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USING FUZZY AHP AND FUZZY TOPSIS METHODS FOR THE ANALYSIS OF DEVELOPMENT AGENCIES PROJECT EVALUATION CRITERIA

ABSTRACT

Regional differences can be seen in the structures of all countries and may cause several social and economic problems. Most of the world countries have been obliged to struggle with this imbalance and put forward different solutions for sustainable development. Regional Development Agencies (RDAs) is support regional firms which play important roles in development. However, due to the lack of an effective evaluation mechanism, the necessity of the supports and value addition to the region, have not yet been clearly demonstrated. Therefore, the selection of projects which will add more value to regions and bear high multiplying effects has great importance. In this study, the supports RDAs providing and the evaluating criteria of these support mechanisms are discussed. Relative weights of criteria are calculated by using fuzzy AHP and projects are ranked by using fuzzy TOPSIS. In this study, an alternative method is presented in the selection of projects.

Keywords: Fuzzy AHP, Fuzzy TOPSIS, JEL Cod C02, JEL Cod O22, JEL Cod R10

KALKINMA AJANSLARI PROJE DEĞERLENDİRME KRİTERLERİNİN ANALİZİ İÇİN BULANIK AHP VE BULANIK TOPSIS METODLARININ KULLANIMI

ÖZET

Bölgesel gelişmişlik farklılıkları, tüm ülkelerin yapısında görülmekte ve sosyo-ekonomik birçok sorunun çıkmasına sebep olmaktadır. Dünyadaki ülkelerin çoğu bu dengesizliklerle mücadele etmek zorunda kalmış ve sürdürülebilir bir kalkınma için farklı çözümler ortaya koymuşlardır. Bölgesel Kalkınma Ajansları(BKA) gelişmede önemli rol oynayan bölgesel firmaları desteklemektedir. Ancak etkin bir değerlendirme mekanizmasının olmaması nedeniyle, sağlanan desteklerin ne kadar yerinde olduğu, bölgeye ne kadar katma değer sağlayacağı net olarak ortaya konulabilmiş değildir. Bu nedenle; bölgeye daha fazla katma değer sağlayacak ve çarpan etkisi yüksek projelerin seçilmesi büyük önem arz etmektedir. Bu çalışmada, BKA'ların sağladıkları destekler ve bu destek mekanizmalarının değerlendirme kriterleri ele alınmıştır. Değerlendirme kriterlerinin göreli ağırlıklarını belirlemek için bulanık AHP, projeleri sıralamada bulanık TOPSIS kullanılmıştır. Çalışmada, proje seçiminde alternatif bir metot gösterilmiştir.

Anahtar Kelimeler: Bulanık AHP, Bulanık TOPSIS, JEL Kod C02, JEL Kod O22, JEL Kod R10

1. INTRODUCTION (GİRİŞ)

Inter-regional development disparities can be seen in the structures of all countries. Such disparities may cause several social and economic problems. Most of the world countries have been obliged to struggle with this imbalance and put forward different solutions to launch a sustainable and balanced development process.

First examples of Regional Development Agencies (RDAs) were founded in 1930s to be one of these solutions. RDAs, accepted to be among the best practice examples in especially European Union countries, have, to many extents, made great contributions to the development of less developed regions. It is vitally important for this purpose to support SMEs, NGOs and public institutions which play important roles in development. However, mostly due to the lack of an effective evaluation mechanism, the necessity of the supports and value addition to the region, have not yet been clearly demonstrated. Therefore, the selection of projects which will add more value to regions, bear high multiplying effects and less risk in practice, is the first steps and has great importance (Pirim, 2014:8).

Ranking and selecting projects is a multiple criteria decision-making (MCDM) problem. MCDM is used as a powerful tool for assessing multiple criteria problems. Because subjective judgment is about evaluating and selecting decision of partner, fuzzy sets theory is applied to MCDM problem. (Büyüközkan, Feyzioğlu & Nebol, 2008; Paksoy, Pehlivan & Kahraman, 2012).

Natural language of perception or judgment is always subjective, uncertain or ambiguous (Wang & Chang, 2007). Fuzzy logic is used for integrating imprecise data into the decision making.

Fuzzy sets can properly show uncertain parameters, and can be manage through different operations on fuzzy numbers. Since uncertain parameters are treated as imprecise values instead of precise ones, the process will be stronger and the results will be more creditable. Fuzzy logic is used to engineering, business, medical and related health sciences, and the natural sciences problems. (Kahraman, 2006).

