

***Civil, and Architectural Engineering***

**Multi-Criteria Optimization for Governmental Projects Priority Ranking Depending on Fuzzified Experts' Opinion using Hygiene Approach**

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**ABSTRACT**

Each organization struggles to exploit each possible opportunity for gaining success and continuing with its work carrier. In this field, organization success can be concluded by fulfilling end user requirements combined with optimizing available resources usage within a specified time and acceptable quality level to gain maximum profit. The project ranking process is governed by the multi-criteria environment, which is more difficult for the governmental organization because other organizations' main target is maximizing profit constrained with available resources. The governmental organization should consider human, social, economic and many more factors. This paper focused on building a multi-criteria optimizing projects ranking framework using hygiene methodology from sequential stages. The proposed framework can deal with numerical and linguistic criteria considering experts, or consultant evaluation on projects, in addition to criteria weights. Fuzzy logic and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) methods are used to control the ranking process within a limited allocated budget. The importance of the proposed approach is making projects ranking getting out from dependence on economic measures that govern the overall process to non – measurable criteria that affect organization success and the proposed projects selection process.

**Keywords:** Multi-criteria optimization, Project priority, Project ranking, Fuzzy, PROMETHEE.

**أمثلية متعددة الخصائص لتصنيف أولوية المشاريع الحكومية بالاعتماد على آراء الخبراء المضببة باستخدام أسلوب هجين.**

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Peer review under the responsibility of University of Baghdad.

<https://doi.org/10.31026/j.eng.2022.12.08>

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Article received: 25/6/2022

Article accepted: 13/8/2022

Article published: 1/12/2022



### الخلاصة

تكافح كل مؤسسة لاستغلال كل فرصة ممكنة لتحقيق النجاح والاستمرار في مجال العمل الخاص بها. في هذا المجال ، يمكن تلخيص نجاح المؤسسة عن طريق تلبية متطلبات المستخدم النهائي مع العمل على أمثلية استخدام الموارد المتاحة في غضون وقت محدد ، ومستوى جودة مقبول لتحقيق أعلى ربح. تخضع عملية تصنيف المشروع لبيئة متعددة المعايير والتي تكون أكثر صعوبة بالنسبة للمنظمات الحكومية لأن الهدف الرئيسي للمؤسسة الأخرى هو تعظيم الأرباح المقيدة بالموارد المتاحة. يجب أن تأخذ المنظمات الحكومية في الاعتبار العوامل البشرية والاجتماعية والاقتصادية والعديد من العوامل الأخرى. يركز هذه البحث على بناء هيكلية متعددة المعايير لتحسين تصنيف المشاريع باستخدام منهجية هجينة تتكون من مراحل متسلسلة. يمكن أن تتعامل الهيكلية المقترحة مع المعايير العددية واللغوية مع الأخذ بنظر الاعتبار تقييم الخبراء ، أو المستشارين للمشاريع ، بالإضافة إلى النسبة الوزنية للمعايير. يتم استخدام المنطق الضبابي وطريقة تنظيم الترتيب التفضيلي لإثراء التقييمات (PROMETHEE) للتحكم في عملية التصنيف ضمن ميزانية مخصصة محدودة. تكمن أهمية النهج المقترح في جعل ترتيب المشاريع يخرج من الاعتماد على المقاييس الاقتصادية التي تحكم العملية الكلية إلى معايير غير قابلة للقياس تؤثر على نجاح المنظمة ، وعملية اختيار المشاريع المقترحة.

**الكلمات الرئيسية:** تصنيف المشاريع، اختيار المشاريع، الامثلية متعددة المعايير، المنطق المضطرب.

## 1. Introduction:

The organization struggles to survive a continually and rapidly changing environment. The opportunity to optimize resource usage can mainly start from selecting the best project process, which is one of the most important priorities for top management (Almusawi, 2020).

For commercial companies and profit base organizations, top management selects projects depending mainly on economic measurements and maximum profit within the company's limitation of available resources. An approach introduced to help the decision maker to evaluate the proposed project with available financial and technical information use four alternative evaluation methods (B/C ratio, ROR NPV, and payback period) in Analytical Hierarchy Process as a criterion weight and improves it with a fuzzy set theory and TOPSIS algorithm (S. Mahmoodzadeh). At the same time, a procedure is based on a research and development project selection model to maximize net present value. The model is quadratic (zero – one) programmed and uses fuzzy logic to deal with project expenditures and (NPV) values as non-crisp numbers (Yi, 2008).

