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EVALUATION OF THE FACTORS AFFECTING THE CAREER CHOICE OF STATISTICS STUDENTS WITH FUZZY DEMATEL AND FUZZY TOPSIS METHODS

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Abstract

Career choice is a pivotal decision that shapes an individual's professional path and has a profound impact on their life. Various factors influence this process, and identifying and prioritizing these influences in real-world scenarios is often challenging. Ranking the factors that are effective in career choice is a problem that can be handled with Multi-Criteria Decision Making (MCDM) methods. Fuzzy logic approach can be used together with MCDM methods. The concept of Fuzzy Logic was developed by Zadeh (Zadeh, 1965) and fuzzy versions of many MCDM methods have been proposed in this context. This study investigates which fields of study hold greater significance during the career planning and preference stages for statistics department graduates, taking into account the influences they encounter in their career selection process. The relationships between the main criteria were analyzed using the Fuzzy DEMATEL method, based on input from expert decision-makers. Subsequently, an initial table was created using the Fuzzy TOPSIS method, incorporating criteria weights derived from the Fuzzy DEMATEL analysis. This approach enabled the identification of the most appropriate decision alternatives and rankings across five different fields of study. The findings indicate that individuals who choose the statistics department due to factors such as numerical ability, skills, interests, environmental influences and family structure, professional values, psychological needs, earnings potential, ease of job acquisition, coursework, and social opportunities tend to prefer working as data specialists after graduation.

Keywords: Fuzzy DEMATEL, Fuzzy TOPSIS, Multi Criteria Decision Making, Carrier Choice.

Jel Codes: C44, D81, C02, M10.

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İSTATİSTİK BÖLÜMÜ ÖĞRENCİLERİNİN KARİYER SEÇİMİNİ ETKİLEYEN FAKTÖRLERİN BULANIK DEMATEL VE BULANIK TOPSIS YÖNTEMLERİ İLE DEĞERLENDİRİLMESİ

Öz

Kariyer seçimi, bireyin mesleki yolunu şekillendiren ve yaşamı üzerinde derin bir etkiye sahip olan önemli bir karardır. Bu süreci çeşitli faktörler etkiler ve gerçek dünya senaryolarında bu etkilerin belirlenmesi ve önceliklendirilmesi genellikle zordur. Kariyer seçiminde etkili olan faktörlerin sıralanması da Çok Kriterli Karar Verme (ÇKKV) yöntemleri ile ele alınabilecek bir problemdir. ÇKKV yöntemleri ile birlikte bulanık mantık yaklaşımı birlikte kullanılabilmektedir. Bulanık Mantık kavramı Zadeh (Zadeh, 1965) tarafından geliştirilmiş ve bu kapsamda pek çok ÇKKV yönteminin bulanık versiyonu önerilmiştir. Bu çalışmada, istatistik bölümü mezunlarının kariyer planlama ve tercih aşamalarında hangi çalışma alanlarının daha önemli olduğu, kariyer seçim sürecinde karşılaştıkları etkiler dikkate alınarak araştırılmıştır. Ana kriterler arasındaki ilişkiler, uzman karar vericilerden alınan girdilere dayalı olarak Bulanık DEMATEL yöntemi kullanılarak analiz edilmiştir. Daha sonra, Bulanık DEMATEL analizinden elde edilen kriter ağırlıklarını içeren Bulanık TOPSIS yöntemi kullanılarak bir başlangıç tablosu oluşturulmuştur. Bu yaklaşım, beş farklı çalışma alanı arasında en uygun karar alternatiflerinin ve sıralamalarının belirlenmesini sağlamıştır. Bulgular, sayısal yetenek, beceri, ilgi alanları, çevresel etkiler ve aile yapısı, mesleki değerler, psikolojik ihtiyaçlar, kazanç potansiyeli, iş bulma kolaylığı, dersler ve sosyal olanaklar gibi faktörler nedeniyle istatistik bölümünü seçen bireylerin, mezun olduktan sonra veri uzmanı olarak çalışmayı tercih etme eğiliminde olduklarını göstermektedir.

Anahtar Kelimeler: Bulanık DEMATEL, Bulanık TOPSIS, Çok Kriterli Karar Verme, Kariyer Seçimi.

Jel Kodları: C44, D81, C02, M10.

1. INTRODUCTION

Profession refers to the regular activities individuals perform to earn an economic return, typically by utilizing their knowledge, skills, and expertise in a specific field (Akın, 2017). Professions are crucial for the functioning of societies and enabling individuals to sustain themselves. Each profession specializes in a particular sector, addressing needs in that area (Kordon, 2006; Karagülle, 2007). Professionals undergo specific educational processes and continually develop their knowledge and skills throughout their careers (Sarıkaya & Khorshid, 2009). Professions significantly shape the economic and social structure of societies, emphasizing individual contributions within areas of expertise (Akın & Akyıldız, 2018).

Success in a profession depends on several factors. First, continuous learning and development are essential. In a rapidly evolving business world, acquiring new skills and staying up-to-date are key to success (Ganser, 2002). Second, effective communication, both written and oral, is vital for interacting with colleagues and clients (Korkut-Owen, 2008). Third, problem-solving abilities help overcome challenges and find innovative solutions. Adhering to business ethics and integrity is critical for sustained success. Building networks also aids career growth by creating opportunities and support (Altıntaş-Yüksel, 2019). Lastly, self-confidence and motivation are crucial for overcoming obstacles and achieving goals (Pilavcı, 2007).

Time management is another essential skill for a successful career. Organizing and prioritizing tasks enhances productivity and performance (Alay, 2000). Additionally, adaptability and flexibility are vital in today's dynamic environment, enabling individuals to navigate changing market conditions and technological advancements (Koch, 1998; Durmaz et al., 2016). Setting clear short-term and long-term goals boosts motivation and determination (Greenhaus et al., 1990). Consistent efforts toward these goals are equally important (Demirdelen & Ulama, 2013).

Maintaining work-life balance is also vital. Overworking can lead to burnout and job dissatisfaction (Okumuş et al., 2022). A healthy balance increases overall happiness and supports long-term success. While individual effort and environmental factors shape success, focusing on the factors above can enhance professional achievements.

Career choice is a complex process and a significant MCDM problem (Pala, 2013). It involves evaluating personal characteristics, abilities, and interests alongside external factors such as economic conditions, labor market demands, opportunities, and competition (Aydemir, 2018). Education plays a critical role in developing the skills necessary for a profession (Abiseva, 1997; Turan & Kayıkçı, 2019). Personal values, work ethics, and perspectives on business also influence career choices.

Family, environment, and cultural factors shape career decisions. Professional experiences of family members, societal expectations, and cultural norms can heavily impact choices. Gender roles, social values, and general societal attitudes also play a role in career choice (Bekleyiş, 2007; Canstantine et al., 2005; Sarıkaya & Khorshid, 2009).

In conclusion, career choice is a MCDM problem. Individuals strive to make optimal decisions by considering personal, educational, economic, cultural, and social factors. Balancing these aspects and ensuring long-term satisfaction is crucial for effective decision-making.

Occupational choice is widely studied in social sciences and psychology. Factors such as gender, family expectations, education, job opportunities, personal skills, and professional interests and values have been examined in many studies in the career choice process of individuals (Frady, 2005; Zunker, 2006; Şeker & Kaya, 2018). Key studies focus on gender (Akbayır, 2002; Patton et al., 2003; Zysberg & Berry, 2005), education (Ayık et al., 2007;

Szabo, 2006), professional interests (Harris & Rottinghaus, 2015; Vardarlı, 2014; Yılmaz, 2011), and values (Atlı, 2012; Moore, 2006; Özhan, 2015). Many theorists (Crites, 1969; Roe, 1956; Super, 1953; Trice et al., 1995) highlight family support as a key factor in career development. Conscious and guided decision-making leads to greater career satisfaction and success. Therefore, the literature continues to evolve to support better career guidance strategies.

Uncertainty in career choice complicates finding the right option among many alternatives. Opportunities and risks associated with professions must also be considered. A good career choice increases satisfaction, while a poor one can have long-term negative effects. MCDM methods effectively address such uncertainty, integrating qualitative and quantitative data (Akın & Akyıldız, 2018).

This study evaluates 10 criteria affecting career choice, based on the opinions of five experts and prior research (Akın, 2017; Kartal et al., 2019). Five career fields for statistics graduates were identified as alternatives. Criteria weights were calculated using the Fuzzy DEMATEL method, and the Fuzzy TOPSIS method was applied to rank fields of study. A review of the literature reveals no prior studies combining these two methods, highlighting the contribution of this research.

The study consists of six chapters. In the first part of the study, the introduction, it is emphasized that the uncertainty encountered in career choice makes the effort to find the right one among many alternatives more complex. The second part of the study includes the determination of the main benefit criteria for choosing a career choice, literature review in the third part, methodology in the fourth part, application in the fifth part and results in the last part.

2. DETERMINATION OF MAIN BENEFIT CRITERIA FOR CHOOSING A CAREER CHOICE

Although career choice is one of the most important decisions in an individual's life, it is a complex process influenced by many factors. The theories explaining this process fall under "theories about career choice." The first of these theories is Parsons' Trait-Factor Theory. According to this theory, individuals should establish a meaningful connection between their personal characteristics and the requirements of their chosen profession. When individuals select a career field aligned with their personal qualities and receive the appropriate training, their professional success and productivity increase (Brown, 2002). Another theory is

Ginzberg et al.'s Process Theory, which considers career choice not as a simple matching process but as a process of development and maturation. Similarly, Donald Super's Conceptual Model views career choice not as a momentary decision but as a lifelong process (Yeşilyaprak, 2012). Anne Roe's Needs Theory, on the other hand, argues that childhood experiences are the most significant factor influencing career choice. According to Roe, the primary determinants of career choice are not intelligence, abilities, or hereditary characteristics but rather unmet needs from early childhood (Adıgüzel & Erdoğan, 2014). Finally, John L. Holland's Personality Theory suggests that career choices reflect an individual's personality. Holland identified six different personality types and stated that career interests largely align with an individual's personality traits (Spokane et al., 2002; Adıgüzel & Erdoğan, 2014).