Fuzzy Analytic Hierarchy Process (FAHP: Fuzzy AHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS: Fuzzy TOPSIS) are the two of efficient methods that have been presented for MCDM problems with the decision makers choice information completely known or unknown. The main difference between AHP and TOPSIS is that; pair wise comparisons for attributes and alternatives can be made in AHP, whereas can’t be in TOPSIS (Kahraman, Ates, Çevik, Gülbay, & Erdogan,2007).

Cakir & Canpolat (2007) suggested an inventory classification system based on FAHP.

Dagdeviren et al., (2009) presented an estimation model based on AHP and TOPSIS, to help the actors in defense industries for the selection of optimal weapon in a fuzzy conditions.

Amiri et al., (2009), proposed a new methodology to provide a simple approach to compare alternative projects for National Iranian Oil Company by using six investment alternatives as criteria in an AHP and fuzzy TOPSIS techniques.

Aydogan (2011) presented a conceptual performance measurement framework that takes into account company- level factors. In this study, AHP is used to improve by rough sets theory (Rough-AHP) and fuzzy TOPSIS (FTOPSIS) method is proposed to obtain final ranking.

Amile et al., (2013) proposed a MCDM model to compare the performance of banks. The variables were weighted using fuzzy AHP (FAHP) and ultimately the banks were ranked applying TOPSIS technique.

Ertugrul & Karakasoglu (2008) applied fuzzy AHP and fuzzy TOPSIS methods for the selection of facility location.

Ballı and Korukoglu (2009) developed a fuzzy MCDM model selecting favorable operating system for computer systems of the firms.

In this study, the supports RDAs provide and the evaluation criteria of these support mechanisms are discussed. The criteria used by RDAs at present were determined in Likert Scale and are composed of equally weighted 20 sub-criteria. By considering the effects of subjective judgments on the criteria and alternatives, instead of using a single Likert scale number fuzzy numbers are adopted to be used to eliminate this ambiguity.

FAHP has been applied since sub-criteria contains a hierarchical structure and fuzzy numbers, and an alternative method FTOPSIS, has been applied to weight the criteria accordingly for the selection.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

The selection of projects to support RDAs has great importance. In this study the project selection problem is modeled as an MCDM problem and presented a simple and selective technique to solve it. Two MCDMs are used in the evaluation procedure: Fuzzy AHP used to determine the relative weights of evaluation criteria, and the Fuzzy TOPSIS used to select the projects. An alternative method is presented in the selection of projects.

3. FUZZY AHP AND FUZZY TOPSIS (BULANIK AHP VE BULANIK TOPSIS)

3.1. Fuzzy AHP Method (Bulanık AHP Metodu)

AHP method is appropriate for making a preference among many alternatives by comparing them. AHP assists the analysts to organize the vital aspects of a problem in a hierarchical structure like a family tree. AHP is used to identify the preferred alternative and set a ranking of the alternatives (Saaty, 1990).

AHP comprises the base of decomposition, pair wise comparisons, and priority vector generation and synthesis. Although the aim of AHP is to reflect the expert’s knowledge, the classical AHP still cannot represent the way of human thinking. Therefore, fuzzy AHP was developed to solve the hierarchical problems (Mahmoodzadeh et al., 2007). The pair wise comparisons in the decision matrix are fuzzy numbers that are changed by the designer’s point in fuzzy-AHP method (Kahraman, Cebeci & Ulukan, 2003).

In general decision makers find it more assured to give interval judgments than the fixed one. Fuzzy AHP has improved to inadequacy of AHP to refer the imprecision and subjectivity in the pair-wise comparison procedure. A range of value is used instead of a crisp one to incorporate the decision maker’s uncertainty in Fuzzy AHP (Kahraman, 2008).

Let $X = \{x_1, x_2, \dots, x_n\}$ be an object set and $U = \{u_1, u_2, \dots, u_m\}$ be a goal set. According to Chang (1992), g_i respectively represents extent analysis for each goal.

Then, m extent analysis values for each object can be obtained, by the following signs:

$$M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m \qquad i = 1,2,\dots,n$$

Where all the $M_{gi}^j \ (j = 1,2,\dots,m)$ are triangular fuzzy numbers (TFNs).

