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CUSTOMS BROKERAGE COMPANY SELECTION PROBLEM WITH HYBRID METHOD

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ABSTRACT

Purpose- Customs are the main transit points in cross-border trade activities. Customs logistics activities are carried out by authorized customs brokerage companies (CBC). Export/import companies that execute customs clearance with the right CBC partners gain competitive advantage. Therefore, selecting the right CBC is an important decision-making problem. In this research, CBC selection problem is handled with fuzzy-based multi criteria decision-making (MCDM) methods.
Methodology- The research application covers the CBC selection process of an export firm. The criteria for the problem are obtained as a result of the literature review. The opinions of the decision makers are also taken. Seven criteria have been identified. These criteria are cost/price, service quality, information system and technology, flexibility, relationship, professionalism, reputation. Fuzzy-based stepwise weight assessment ratio analysis (F-SWARA) method is used for criterion weighting. In order of alternatives, ranking of alternatives through functional mapping of criterion sub-intervals into single interval (F-RAFSI) method is applied. Four decision makers are used to compare the criteria.
Findings- Four CBC alternative rankings based on criteria are made. According to the research findings, the highest criterion weight is determined as service quality. The first alternative is chosen as the best alternative.
Conclusion- CBC alternative sequencing has been made for the export company by applying fuzzy-based MCDM methods. Thus, the applicability of MCDM methods is supported in CBC company selection. In addition, the CBC selection criteria are determined, and the CBC selection problem are shed light on. Suggestions are also made to export companies and researchers based on the results of the research.

Keywords: Customs brokerage companies, customs logistics, MCDM, F-SWARA, F-RAFSI
JEL Codes: C02, C44, D81,

1. INTRODUCTION

Customs, which are the transit points of international trade, have a vital importance in the realization of import and export activities among countries. The contribution of customs to the country's economy in terms of logistics supports the customs performance to be among the country's logistics performance indicators (Martí et al, 2014). The complex structure of customs logistics necessitates the establishment of customs facilities in the execution and control of border trade activities. In addition, the standards to be applied in customs clearance activities are defined by legal regulations (Pasichnyk et al., 2017). These regulations specify both the rights and obligations of citizens (Edirisinghe and Jayathilake, 2013). Fulfilling the responsibilities arising from the legislation and different customs regime applications require expertise in customs transactions (Luzhanska et al., 2019). This need for expertise is provided by customs brokers. The authority to represent import and export companies in customs procedures has been given to customs brokers by customs authorities (Lileikis and Staniūtė, 2020). Documents of export, import and transit goods of companies are prepared by customs brokers. Taking samples of goods and issuing origin documents are also handled by customs brokers.

Import and export companies carry out logistics activities in the form of outsourcing to concentrate on basic trade activities. Logistics service providers contribute to the country's economy indirectly by increasing the performance of trade activities. Customs clearance activities, which are among the logistics activities, are also carried out by logistics service providers. In the literature, logistics service providers are defined as “third party logistics provider (3PL firms)” (Zacharia et al., 2011). The customs brokerage companies (CBC), which have customs brokers and carry out the logistics services of the companies, are among the 3PL companies. The main services provided by CBC to export and import companies are: (i) consultation, (ii) issuance of customs pass documents, (iii) issuance of customs declarations, (iv) issuance of documents related to customs cleared goods, (v) to represent import and export companies in customs processes, (vi) professional for customs and tariff legislation is to serve (Llanto et al., 2013). The performance of these services directly affects the customs clearance performance. For this reason, it is necessary to carry out customs procedures with the right CBC partner. The main purpose of this research is to determine the criteria for the CBC selection problem and to apply the CBC selection based on these criteria.

It is known in the literature that multi criteria decision making (MCDM) methods are frequently applied to solve the 3PL firm selection problem. In this study, it is aimed to solve the CBC selection problem with fuzzy-based MCDM methods. In this direction, in the second part of the research, the criteria are determined by literature review. In addition, MCDM methods used in 3PL firm selection are observed. The nomenclature of MCDM methods is presented in Table 1. Afterwards, it is decided to apply fuzzy Stepwise Weight Assessment Ratio Analysis (F-SWARA) method to determine the criterion weights and to apply fuzzy ranking of alternatives through functional mapping of criterion sub-intervals into a single interval (F-RAFSI) method for ranking the alternatives. F-SWARA and F-RAFSI steps are also explained. In the third part, the application is made. In the last section, results and conclusion are presented.

Table 1: Nomenclature

Abbreviations	Full spelling of abbreviations
AHP	Analytic hierarchy process
F-AHP	Fuzzy analytic hierarchy process
EDAS	The evaluation based on distance from average solution
EAMR	Evaluation by an area-based method of ranking
SWARA	Stepwise Weight Assessment Ratio Analysis
WASPAS	The weighted aggregated sum product assessment
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
IVFRN-FARE-MABAC	Interval-valued fuzzy-rough numbers-based factor relationship and multi-attributive border approximation area comparison
HF-CoCoSo	Hesitant fuzzy based a combined compromise solution
IRN-WASPAS	Interval rough number based the weighted aggregated sum product assessment
IRN-MABAC	Interval rough number based multi-attributive border approximation area comparison
IRN-BWM	Interval rough number based best and wort method
GP	Goal programing
IV-IF-TOPSIS	Interval-valued based Intuitionistic fuzzy technique for Order Preference by Similarity to Ideal Solution
D-AHP	D numbers based analytic hierarchy process
HMCDM	Hybrid multi criteria decision making
Z-MABAC	Z numbers based multi-attributive border approximation area comparison
ARAS	The additive ratio assessment
CRITIC	Criteria importance through inter- criteria correlation
DEMATEL	Decision making trial and evaluation laboratory
COPRAS	The complex proportional assessment
q-ROF CODAS	q-rung orthopair fuzzy set combinative distance-based assessment
F-SWARA	Fuzzy stepwise weight assessment ratio analysis
F-RAFSI	Fuzzy ranking of alternatives through functional mapping of criterion sub-intervals into a single interval

2. METHODOLOGY

The research is handled as a fuzzy-based MCDM problem. For this reason, it is necessary to determine the criteria used in the research and to explain the method steps. In this part, the criteria selection process is explained first. Then, fuzzy-based MCDM method steps are presented. Afterwards, the application steps of the problem are explained in the application part.