As stated in the introduction, career choice is a multi-criteria decision-making problem since it is affected by numerous factors, including gender, societal expectations, peer influence, family expectations, educational background, job opportunities after graduation, personal qualities (both general and specialized abilities), and professional interests and values. Although many factors influence an individual's career choice, numerical ability, interest, and professional values are considered particularly important for statistics students. Ability is generally defined as a person's capacity or performance in executing a particular activity (Krane & Tirre, 2005). Career counselors can benefit from understanding the skills required for various professions. For example, students with strong spatial reasoning skills may be better suited for fields such as engineering, while those with strong reading and comprehension skills may excel in fields such as law or political science (Özyürek, 2013). Interest refers to an individual's preference for and enjoyment of a specific activity (Brown, 2003). People tend to spend more time and perform better in activities that interest them, contributing to their overall happiness and satisfaction. Occupational value represents a person's expectations regarding the outcomes and goals associated with a particular job or activity. This definition reflects an individual's core beliefs about the reasons for engaging in a profession (Round & Armstrong, 2005). Other factors influencing career choice in this study were identified based on the research of Akın (2017) and Akın & Akyıldız (2018). The fields of study impacting career choice were determined through a joint decision following expert interviews conducted as part of the study.

3. LITERATURE REVIEW

Various methods are used in career selection and the evaluation of career selection criteria. These methods can generally be categorized as mathematical, statistical, and Multi-Criteria Decision Making (MCDM) methods. Since such problems are assessed based on multiple criteria, MCDM methods are frequently used to determine the weights of the criteria and rank alternatives. Additionally, in cases where decision-makers rely on subjective evaluations, MCDM methods are combined with fuzzy logic and analyzed using the Fuzzy MCDM method (Carlsson & Fuller, 1996).

Several studies in the literature have applied MCDM methods to career selection. Research on the factors affecting career and occupational preferences has been reviewed, along with an examination of the statistical programs used in these studies. Additionally, studies employing Fuzzy DEMATEL and Fuzzy TOPSIS methods, which are among the MCDM methods, are discussed under this heading.

Kıyak (2006) examined the main criteria considered by general high school students when choosing a profession and analyzed the data using SPSS. Through one-way analysis of variance (ANOVA) and paired sample t-tests, the study found that factors such as job security, social security, ease of finding employment, and high salary influenced students' career choices. Similarly, Özkaya (2007) conducted a survey to investigate the relationship between the interests of Istanbul Mevlana High School students and their career choices, also analyzing the data with SPSS. The study revealed that students' career decisions were shaped by material factors such as job security, social security, ease of employment, and salary.

Kılınç (2007) analyzed survey data using frequency, percentage, mean, standard deviation, and t-tests in his thesis on the factors influencing university and department preferences. The findings indicated that parents' level of education, family income, and school type played a significant role in students' university choices. Ecer (2007), in his doctoral thesis, evaluated candidates in human resource selection using the Fuzzy TOPSIS method. Similarly, Eleren and Ersoy (2007) applied the Fuzzy TOPSIS method to rank the most appropriate cutting methods in marble and natural stone processing. Küçük and Ecer (2007) also utilized the Fuzzy TOPSIS method for supplier evaluation.

Yelken (2008) studied the university preferences of senior secondary school students in Sakarya and the factors influencing their career choices. Data analyzed with SPSS 12.0 revealed that female students preferred professions such as civil service and teaching, which offer stability, while male students were more inclined toward numerically based professions. Başkal (2009), in his master's thesis, investigated the occupational selection anxiety of senior students in Anatolian, science, and general high schools based on various variables. Using SPSS 15.0 and tests such as the independent group t-test, Mann-Whitney U test, Kruskal-Wallis H test, ANOVA, and Scheffe test, the study found that students' career selection anxiety significantly varied depending on factors such as gender, school type, field of study, parents' education level, occupation, family status, and income level.

Çelik (2009) examined the criteria affecting the occupational preferences of senior Anatolian high school students in Istanbul and analyzed the data using SPSS 13.0. The results indicated that job security, career opportunities, the ability to utilize one's skills, development opportunities, and salary were key influencing factors. Arı (2009) developed software based on fuzzy logic rules for vocational guidance, which processes input data to generate career suggestions and predicts that computers can produce more accurate results when processing fuzzy expressions.

Hsu et al. (2009) used the Fuzzy TOPSIS method to identify the factors influencing tourists' preferences. Similarly, Polychroniou and Giannikos (2009) applied a fuzzy multi-criteria decision-making method for human resource selection in a Greek bank. Vurucu (2010) examined the effects of family and socio-economic environment on career choices among vocational high school students in Kocaeli through a survey. The study found that 59% of students were influenced by family expectations, 47% by friends and their environment, and 80% were satisfied with their chosen profession. Various statistical analyses, including frequency, percentage, mean, standard deviation, t-test, ANOVA, and Kruskal-Wallis H test, were applied. Similarly, Kuştarcı (2010) investigated the impact of family socio-economic structure on students' faculty or college preferences and found that this structure significantly influenced their choices. The study utilized SPSS 15.0 and applied the Chi-square (x^2) test. Tan et al. (2010) used the Fuzzy TOPSIS method to support project selection for contractors in the construction industry, while Erginel et al. (2010) applied the same method to rank GSM operator preferences in Turkey following the implementation of number portability. Highlighting the complexity of manager selection, Kelemenis et al. (2011) used the Fuzzy TOPSIS method for selection processes requiring group decisions, specifically in the selection of support managers through an extended TOPSIS approach.

Madi and Md-Tap (2011) used the Fuzzy TOPSIS method by incorporating operational risks when selecting the most appropriate investment instruments in the investment market. Ada et al. (2011) applied the Fuzzy DEMATEL method to analyze relationships between key factors in flexible manufacturing systems. Kars (2012) studied the impact of socio-economic and cultural factors on the career choices of senior high school students and found that family, job opportunities, education level, social environment, financial gain, and alignment with interests and abilities were significant determinants. Pekkaya and Çolak (2013) identified job security, earnings, and career opportunities as the most influential factors in university students' career choices, using the analytic hierarchy process to determine this finding.

Ayhan (2013) compared the results of AHS, ELECTRE, and TOPSIS methods in his research on supplier selection and management in the furniture industry. Similarly, Özkan (2013) examined the applicability of Fuzzy TOPSIS and AHP methods in animal husbandry by comparing both approaches. Abbasi et al. (2013) applied generic DEMATEL deployments to assess risks in knowledge-based networks used in new product development, while Organ (2013) utilized the Fuzzy DEMATEL method to analyze factors affecting machine selection in the textile industry. In a study by Çınar (2013), the multi-criteria decision problem related to choosing a career or field of study among university students and graduates was modeled using a combined approach of DEMATEL and simple weighting methods, with findings linked to individuals' attitudes toward risk. Ecer et al. (2014) employed the Fuzzy TOPSIS method to evaluate firms in the cement sector and create an optimal portfolio. Additionally, Srikrishna et al. (2014) applied the TOPSIS technique in their research on automobile selection.

Ertuğrul and Özçil (2014) conducted research on air conditioner selection using multi-criteria decision-making methods such as TOPSIS and VIKOR. Yazıcılar (2015) applied a combination of Fuzzy AHP and Shannon Entropy-based TOPSIS methods to select machinery and equipment, aiming to gain a competitive advantage in manufacturing factories. Eray (2015) examined differences between AHP, ELECTRE III, PROMETHEE, and TOPSIS, as well as their fuzzy counterparts—Fuzzy AHP, Fuzzy ELECTRE, and Fuzzy TOPSIS—in supplier selection within the construction sector. Similarly, Ayvaz et al. (2015) utilized the Fuzzy TOPSIS method for supplier selection in the banking sector. Nilashi et al. (2015) employed DEMATEL and analytic network process methods to evaluate critical success factors in construction projects. Altan and Aydın (2015) used the Fuzzy DEMATEL method to analyze interactions among criteria for selecting a third-party logistics company in the pipe manufacturing industry, while also applying the Fuzzy TOPSIS method to examine the hierarchy of these criteria. Finally, Çakın and Özdemir (2015) used DEMATEL-based analytical network process and TOPSIS methods to rank the research and innovation performance of 12 regions in Turkey, focusing on regions classified at level 1 in the statistical regional unit classification.

Damgacı (2016) aimed to determine the most efficient energy source by evaluating alternative energy sources using the heuristic Fuzzy TOPSIS method. Similarly, Özdemir (2016) applied Fuzzy DEMATEL and Fuzzy TOPSIS methods to analyze the relationships and importance levels of factors contributing to occupational accidents in ports and to rank alternative solutions. Özçil and Ertuğrul (2016) used these methods to evaluate the financial performance of insurance companies traded on the ISE. Karaatlı et al. (2016) employed the DEMATEL method to determine the weights of various criteria and utilized the Fuzzy TOPSIS method for performance evaluation in sugar factories. In the field of education, Akın (2017) applied the Fuzzy DEMATEL method to examine the criteria influencing students' career planning and preferences, while Akın and Akyıldız (2018) used the Fuzzy TOPSIS method to investigate the factors affecting high school students' career choices. More recently, Kumar and Singh (2019) examined the integration of AHP and TOPSIS methods for supplier evaluation and selection in the steel manufacturing sector, where AHP was used to prioritize criteria and TOPSIS was applied to rank suppliers based on optimal and suboptimal choices.

Agrawal et al. (2020) analyzed the factors influencing service quality in banking, finding that reliability and ease of use were the most significant determinants of e-service quality. Similarly, Gülsün and Erdoğmuş (2021) employed Fuzzy TOPSIS and Fuzzy AHS methods to rank the performance of banks, concluding that the income and expense structure was the most critical factor affecting financial performance. Lu et al. (2022) combined DEMATEL and EDAS methods to explore the factors influencing consumers' intentions to use cross-border e-commerce platforms. In a related study, Tsai et al. (2023) examined the selection and evaluation process of a food distribution platform using DEMATEL, DANP, and modified VIKOR methods. More recently, Özüdoğru and Uzun (2024) investigated service quality in the insurance sector by applying AHS and TOPSIS methods.

When the literature is examined, it is seen that career choice is influenced by many factors. These factors include the individual's interests, abilities, values, personality traits, gender, age, family structure, economic status of the family, social environment, status of the profession, financial gain and working conditions. In addition, the statistical programs used in the studies in the literature were also carefully examined. In most studies, various analysis techniques were applied with the SPSS statistical program and important findings were obtained.