Chang’s extent analysis can be given in three steps:

Step 1. The value of fuzzy synthetic extent with respect to *i*. object is defined as Equation (1);

$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} \mathrm{M}_{\mathrm{gi}}^{\mathrm{j}}\right]$ (1)

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that;

$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_i, \sum_{j=1}^{m} m_i, \sum_{j=1}^{m} u_i\right)$ (2)

And to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, perform the fuzzy addition operation of $\mathrm{M}_{\mathrm{gi}}^{\mathrm{j}}\ (\mathrm{j} = 1,2,\dots,\mathrm{m})$ values such that

$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right)$ (3)

and then compute the inverse of the vector in a previous equation in Equation (4).

$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right)$ (4)

Step 2. The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as

$V(M_2 \geq M_1) = \sup_{y \geq x}\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right]$ (5)

And can be equivalently expressed follow as follows:

$V(M_2 \geq M_1) = hgt(M_2 \cap M_1) = \mu_{M2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases}$ (6)

Where d is the ordinate of highest intersection point D between μ_{M_1} and μ_{M_2}

For k=1,2,…,n; k≠i. Then the weight vector is given by

$\mathrm{W}' = \left(d'(A_1), d'(A_2), \dots, d'(A_n)\right)$ (7)

Where $\mathrm{A}_i (i = 1,2,\dots,n)$ are "n" elements.

Step 3. By normalization, the normalized weight vectors are found as

$\mathrm{W} = \left(d(A_1), d(A_2), \dots, d(A_n)\right)$ (8)

Where W is a non-fuzzy number.

There are different scales for fuzzy AHP in the literature. The scale used in the study is obtained from Paksoy (2012). The fuzzy conversion scale is presented in Table 1.

3.2. Fuzzy TOPSIS Method (Bulanık TOPSIS Metodu)

TOPSIS presents a MCDM problem with m alternatives as geometric systems with m points in the n-dimensional space. The alternative that has shortest distance from the positive-ideal solution (PIS) and the longest distance from the negative ideal solution (NIS) is chosen by TOPSIS. The method identifies an index called similarity to the PIS and the remoteness from the NIS. Finally, TOPSIS chooses the alternative with the maximum similarity to the PIS (Chaghooshi, Fathi, & Kashef, 2012). The distances may be either added up in the Euclidean sense or pondered, hence prioritizing one of the two distances (Bottani & Rizzi, 2006). Assigning a precise performance rating to an alternative for the attributes under consideration is often difficult for a decision- maker. The advantage of fuzzy approach is the allocation of the relative importance of attributes by using fuzzy numbers instead of precise ones (Chaghooshi et al., 2012). Fuzzy TOPSIS has seven steps; (Wang and Chang 2007).

Step 1: Determining the evaluation criteria weights.

Criteria weights are determined by the Interval Shannon's entropy. For sensitivity analysis of criteria weights α= 0.1, 0.5 and 0.9 have been calculated.

Table 1. Triangular fuzzy scale of preferences
(Tablo 1. Tercihlerin üçgensel bulanık ölçeği)

Saaty's scale relative importance	Definition	Fuzzy AHP scale	
		Triangular fuzzy scale	Triangular fuzzy reciprocal scale
1	Equally importance	(1, 1, 1)	(1, 1, 1)
3	Moderate importance of one over another	(2, 3, 4)	(1/4, 1/3, 1/2)
5	Essential or strong	(4, 5, 6)	(1/6, 1/5, 1/4)
7	Demonstrated importance	(6, 7, 8)	(1/8, 1/7, 1/6)
9	Extreme importance	(9, 9, 9)	(1/9,1/ 9, 1/9)
2	Intermediate values between two adjacent judgments	(1, 2, 3)	(1/3, 1/2, 1)
4		(3, 4, 5)	(1/5, 1/4, 1/3)
6		(5, 6, 7)	(1/7, 1/6, 1/5)
8		(7, 8, 9)	(1/9, 1/8, 1/7)

Step 2: Constructing the fuzzy matrix.

$$\tilde{D} = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{matrix} C_1 & C_2 & \dots & C_n \\ \left[\begin{matrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \vdots & \tilde{x}_{mn} \end{matrix}\right] \end{matrix}, i = 1,2,\dots,m; \quad j = 1,2,\dots,n \tag{9}$$

Where $\tilde{x}_{ij}$ is the categorizing of alternative Ai with respect to criterion Cj evaluated by data from official sites.