For private sector companies, project selection process is constrained by organization resources. Many opportunities emerged to manage resources and maximize benefits by optimizing the project selection process (Burhan, 2022). A mathematical formula is developed as a mixed integer linear program, and the ant colony method deploys four criteria of ant generation, colonial, update Pareto front, and pheromone updating mechanisms. Scatter search and Genetic algorithm are used as a comparison algorithm with this multi-criteria mathematical model (Ali Asghar Tofighian, 2015).

This process is more complex for the non – governmental organization or governmental authorities having multi goals and scopes. In order to perform a successful project selection process, we need to detect the selection criteria that govern the overall process (Ahmed R. R., 2018). Many researchers are worked on this issue. A linear goal programming model was presented for public sector project selection with seven priority levels categorized into (no multiple projects, economic goals, social, political, and other goals) (Benjamin, 1985).



Most of this type of organization deal with multi-criteria and/or multiobjective optimization. A proposed multi-criteria selection model that uses fuzzy logic for governmental projects (**Lilian Noronha Nassif, 2013**) extends the methodology of macro procedures of portfolio management introduced by (**Mulcahy, 2009**). The methodology consists of seven stages and adopted criteria pair comparison that affects project success potential. At the same time, a multiobjective model was formulated using a probability distribution. With data from American governmental agencies for more than 80 projects, the model combines Analytic Hierarchy Process and Monte Carlo simulations (**Steven A. Gabriel, 2005**). The main objectives of this model are average cost and project value labor requirements due to its easiness of dealing with the randomness of ambiguous factors.

Due to uncertainty associated with the project life cycle environment, fuzzy logic can be used combined with optimization methods to deal with uncertainty and preferred to rank projects. This can be noticed when fuzzy triangular numbers are used to evaluate the criteria of examining seven critical paths of the project found by the analytical hierarchy process and ranked by the Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) (**Cristobal, 2013**). A fuzzy Visekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) approach is used to detect the best project critical path (**A. Ali-Mohammad, 2010**). The researcher used a fuzzy analytical network process to find activities' priorities and correlations to each other for the effect of the project's minimum duration.

The project selection approach is formulated work on by merging Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) responsible for project selection based on criteria recommended by experts under an ambiguous environment with evaluate Decision – Making Trial and Evaluation Laboratory (DEMATEL) as triangular neutrosophic number (**Mohamed Abdel-Basset, 2018**).

## 2. Project Ranking Process Framework.

Due to complicated circumstances and continuously changing boundary conditions that affect the project ranking process, most organizations depend on experts committee to evaluate proposed projects depending on various criteria to reveal their goals (**Hela Moalla Frikha, 2017**). One of the most governed constraints is the allocated budget which forced us to optimize project selection. The proposed framework gives high flexibility by dealing with a numerical value of quantitative criteria and linguistic evaluation of qualitative criteria type. Ranking criteria behavior can be benefit or non–benefit criteria considering criteria weight.

The project ranking framework consists of multi stages that deal with all details of the ranking process. The first stage is working on ranking process criteria identification and detecting its relative importance weight. In addition, clarify ranking criteria categories, whether qualitative or quantitative. Real data is used to verify the model, and the proposed project is evaluated according to six ranking criteria using an expert committee and decision–making procedure.

In this part, the main abbreviations and equations used to build the ranking framework re introduced.

- I. List of proposed Projects  $Pr_i$  ( $Pr_1, Pr_2, Pr_3, \dots, Pr_i$ ) where  $i$  = total no. of projects.



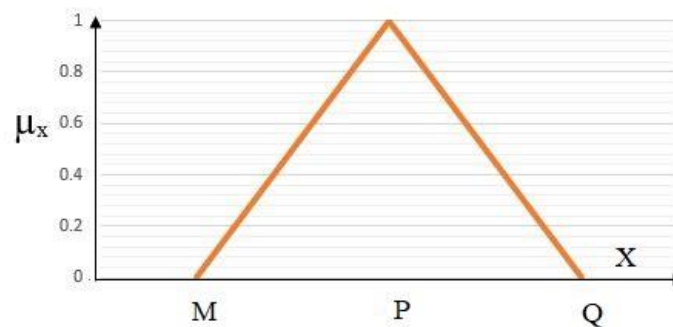
- II. List of Experts or decision makers  $Ex_j$  ( $Ex_1, Ex_2, Ex_3, \dots, Ex_j$ ) where  $j$  = total number of experts.
- III. List of ranking Criteria  $Cr_n$  ( $Cr_1, Cr_2, Cr_3, \dots, Cr_n$ ) where  $n$  = total number of ranking criteria.
- IV.  $F_{nij}$  is Expert opinion related to each project according to specific criteria.
- V.  $W_{cn}$  is the weight of the criteria. (Can be applied if required).