Fuzzy DEMATEL and Fuzzy TOPSIS methods, as multi-criteria decision making methods, are effective methods for making group decisions and solving problems involving fuzzy expressions. In these methods, fuzzy expressions are represented by fuzzy numbers, membership values are assigned and these expressions are analyzed. In the literature, Fuzzy DEMATEL and Fuzzy TOPSIS are widely used in many sectors such as supplier selection, equipment procurement, determination of tourist preferences in tourism, banking, communication, construction, human resources selection and selection of the most appropriate investment instruments in capital markets.

Career choice and the factors affecting these choices are problems that can be solved with multi-criteria decision making methods. In the literature review, there is no research on this issue in which Fuzzy DEMATEL and Fuzzy TOPSIS methods are used together. For this reason, it is preferred to use Fuzzy DEMATEL and Fuzzy TOPSIS methods together to rank students' career choices and the factors affecting them.

4. METHOD

The evaluation of quantitative and qualitative criteria in decision-making involves uncertainty, as it relies on subjective opinions of decision-makers. Fuzzy set theory, developed by Zadeh, offers a solution for modeling such uncertainty. In this study, Fuzzy DEMATEL and Fuzzy TOPSIS, both MCDM methods, were applied to a career selection case (Zadeh, 1965).

The solution proposal stages for the decision process were structured as follows:

- - Phase 1

Purpose: Identification of aims, criteria and alternatives

Method: Obtaining Expert Opinions

- - Phase 2

Purpose: To determine the relationships between the main criteria and their weights

Method: Fuzzy DEMATEL

- - Phase 3

Purpose: Evaluation of alternatives and selection of the best alternative

Method: Fuzzy TOPSIS

4.1. Fuzzy DEMATEL Method

Decision-making involves actions individuals take, consciously or unconsciously, in both business and social contexts. Uncertainties about the future complicate the decision-making process. Therefore, to make the right decision, a systematic, mathematically grounded approach should be used, considering all available data and possible alternatives (Özdağoğlu, 2008).

The DEMATEL method, a MCDM technique developed between 1972 and 1976 by the Battelle Memorial Institute's Science and Human Relations Program in Geneva, addresses complex, nested problems (Fontela & Gabus, 1974). Like other MCDM methods, it relies on expert knowledge to analyze decision-making challenges. It assesses the cause-and-effect relationships between criteria and evaluates the weight of those relationships.

The goal of the DEMATEL method is to visualize complex cause-and-effect relationships and draw meaningful conclusions. However, determining the degree of interaction between factors is challenging because such interactions are difficult to quantify. As a result, the DEMATEL method has been extended to a fuzzy environment (Öztürk, 2009).

The Fuzzy DEMATEL method integrates the traditional DEMATEL approach with Fuzzy Set Theory (Zadeh, 1965) to address uncertainties stemming from human nature and uses fuzzy numbers for solutions. This approach allows relationships between criteria to be evaluated using inexact (relative) concepts instead of precise values. The steps of the fuzzy DEMATEL method are summarized as follows (Lin & Wu, 2008; Dalalah et al., 2011; Jassbi et al., 2011; Büyüközkan & Çifçi, 2012; Baykaşoğlu et al., 2013; Altan & Karaş-Aydın, 2015; Gök-Kısa & Perçin, 2017; Gök-Kısa & Çelik, 2022).

Step 1: Identifying the Criteria and Creating the Fuzzy Scale

In this step, all criteria identified as influencing the decision-making problem through expert opinions are determined. Then, pairwise comparisons are made between these criteria, with the extent of one criterion's influence on another expressed as a linguistic variable. A numerical scale and a fuzzy scale are applied to represent these influences (Li, 1999; Kiraz & Gürsoy, 2019).

This fuzzy scale is given in Table 1.

Table 1. Linguistic Variables, Numerical and Fuzzy Equivalents

Linguistic Variables	Numerical Equivalents	Fuzzy Equivalents
Very Low (VL)	1	(0, 0, 0.1)
Low (L)	2	(0, 0.1, 0.3)
Slightly Low (SL)	3	(0.1, 0.3, 0.5)
Middle (M)	4	(0.3, 0.5, 0.7)
Slightly High (SH)	5	(0.5, 0.7, 0.9)
High (H)	6	(0.7, 0.9, 1.0)
Very High (VH)	7	(0.9, 1.0, 1.0)

Source. Chen, 2000

Step 2: Creating the Fuzzy Direct Relationship Matrix

In order to determine the relationships between the criteria C = {Ci | i=1,2,...,n}, a decision-making group consisting of p experts make pairwise comparisons to extract the interaction between the criteria with the numerical equivalents of the linguistic variables given above. In this way, p $\tilde{Z}^1, \tilde{Z}^2, ..., \tilde{Z}^p$ fuzzy matrices are created.

Accordingly, the direct relationship matrix consisting of triangular fuzzy numbers $\tilde{Z}^k{}_{ij} = (l^k{}_{ij,} m^k{}_{ij,} u^k{}_{ij})$ of k experts whose elements indicate the degree of influence of criterion i on criterion j is shown in Equation 1.

$$\tilde{Z}^k = \begin{bmatrix} 0 & \dots & \tilde{Z}^k{}_{1n} \\ . & . & . \\ . & . & . \\ \tilde{Z}^k{}_{n1} & \dots & 0 \end{bmatrix}, k = 1, 2, ..., p; i = 1, 2, ..., n \quad (1)$$

Step 3: Constructing the Normalized Fuzzy Direct Relationship Matrix

Once the direct relationship matrix is obtained, this matrix needs to be normalized.

The normalized fuzzy direct relationship matrix, denoted as $\tilde{X}^k = \left[\tilde{X}_{ij}{}^k\right]_{nxn}$, is obtained using Equation 2 and Equation 3.

$$\tilde{X}_{ij}{}^k = \frac{\tilde{z}_{ij}{}^k}{r^k} = \left(\frac{l_{ij}{}^k}{r^k}, \frac{m_{ij}{}^k}{r^k}, \frac{u_{ij}{}^k}{r^k}\right) \quad (2)$$

$$r^k = \max_{1<i<n}\left(\sum_{j=1}^{n} u_{ij^k}\right) \tag{3}$$

The normalized relationship matrix is created by using Equation 2 and Equation 3. In the expressions in the Equations, “l” is the first triangular fuzzy number, “m” is the second triangular fuzzy number and “u” is the last triangular fuzzy number. Using Equation 3, all “u ”s are summed as columns and a value is found for each column. The largest of these values is selected and gives “r”. Then the whole matrix is divided by “r” and the normalized direct relationship matrix is obtained. The normalized direct relationship matrix is denoted by “ $\bar{X}$ ”. The normalized fuzzy direct relationship matrix is given in Equation 4.

$$\tilde{X} = \begin{bmatrix} \tilde{X}_{11} & \tilde{X}_{12} & \dots & \tilde{X}_{1n} \\ \tilde{X}_{21} & \tilde{X}_{22} & \dots & \tilde{X}_{2n} \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \\ \cdot & \cdot & \cdot & \dots \\ \tilde{X}_{n1} & \tilde{X}_{n2} & \dots & \tilde{X}_{nn} \end{bmatrix} \tag{4}$$

Step 4: Constructing the Total Fuzzy Direct Relationship Matrix

Once the normalized relationship matrix is obtained, the total relationship matrix will be created using Equation 5.

$$\tilde{T} = \tilde{X} + \tilde{X}^2 + \tilde{X}^3 + \dots = \sum_{i=1}^{\infty} \tilde{X}^i = \tilde{X}(1-\tilde{X})^{-1} \tag{5}$$

Since it is difficult to apply this to the normalized fuzzy direct relationship matrix composed of triangular numbers, a separate matrix is created from each of the numbers l, m, u and applied in this way. These three matrices are first subtracted from the unit matrix; then the inverse of the resulting matrix is taken and multiplied by the initial form of the matrix. After repeating this process for all three, the results are combined and a single total relationship matrix consisting of triangular fuzzy numbers, denoted by “$\tilde{T}$”, is obtained as shown in Equation 6.

$$\tilde{T}=\begin{bmatrix} \tilde{T}_{11} & \tilde{T}_{12} & \dots & \tilde{T}_{1n} \\ \tilde{T}_{21} & \tilde{T}_{22} & \dots & \tilde{T}_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ \tilde{T}_{n1} & \tilde{T}_{n2} & \dots & \tilde{T}_{nn} \end{bmatrix} \tag{6}$$

Step 5: Identifying Cause and Effect Relationships (Sender-Receiver Groups)

After the total relationship matrix is created, the sum of the column elements of this matrix, $\tilde{D}_i$, and the sum of the row elements, $\tilde{R}_i$, are found. Summing these values yields the values $\tilde{D}_i+\tilde{R}_i$ and $\tilde{D}_i-\tilde{R}_i$. Since these values are still composed of triangular fuzzy numbers, these values are clarified by applying the formulas in Equation 7 and Equation 8.

$$\tilde{D}_i^{Def}+\tilde{R}_i^{Def}=\frac{1}{4}(x_{ij,l}+2x_{ij,m}+x_{ij,u}) \tag{7}$$

$$\tilde{D}_i^{Def}-\tilde{R}_i^{Def}=\frac{1}{4}(x_{ij,l}+2x_{ij,m}+x_{ij,u}) \tag{8}$$

While the $\tilde{D}_i^{Def}+\tilde{R}_i^{Def}$ value indicates the importance and total impact of a criterion within other criteria, the $\tilde{D}_i^{Def}-\tilde{R}_i^{Def}$ value allows the criteria to be divided into two groups as sender or receiver. If this value is positive, the criterion is in the sending group and has a high impact on other criteria. If this value is negative, the criterion is in the receiver group and its impact on other criteria is low. With the help of this data, a cause and effect relationship diagram can be drawn, also called an influence directional graph diagram.

Step 6: Calculation of Weights

Criteria weights are calculated according to the formula given in Equation 9.

$$w_i=\left\{(\tilde{D}_i^{Def}+\tilde{R}_i^{Def})^2+(\tilde{D}_i^{Def}-\tilde{R}_i^{Def})^2\right\}^{1/2}, W_i=\frac{w_i}{\sum_{i=1}^{n}w_i},\ \sum_{i=1}^{n}W_i=1 \tag{9}$$

4.2. Fuzzy TOPSIS Method

One of the most common methods in MCDM problems is the TOPSIS method, first proposed in 1981 (Hwang & Yoon, 1981; Çınar, 2010). The TOPSIS method, as in other MCDM methods, can use expert opinions for the selection of decision criteria in the decision-making process. In this case, the method provides objective evaluation according to the selected criteria. Its core principle involves calculating distances to the ideal solution, separately considering the positive ideal solution and the negative ideal solution. The best alternative is the one closest to the positive ideal solution and farthest from the negative ideal solution (Gürsoy, 2019).