Step 3: Normalizing the fuzzy decision matrix.
The normalized fuzzy decision matrix represented by $\tilde{R}$ is shown as equation (10):

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn}, \quad i = 1,2,\dots,m; \quad j = 1,2,\dots n \tag{10}$$

Where

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{c_j^+}, \frac{m_{ij}}{c_j^+}, \frac{u_{ij}}{c_j^+}\right), \qquad c_j^+ = \max_i c_{ij} \tag{11}$$

Step 4: Constructing weighted normalized fuzzy decision matrix.
The weighted normalized decision matrix $\tilde{V}$ is defines as

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn}, \quad i = 1,2,\dots m; \quad j = 1,2,\dots,n \tag{12}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j \tag{13}$$

Where $\tilde{w}_j$ represents the importance weight of criterion C_j.

Step 5: Determining the fuzzy positive- ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS).
Because the positive triangular fuzzy numbers are involved in the interval [0,1], the fuzzy positive ideal reference point (FPIS,A^+) and fuzzy negative ideal reference point (FNIS, A^-) hence can be defined as

$$A^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \dots, \tilde{v}_n^+) \tag{14}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-) \tag{15}$$

Where $\tilde{v}_1^+ = (1,1,1)$ and $\tilde{v}_1^- = (0,0,0)$, $j = 1,2,\dots,n$.

Step 6: Calculating the distances of each alternative from FPIS and FNIS.
The distances (d_i^+ and d_i^-) of each alternative A^+ from and A^- can be currently calculated by the area compensation method.

$$d_i^+ = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^+), \quad i = 1,2,\dots,m; \quad j = 1,2,\dots,n \tag{16}$$

$$d_i^- = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2,\dots,m; \quad j = 1,2,\dots,n \tag{17}$$

Step 7: Obtaining the closeness coefficient and rank the order of alternatives.
After determining the closeness coefficient, the ranking order of all alternatives can be achieved. Then policy makers can select the most feasible alternative. The closeness coefficient for all alternatives is calculated as Equation (18).

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1,2,\dots,m \tag{18}$$

4. EXPERIMENTAL-ANALYTICAL STUDY (DENEYSEL-ANALİTİK ÇALIŞMA)

In this study, a new method for project evaluation is proposed to development agencies in Turkey. The new method is based on the criteria used by these agencies between 2010 and 2013. At present the main evaluation criteria are weighted but sub criteria are obtained as equiponderant. In the study, main and sub criteria are weighted again by the help of survey carried out with 16 project evaluators.

Fuzzy logic theory is used in order to eliminate the subjectivity in the evaluation. Since the criteria of project evaluation had a hierarchy, fuzzy AHP is preferred in the comparison of these criteria. The scoring in the evaluation of the project is ambiguous. Because of this fuzzy TOPSIS is used in sorting of the projects according to weighted criteria.

Step 1: The criteria used by development agencies in project evaluation.
In Table 2, the criteria used by RDA for project evaluation is presented. All of sub criteria is same weights.

Table 2. The criteria used by development agencies for project evaluation
(Tablo 2. Proje değerlendirme için kalkınma ajansları tarafından kullanılan kriterler)

C1- Financial and business capacity	C11- Project management experience C12- Technical expertise C13- Management capacity C14- Financing
C2- Relevancy	C21- Relevance to objectives and priorities C22- Gender equality, equal opportunities, protection of the environment, relevance to sustainable development C23- Relevance to needs of the region C24- Relevance to beneficiaries C25- Relevance to the needs of target groups
C3- Method	C31- Compatibility of operations with expected results C32- Overall design consistency C33- Level of the contribution of partners C34- Applicability of operational plan C35- Objectively verifiable indicators C36- Visibility
C4-Sustainability	C41- Tangible impact on target groups C42- Multiplier effect C43- Sustainability of the expected results
C5- Budget and cost effectiveness	C51- Compatibility between the estimated costs and the expected results C52- Necessity of spending

Step 2: Determination of fuzzy transformation tables and normalized weights of the criteria.
Fuzzy transformation tables are obtained by using the arithmetic mean of low, medium and upper values in pair wise comparison matrix. Fuzzy comparison matrix of five decision criteria is given Table 3.