2.1. Criteria Selection

Customs processes of export/import companies are carried out with the help of customs brokers. The success of export/import services is parallel to the success of customs clearance processes. The completeness of the documents requested by the countries increases the success of customs clearance. Thus, it is necessary to develop long-term partnerships by choosing the CBC that follow the customs clearance procedures of the export/import companies. This selection process is basically a decision problem. Decision-making problems are solved based on criteria. In the literature review, no research was found specifically addressing the CBC selection problem. At this point, the research for the determination of the research criteria is carried out by focusing on the criteria used in the selection of 3PL companies. As a result of the literature review, it is aimed to determine the most used criteria in the 3PL selection problem. The suitability of the CBC selection criteria is determined as a result of the interviews with the decision makers.

Ozcan and Ahıskalı (2020) used Goal Programing, AHP and TOPSIS methods by using seven criteria for 3PL selection. Akpınar (2021) applied SWARA and WASPAS methods in 3PL selection. Twelve criteria were used in the study. Jovčić and Průša (2021) applied Entropy, ARAS, and CRITIC methods. Jovcic et al. (2019a) preferred F-AHP and TOPSIS methods using 5 criteria in the 3PL selection problem. Jovcic et al. (2019b) used the F-AHP method by using the fuzzy logic approach in 3PL firm selection. Ten criteria were used in the study. The cost criterion was determined as the best criterion. Yuan et al. (2022) used DEMATEL and COPRAS methods to solve the problem for 3PL selection under uncertainty. Four criteria were used in the study. The highest criterion weight was determined as the cost criterion. Liu et al. (2020) investigated the logistics service provider selection problem using the hybrid MCDM method. In the research, five alternative 3PL companies were ranked by using five criteria. Roy et al. (2019) applied IVFRN-FARE-MABAC methods in 3PL selection based on sustainable perspective. The criteria were handled in three basic dimensions and 15 criteria were used. As a result of the research, six alternative 3PL companies were ranked. Karbassi Yazdi et al. (2018) discussed the problem of choosing the best 3PL company in the automobile industry. They determined eleven criteria by using the Delphi method. Nine alternative 3PL firm rankings were made using the EAMR method. Kahraman et al. (2020) used the IV-IF-TOPSIS method. Selection was made based on five criteria. Pinar et al. Boran (2022) applied the q-ROF CODAS method for retail companies. Three decision makers, seven criteria and six alternative companies were used in the research. Wen et al. (2019) applied the CoCoSo technique using hesitant fuzzy numbers. Eight criteria were used in the selection of 3PL in the study. Flexibility criterion weight was calculated as the highest. Ecer (2018) discussed the 3PL firm selection problem for the marble company. Fuzzy AHP and EDAS methods were used in the research. Using eleven criteria, the best 3PL firm was determined among the four alternatives. Bulgurcu and Nakiboğlu (2018) applied the 3PL selection problem in the cement industry. Five basic criteria and twenty-nine sub-criteria were used. Criterion weights were determined using the F-AHP technique. The highest sub-criteria weight was determined as Price of the service. Ejem et al. (2021) used SWARA and TOPSIS techniques in the 3PL selection problem in Nigeria. Five criteria were used in the research. The highest criterion weight is the Service level criterion. In addition, the best logistics service provider company was chosen among six alternatives. Pamucar et al. (2019) applied WASPAS, MABAC and BWM methods using interval rough numbers. Five main criteria and seventeen sub-criteria were used in the study. Dadashpour and Bozorgi-Amiri (2020) used the D-AHP method in the selection of sustainable 3PL companies. Five main criteria and fourteen sub-criteria were used in the study. Bianchini (2018) applied the AHP and TOPSIS methods as a hybrid in the 3PL providers selection problem. In the research, the best logistics service provider company was selected by using six criteria. The literature review for the 3PL firm selection problem is presented in Table 2.

Table 2: Literature Review on the 3PL Firm Selection Problem

Authors	Method	Criteria
Bulgurcu and Nakiboğlu (2018)	F-AHP	Cost, Service/operation quality, Competencies, General attributes of firm, Relational factors (5 main criteria and 29 sub-criteria)
Ecer (2018)	Fuzzy AHP, EDAS	Cost, Relationship, Services, Quality, Information System, Flexibility, Delivery, Professionalism, Financial Position, Location, Reputation (11 criteria)
Karbassi Yazdi et al. (2018)	EAMR	Information technology, Human resource, Inventory, Service, Communication, Cost, Time, Quality, Location, Reputation, Professionalism (11 criteria)
Sremac et al. (2018)	SWARA, WASPAS	Vehicle fleet condition, financial stability, Professionalization of drivers, Cost of transport, Application of risk mitigation measures, Application of IT in transport organization, Compensation for damages caused during transportation, Reliability (8 criteria)
Bianchini (2018)	AHP, TOPSIS	cost of service, service level, level of professionalism, geographical location, specific references in the same sector, innovation capacity and collaboration with the customer (6 criteria)
Jovčić et al. (2019a)	F-AHP, TOPSIS	Price, Delivery, Safety, Technology Level, Social Responsibility (5 criteria)
Roy et al. (2019)	IVFRN-FARE-MABAC	Economic, Environmental, Social (3 main criteria and 15 sub-criteria)