In the fuzzy TOPSIS method, most steps of TOPSIS (except min and max operations) are generalized to fuzzy (Wang & Lee, 2007). Human preferences and decisions are often imprecise and cannot be expressed as exact numerical values. Thus, using linguistic values is often more realistic. The fuzzy TOPSIS method was developed to address uncertainty in human judgments, especially for group decision-making problems involving linguistic uncertainty (Chen, 2000). The optimal solution is determined where the positive ideal solution is closest and the negative ideal solution is farthest (Büyüközkan & Çifçi, 2012; Soba et al., 2014).

TOPSIS has been widely applied to MCDM problems (Chu, 2002; Chu et al., 2003; Lai et al., 1994; Wang et al., 2005). While the traditional TOPSIS method assumes precise information, real-world evaluations often involve uncertainty. To address this, fuzzy set theory (Zadeh, 1965) was integrated into TOPSIS, making it more suitable for uncertain decision-making (Bali et al., 2014; Chen, 2000; Kulak et al., 2005). Fuzzy TOPSIS has been applied in many studies to rank alternatives in MCDM problems (Wang & Elhag, 2006; Kahraman et al., 2007; Önüt & Soner, 2008; Yang & Hung, 2007).

This study utilizes the fuzzy TOPSIS method presented by Chen (2000) for evaluating and ranking alternatives. Triangular fuzzy numbers are used for the evaluations. The following steps are followed in applying the fuzzy TOPSIS method (Chen, 2000).

Step 1: Selection of Decision Makers and Solution Alternatives

A decision-making group is formed from the people who will be authorized to decide on the solution of the problem and alternatives are identified.

Step 2: Making Evaluations with Linguistic Variables

After selecting the appropriate linguistic variables for the importance weights of the criteria, the linguistic variables are used to evaluate the alternatives according to the criteria.

Step 3: Transforming Assessments into Fuzzy Numbers

The verbal variables that decision makers set for importance weights and evaluation of alternatives are transformed into triangular or trapezoidal fuzzy numbers.

Step 4: Creating the Fuzzy Decision Matrix

At this stage, the decisions made by each group of decision makers are converted into fuzzy numbers and a fuzzy decision matrix is formed by averaging these numbers. Decision makers (K of them) make their evaluations among alternative solutions $A_1, A_2, ..., A_m$ by considering the decision criteria defined by $C = \{Ci \backslash i = 1, 2, \cdots, n\}$. The fuzzy decision matrix $\tilde{D}$ in Equation 10 consists of $\tilde{x}_{ij}$ elements as shown in Equation 11, which represent the performance of alternatives $A_i (i = 1, 2, ..., m)$ with respect to criteria $C_j (j = 1, 2, ..., n)$. W, shown in Equation 12, is the matrix of decision criteria consisting of $\tilde{w}_i$ elements representing the importance weights of the $C_j (j = 1, 2, ..., n)$ criteria.

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \dots & \tilde{x}_{1n} \\ . & . & . \\ . & . & . \\ . & . & . \\ \tilde{x}_{m1} & \dots & \tilde{x}_{mn} \end{bmatrix} \tag{10}$$

$$\tilde{x}_{ij} = \frac{1}{K}\left[\tilde{x}_{ij}^{1} + \tilde{x}_{ij}^{2} + \ldots + \tilde{x}_{ij}^{K}\right] \tag{11}$$

$$W = \left[\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n\right] \tag{12}$$

Step 5: Creating the Normalized Fuzzy Decision Matrix

By applying the formulas in Equation 13 and Equation 14 to the fuzzy decision matrix, the normalized fuzzy decision matrix is obtained. Here $\tilde{r}_{ij}$ constitutes the elements of the normalized fuzzy decision matrix.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \; j \in B, \; c_j^* = \max_i c_{ij} \tag{13}$$

$$\tilde{r}_{ij} = \left(\frac{a_{j^-}}{c_{ij}}, \frac{a_{j^-}}{b_{ij}}, \frac{a_{j^-}}{a_{ij}} \right), \ j \in C, \ a_j^- = \min_i a_{ij} \quad (14)$$

Decision criteria can be divided into benefit and cost criteria. In Equation 13 and Equation 14, B is the benefit criterion and C is the cost criterion. The resulting normalized fuzzy decision matrix is denoted by $\tilde{R}$ as in Equation 15.

$$\tilde{R} = \left[\tilde{r}_{ij} \right] \ i = 1, 2, \ldots m, \ j = 1, 2, \ldots n \quad (15)$$

Step 6: Determination of the Weighted Normalized Decision Matrix

The weighted normalized fuzzy decision matrix is the $\tilde{V}$ matrix consisting of $\tilde{v}_{ij}$ elements and is shown in Equation 16.

$$\tilde{V} = \left[\tilde{v}_{ij} \right] = \tilde{r}_{ij} \, x \, \tilde{w}_j, \ i = 1, 2, \ldots, m, \ j = 1, 2, \ldots, n \quad (16)$$

Step 7: Determination of Fuzzy Positive and Negative Ideal Solutions

A^* = Fuzzy positive ideal solution, calculated as given in Equation 17.

A^- = Fuzzy negative ideal solution, calculated as given in Equation 18.

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*) \quad j = 1, 2, \ldots, n \quad (17)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-) \quad j = 1, 2, \ldots, n \quad (18)$$

In this formulation $\tilde{v}_j^* = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$.

Step 8: Calculation of Proximity Coefficients

The distances of each solution alternative from the fuzzy positive ideal solution and the fuzzy negative ideal solution are calculated according to Equation 19 and Equation 20. d_i^* is the distance from the fuzzy positive ideal solution and d_i^- is the distance from the fuzzy negative ideal solution.

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{j^*}), \ i = 1, 2, \ldots, m \quad (19)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{j^*}), \ i = 1, 2, ..., m \tag{20}$$

Here d (..., ...) is the distance between two fuzzy numbers and is calculated by the Vertex method. This method is calculated as in Equation (21) for the distance between two triangular fuzzy numbers such as $\tilde{m} = (m_1, m_2, m_3)$ and $\tilde{n} = (n_1, n_2, n_3)$.

$$d(\tilde{m}, \tilde{n}) = \sqrt{\frac{1}{3}\ [(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \tag{21}$$

Step 9: Finding Proximity Coefficients for Each Alternative

Proximity coefficients for all alternatives are calculated according to the formula given in Equation 22.

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, i = 1, 2, ..., m \tag{22}$$

Step 10: Ranking of Alternatives

According to the proximity coefficients calculated for each alternative, a ranking is made from the largest number to the smallest. The alternative with the largest proximity coefficient is selected as the alternative solution. If the closeness coefficient is high, the alternative is closer to the fuzzy positive ideal solution and further away from the fuzzy negative ideal solution.

5. APPLICATION

Graduates of the Department of Statistics can work in various public or private institutions where data analysis is required. Besides being statisticians, they can also serve as data specialists, software developers, production planners, or quality specialists. Graduates may further pursue academic development by enrolling in graduate programs in fields such as Biostatistics, Economics, Business Administration, Econometrics, Industrial Engineering, Computer Engineering, Actuarial Science, Mathematics, and Statistics.

In this study, the criteria emphasized by 5 different students who graduated from the Department of Statistics at Mimar Sinan Fine Arts University while making career choices and their perspectives and perceptions of working areas in the context of these criteria were evaluated. The perceptions and thoughts of the graduates about the professions are very important for the students who will choose the statistics department for their career choice.

For this reason, it is thought that it will be possible for the sectors that want to employ new graduates to better explain their sectors by knowing and benefiting from their perspectives and evaluations on professions. The career groups that the students of the Department of Statistics will work in when they graduate and the criteria they will take into consideration when choosing these business lines will be evaluated with the Fuzzy DEMATEL and Fuzzy TOPSIS method, which is an analytical method and frequently used in multi-criteria decision making problems, and the results will be compared. Thus, students' perceptions and aspirations regarding their career choices will be revealed specific to the statistics department, realities and perceptions can be compared on the basis of each criterion, a new vision can be determined in the triangle of university, student and sector in line with the results, and a study that can be a source of inspiration for new research on this subject will be revealed.

This study aims to determine whether the factors influencing individuals' career selection significantly affect the key fields of study in career planning. In the first stage of the solution proposal, criteria and alternatives for the decision-making process were identified, incorporating both criteria used in previous occupational selection studies and those provided by expert decision-makers. In the second stage, expert opinions were analyzed using the Fuzzy DEMATEL method to identify relationships between the main criteria in the decision-making process. In the third stage, an initial table was constructed using the Fuzzy TOPSIS method based on scores from expert decision-makers. The criteria weights obtained from Fuzzy DEMATEL were then applied in the Fuzzy TOPSIS method to rank the decision alternatives in the five study areas determined as a result of a joint decision as a result of interviews with the experts in the study.

The solutions for both fuzzy DEMATEL and fuzzy TOPSIS methods were implemented using Excel.

The main criteria in the decision process solution model and the alternatives identified as study areas are given in Table 2 and Table 3 respectively. In the analysis to be made, the criteria that are considered to be effective in career choice as a result of literature review and interviews with experts will positively affect the success of the analysis. The calculations made in terms of the application problem are given below in tables with the calculation results. All criteria given in Table 2 are considered as benefit criteria for the evaluation of alternatives.

Table 2. Main Benefit Criteria for Career Choice

Main Criteria	Coding
Numerical ability	K1
Skill	K2
Interest	K3
Environmental influences and family structure	K4
Professional values (prestige, status, earnings, other opportunities, secure income)	K5
Psychological needs (Characteristics such as order, achievement, attention, closeness, understanding emotions, aggression are important in choosing a profession. In physical competencies; basic physical characteristics that can be listed as height, weight, bone and muscle structure are important in terms of occupational selection).	K6
Earnings potential	K7
Ease of job acquisition	K8
Coursework	K9
Social opportunities	K10

Table 3. Alternatives Determined as Working Areas in Career Profession Selection

Alternatives	Coding
Statistician	A1
Production Planning and Quality Specialist	A2
Data Specialist	A3
Software Developer	A4
Academic	A5

5.1. Determining the Relationship Between the Main Criteria and Their Weights

At this stage, 5 decision makers evaluate the main criteria and the relationships between the main criteria are extracted and evaluated by Fuzzy DEMATEL method.