Table 3. Fuzzy comparison matrix of five decision criteria from the point of the priority vectors and goals
(Tablo 3. Öncelikli vektörler ve hedefleri açısından beş karar kriterinin bulanık karşılaştırma matrisi)

criteria	C1	C2	C3	C4	C5	priority vector (WG)
C1	1.00,1.00,1.00	1.20,1.53,1.88	2.90,3.72,4.55	2.00,2.39,2.81	1.36,1.74,2.14	0.27086
C2	2.69,3.03,3.40	1.00,1.00,1.00	2.32,2.86,3.45	1.29,1.58,1.93	1.76,2.21,2.68	0.28168
C3	0.60,0.77,0.99	0.74,1.02,1.33	1.00,1.00,1.00	0.88,1.18,1.52	0.94,1.24,1.61	0.01107
C4	1.75,2.01,2.29	1.42,1.88,2.34	2.31,2.89,3.48	1.00,1.00,1.00	1.48,1.77,2.11	0.23692
C5	1.40,1.68,2.00	1.62,2.04,2.52	1.44,1.96,2.52	1.48,1.93,2.38	1.00,1.00,1.00	0.19947

In this study, Chang's extent analysis method on FAHP is used because of its computational simpleness and effectiveness. The fuzzy comparison matrix of FAHP are taken from the fuzzing comparison matrix in Paksoy et al.(2007). In this approach, triangular fuzzy scale is used for solving FAHP.
From Table 3,

$S_{C1}=(8.46,\ 10.39,\ 12.48) \otimes (36.59,\ 44.43,\ 52.94)^{-1}$
$=(8.46,\ 10.39,\ 12.48) \otimes (0.019,\ 0.023,\ 0.027)$
$=(0.160,\ 0.234,\ 0.338)$
$S_{C2}=(0.171,\ 0.240,\ 0.341)$
$S_{C3}=(0.079,\ 0.117,\ 0.176)$
$S_{C4}=(0.150,\ 0.215,\ 0.307)$
$S_{C5}=(0.131,\ 0.194,\ 0.285)$
are obtained. Using these vectors,

$V(S_{C2}\geq S_{C1})=1$ $V(S_{C3}\geq S_{C1})=0.125$ $V(S_{C4}\geq S_{C1})=0.886$ $V(S_{C5}\geq S_{C1})=0.757$
$V(S_{C2}\geq S_{C3})=1$ $V(S_{C3}\geq S_{C2})=0.039$ $V(S_{C4}\geq S_{C2})=0.841$ $V(S_{C5}\geq S_{C2})=0.708$
$V(S_{C2}\geq S_{C4})=1$ $V(S_{C3}\geq S_{C4})=0.210$ $V(S_{C4}\geq S_{C3})=1$ $V(S_{C5}\geq S_{C3})=1$
$V(S_{C2}\geq S_{C5})=1$ $V(S_{C3}\geq S_{C5})=0.372$ $V(S_{C4}\geq S_{C5})=1$ $V(S_{C5}\geq S_{C4})=0.864$

are obtained. Thus the weight vector from Table 1 is calculated as,
WG=(0.27086, 0.28168, 0.01107, 0.23692, 0.19947)'
Similarly, the sub-criteria priority vectors are presented in Table 4.

Table 4. Fuzzy comparison matrix of with respect to C1, C2, C3, C4, C5 and its priority vectors
(Tablo 4. C1, C2, C3, C4, C5 ve öncelik vektörleri için bulanık karşılaştırma matrisi)

C1	C11	C12	C13	C14	(WC1)
C11	(1.0,1.0,1.0)	(1.6,1.9,2.1)	(0.8,1.1,1.3)	(0.8,1.1,1.5)	0.0947
C12	(2.2,2.8,3.5)	(1.0,1.0,1.0)	(0.9,1.2,1.5)	(1.1,1.3,1.5)	0.2200
C13	(2.2,2.8,3.5)	(1.5,1.9,2.3)	(1.0,1.0,1.0)	(0.9,1.1,1.5)	0.2740
C14	(2.4,2.9,3.6)	(2.0,2.6,3.1)	(1.8,2.4,2.9)	(1.0,1.0,1.0)	0.4106

C2	C21	C22	C23	C24	C25	WC2
C21	(1.0,1.0,1.0)	(2.1,2.8,3.5)	(1.7,2.0,2.5)	(2.1,2.5,3.0)	(2.0,2.5,2.9)	0.3895
C22	(0.8,1.2,1.5)	(1.0,1.0,1.0)	(1.2,1.3,1.6)	(2.0,2.4,2.9)	(1.2,1.3,1.5)	0.1581
C23	(1.4,1.8,2.2)	(1.7,2.3,2.8)	(1.0,1.0,1.0)	(1.8,2.1,2.5)	(1.6,2.0,2.3)	0.2980
C24	(1.0,1.3,1.6)	(1.0,1.2,1.5)	(1.3,1.5,1.8)	(1.0,1.0,1.0)	(1.3,1.4,1.5)	0.0990
C25	(1.3,1.6,2.0)	(1.6,2.1,2.6)	(1.5,1.8,2.2)	(1.5,1.8,2.1)	(1.0,1.0,1.0)	0.0554