Jovčić et al. (2019b)	F-AHP	Total cost of logistics outsourcing, Delivery, Flexibility, Professionalism, Connection with other transport modes, social responsibility, Reputation, Information and equipment system, Quality (10 criteria)
Wen et al. (2019)	HF-CoCoSo	Diversity of services available, Ability to provide value-added services, Information accessibility, Flexibility, Financial stability, Response time, Incompatibility, Willingness (8 criteria)
Pamucar et al. (2019)	IRN-WASPAS, IRN-MABAC, IRN-BWM	Services, Logistics cost, Information system, Intangible, Geographical location (5 main criteria and 17 sub-criteria)
Ozcan and Ahıskalı (2020)	GP, AHP, TOPSIS	Speed of respond to offer request, Operational performance, Accessibility to authorized persons, Company image, Quality, Ease of shipment at competitive prices, long term relationship (7 criteria)
Kahraman et al. (2020)	IV-IF-TOPSIS	Delivery reliability, Quality, Operations standardization, Technology and communication, Cost (5 criteria)
Dadashpour and Bozorgi-Amiri (2020)	D-AHP	Economically, Environmental, Social, Technical, Reputation (5 main criteria and 14 sub-criteria)
Liu et al. (2020)	HMCDM	Total assets, Transport cost, On time rate, Customer satisfaction, Personalized service, Technology level (5 criteria)
Fan et al. (2020)	Z-MABAC	Service quality, logistics cost, operational capability, risk factor, development potential (5 criteria)
Ejem et al. (2021)	SWARA, TOPSIS	Cost, Service level, Financial Capability, Reputation, Long-term relationship (5 criteria)
Akpinar (2021)	SWARA, WASPAS	Price, Speed, Service diversity, Flexibility, Environmental sensitivity, Reliability, Information and communication technologies, Logistics equipment, financial strength, Closeness to the facility, Logistics experience, Reputation in the market (12 criteria)
Jovčić and Průša (2021)	Entropy, ARAS, CRITIC	Price, Delivery service, customer experience, Territorial coverage, Flexibility (5 criteria)
Yuan et al. (2022)	DEMATEL, COPRAS	the cost of logistics, transportation and distribution time, customer service level, storage level (4 criteria)
Pinar and Boran (2022)	q-ROF CODAS	Quality, Delivery, Cost, Financial situation, Customer relations, Reputation and position in the industry, Management (7 criteria)

The criteria used in the 3PL firm selection problem are examined and the criteria that are deemed appropriate to be used in the selection of customs broker firm are as follows: Cost/Price (C1), Service Quality (C2), Information system and technology (C3), Flexibility (C4), Relationship (C5), Professionalism (C6) and Reputation (C7). Table 3 includes other studies that used the criteria to be used in this study.

Table 3: Criteria Used in this Research

Criteria	Research using criteria
Cost/Price (C1)	Bulgurcu and Nakiboğlu (2018), Ecer (2018), Karbassi Yazdi et al. (2018), Sremac et al. (2018), Bianchini (2018), Jovčić et al. (2019b), Pamucar et al. (2019), Kahraman et al. (2020), Liu et al. (2020), Fan et al. (2020), Ejem et al. (2021), Yuan et al. (2022), Pinar and Boran (2022), Jovčić et al. (2019a), Ozcan and Ahıskalı (2020), Akpınar (2021), Jovčić and Průša (2021)
Service Quality (C2)	Bulgurcu and Nakiboğlu (2018), Ecer (2018), Karbassi Yazdi et al. (2018), Bianchini (2018), Wen et al. (2019), Pamucar et al. (2019), Liu et al. (2020), Fan et al. (2020), Ejem et al. (2021), Akpınar (2021), Jovčić and Průša (2021), Yuan et al. (2022), Jovčić et al. (2019b), Ozcan and Ahıskalı (2020), Kahraman et al. (2020), Pinar and Boran (2022)
Information system and technology (C3)	Ecer (2018), Karbassi Yazdi et al. (2018), Jovčić et al. (2019b), Wen et al. (2019), Pamucar et al. (2019), Akpınar (2021), Jovčić et al. (2019a), Kahraman et al. (2020), Dadashpour and Bozorgi-Amiri (2020), Liu et al. (2020)
Flexibility (C4)	Ecer (2018), Jovčić et al. (2019b), Wen et al. (2019), Akpınar (2021), Jovčić and Průša (2021)
Relationship (C5)	Bulgurcu and Nakiboğlu (2018), Ecer (2018), Sremac et al. (2018), Ozcan and Ahıskalı (2020), Kahraman et al. (2020), Ejem et al. (2021), Akpınar (2021), Pinar and Boran (2022), Karbassi Yazdi et al. (2018)

Professionalism (C6)	Ecer (2018), Karbassi Yazdi et al. (2018), Sremac et al. (2018), Bianchini (2018), Bianchini (2018), Akpınar (2021)
Reputation (C7)	Ecer (2018), Karbassi Yazdi et al. (2018), Jovčić et al. (2019b), Dadashpour and Bozorgi-Amiri (2020), Ejem et al. (2021), Akpınar (2021), Pinar and Boran (2022), Ozcan and Ahıskalı (2020)

2.2. Fuzzy The Stepwise Weight Assessment Ratio Analysis Method (F-SWARA)

The SWARA method was developed by Keršuliene et al. (2010). The most important feature of this method is that it sorts the criteria within itself according to the opinions of the decision makers. The F-SWARA method, on the other hand, was developed by Mavi et al. (2017) with the idea that decision makers could explain it more easily with linguistic expressions. This method consists of 6 steps. These steps are described in order (Mavi et al., 2017; Zarbakhshnia et al., 2018; Ansari et al., 2020; Mishra et al., 2020):

Step 1-1: The criteria are ranked according to their importance by the decision makers.

Step 1-2: The *(j+1)th* criterion among the listed criteria is compared with the *jth* criterion. This comparison is made according to Table 4. (l, m, u) values represent triangular fuzzy numbers.