Step 1: Identifying Criteria and Creating a Fuzzy Evaluation Scale

The evaluations of the decision makers for the main criteria are taken with numerical data according to Table 1 and translated into fuzzy numbers according to the fuzzy scale. The 1st Expert's evaluation results are given numerically in Table 4 and translated into fuzzy numbers in Table 5 as an example.

Table 4. 1. Expert's Assessment of the Main Criteria

Decision Maker 1										
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
K1	*	6	5	6	4	7	2	1	6	4
K2	5	*	4	5	4	6	1	2	5	4

K3	3	4	*	5	3	5	4	1	6	5
K4	2	3	3	*	2	4	2	1	4	3
K5	5	5	4	6	*	6	4	4	7	6
K6	2	1	3	4	2	*	3	2	4	5
K7	6	7	4	6	4	5	*	5	6	5
K8	7	6	7	7	4	6	5	*	6	6
K9	2	3	2	4	1	4	2	2	*	5
K10	4	4	3	5	2	3	3	2	3	*

Table 5. 1. Conversion of the Expert's Main Criteria Evaluation into Fuzzy Numbers

	Decision Maker 1 (l, m, u)										
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
L	**K1**	0	0.7	0.5	0.7	0.3	0.9	0	0	0.7	0.3
	K2	0.5	0	0.3	0.5	0.3	0.7	0	0	0.5	0.3
	K3	0.1	0.3	0	0.5	0.1	0.5	0.3	0	0.7	0.5
	K4	0	0.1	0.1	0	0	0.3	0	0	0.3	0.1
	K5	0.5	0.5	0.3	0.7	0	0.7	0.3	0.3	0.9	0.7
	K6	0	0	0.1	0.3	0	0	0.1	0	0.3	0.5
	K7	0.7	0.9	0.3	0.7	0.3	0.5	0	0.5	0.7	0.5
	K8	0.9	0.7	0.9	0.9	0.3	0.7	0.5	0	0.7	0.7
	K9	0	0.1	0	0.3	0	0.3	0	0	0	0.5
	K10	0.3	0.3	0.1	0.5	0	0.1	0.1	0	0.1	0
M		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0	0.9	0.7	0.9	0.5	1	0.1	0	0.9	0.5
	K2	0.7	0	0.5	0.7	0.5	0.9	0	0.1	0.7	0.5
	K3	0.3	0.5	0	0.7	0.3	0.7	0.5	0	0.9	0.7
	K4	0.1	0.3	0.3	0	0.1	0.5	0.1	0	0.5	0.3
	K5	0.7	0.7	0.5	0.9	0	0.9	0.5	0.5	1	0.9
	K6	0.1	0	0.3	0.5	0.1	0	0.3	0.1	0.5	0.7
	K7	0.9	1	0.5	0.9	0.5	0.7	0	0.7	0.9	0.7
	K8	1	0.9	1	1	0.5	0.9	0.7	0	0.9	0.9
	K9	0.1	0.3	0.1	0.5	0	0.5	0.1	0.1	0	0.7
	K10	0.5	0.5	0.3	0.7	0.1	0.3	0.3	0.1	0.3	0
U		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0	1	0.9	1	0.7	1	0.3	0.1	1	0.7
	K2	0.9	0	0.7	0.9	0.7	1	0.1	0.3	0.9	0.7
	K3	0.5	0.7	0	0.9	0.5	0.9	0.7	0.1	1	0.9
	K4	0.3	0.5	0.5	0	0.3	0.7	0.3	0.1	0.7	0.5
	K5	0.9	0.9	0.7	1	0	1	0.7	0.7	1	1

	K6	0.3	0.1	0.5	0.7	0.3	0	0.5	0.3	0.7	0.9
	K7	1	1	0.7	1	0.7	0.9	0	0.9	1	0.9
	K8	1	1	1	1	0.7	1	0.9	0	1	1
	K9	0.3	0.5	0.3	0.7	0.1	0.7	0.3	0.3	0	0.9
	K10	0.7	0.7	0.5	0.9	0.3	0.5	0.5	0.3	0.5	0

Step 2: Creating the Fuzzy Direct Relationship Matrix

Based on the data received from 5 expert decision makers, the fuzzy direct relationship matrix is created as in Table 6 by averaging each cell of 5 of the matrices created as in Table 5.

Table 6. Fuzzy Direct Relationship Matrix

	Fuzzy Direct Relationship Matrix (l, m, u)										
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
L	**K1**	0	0.5	0.46	0.78	0.22	0.62	0.02	0.02	0.54	0.42
	K2	0.26	0	0.38	0.62	0.1	0.54	0.02	0.02	0.54	0.42
	K3	0.16	0.2	0	0.66	0.02	0.46	0.08	0	0.54	0.38
	K4	0	0.04	0.08	0	0	0.26	0	0	0.18	0.16
	K5	0.42	0.58	0.58	0.82	0	0.78	0.18	0.18	0.74	0.74
	K6	0.02	0	0.18	0.42	0	0	0.02	0	0.26	0.24
	K7	0.7	0.7	0.66	0.82	0.42	0.74	0	0.34	0.82	0.66
	K8	0.74	0.7	0.78	0.82	0.42	0.82	0.34	0	0.78	0.58
	K9	0.1	0.1	0.1	0.42	0.02	0.34	0	0	0	0.24
	K10	0.18	0.18	0.22	0.46	0	0.38	0.04	0.06	0.38	0
M		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0	0.7	0.66	0.94	0.42	0.8	0.12	0.1	0.74	0.62
	K2	0.46	0	0.58	0.8	0.26	0.74	0.12	0.12	0.74	0.62
	K3	0.34	0.38	0	0.84	0.12	0.66	0.18	0.06	0.74	0.58
	K4	0.08	0.16	0.2	0	0.04	0.46	0.04	0.04	0.38	0.34
	K5	0.62	0.78	0.78	0.96	0	0.94	0.38	0.38	0.9	0.92
	K6	0.1	0.06	0.38	0.62	0.06	0	0.1	0.04	0.46	0.42
	K7	0.88	0.88	0.82	0.96	0.62	0.9	0	0.54	0.96	0.84
	K8	0.9	0.88	0.94	0.96	0.62	0.96	0.54	0	0.94	0.78
	K9	0.26	0.26	0.26	0.62	0.1	0.54	0.04	0.06	0	0.42
	K10	0.38	0.38	0.42	0.66	0.08	0.58	0.16	0.22	0.58	0
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0	0.86	0.84	1	0.62	0.92	0.3	0.26	0.9	0.82
	K2	0.66	0	0.76	0.94	0.46	0.9	0.3	0.3	0.9	0.82
	K3	0.54	0.58	0	0.96	0.3	0.84	0.34	0.22	0.9	0.78

U	**K4**	0.26	0.34	0.38	0	0.18	0.66	0.18	0.18	0.58	0.54
	K5	0.82	0.94	0.92	1	0	1	0.58	0.58	0.98	1
	K6	0.26	0.22	0.58	0.82	0.22	0	0.26	0.18	0.66	0.62
	K7	0.98	0.98	0.92	1	0.82	0.98	0	0.74	1	0.96
	K8	0.98	0.98	1	1	0.82	1	0.74	0	1	0.94
	K9	0.46	0.46	0.46	0.82	0.26	0.74	0.18	0.22	0	0.62
	K10	0.58	0.58	0.62	0.84	0.26	0.76	0.34	0.42	0.76	0

Step 3: Constructing the Normalized Fuzzy Direct Relationship Matrix

Each cell of the fuzzy direct relationship matrix is divided by the value in the maximum "Total u" row to obtain the normalized direct relationship matrix. The resulting normalized fuzzy direct relationship matrix is shown in Table 7.

Table 7. Normalized Fuzzy Direct Relationship Matrix

	Normalized Fuzzy Direct Relationship Matrix (l, m, u)										
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
L	**K1**	0	0.059	0.054	0.092	0.026	0.073	0.002	0.002	0.064	0.05
	K2	0.031	0	0.045	0.073	0.012	0.064	0.002	0.002	0.064	0.05
	K3	0.019	0.024	0	0.078	0.002	0.054	0.009	0	0.064	0.045
	K4	0	0.005	0.009	0	0	0.031	0	0	0.021	0.019
	K5	0.05	0.069	0.069	0.097	0	0.092	0.021	0.021	0.087	0.087
	K6	0.002	0	0.021	0.05	0	0	0.002	0	0.031	0.028
	K7	0.083	0.083	0.078	0.097	0.05	0.087	0	0.04	0.097	0.078
	K8	0.087	0.083	0.092	0.097	0.05	0.097	0.04	0	0.092	0.069
	K9	0.012	0.012	0.012	0.05	0.002	0.04	0	0	0	0.028
	K10	0.021	0.021	0.026	0.054	0	0.045	0.005	0.007	0.045	0
M		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0	0.083	0.078	0.111	0.05	0.095	0.014	0.012	0.087	0.073
	K2	0.054	0	0.069	0.095	0.031	0.087	0.014	0.014	0.087	0.073
	K3	0.04	0.045	0	0.099	0.014	0.078	0.021	0.007	0.087	0.069
	K4	0.009	0.019	0.024	0	0.005	0.054	0.005	0.005	0.045	0.04
	K5	0.073	0.092	0.092	0.113	0	0.111	0.045	0.045	0.106	0.109
	K6	0.012	0.007	0.045	0.073	0.007	0	0.012	0.005	0.054	0.05
	K7	0.104	0.104	0.097	0.113	0.073	0.106	0	0.064	0.113	0.099
	K8	0.106	0.104	0.111	0.113	0.073	0.113	0.064	0	0.111	0.092
	K9	0.031	0.031	0.031	0.073	0.012	0.064	0.005	0.007	0	0.05
	K10	0.045	0.045	0.05	0.078	0.009	0.069	0.019	0.026	0.069	0
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**

