2
C Cargo	-2,05	0,83	3,20	0,66	3
D Cargo	-1,85	0,88	3,54	0,85	1

In Table 25, as_i values are not fuzzy numbers, and the ranking of the cargo companies is based on these values.

FIGURE 5 | EDAS Evaluation Results



The application results of the fuzzy EDAS method are shown in Figure 5. It is clearly seen that D cargo company should be preferred with the highest score.

VI. Sensitivity Analysis

A sensitivity analysis has been performed to determine how the model's criteria affect the evaluation of the alternatives. This is because changes in the opinions of decision makers will definitely affect the ranking of the alternatives. In the sensitivity analysis, different scenarios are created based on changes to the main criteria weights, as determined by the Fuzzy AHP method. The four different scenarios are shown in Table 26.

TABLE 26 | Test Scenarios

Main Criteria	1.Scenario	2. Scenario	3. Scenario	4. Scenario
Delivery	+0,15	-0,05	-0,05	-0,05
Quality	-0,05	+0,15	-0,05	-0,05
System Sufficiency	-0,05	-0,05	+0,15	-0,05
Trust	-0,05	-0,05	-0,05	+0,15

For example, in the first scenario, the weight of the main criterion "Delivery" from the Fuzzy AHP method is increased by 15% while the weights of the other main criteria are reduced by 5%.

TABLE 27 | Test Scenario Results of the Model

Alternatives	Current State	1.Scenario	2. Scenario	3. Scenario	4. Scenario
A Cargo	0,23 (4)	0,27 (4)	0,22 (4)	0,21 (4)	0,23 (4)
B Cargo	0,83 (2)	0,83 (2)	0,85 (1)	0,85 (1)	0,81 (2)
C Cargo	0,66 (3)	0,65 (3)	0,64 (3)	0,68 (3)	0,67 (3)
D Cargo	0,85 (1)	0,87 (1)	0,84 (2)	0,82 (2)	0,89 (1)

In Table 27, the terms (1), (2), (3), and (4) indicate the ranking of the alternative in the applied scenario. As a result of the sensitivity analysis conducted with four different scenarios, there is no change in the ranking of the alternatives when scenario 1 and scenario 4 are compared with the current state. However, when scenario 2 and scenario 3 have been compared with the current situation, it has been determined that the first two ranked alternatives are replaced with a very close score. As a result of the sensitivity analysis, in addition to the fact that the ranking of B and C cargo companies has not changed in all four scenarios, the replacement of A and B cargo companies with very close scores shows that the sensitivity level of the model is good.

CONCLUSION

This study is conducted to determine the appropriate cargo company to cooperate with a business that sells both electronics and stores because the competitiveness of the business in the market is one of the important issues of delivering orders to customers with a high level of satisfaction. For this reason, delivery, quality, system adequacy, and reliability criteria should be considered among the characteristics of the appropriate cargo company. Since there is more than one conflicting criterion in the characteristics of the cargo company to be preferred, the process is determined as a multi-criteria decision-making problem.

The solution of the decision model is determined as Fuzzy AHP and Fuzzy EDAS. By applying the Fuzzy AHP method, the weights of the main criteria and sub-criteria are determined. The weights obtained are used in the Fuzzy EDAS method, and the most suitable cargo company is recommended. In evaluating the decision matrices created with the participation of four personnel working on warehouse and shipment processes within the company and two academicians from the field of logistics and supply chain management, the importance of the main criteria of delivery, quality, system adequacy and trust has emerged equally. "Company Cargo Tracking System (0.140)" and 'Responding to Customers (0.133)' are found to be the two most important criteria. The sub-criteria "flexibility" and "number of branches and accessibility" are found to be the least important criteria with an importance level of 0.038 and 0.045, respectively. From this point of view, it is thought that the company where the application is made wants to work with a customer satisfaction-oriented cargo company. When this result is evaluated in terms of competitiveness, it is seen that it supports the purpose of the study.

In the study, four large cargo companies operating in Turkey are determined as alternatives. The alternatives determined by the opinions of the decision team members participating in the research are ranked as D cargo (0,85), B cargo (0.83), C cargo (0.66) and A cargo (0.23) respectively according to the Fuzzy EDAS evaluation results. It is seen that the most suitable alternative is D cargo.

This study is conducted using a specific set of main criteria and sub-criteria. The application of the same model in different enterprises may yield different results. Again, it is possible to include appropriate criteria in the study in the application to be made in enterprises operating in different sectors. It is also open to evaluating the model used in the study using different multi-criteria decision-making methods. Finally, it is thought that this study will shed light on future studies in similar fields.

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