Table 4: Linguistic Expressions and Triangular Fuzzy Number Values for Criterion Weighting (F-SWARA)

Symbol	Definition	Triangular Fuzzy Number Value $\tilde{s}_j$)		
		l	m	u
VL	Very low	0,00	0,00	0,10
L	Low	0,00	0,10	0,30
ML	Medium low	0,10	0,30	0,50
M	Medium	0,30	0,50	0,70
MH	Medium High	0,50	0,70	0,90
H	High	0,70	0,90	1,00
VH	Very High	0,90	1,00	1,00

Step 1-3: Eq. 1 calculates the coefficient $\tilde{k}_j$. And $\tilde{s}_j$ represents triangular fuzzy number values.

$$\tilde{k}_j = \begin{cases} 1, \ j = 1 \\ \tilde{s}_j + 1, \ j > 1 \end{cases} \tag{1}$$

Step 1-4: $\tilde{q}_j$ is calculated by Eq. 2.

$$\tilde{q}_j = \begin{cases} 1, \ j = 1 \\ \frac{\tilde{q}_{j-1}}{\tilde{k}_j}, \ j > 1 \end{cases} \tag{2}$$

Step 1-5: The fuzzy weight values of the criteria $(\widetilde{w}_j)$ are calculated with Eq. 3.

$$\widetilde{w}_j = \frac{\tilde{q}_j}{\sum_{j=1}^{n} \tilde{q}_j} \tag{3}$$

Step 1-6: The fuzzy weight values of the criteria are defuzzied with Eq. 4. In this equation (l, m, u) values represent triangular fuzzy numbers.

$$w_j = \frac{(\widetilde{w}^u{}_j - \widetilde{w}^l{}_j) + (\widetilde{w}^m{}_j - \widetilde{w}^l{}_j)}{3} + \widetilde{w}^l{}_j \tag{4}$$

2.3. Fuzzy Ranking of Alternatives Through Functional Mapping of Criterion Sub-Intervals into A Single Interval Method (F-RAFSI)

The F-RAFSI method is the MCDM method developed by Žižović et al. (2020) for ranking alternatives. This method has been introduced as a technique that can transform from the initial decision matrix to an interval instead of the usual normalization operations. The steps of this method are shown below (Pamučar et al., 2020; Žižović et al., 2020; Alosta et al., 2021; Božanić et al., 2021):

Step 2-1: *Creating the Decision Matrix:* Using the linguistic and triangular fuzzy values shown in Table 5, a decision matrix consisting of *m* alternatives and *n* criteria is created by the *kth* decision maker in Eq. 5 (Liang et al., 2021).

Table 5: Linguistic Expressions and Triangular Fuzzy Number Values for Criterion Weighting (F-RAFSI)

Symbol	Definition	Triangular Fuzzy Number Value ($\tilde{\xi}_{ij}$)		
		l	m	u
VL	Very low	0,1	0,2	0,3
L	Low	0,2	0,3	0,4
ML	Medium low	0,3	0,4	0,5
M	Medium	0,4	0,5	0,6
MH	Medium High	0,5	0,6	0,7
H	High	0,6	0,7	0,8
VH	Very High	0,7	0,8	0,9

$$X^k = \begin{bmatrix} \tilde{\xi}_{11k} & \cdots & \tilde{\xi}_{1jk} & \cdots & \tilde{\xi}_{1nk} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\xi}_{i1k} & \cdots & \tilde{\xi}_{ijk} & \dots & \tilde{\xi}_{ink} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\xi}_{m1k} & \cdots & \tilde{\xi}_{mjk} & \dots & \tilde{\xi}_{mnk} \end{bmatrix} \tag{5}$$

$\tilde{\xi}_{ijk} = (\tilde{\xi}^l{}_{ijk}, \tilde{\xi}^m{}_{ijk}, \tilde{\xi}^u{}_{ijk})$, It is the evaluation of the k^{th} decision maker according to the j^{th} criterion for the i^{th} alternative. Eq. 6 is used to combine the alternatives and criteria evaluated by the decision makers (Yazdani et al., 2011).

$$X\tilde{\xi}^l{}_{ij} = min\{\tilde{\xi}_{ijk}\},\ \tilde{\xi}^m{}_{ij} = \frac{1}{k}\sum_{k=1}^{K} \tilde{\xi}_{ijk},\ \tilde{\xi}^u{}_{ij} = max\{\tilde{\xi}_{ijk}\} \tag{6}$$

Step 2-2: *Identification of ideal and anti-ideal values:* The ideal value ($C_j\left(\tilde{\xi}_{I_j}\right)$) or anti-ideal values ($C_j\left(\tilde{\xi}_{N_j}\right)$) of each criterion are determined by Eq. 7.

$$C_j \in \begin{cases} \left[\tilde{\xi}_{N_j}, \tilde{\xi}_{I_j}\right], for\ benefit\ criteria \\ \left[\tilde{\xi}_{I_j}, \tilde{\xi}_{N_j}\right], for\ cost\ criteria \end{cases} \tag{7}$$

Step 2-3: *Creating a standardized decision-making matrix* $\left(T = \left[\tilde{\varphi}_{ij}\right]_{mxn}\right)$*:* The $\tilde{f}_{A_i}(C_j)$ function is defined by using Eq. 8 from the decision matrices created in Step 2-1.

$$\tilde{f}_{A_i}(C_j) = \tilde{\varphi}_{ij} = \frac{n_b - n_1}{\tilde{\xi}_{I_j} - \tilde{\xi}_{N_j}}\tilde{\xi}_{ij} + \frac{\tilde{\xi}_{I_j}.n_1 - \tilde{\xi}_{N_j}.n_b}{\tilde{\xi}_{I_j} - \tilde{\xi}_{N_j}} \tag{8}$$

Here n_b and n_1 represent how well the ideal value is compared to the anti-ideal value. In addition, since the ideal value is suggested to be 6 times more important than the anti-ideal value, $n_1 = 1$ and $n_b = 6$ are assigned.

$$T = \begin{bmatrix} \tilde{\varphi}_{11} & \cdots & \tilde{\varphi}_{1j} & \cdots & \tilde{\varphi}_{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\varphi}_{i1} & \cdots & \tilde{\varphi}_{ij} & \dots & \tilde{\varphi}_{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\varphi}_{m1} & \cdots & \tilde{\varphi}_{mj} & \dots & \tilde{\varphi}_{mn} \end{bmatrix}, \tilde{\varphi}_{ij} \in [n_1, n_b] \tag{9}$$