U	**K1**	0	0.102	0.099	0.118	0.073	0.109	0.035	0.031	0.106	0.097
	K2	0.078	0	0.09	0.111	0.054	0.106	0.035	0.035	0.106	0.097
	K3	0.064	0.069	0	0.113	0.035	0.099	0.04	0.026	0.106	0.092
	K4	0.031	0.04	0.045	0	0.021	0.078	0.021	0.021	0.069	0.064
	K5	0.097	0.111	0.109	0.118	0	0.118	0.069	0.069	0.116	0.118
	K6	0.031	0.026	0.069	0.097	0.026	0	0.031	0.021	0.078	0.073
	K7	0.116	0.116	0.109	0.118	0.097	0.116	0	0.087	0.118	0.113
	K8	0.116	0.116	0.118	0.118	0.097	0.118	0.087	0	0.118	0.111
	K9	0.054	0.054	0.054	0.097	0.031	0.087	0.021	0.026	0	0.073
	K10	0.069	0.069	0.073	0.099	0.031	0.09	0.04	0.05	0.09	0

Step 4: Creation of the Total Fuzzy Direct Relationship Matrix

Matrices $Lx(I-L)^{-1}$, $Mx(I-M)^{-1}$ and $Ux(I-U)^{-1}$ are created using the unit matrix I. These matrices are shown in Equation 23, Equation 24 and Equation 25. With these matrices, the total fuzzy direct relationship matrix is created.

$$Lx(I-L)^{-1}=\begin{bmatrix} 0.008 & 0.067 & 0.066 & 0.119 & 0.028 & 0.095 & 0.004 & 0.004 & 0.084 & 0.067 \\ 0.036 & 0.008 & 0.054 & 0.095 & 0.014 & 0.081 & 0.004 & 0.003 & 0.079 & 0.062 \\ 0.023 & 0.029 & 0.008 & 0.095 & 0.004 & 0.068 & 0.01 & 0.001 & 0.076 & 0.055 \\ 0.001 & 0.006 & 0.011 & 0.006 & 0 & 0.034 & 0 & 0 & 0.025 & 0.022 \\ 0.062 & 0.083 & 0.088 & 0.139 & 0.005 & 0.126 & 0.024 & 0.024 & 0.119 & 0.112 \\ 0.004 & 0.002 & 0.024 & 0.056 & 0 & 0.007 & 0.003 & 0 & 0.036 & 0.032 \\ 0.099 & 0.104 & 0.105 & 0.151 & 0.056 & 0.132 & 0.005 & 0.043 & 0.138 & 0.112 \\ 0.104 & 0.104 & 0.119 & 0.153 & 0.057 & 0.142 & 0.044 & 0.004 & 0.135 & 0.104 \\ 0.014 & 0.014 & 0.016 & 0.058 & 0.003 & 0.047 & 0.001 & 0 & 0.007 & 0.033 \\ 0.025 & 0.026 & 0.033 & 0.069 & 0.002 & 0.056 & 0.006 & 0.008 & 0.055 & 0.01 \end{bmatrix} \tag{23}$$

$$Mx(I-M)^{-1}=\begin{bmatrix} 0.036 & 0.118 & 0.123 & 0.185 & 0.066 & 0.16 & 0.029 & 0.026 & 0.151 & 0.128 \\ 0.082 & 0.035 & 0.108 & 0.159 & 0.046 & 0.144 & 0.027 & 0.026 & 0.141 & 0.12 \\ 0.065 & 0.072 & 0.036 & 0.153 & 0.028 & 0.126 & 0.031 & 0.017 & 0.132 & 0.108 \\ 0.021 & 0.031 & 0.039 & 0.027 & 0.011 & 0.075 & 0.01 & 0.009 & 0.065 & 0.058 \\ 0.122 & 0.145 & 0.157 & 0.217 & 0.029 & 0.202 & 0.065 & 0.063 & 0.194 & 0.183 \\ 0.027 & 0.024 & 0.063 & 0.103 & 0.014 & 0.03 & 0.018 & 0.011 & 0.08 & 0.072 \\ 0.159 & 0.167 & 0.173 & 0.235 & 0.104 & 0.213 & 0.027 & 0.084 & 0.216 & 0.187 \\ 0.162 & 0.168 & 0.187 & 0.237 & 0.104 & 0.221 & 0.087 & 0.024 & 0.215 & 0.183 \\ 0.046 & 0.049 & 0.054 & 0.109 & 0.021 & 0.095 & 0.012 & 0.014 & 0.033 & 0.076 \\ 0.068 & 0.072 & 0.083 & 0.13 & 0.024 & 0.115 & 0.029 & 0.034 & 0.113 & 0.041 \end{bmatrix} \tag{24}$$

$$Ux(I-U)^{-1}=\begin{bmatrix} 0.123 & 0.224 & 0.239 & 0.307 & 0.153 & 0.283 & 0.108 & 0.101 & 0.277 & 0.255 \\ 0.186 & 0.121 & 0.22 & 0.286 & 0.131 & 0.268 & 0.103 & 0.1 & 0.264 & 0.242 \\ 0.161 & 0.172 & 0.122 & 0.269 & 0.105 & 0.243 & 0.099 & 0.084 & 0.246 & 0.222 \\ 0.093 & 0.106 & 0.119 & 0.104 & 0.065 & 0.168 & 0.059 & 0.058 & 0.157 & 0.145 \\ 0.242 & 0.265 & 0.283 & 0.352 & 0.108 & 0.334 & 0.156 & 0.152 & 0.327 & 0.312 \\ 0.102 & 0.103 & 0.15 & 0.207 & 0.075 & 0.108 & 0.073 & 0.063 & 0.178 & 0.165 \\ 0.273 & 0.285 & 0.3 & 0.374 & 0.208 & 0.352 & 0.101 & 0.178 & 0.349 & 0.326 \\ 0.275 & 0.286 & 0.31 & 0.376 & 0.209 & 0.356 & 0.182 & 0.098 & 0.351 & 0.326 \\ 0.13 & 0.136 & 0.148 & 0.219 & 0.085 & 0.2 & 0.069 & 0.071 & 0.117 & 0.176 \\ 0.164 & 0.171 & 0.188 & 0.253 & 0.101 & 0.232 & 0.098 & 0.104 & 0.229 & 0.134 \end{bmatrix} \quad (25)$$

The total fuzzy direct relationship matrix is tabulated in Table 8.

Table 8. Total Fuzzy Direct Relationship Matrix

	Total Fuzzy Direct Relationship Matrix (l, m, u)										
L		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0.008	0.067	0.066	0.119	0.028	0.095	0.004	0.004	0.084	0.067
	K2	0.036	0.008	0.054	0.095	0.014	0.081	0.004	0.003	0.079	0.062
	K3	0.023	0.029	0.008	0.095	0.004	0.068	0.01	0.001	0.076	0.055
	K4	0.001	0.006	0.011	0.006	0	0.034	0	0	0.025	0.022
	K5	0.062	0.083	0.088	0.139	0.005	0.126	0.024	0.024	0.119	0.112
	K6	0.004	0.002	0.024	0.056	0	0.007	0.003	0	0.036	0.032
	K7	0.099	0.104	0.105	0.151	0.056	0.132	0.005	0.043	0.138	0.112
	K8	0.104	0.104	0.119	0.153	0.057	0.142	0.044	0.004	0.135	0.104
	K9	0.014	0.014	0.016	0.058	0.003	0.047	0.001	0	0.007	0.033
	K10	0.025	0.026	0.033	0.069	0.002	0.056	0.006	0.008	0.055	0.01
M		**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0.036	0.118	0.123	0.185	0.066	0.16	0.029	0.026	0.151	0.128
	K2	0.082	0.035	0.108	0.159	0.046	0.144	0.027	0.026	0.141	0.12
	K3	0.065	0.072	0.036	0.153	0.028	0.126	0.031	0.017	0.132	0.108
	K4	0.021	0.031	0.039	0.027	0.011	0.075	0.01	0.009	0.065	0.058
	K5	0.122	0.145	0.157	0.217	0.029	0.202	0.065	0.063	0.194	0.183
	K6	0.027	0.024	0.063	0.103	0.014	0.03	0.018	0.011	0.08	0.072
	K7	0.159	0.167	0.173	0.235	0.104	0.213	0.027	0.084	0.216	0.187
	K8	0.162	0.168	0.187	0.237	0.104	0.221	0.087	0.024	0.215	0.183
	K9	0.046	0.049	0.054	0.109	0.021	0.095	0.012	0.014	0.033	0.076
	K10	0.068	0.072	0.083	0.13	0.024	0.115	0.029	0.034	0.113	0.041
		K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
	K1	0.123	0.224	0.239	0.307	0.153	0.283	0.108	0.101	0.277	0.255
	K2	0.186	0.121	0.22	0.286	0.131	0.268	0.103	0.1	0.264	0.242

U	**K3**	0.161	0.172	0.122	0.269	0.105	0.243	0.099	0.084	0.246	0.222
	K4	0.093	0.106	0.119	0.104	0.065	0.168	0.059	0.058	0.157	0.145
	K5	0.242	0.265	0.283	0.352	0.108	0.334	0.156	0.152	0.327	0.312
	K6	0.102	0.103	0.15	0.207	0.075	0.108	0.073	0.063	0.178	0.165
	K7	0.273	0.285	0.3	0.374	0.208	0.352	0.101	0.178	0.349	0.326
	K8	0.275	0.286	0.31	0.376	0.209	0.356	0.182	0.098	0.351	0.326
	K9	0.13	0.136	0.148	0.219	0.085	0.2	0.069	0.071	0.117	0.176
	K10	0.164	0.171	0.188	0.253	0.101	0.232	0.098	0.104	0.229	0.134

Step 5: Identify Cause and Effect Relationships

The column totals in the total fuzzy direct relationship matrix are $\overset{:}{D}_i$ and row totals are $\overset{:}{R}_i$ as shown in Table 9.