C3	C31	C32	C33	C34	C35	C36	(WC3)
C31	1.0,1.0,1.0	1.8,2.2,2.7	3.2,3.9,4.7	2.1,2.5,2.9	2.0,2.4,2.8	3.8,4.5,5.3	0.3179
C32	1.0,1.2,1.4	1.0,1.0,1.0	3.7,4.4,5.1	1.8,2.2,2.6	2.1,2.5,2.9	4.0,4.8,5.5	0.3004
C33	1.0,1.1,1.3	0.8,0.9,0.9	1.0,1.0,1.0	0.7,0.9,1.1	1.00,1.2,1.4	2.1,2.7,3.2	0.0000
C34	1.1,1.2,1.4	1.6,1.8,2.1	2.9,3.5,4.1	1.0,1.0,1.0	2.3,2.8,3.4	3.3,4.0,4.8	0.2445
C35	1.4,1.6,1.8	1.3,1.4,1.6	2.2,2.7,3.3	1.2,1.3,1.4	1.0,1.0,1.0	3.2,3.8,4.5	0.1372
C36	0.8,0.9,0.9	0.8,0.8,0.9	1.6,1.7,1.8	0.8,0.9,1.0	0.7,0.8,0.9	1.0,1.0,1.0	0.0000

C4	C41	C42	C43	(WC4)
C41	1.0,1.0,1.0	2.1,2.6,3.1	1.7,2.0,2.3	0.4562
C42	1.4,1.8,2.2	1.0,1.0,1.0	1.3,1.4,1.5	0.2045
C43	1.2,1.5,1.8	1.8,2.3,2.9	1.0,1.0,1.0	0.3394

C5	C51	C52	(WC5)
C51	1.0,1.0,1.0	1.3,1.6,2.0	0.3466
C52	2.0,2.3,1.8	1.0,1.0,1.0	0.6534

Figure 1 shows local weights of all criteria and sub criteria. Table 5 also shows overall or global importance levels for the sub criteria in order to select the best projects.

According to these results, C52 (Necessity of spending) criteria has been determined as the most important criteria. It is followed by C14(Financing), C21 (Relevance to objectives and priorities) and C41(Tangible impact on target groups). The sub-criteria C33 (Level of the contribution of partners) and C36 (Visibility) have no effect in project evaluation.

Figure 1. Local weights of criteria and sub-criteria
(Şekil 1. Kriterler ve alt kriterlerin yerel ağırlıkları)

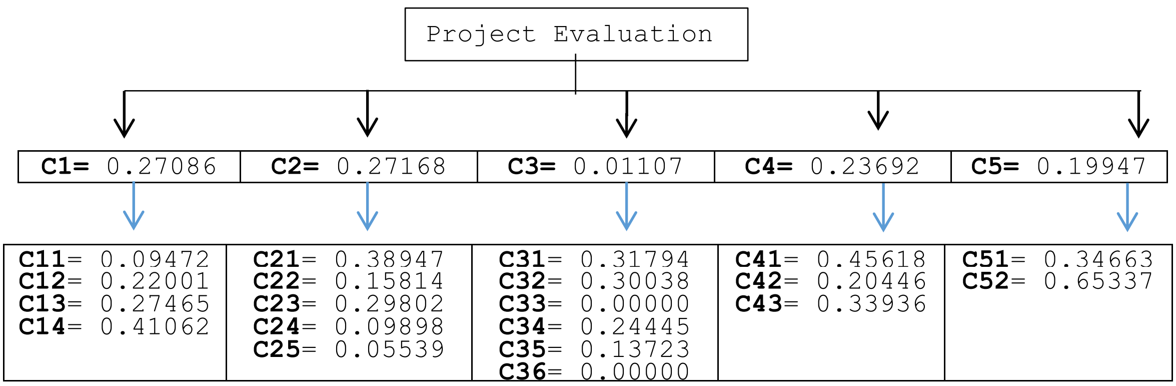

Table 5. Global weights of sub-criteria
(Tablo 5. Alt kriterlerin global ağırlıkları)

sub-criteria	global weights	sub-criteria	global weights
C11	0.025655	C31	0.003519
C12	0.059592	C32	0.003325
C13	0.074391	C33	0.000000
C14	0.111219	C34	0.002706
C21	0.109707	C35	0.001519
C22	0.044546	C36	0.000000
C23	0.083947	C41	0.108079
C24	0.027880	C42	0.048441
C25	0.015603	C43	0.080401
		C51	0.069142
		C52	0.130328

Step 3. The sorting and evaluation of projects by fuzzy TOPSIS method.