Step 2-4: *Generating the normalized decision matrix* $\left(N = \left[\tilde{\varphi}_{ij}\right]_{mxn}\right)$*:* With Eq. 10, the decision matrix is normalized. The normalized decision matrix in Eq.13 is created with the obtained values.

$$\tilde{\gamma}_{ij} \in \begin{cases} \frac{\tilde{\varphi}_{ij}}{2A}, for\ benefit\ criteria \\ \frac{H}{2\tilde{\varphi}_{ij}}, for\ cost\ criteria \end{cases} \tag{10}$$

A represents the arithmetic mean of n_b and n_1 elements (Eq. 11). H represents the harmonic mean (Eq. 12).

$$A = \frac{n_b + n_1}{2} \tag{11}$$

$$H = \frac{2}{\frac{1}{n_1} + \frac{1}{n_b}} \tag{12}$$

$$N = \begin{bmatrix} \tilde{\gamma}_{11} & \cdots & \tilde{\gamma}_{1j} & \cdots & \tilde{\gamma}_{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\gamma}_{i1} & \cdots & \tilde{\gamma}_{ij} & \cdots & \tilde{\gamma}_{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \tilde{\gamma}_{m1} & \cdots & \tilde{\gamma}_{mj} & \cdots & \tilde{\gamma}_{mn} \end{bmatrix} \quad (13)$$

Step 2-5: *Calculation of criterion functions of alternatives* $\left(\tilde{Q}(A_i)\right)$*:* With Eq. 14, the criterion functions of the alternatives are calculated.

$$\tilde{Q}(A_i) = \sum_{j=1}^{n} w_j \tilde{\gamma}_{ij} \quad (14)$$

Step 2-6: *Defuzzied of criteria functions of alternatives and determination of the best alternative:* Defuzzied is done with Eq. 15 and the alternatives are ranked.

$$Q(A_i) = \left(\tilde{Q}(A_i)^l + \tilde{Q}(A_i)^m + \tilde{Q}(A_i)^u\right)/6 \quad (15)$$

3. APPLICATION

In this research, the CBC selection problem serving in Sarp customs region of Turkey is discussed. The best CBC selection problem of an export firm using Sarp customs has been determined by applying F-SWARA and F-RAFSI methods. Data were collected from four decision makers from the export company (k=1,2,3,4). For the decision problem, seven criteria were used (j=1,2,3,4,5,6,7). Four CBCs determined as alternatives (i=1,2,3,4). The weights of the criteria were calculated using the F-SWARA method. Then, the alternatives were ranked using the F-RAFSI method. The steps applied are presented below:

Step 1-1: Table 6 shows the criteria ordered by the decision makers according to their importance.

Table 6: Ranking of Criteria by Decision Makers in order of Importance

DM1	DM2	DM3	DM4
C2	C2	C6	C6
C6	C6	C2	C2
C5	C7	C4	C5
C4	C5	C5	C4
C1	C4	C3	C7
C3	C3	C1	C3
C7	C1	C7	C1

Step 1-2: The criteria are evaluated linguistically by the decision makers according to the previous criteria. Linguistic expressions are shown in Table 7. Triangular fuzzy number values are shown in Table 8.

Table 7: Evaluation of Criteria by Decision Makers (Linguistic Expressions)

DM1		DM2		DM3		DM4	
C2		**C2**		**C6**		**C6**	
C6	VH	**C6**	VH	**C2**	VL	**C2**	VL
C5	L	**C7**	VL	**C4**	M	**C5**	L
C4	VL	**C5**	VH	**C5**	L	**C4**	VL
C1	MH	**C4**	ML	**C3**	H	**C7**	MH
C3	L	**C3**	M	**C1**	L	**C3**	VL
C7	VL	**C1**	VL	**C7**	MH	**C1**	M

Table 8: Evaluation of Criteria by Decision Makers (Triangular Fuzzy Number Values, $\tilde{s}_j$)

DM1				DM2				DM3				DM4			
	l	m	u		l	m	u		l	m	u		l	m	u
C2				**C2**				**C6**				**C6**			
C6	0.90	1.00	1.00	**C6**	0.90	1.00	1.00	**C2**	0.00	0.00	0.10	**C2**	0.00	0.00	0.10
C5	0.00	0.10	0.30	**C7**	0.00	0.00	0.10	**C4**	0.30	0.50	0.70	**C5**	0.00	0.10	0.30
C4	0.00	0.00	0.10	**C5**	0.90	1.00	1.00	**C5**	0.00	0.10	0.30	**C4**	0.00	0.00	0.10
C1	0.50	0.70	0.90	**C4**	0.10	0.30	0.50	**C3**	0.70	0.90	1.00	**C7**	0.50	0.70	0.90

C3	0.00	0.10	0.30	**C3**	0.30	0.50	0.70	**C1**	0.00	0.10	0.30	**C3**	0.00	0.00	0.10
C7	0.00	0.00	0.10	**C1**	0.00	0.00	0.10	**C7**	0.50	0.70	0.90	**C1**	0.30	0.50	0.70

Step 1-3: $\tilde{k}_j$ coefficients are calculated by Eq. 1. It is shown in Table 9.