Table 9. $\overset{:}{D}_i$ and $\overset{:}{R}_i$ Values

$\overset{:}{D}_i$ **Values (l, m, u)**										
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
l	0.377	0.443	0.525	0.94	0.169	0.788	0.101	0.087	0.755	0.608
m	0.789	0.881	1.023	1.556	0.446	1.379	0.336	0.308	1.341	1.155
u	1.748	1.868	2.078	2.747	1.241	2.544	1.048	1.009	2.494	2.304
$\overset{:}{R}_i$ **Values (l,m,u)**										
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
l	0.542	0.435	0.369	0.105	0.784	0.165	0.946	0.965	0.194	0.288
m	1.022	0.888	0.768	0.347	1.376	0.442	1.565	1.587	0.509	0.709
u	2.071	1.919	1.723	1.074	2.53	1.224	2.746	2.769	1.351	1.673

Table 10. $\overset{:}{D}_i$ and $\overset{:}{R}_i$ Values

$\overset{:}{D}_i + \overset{:}{R}_i$ **Values (l, m, u)**										
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
l	0.919	0.878	0.894	1.046	0.953	0.953	1.047	1.052	0.949	0.897
m	1.811	1.769	1.791	1.903	1.822	1.821	1.9	1.896	1.849	1.864
u	3.819	3.787	3.8	3.822	3.77	3.768	3.794	3.778	3.846	3.977
$\overset{:}{D}_i - \overset{:}{R}_i$ **Values (l,m,u)**										
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**
l	-0.166	0.008	0.156	0.835	-0.614	0.622	-0.845	-0.878	0.561	0.32
m	-0.234	-0.007	0.255	1.209	-0.93	0.937	-1.229	-1.279	0.832	0.446

u	-0.323	-0.05	0.355	1.673	-1.289	1.319	-1.698	-1.76	1.143	0.63

According to the formulas in Equation 7 and Equation 8, $\tilde{D}_i^{Def} + \tilde{R}_i^{Def}$ and $\tilde{D}_i^{Def} - \tilde{R}_i^{Def}$ values are found as in Table 11. This process is called defuzzification, "def" comes from the English word "defuzzying".

Table 11. $\tilde{D}_i^{Def} + \tilde{R}_i^{Def}$ and $\tilde{D}_i^{Def} - \tilde{R}_i^{Def}$ Values

Main Criteria	$\tilde{D}_i^{Def} + \tilde{R}_i^{Def}$	$\tilde{D}_i^{Def} - \tilde{R}_i^{Def}$
K1	2.09	-0.239
K2	2.051	-0.014
K3	2.069	0.255
K4	2.168	1.231
K5	2.092	-0.941
K6	2.091	0.954
K7	2.16	-1.25
K8	2.155	-1.299
K9	2.123	0.842
K10	2.15	0.461

Step 6: Determination of Main Criteria Weights

According to the formulation in Equation 9, criteria weights are created as in Table 12.

Table 12. Criteria Weights

Main Criteria	w	W
K1	2.104	0.093
K2	2.051	0.09
K3	2.085	0.091
K4	2.493	0.109
K5	2.294	0.101
K6	2.298	0.101
K7	2.496	0.109
K8	2.517	0.11
K9	2.284	0.1
K10	2.199	0.096

5.2. Evaluation of Alternatives and Selection of the Best Alternative

At this stage, the 5 decision makers in the project evaluate the relationship between the main criteria and the alternatives, and based on these relationships, the alternatives are ranked using the Fuzzy TOPSIS method.

Step 1: Selection of Decision Makers and Solution Alternatives

After the evaluation of the decision-making group, which will have the authority to decide on the solution of the problem and determine the criteria weights, 5 different solution alternatives are identified.

Step 2: Evaluation of Criteria and Alternatives with Linguistic Variables

Alternatives are evaluated with linguistic variables according to the criteria. Evaluations are made by 5 different experts. For example, the evaluations made by the 1st Expert are given in Table 13.

Table 13. 1. Expert's Assessment of Main Criteria-Alternatives

Decision Maker 1					
	A1	**A2**	**A3**	**A4**	**A5**
K1	7	2	6	5	5
K2	5	4	6	7	5
K3	4	5	7	7	6
K4	2	1	5	5	4
K5	5	4	6	6	7
K6	3	2	4	5	6
K7	5	4	7	7	6
K8	4	4	6	6	5
K9	5	4	7	5	4
K10	6	5	6	7	5

Step 3: Transforming the Assessments into Fuzzy Numbers

In step 2, the evaluations made are converted into fuzzy numbers according to the fuzzy scale determined in Table 1. In Table 14, the evaluation results of Expert 1 are transformed into triangular fuzzy numbers according to the fuzzy scale.

Table 14. 1.Triangular Fuzzy Number Representation of the Expert's Evaluation of the Main Criteria-Alternatives

	Decision Maker 1 (l, m, u)

		A1	A2	A3	A4	A5
L	K1	0.9	0	0.7	0.5	0.5
	K2	0.5	0.3	0.7	0.9	0.5
	K3	0.3	0.5	0.9	0.9	0.7
	K4	0	0	0.5	0.5	0.3
	K5	0.5	0.3	0.7	0.7	0.9
	K6	0.1	0	0.3	0.5	0.7
	K7	0.5	0.3	0.9	0.9	0.7
	K8	0.3	0.3	0.7	0.7	0.5
	K9	0.5	0.3	0.9	0.5	0.3
	K10	0.7	0.5	0.7	0.9	0.5
M		A1	A2	A3	A4	A5
	K1	1	0.1	0.9	0.7	0.7
	K2	0.7	0.5	0.9	1	0.7
	K3	0.5	0.7	1	1	0.9
	K4	0.1	0	0.7	0.7	0.5
	K5	0.7	0.5	0.9	0.9	1
	K6	0.3	0.1	0.5	0.7	0.9
	K7	0.7	0.5	1	1	0.9
	K8	0.5	0.5	0.9	0.9	0.7
	K9	0.7	0.5	1	0.7	0.5
	K10	0.9	0.7	0.9	1	0.7
U		A1	A2	A3	A4	A5
	K1	1	0.3	1	0.9	0.9
	K2	0.9	0.7	1	1	0.9
	K3	0.7	0.9	1	1	1
	K4	0.3	0.1	0.9	0.9	0.7
	K5	0.9	0.7	1	1	1
	K6	0.5	0.3	0.7	0.9	1
	K7	0.9	0.7	1	1	1
	K8	0.7	0.7	1	1	0.9
	K9	0.9	0.7	1	0.9	0.7
	K10	1	0.9	1	1	0.9

Step 4: Creation of the Fuzzy Decision Matrix

Based on the data received from 5 expert decision makers, the fuzzy decision matrix is created as in Table 15 by averaging each cell of 5 of the matrices created as in Table 14, that is, by applying the formula in Equation 11.

Table 15. Fuzzy Decision Matrix

	Fuzzy Decision Matrix (l, m, u)					
L		**A1**	**A2**	**A3**	**A4**	**A5**
	K1	0.74	0.24	0.74	0.5	0.28
	K2	0.62	0.46	0.82	0.78	0.5
	K3	0.62	0.46	0.82	0.58	0.54
	K4	0.1	0.04	0.5	0.5	0.62
	K5	0.7	0.46	0.82	0.7	0.78
	K6	0.32	0.14	0.46	0.38	0.78
	K7	0.62	0.42	0.82	0.74	0.38
	K8	0.34	0.24	0.82	0.74	0.42
	K9	0.74	0.24	0.74	0.28	0.2
	K10	0.62	0.46	0.78	0.7	0.66
M		**A1**	**A2**	**A3**	**A4**	**A5**
	K1	0.9	0.42	0.9	0.7	0.46
	K2	0.8	0.66	0.96	0.92	0.7
	K3	0.8	0.66	0.96	0.76	0.74
	K4	0.24	0.16	0.7	0.7	0.8
	K5	0.88	0.66	0.96	0.88	0.94
	K6	0.5	0.3	0.66	0.58	0.94
	K7	0.8	0.62	0.96	0.92	0.58
	K8	0.54	0.42	0.96	0.92	0.62
	K9	0.9	0.42	0.9	0.46	0.38
	K10	0.8	0.66	0.94	0.88	0.82
		A1	**A2**	**A3**	**A4**	**A5**
U	**K1**	0.98	0.62	0.98	0.86	0.66
	K2	0.92	0.84	1	0.98	0.88
	K3	0.92	0.84	1	0.9	0.9
	K4	0.42	0.34	0.88	0.88	0.92
	K5	0.98	0.84	1	0.98	1
	K6	0.68	0.5	0.84	0.78	1
	K7	0.92	0.82	1	1	0.76
	K8	0.74	0.62	1	1	0.82
	K9	0.98	0.62	0.98	0.66	0.58
	K10	0.92	0.84	1	0.98	0.92

Step 5: Constructing the Normalized Fuzzy Decision Matrix

In Step 4, the fuzzy decision matrix is normalized by the formula given in Equation 13. In short, the values below each alternative are divided by the largest value within that alternative. In this way, the normalized fuzzy decision matrix in Table 16 is created.

Table 16. Normalized Fuzzy Decision Matrix

	Normalized Fuzzy Decision Matrix (l, m, u)					
		A1	**A2**	**A3**	**A4**	**A5**
L	**K1**	0.154	0.05	0.154	0.104	0.058
	K2	0.129	0.096	0.171	0.163	0.104
	K3	0.129	0.096	0.171	0.121	0.113
	K4	0.021	0.008	0.104	0.104	0.129
	K5	0.146	0.096	0.171	0.146	0.163
	K6	0.067	0.029	0.096	0.079	0.163
	K7	0.129	0.088	0.171	0.154	0.079
	K8	0.071	0.05	0.171	0.154	0.088
	K9	0.154	0.05	0.154	0.058	0.042
	K10	0.129	0.096	0.163	0.146	0.138
M		**A1**	**A2**	**A3**	**A4**	**A5**
	K1	0.188	0.088	0.188	0.146	0.096
	K2	0.167	0.138	0.2	0.192	0.146
	K3	0.167	0.138	0.2	0.158	0.154
	K4	0.05	0.033	0.146	0.146	0.167
	K5	0.183	0.138	0.2	0.183	0.196
	K6	0.104	0.063	0.138	0.121	0.196
	K7	0.167	0.129	0.2	0.192	0.121
	K8	0.113	0.088	0.2	0.192	0.129
	K9	0.188	0.088	0.188	0.096	0.079
	K10	0.167	0.138	0.196	0.183	0.171
U		**A1**	**A2**	**A3**	**A4**	**A5**
	K1	0.204	0.129	0.204	0.179	0.138
	K2	0.192	0.175	0.208	0.204	0.183
	K3	0.192	0.175	0.208	0.188	0.188
	K4	0.088	0.071	0.183	0.183	0.192
	K5	0.204	0.175	0.208	0.204	0.208
	K6	0.142	0.104	0.175	0.163	0.208
	K7	0.192	0.171	0.208	0.208	0.158
	K8	0.154	0.129	0.208	0.208	0.171
	K9	0.204	0.129	0.204	0.138	0.121

	K10	0.192	0.175	0.208	0.204	0.192

Step 6: Constructing a Weighted Normalized Fuzzy Decision Matrix

The weighted normalized fuzzy decision matrix is calculated according to the formulation in Equation 16. In short, the weighted normalized fuzzy decision matrix is obtained by multiplying the normalized fuzzy decision matrix found in step 5 by the sub-criteria weights found by the Fuzzy DEMATEL method in section 5.1. The weighted normalized fuzzy decision matrix is given in Table 17.