Step 3.1. Determining the first Fuzzy TOPSIS account table in the base of FAHP criteria weights.
In order to evaluate the projects in the base of 20 criteria, the decision matrix is expressed as fuzzy numbers by using experts' opinion (Table 6).

Table 6. Decision matrix which expressed as fuzzy numbers by using experts' opinion
(Tablo 6. Uzman görüşlerinin bulanık sayılarla ifade edildiği karar matrisi)

Criteria weights/ **Alternatives**	**C11 +**			**C12 +**						**C52 +**		
	0,025655133			**0,059591671**			…			**0,130327928**		
p1	(1,00	3,00	5,00)	(1,00	4,50	5,00)				(1,00	4,00	5,00)
p2	(1,00	5,00	5,00)	(1,00	5,00	5,00)				(1,00	3,50	5,00)
⋮		⋮			⋮						⋮	
p19	(1,00	2,00	5,00)	(1,00	4,50	5,00)				(1,00	3,00	5,00)
p20	(1,00	5,00	5,00)	(1,00	4,67	5,00)				(1,00	3,33	5,00)
Cost-Benefit			**5,00**			**5,00**						**5,00**

Step 3.2. Normalizing the decision matrix.
Normalized fuzzy decision matrix $\tilde{R}$ is determined as following:

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn}, \quad i = 1,2,\dots,m; \quad j = 1,2,\dots n$$

Where $\tilde{r}_{ij} = \left(\frac{l_{ij}}{c_j^+}, \frac{m_{ij}}{c_j^+}, \frac{u_{ij}}{c_j^+}\right), \quad c_j^+ = \max_i c_{ij}$

Results are represented in Table 7.

Table 7. Normalized decision matrix
(Tablo 7. Normalize karar matrisi)

Criteria weights/ Alternatives	**C11 +**			**C12 +**						**C52 +**		
	0,025655133			**0,059591671**			…			**0,130327928**		
p1	(0,20	0,60	1,00)	(0,20	0,90	1,00)				(0,20	0,80	1,00)
p2	(0,20	1,00	1,00)	(0,20	1,00	1,00)				(0,20	0,70	1,00)
⋮		⋮			⋮						⋮	
p19	(0,20	0,40	1,00)	(0,20	0,90	1,00)				(0,20	0,60	1,00)
p20	(0,20	1,00	1,00)	(0,20	0,93	1,00)				(0,20	0,67	1,00)

Step 3.3. Calculating weighted normalized decision matrix.
The weighted normalized decision matrix $\tilde{V}$ is defined as;

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn}, \quad i = 1,2,\dots m; \quad j = 1,2,\dots,n$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j$$

Weighted normalized decision matrix is given in Table 8.

Table 8. Weighted normalized decision matrix
(Tablo 8. Ağırlıklandırılmış normalize karar matrisi)

Criteria/ Alternatives	C11 +			C12 +				C52 +		
p1	0,0257	0,0770	0,1283	0,0596	0,2682	0,2976	…	0,0261	0,1043	0,1303
p2	0,0257	0,1283	0,1283	0,0596	0,2980	0,2976	…	0,0261	0,0912	0,1303
		⋮			⋮				⋮	
p19	0,0257	0,0513	0,1283	0,0596	0,2682	0,2976	…	0,0261	0,0782	0,1303
p20	0,0257	0,1283	0,1283	0,0596	0,2781	0,2976	…	0,0261	0,0869	0,1303

Step 3.4. Determining FPIS and FNIS.
Criteria vectors for FPIS and FNIS are;

$$A^{+} = \big((1,1,1),(1,1,1),\ldots,(1,1,1)\big)$$
$$A^{-} = \big((0,0,0),(0,0,0),\ldots,(0,0,0)\big)$$

Since positive triangular fuzzy numbers are included in the interval [0,1], the fuzzy positive ideal reference point (FPIS, A^{+}) and fuzzy negative ideal reference point (FNIS, A^{-}) can be defined as;

$A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \ldots, \tilde{v}_n^{+})$

$A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \ldots, \tilde{v}_n^{-})$

Where $\tilde{v}_1^{+} = (1,1,1)$ and $\tilde{v}_1^{-} = (0,0,0)\,, j = 1,2,\ldots,n.$

Step 3.5. Determining the distance of each alternative to FPIS and FNIS value.
Distance of each alternative to FPIS and FNIS value is determined and given Table 9.