Table 9: $\tilde{k}_j$ Coefficients

	DM1				**DM2**				**DM3**				**DM4**		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C2	1,00	1,00	1,00	**C2**	1,00	1,00	1,00	**C6**	1,00	1,00	1,00	**C6**	1,00	1,00	1,00
C6	1,90	2,00	2,00	**C6**	1,90	2,00	2,00	**C2**	1,00	1,00	1,10	**C2**	1,00	1,00	1,10
C5	1,00	1,10	1,30	**C7**	1,00	1,00	1,10	**C4**	1,30	1,50	1,70	**C5**	1,00	1,10	1,30
C4	1,00	1,00	1,10	**C5**	1,90	2,00	2,00	**C5**	1,00	1,10	1,30	**C4**	1,00	1,00	1,10
C1	1,50	1,70	1,90	**C4**	1,10	1,30	1,50	**C3**	1,70	1,90	2,00	**C7**	1,50	1,70	1,90
C3	1,00	1,10	1,30	**C3**	1,30	1,50	1,70	**C1**	1,00	1,10	1,30	**C3**	1,00	1,00	1,10
C7	1,00	1,00	1,10	**C1**	1,00	1,00	1,10	**C7**	1,50	1,70	1,90	**C1**	1,30	1,50	1,70

Step 1-4: $\tilde{q}_j$ values are calculated by Eq. 2. It is shown in Table 10.

Table 10: $\tilde{q}_j$ Values

	DM1				**DM2**				**DM3**				**DM4**		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C2	1,0000	1,0000	1,0000	**C2**	1,0000	1,0000	1,0000	**C6**	1,0000	1,0000	1,0000	**C6**	1,0000	1,0000	1,0000
C6	0,5263	0,5000	0,5000	**C6**	0,5263	0,5000	0,5000	**C2**	1,0000	1,0000	0,9091	**C2**	1,0000	1,0000	0,9091
C5	0,5263	0,4545	0,3846	**C7**	0,5263	0,5000	0,4545	**C4**	0,7692	0,6667	0,5348	**C5**	1,0000	0,9091	0,6993
C4	0,5263	0,4545	0,3497	**C5**	0,2770	0,2500	0,2273	**C5**	0,7692	0,6061	0,4114	**C4**	1,0000	0,9091	0,6357
C1	0,3509	0,2674	0,1840	**C4**	0,2518	0,1923	0,1515	**C3**	0,4525	0,3190	0,2057	**C7**	0,6667	0,5348	0,3346
C3	0,3509	0,2431	0,1416	**C3**	0,1937	0,1282	0,0891	**C1**	0,4525	0,2900	0,1582	**C3**	0,6667	0,5348	0,3042
C7	0,3509	0,2431	0,1287	**C1**	0,1937	0,1282	0,0810	**C7**	0,3017	0,1706	0,0833	**C1**	0,5128	0,3565	0,1789

Step 1-5: $\tilde{w}_j$ values are calculated by Eq. 3. It is shown in Table 11.

Table 11: $\tilde{w}_j$ Values

	DM1				**DM2**				**DM3**				**DM4**		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C2	0,2754	0,3162	0,3719	**C2**	1,0000	1,0000	1,0000	**C6**	0,2107	0,2468	0,3028	**C6**	0,1711	0,1907	0,2462
C6	0,1449	0,1581	0,1860	**C6**	0,5263	0,5000	0,5000	**C2**	0,2107	0,2468	0,2753	**C2**	0,1711	0,1907	0,2238
C5	0,1449	0,1437	0,1431	**C7**	0,5263	0,5000	0,4545	**C4**	0,1621	0,1645	0,1619	**C5**	0,1711	0,1734	0,1722
C4	0,1449	0,1437	0,1301	**C5**	0,2770	0,2500	0,2273	**C5**	0,1621	0,1496	0,1246	**C4**	0,1711	0,1734	0,1565
C1	0,0966	0,0845	0,0684	**C4**	0,2518	0,1923	0,1515	**C3**	0,0954	0,0787	0,0623	**C7**	0,1140	0,1020	0,0824
C3	0,0966	0,0769	0,0527	**C3**	0,1937	0,1282	0,0891	**C1**	0,0954	0,0716	0,0479	**C3**	0,1140	0,1020	0,0749
C7	0,0966	0,0769	0,0479	**C1**	0,1937	0,1282	0,0810	**C7**	0,0636	0,0421	0,0252	**C1**	0,0877	0,0680	0,0441

Step 1-6: The geometric mean of the values in Table 11 was taken. Then, it was defuzzied with Eq. 4 and the weights of the criteria were calculated. The degree of importance and order of the criteria are shown in Table 12.

Table 12: Criteria Weights and Ranking

Criteria	$\mathbf{w_j}$	**Rankings**
C2	0,2741	1
C6	0,1988	2
C5	0,1349	3
C4	0,1285	4
C1	0,0661	7
C3	0,0730	6
C7	0,0864	5

Step 2-1: The linguistic expressions of the decision makers are shown in Table 13 and the triangular fuzzy number values are shown in Table 14. The l, m and u values of the decision matrix combined with Eq. 6 are obtained. The combined decision matrix obtained is shown in Table 15.

Table 13: Decision Matrix (Linguistic Expressions)

		C1	C2	C3	C4	C5	C6	C7
DM1	A1	M	VH	H	MH	H	H	H
	A2	L	H	H	M	M	H	MH
	A3	H	MH	M	ML	M	H	M
	A4	H	L	ML	H	H	M	L
		C1	C2	C3	C4	C5	C6	C7
DM2	A1	M	H	MH	M	VH	M	VH
	A2	M	H	MH	M	VH	VH	M
	A3	ML	MH	ML	M	M	H	H
	A4	L	M	L	H	ML	ML	L
		C1	C2	C3	C4	C5	C6	C7
DM3	A1	ML	H	MH	H	H	VH	VH
	A2	ML	H	MH	VH	H	H	H
	A3	MH	MH	M	MH	M	M	M
	A4	H	M	ML	H	ML	ML	M
		C1	C2	C3	C4	C5	C6	C7
DM4	A1	H	M	H	M	MH	H	H
	A2	ML	M	MH	M	H	M	MH
	A3	H	M	MH	M	M	M	MH
	A4	VL	M	M	ML	VL	L	M

Table 14: Decision Matrix (Triangular fuzzy number values, $\tilde{\tilde{\xi}}_{ij}$)