Table 17. Weighted Normalized Fuzzy Decision Matrix

	Weighted Normalized Fuzzy Decision Matrix (l, m, u)					
		A1	**A2**	**A3**	**A4**	**A5**
L	**K1**	0.014	0.005	0.014	0.01	0.005
	K2	0.012	0.009	0.015	0.015	0.009
	K3	0.012	0.009	0.016	0.011	0.01
	K4	0.002	0.001	0.011	0.011	0.014
	K5	0.015	0.01	0.017	0.015	0.016
	K6	0.007	0.003	0.01	0.008	0.016
	K7	0.014	0.01	0.019	0.017	0.009
	K8	0.008	0.006	0.019	0.017	0.01
	K9	0.015	0.005	0.015	0.006	0.004
	K10	0.012	0.009	0.016	0.014	0.013
M		**A1**	**A2**	**A3**	**A4**	**A5**
	K1	0.017	0.008	0.017	0.014	0.009
	K2	0.015	0.012	0.018	0.017	0.013
	K3	0.015	0.013	0.018	0.014	0.014
	K4	0.005	0.004	0.016	0.016	0.018
	K5	0.019	0.014	0.02	0.019	0.02
	K6	0.011	0.006	0.014	0.012	0.02
	K7	0.018	0.014	0.022	0.021	0.013
	K8	0.012	0.01	0.022	0.021	0.014
	K9	0.019	0.009	0.019	0.01	0.008
	K10	0.016	0.013	0.019	0.018	0.016
		A1	**A2**	**A3**	**A4**	**A5**
	K1	0.019	0.012	0.019	0.017	0.013
	K2	0.017	0.016	0.019	0.018	0.017
	K3	0.017	0.016	0.019	0.017	0.017
	K4	0.01	0.008	0.02	0.02	0.021

U	**K5**	0.021	0.018	0.021	0.021	0.021
	K6	0.014	0.011	0.018	0.016	0.021
	K7	0.021	0.019	0.023	0.023	0.017
	K8	0.017	0.014	0.023	0.023	0.019
	K9	0.02	0.013	0.02	0.014	0.012
	K10	0.018	0.017	0.02	0.02	0.018

Step 7: Determination of Fuzzy Positive and Negative Ideal Solutions

Fuzzy positive ideal solution and fuzzy negative ideal solution values are found as given in Equation 26 and Equation 27 respectively.

$$A^{*}=\left[(0.015,0.019,0.021),(0,01,0.014,0.019),(0.019,0.022,0.023),(0.017,0.021,0.023),(0.016,0.02,0.021)\right] \quad (27)$$

$$A^{-}=\left[(0.002,0.005,0.01),(0.001,0.004,0.008),(0.01,0.014,0.018),(0.006,0.01,0.014),(0.004,0.008,0.012)\right] \quad (28)$$

Step 8: Calculation of Proximity Coefficients

The positive and negative distances of the 5 alternative solutions according to the 10 main criteria are first calculated according to the Vertex method in Equation 21. Then, the distances of each solution alternative from the fuzzy positive ideal solution and the fuzzy negative ideal solution are calculated according to Equation 19 and Equation 20. These values are given in Table 18 and Table 19 respectively.

Table 18. The Distance (Proximity Coefficients) Between Ai=(i=1,...5) and A^* for Each Criterion

Criteria	d(A1, A^*)	d(A2, A^*)	d(A3, A^*)	d(A4, A^*)	d(A5, A^*)
K1	0.001	0.006	0.004	0.007	0.01
K2	0.004	0.002	0.004	0.004	0.006
K3	0.004	0.002	0.004	0.006	0.005
K4	0.013	0.01	0.006	0.005	0.002
K5	0	0.001	0.002	0.002	0
K6	0.008	0.008	0.008	0.008	0
K7	0.001	0	0	0	0.006
K8	0.006	0.004	0	0	0.005
K9	0	0.005	0.003	0.011	0.011
K10	0.003	0.001	0.003	0.003	0.003

Table 19. The Distance (Proximity Coefficients) Between Ai=(i=1,...5) and A^{-} for Each Criterion

Criteria	d(A1, A^{-})	d(A2, A^{-})	d(A3, A^{-})	d(A4, A^{-})	d(A5, A^{-})
K1	0.011	0.004	0.003	0.004	0.001
K2	0.009	0.008	0.004	0.007	0.005
K3	0.009	0.008	0.004	0.005	0.006
K4	0	0	0.002	0.006	0.01
K5	0.012	0.01	0.006	0.008	0.011
K6	0.005	0.003	0	0.002	0.011
K7	0.012	0.01	0.007	0.01	0.005
K8	0.007	0.006	0.008	0.011	0.006
K9	0.012	0.005	0.005	0	0
K10	0.01	0.009	0.005	0.007	0.008

Step 9: Finding Proximity Coefficients for Alternatives

After calculating the distances of all 5 alternatives to the positive and negative ideal solution for all criteria, d_i^* and d_i^- values are obtained for the alternatives and CC_i proximity coefficients are found for each alternative according to the formulation in Equation 22. These values are given in Table 20.

Table 20. Finding the Closeness Coefficients for Each Alternative

	A1	**A2**	**A3**	**A4**	**A5**
d_i^*	0.04	0.039	0.033	0.046	0.049
d_i^-	0.087	0.062	0.044	0.061	0.063
$d_i^* + d_i^-$	0.127	0.101	0.078	0.107	0.112
CC_i	0.687	0.616	1.323	0.567	0.562

Step 10: Ranking of Alternatives

In other words, when the closeness coefficients of the alternatives are ranked from largest to smallest, A3>A1>A2>A4>A5. In other words, the alternative solution numbered 3 “to be a data specialist” was determined as the field in which the graduates of the statistics department wanted to work the most, followed by “to be a statistician”, “to be a production planning and quality specialist”, “to be a software developer” and “to be an academician”.

6. CONCLUSION AND RECOMMENDATIONS

In this study has effectively analyzed the factors influencing career selection among statistics graduates and identified the significance of various criteria in shaping their preferences. Individuals' personality traits, values, interests, abilities, and skills are critical in determining their career paths, alongside societal perceptions of professions and their financial and moral rewards. To evaluate these factors comprehensively, Multi-Criteria Decision-Making (MCDM) methods, including fuzzy DEMATEL and fuzzy TOPSIS, were applied. Relationships between the main criteria were analyzed using fuzzy DEMATEL based on expert opinions, followed by ranking alternatives using fuzzy TOPSIS. This mixed approach provided a systematic framework to identify the most suitable career alternatives across five fields of study and addressed the inherent uncertainty in decision-making processes.

The findings revealed that graduates who prioritize numerical aptitude, professional values, and social facilities often prefer careers as data specialists. It was observed that factors such as interests, skills, family influence, psychological needs, financial returns, job prospects, coursework, and social opportunities also significantly influence career choices. The demand for data-driven roles, particularly data specialists, has grown significantly in today's job market, placing this profession among the top 10 most lucrative careers globally (Horat & Deniz, 2020). This aligns with the increasing emphasis on big data and the need for professionals capable of extracting actionable insights.

However, statistics departments, which primarily offer theoretical education, may lose ground to engineering faculties, particularly computer engineering, for students aiming to become data scientists or pursue similar roles. Data scientists require a deeper understanding of statistics than programmers and greater programming expertise than traditional statisticians, driving demand for graduates with interdisciplinary skills. To remain competitive, statistics departments must adapt by integrating practical, industry-relevant skills, such as data science, programming, machine learning, and artificial intelligence, into their curricula.

To address these challenges, universities should enhance their curricula with applied skills like data visualization, advanced programming, and AI. Offering specialized certifications or interdisciplinary programs that bridge statistics with computer engineering or business administration can further prepare students for versatile career paths. Career guidance initiatives, such as mentorship programs and workshops, should also help students identify their strengths and align them with suitable career goals. Additionally, students should actively pursue internships and projects in data-centric roles to gain hands-on experience, while self-assessment tools can help them better understand their values and aptitudes.

Employers, on the other hand, should strengthen collaborations with academia by providing internships, real-world projects, and guest lectures to prepare students for workforce demands. Companies should also invest in upskilling initiatives to further enhance the statistical and technical expertise of their employees. Moreover, working with statistics graduates, who are true data experts, is critical for collecting and organizing high-quality data for accurate analysis and stronger future predictions. Challenges such as the rejection of data requests or difficulties in data storage and organization highlight the need for statisticians' expertise in ensuring reliable and actionable data insights.

Future research can build on this study by applying the integrated fuzzy DEMATEL and fuzzy TOPSIS methodology to other disciplines, validating its robustness and adaptability. Longitudinal studies tracking graduates' career trajectories could provide valuable insights into how preferences evolve and which criteria have lasting impacts on career satisfaction. Additionally, integrating other MCDM methods or conducting sensitivity analyses could further enhance the reliability of these findings.

In today's era of technological transformation, the demand for professionals skilled in big data, analytics, and machine learning will continue to rise. Statistics departments must adapt to this reality by incorporating cutting-edge technologies into their programs, ensuring that graduates are well-prepared to meet industry demands. Governments and institutions should also promote statistical education through funding and interdisciplinary innovation, enabling graduates to thrive in emerging fields. By aligning curricula, research, and career guidance with market trends, stakeholders can ensure that statistics graduates excel in their careers and contribute meaningfully to a data-driven world.

Declaration of Research and Publication Ethics

In order to apply the survey method in this study, permission was obtained from the Mimar Sinan Fine Arts University Science and Engineering Scientific Research and Publication Ethics Committee dated 24.05.2024, number E-15207191-050.04-168133, and research and publication ethics were complied with in this study.

Researcher's Contribution Rate Statement

In this study, Mert Ersen contributed 50%, Semra Erbolat Taşabat 30% and Kemal Cem Söylemez 20%.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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