Table 9. Distance of each alternative to FPIS and FNIS value
(Tablo 9. Her alternatifin FPIS ve FNIS değerine uzaklığı)

	$d_{alternatives}^{FPIS}$	$d_{alternatives}^{FNIS}$	$CC_{alternatives}$
p1	19,33659	0,75304	0,03748
p2	19,33968	0,74934	0,03730
p3	19,37172	0,71639	0,03566
p4	19,34181	0,74561	0,03712
p5	19,37516	0,71607	0,03564
p6	19,36135	0,72639	0,03616
p7	19,38873	0,69994	0,03484
p8	19,38446	0,70484	0,03509
p9	19,34904	0,73993	0,03683
p10	19,35845	0,73113	0,03639
p11	19,33123	0,75731	0,03770
p12	19,37714	0,71241	0,03546
p13	19,33457	0,75597	0,03763
p14	19,35318	0,73604	0,03664
p15	19,35155	0,73571	0,03663
p16	19,32278	0,76888	0,03827
p17	19,33795	0,75045	0,03736
p18	19,35481	0,73490	0,03658
p19	19,34682	0,74421	0,03704
p20	19,33049	0,75959	0,03781

After determining closeness coefficient, the ranking order of all alternatives can be obtained. The best alternative has the largest coefficient. The closeness coefficient of each alternative is calculated as;

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1,2,\ldots,m$$

5. FINDINGS AND DISCUSSIONS (BULGULAR VE TARTIŞMA)

In the application part of the new assessment rubric in the light of the results arranged as Table 10.

Table 10. The comparison table of current and proposed scales
(Tablo 10. Mevcut ve önerilen ölçeğin karşılaştırma tablosu)

Criteria			Sub-criteria		
Criteria	Current scale	Criteria	Current scale	Criteria	Current scale
C1	20	27	C11	5	3
			C12	5	6
			C13	5	7
			C14	5	11
C2	25	28	C21	5	11
			C22	5	4
			C23	5	8
			C24	5	3
			C25	5	2
C3	30	1	C31	5	0,5
			C32	5	0,5
			C33	5	0
			C34	5	0
			C35	5	0
			C36	5	0
C4	15	24	C41	5	11
			C42	5	5
			C43	5	8
			C51	5	7
			C52	5	13
TOTAL	100	100	TOTAL	100	100

In the base of new evaluation criteria, the ranking of the projects change. In the current situation P20 is the first Project. When the proposed scales are used P16 becomes the first. The extreme change is the decline of P15 from second order to twelfth (Table 11).

Table 11. The order of the projects for current and proposed scales
(Tablo 11. Mevcut ve önerilen ölçeğe göre projelerin sıralanması)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Current	p20	p15	p16	p11	p4	p13	p17	p1	p2	p14	p5	p19	p18	p9	p3	p12	p7	p8	p6	p10
Proposed	p16	p20	p11	p13	p1	p17	p2	p4	p19	p9	p14	p15	p18	p10	p6	p3	p5	p12	p8	p7

6. CONCLUSION AND RECOMMENDATIONS (SONUÇ VE ÖNERİLER)

Development agencies use 5 main and 20 sub-criteria in evaluation of project proposals. These criteria are determined by likert scale. In interviews with independent assessors, these assessors have stated that, judgments also may have effect on the criteria and alternatives during the evaluation period. To get rid of ambiguity fuzzy numbers are used instead of Likert scale numbers.

In the current evaluation process also the sub-criteria are assumed as equiponderant. But it is understood from the results of the survey that a new weighting among the sub-criteria is needed. Because of this FAHP is used in the determination of new weightiness and FTOPSIS is applied in the scaling of project proposals by weighted criteria.
In this study, a new evaluation is presented in the selection of projects that will provide more precise decisions. The new scaling table that allows taking the truth decision in project evaluation is presented.

NOTICE (NOT)

This study is produced from Lokman PİRİM's thesis under the supervision of Asst. Prof. Hasan SÖYLER.

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