		C1			C2			C3			C4			C5			C6			C7		
		l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
DM1	A1	0,4	0,5	0,6	0,7	0,8	0,9	0,6	0,7	0,8	0,5	0,6	0,7	0,6	0,7	0,8	0,6	0,7	0,8	0,6	0,7	0,8
	A2	0,2	0,3	0,4	0,6	0,7	0,8	0,6	0,7	0,8	0,4	0,5	0,6	0,4	0,5	0,6	0,6	0,7	0,8	0,5	0,6	0,7
	A3	0,6	0,7	0,8	0,5	0,6	0,7	0,4	0,5	0,6	0,3	0,4	0,5	0,4	0,5	0,6	0,6	0,7	0,8	0,4	0,5	0,6
	A4	0,6	0,7	0,8	0,2	0,3	0,4	0,3	0,4	0,5	0,6	0,7	0,8	0,6	0,7	0,8	0,4	0,5	0,6	0,2	0,3	0,4
DM2	A1	0,4	0,5	0,6	0,6	0,7	0,8	0,5	0,6	0,7	0,4	0,5	0,6	0,7	0,8	0,9	0,4	0,5	0,6	0,7	0,8	0,9
	A2	0,4	0,5	0,6	0,6	0,7	0,8	0,5	0,6	0,7	0,4	0,5	0,6	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,5	0,6
	A3	0,3	0,4	0,5	0,5	0,6	0,7	0,3	0,4	0,5	0,4	0,5	0,6	0,4	0,5	0,6	0,6	0,7	0,8	0,6	0,7	0,8
	A4	0,2	0,3	0,4	0,4	0,5	0,6	0,2	0,3	0,4	0,6	0,7	0,8	0,3	0,4	0,5	0,3	0,4	0,5	0,2	0,3	0,4
DM3	A1	0,3	0,4	0,5	0,6	0,7	0,8	0,5	0,6	0,7	0,6	0,7	0,8	0,6	0,7	0,8	0,7	0,8	0,9	0,7	0,8	0,9
	A2	0,3	0,4	0,5	0,6	0,7	0,8	0,5	0,6	0,7	0,7	0,8	0,9	0,6	0,7	0,8	0,6	0,7	0,8	0,6	0,7	0,8
	A3	0,5	0,6	0,7	0,5	0,6	0,7	0,4	0,5	0,6	0,5	0,6	0,7	0,4	0,5	0,6	0,4	0,5	0,6	0,4	0,5	0,6
	A4	0,6	0,7	0,8	0,4	0,5	0,6	0,3	0,4	0,5	0,6	0,7	0,8	0,3	0,4	0,5	0,3	0,4	0,5	0,4	0,5	0,6
DM4	A1	0,6	0,7	0,8	0,4	0,5	0,6	0,6	0,7	0,8	0,4	0,5	0,6	0,5	0,6	0,7	0,6	0,7	0,8	0,6	0,7	0,8
	A2	0,3	0,4	0,5	0,4	0,5	0,6	0,5	0,6	0,7	0,4	0,5	0,6	0,6	0,7	0,8	0,4	0,5	0,6	0,5	0,6	0,7
	A3	0,6	0,7	0,8	0,4	0,5	0,6	0,5	0,6	0,7	0,4	0,5	0,6	0,4	0,5	0,6	0,4	0,5	0,6	0,5	0,6	0,7
	A4	0,1	0,2	0,3	0,4	0,5	0,6	0,4	0,5	0,6	0,3	0,4	0,5	0,1	0,2	0,3	0,2	0,3	0,4	0,4	0,5	0,6

Table 15: Aggregated Decision Matrix

	C1			C2			C3			C4			C5			C6			C7		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
A1	0,3 00	0,5 25	0,8 00	0,4 00	0,6 75	0,9 00	0,5 00	0,6 50	0,8 00	0,4 00	0,5 75	0,8 00	0,5 00	0,7 00	0,9 00	0,4 00	0,6 75	0,9 00	0,6 00	0,7 50	0,9 00
A2	0,2 00	0,4 00	0,6 00	0,4 00	0,6 50	0,8 00	0,5 00	0,6 25	0,8 00	0,4 00	0,5 75	0,9 00	0,4 00	0,6 75	0,9 00	0,4 00	0,6 75	0,9 00	0,4 00	0,6 00	0,8 00
A3	0,3 00	0,6 00	0,8 00	0,4 00	0,5 75	0,7 00	0,3 00	0,5 00	0,7 00	0,3 00	0,5 00	0,7 00	0,4 00	0,5 00	0,6 00	0,4 00	0,6 00	0,8 00	0,4 00	0,5 75	0,8 00
A4	0,1 00	0,4 75	0,8 00	0,2 00	0,4 50	0,6 00	0,2 00	0,4 00	0,6 00	0,3 00	0,6 25	0,8 00	0,1 00	0,4 25	0,8 00	0,2 00	0,4 00	0,6 00	0,2 00	0,4 00	0,6 00

Step 2-2: $C_j\left(\tilde{\xi}_{I_j}\right)$ and $C_j\left(\tilde{\xi}_{N_j}\right)$ values are shown in Table 16.

Table 16: Ideal and Anti-Ideal Values of the Criteria

	C1	C2	C3	C4	C5	C6	C7
Benefit criteria		[0,2; 0,9]	[0,2; 0,8]	[0,3; 0,9]	[0,1; 0,9]	[0,2; 0,9]	[0,2; 0,9]
Non-benefit criteria	[0,1; 0,8]						

Step 2-3: Standardized decision-making matrix $\left(\mathrm{T}=\left[\tilde{\varphi}_{\mathrm{ij}}\right]_{\mathrm{mxn}}\right)$ in Equation 9 is created with the $\tilde{f}_{A_i}(C_j)$ functions calculated by Eq. 8. T matrix is shown in Table 17.

Table 17: Standardized Decision-Making Matrix $(\mathbf{T\ Matrix})$

	C1			C2			C3			C4			C5			C6			C7		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
A1	2,429	4,036	6,000	2,429	4,393	6,000	3,500	4,750	6,000	1,833	3,292	5,167	3,500	4,750	6,000	2,429	4,393	6,000	3,857	4,929	6,000
A2	1,714	3,143	4,571	2,429	4,214	5,286	3,500	4,542	6,000	1,833	3,292	6,000	2,875	4,594	6,000	2,429	4,393	6,000	2,429	3,857	5,286
A3	2,429	4,571	6,000	2,429	3,679	4,571	1,833	3,500	5,167	1,000	2,667	4,333	2,875	3,500	4,125	2,429	3,857	5,286	2,429	3,679	5,286
A4	1,000	3,679	6,000	1,000	2,786	3,857	1,000	2,667	4,333	1,000	3,708	5,167	1,000	3,031	5,375	1,000	2,429	3,857	1,000	2,429	3,857

Step 2-4: With Eq. 10, the decision matrix is normalized $\left(N=\left[\tilde{\varphi}_{ij}\right]_{mxn}\right)$. The resulting normalized decision matrix is shown in Table 18.

Table 18: Normalized Decision-Making Matrix $(\mathbf{N\ Matrix})$

	C1			C2			C3			C4			C5			C6			C7		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
A1	0,353	0,212	0,143	0,347	0,628	0,857	0,500	0,679	0,857	0,262	0,470	0,738	0,500	0,679	0,857	0,347	0,628	0,857	0,551	0,704	0,857
A2	0,500	0,273	0,188	0,347	0,602	0,755	0,500	0,649	0,857	0,262	0,470	0,857	0,411	0,656	0,857	0,347	0,628	0,857	0,347	0,551	0,755
A3	0,353	0,188	0,143	0,347	0,526	0,653	0,262	0,500	0,738	0,143	0,381	0,619	0,411	0,500	0,589	0,347	0,551	0,755	0,347	0,526	0,755
A4	0,857	0,233	0,143	0,143	0,398	0,551	0,143	0,381	0,619	0,143	0,530	0,738	0,143	0,433	0,768	0,143	0,347	0,551	0,143	0,347	0,551

Step 2-5: The criterion function values of the alternatives calculated by Eq. 14 are shown in Table 19 $\left(\tilde{Q}(A_i)\right)$.

Table 19: Criterion Function Values of Alternatives $\left(\tilde{\boldsymbol{Q}}(\boldsymbol{A_i})\right)$

	l	m	u
A1	0,373	0,573	0,762
A2	0,353	0,552	0,743
A3	0,310	0,464	0,617
A4	0,185	0,378	0,561

Step 2-6: The ranking of the alternatives obtained as a result of the defuzzification process with Eq. 15 is shown in Table 20.

Table 20: Ranking of Alternatives

Alternatives	A1	A2	A3	A4
$\boldsymbol{Q(A_i)}$	0,2846	0,2746	0,2319	0,1873
Rankings	1	2	3	4

4. RESULTS AND CONCLUSION

Customs clearance, storage, export/import documentation of commercial goods, preparation of goods documents according to customs tariff codes and customs regimes are carried out at customs, which are the connection points of international trade. These processes require expertise. CBCs offer services to import/export companies as experts by being authorized directly. In this research, the selection problem of CBCs serving in the Sarp customs region of Turkey is discussed. In this context, F-SWARA and F-RAFSI methods were applied. The criteria were weighted with the F-SWARA method. Before the application of the method, a literature review was made, and a cluster of selection criteria was determined. Subsequently, the most suitable seven criteria were determined from this cluster. As a result of the F-SWARA method application, the highest criterion weight was determined as the *Service Quality* ($\mathrm{w}_2 = 0{,}2741$). The lowest weight was determined as the *Reputation* ($\mathrm{w}_7 = 0{,}0864$). The order of priority of the other criteria is as follows: *Professionalism* ($\mathrm{w}_6 = 0{,}1988$), *Relationship* ($\mathrm{w}_5 = 0{,}1349$), *Flexibility* ($\mathrm{w}_4 = 0{,}1285$), *Cost/Price* ($\mathrm{w}_1 = 0{,}0661$), *Information system and technology* ($\mathrm{w}_3 = 0{,}0730$). According to these results, it is understood that the service quality of CBCs comes first. Since customs clearance activities are service-oriented activities, it is an expected result that this criterion appears as the most effective criterion. However, the reputation, which has a parallel relationship with service quality, is not among the results expected to be the lowest criterion. At this point, it can be mentioned that instead of gaining prestige in choosing a CBC, being a pioneer in service quality provide an advantage. It is also understood that CBC acting professionally and following effective strategies in customer relations make the companies preferable. F-RAFSI method was applied to select the best company among the four companies serving in the Sarp customs region. For the research findings, the first alternative $Q(A_1) = 0{,}2846$ is at the top of the ranking. However, there is a 1% difference between the second alternative and the first alternative $Q(A_2) = 0{,}2746$. It has been observed that this difference is statistically very close. Other alternatives are at a lower level in terms of preference than the first two alternatives. Finally, the first alternative was preferred in the problem that was solved with fuzzy-based MCDM problem methods.

With this research, two important contributions were made to the literature by making the CBC selection application, which is a logistics service provider company. Firstly, the criteria and criterion weights used in the CBC selection problem were determined and shed light on practical applications. Secondly, it has been proven that fuzzy-based decision-making problem can be handled in CBC selection as in other 3PL firm selection problems. Thus, suggestions have been developed for researchers and export companies. Suggestions to export companies are as follows: (i) CBCs should focus on the service quality of the companies in their selection. (ii) CBCs should apply multi criteria decision making techniques instead of intuitive decision making. (iii) While evaluating among the alternatives, CBCs should make choices based on many criteria instead of accepting the reputation levels of the firms. (iv) Expert opinions should be considered in selecting a CBC. Suggestions for researchers include: (i) The criteria determined in this research can be used in different fields. (ii) Various fuzzy-based MCDM methods can be applied for this problem. (iii) The problem can be solved by increasing the criteria for different areas. (iv) CBC selection problem of import companies can be applied by dealing with same methods or different methods.

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