Ranking criteria can be divided depending on behavior to fitness function into two types: benefits criteria are maximizing the fitness function when its maximized, while cost criteria are maximizing the fitness function when minimized. Even more, the criteria can be quantitative (input as number value) or qualitative (linguistic formula), expert opinion, or evaluation.

Projects will be evaluated individually according to experts' opinions with respect to qualitative ranking criteria (Zadeh, 1988). These evaluations will be interred on five Likert scales (Very High, High, Medium, Low, Very Low). These evaluations will be processed by fuzzy logic using triangular fuzzy numbers shown in Fig. 1 and their values shown in Table 1 below.

**Table 1 Linguistic five Likert scale using triangular fuzzy number.**

Linguistic evaluation	Fuzzy number
Very High (VH)	(4, 5, 5)
High (H)	(3, 4, 5)
Medium (M)	(2, 3, 4)
Low (L)	(1, 2, 3)
Very Low (VL)	(1, 1, 2)



**Figure 1 Triangular fuzzy number.**

The framework starts by dealing with inputs using fuzzy logic due to its ability to deal with qualitative and quantitative variables. The evaluation of experts and project quantitative variables will be entered with their respective weights. The membership function shown in equation (1) will be used to deal with linguistic evaluation on qualitative criteria in addition to quantitative one  $F$  ( $M, P, Q$ ) where ( $M < P < Q$ ) and all values on the  $x$ -axis. All the criteria will be represented by the fuzzification process considering criteria weights.



$$\mu(x) = \begin{cases} \text{If } X_i \in [M, P] & \frac{X - M}{P - M} \\ \text{If } X_i \in [P, Q] & \frac{Q - X}{Q - P} \\ \text{Otherwise} & 0 \end{cases} \quad (1)$$

For a better understanding of the model framework, suppose we have  $j$  of experts ( $Ex_1, Ex_2, \dots, Ex_j$ ). The proposed number of projects is equal to  $i$  ( $Pr_1, Pr_2, \dots, Pr_i$ ) are needed to be ranked according to the evaluation of the qualitative and numerical value of quantitative criteria. The number of ranking criteria  $n$  ( $Cr_1, Cr_2, \dots, Cr_n$ ) with criteria weights  $Wc_n$  ( $Wc_1, Wc_2, \dots, Wc_n$ ) that evaluate proposed projects.

Each expert will evaluate the proposed projects related to the qualitative criteria on a five Likert scale measure (Very High, High, Medium, Low, Very Low). So, each expert will provide a matrix that needs to be collected into one matrix to compensate linguistic evaluation by respective triangular fuzzy numbers using equation 2.

$$F_{nij} = (M_{nij}, P_{nij}, Q_{nij}) \quad (2)$$

For example, each expert will give his opinion about projects according to a specific qualitative criterion as a matrix.

$$\text{Expert on.1 evaluation matrix} = \begin{bmatrix} f_{111} & f_{211} & f_{311} & \dots & f_{n11} \\ f_{121} & f_{221} & f_{321} & & \vdots \\ \vdots & & & & \vdots \\ \vdots & & & & \vdots \\ f_{1i1} & \dots & \dots & \dots & f_{nij} \end{bmatrix}$$

All resulted matrices need to be an aggregated fuzzified matrix for each individual criterion according to equation (3). Each criterion will be transformed from a fuzzy number to a crisp value using the geometric mean value shown in equation (4). Depending on criteria behavior, whether its benefit criteria (better project having lower evaluation) or non-benefit criteria (better project having higher evaluation), the normalization process needs to be performed with ranking criteria according to equation (5) and equation (6) which is considered the starting of PROMETHEE II method (Brans, 1982).

$$\tilde{F} = (\sqrt[j]{(M_{111} \times M_{112} \times \dots \times M_{N1j})}, \sqrt[j]{(P_{111} \times P_{112} \times \dots \times P_{N1j})}, \sqrt[j]{(Q_{111} \times Q_{112} \times \dots \times Q_{N1j})}) \quad (3)$$

$$\tilde{F} = \frac{(M_{nij} + P_{nij} + Q_{nij})}{3} \quad (4)$$



$$\tilde{F} = \frac{[X_{ij} - \min(X_{ij})]}{[\max(X_{ij}) - \min(X_{ij})]} \text{ for benefit criteria} \tag{5}$$

$$\tilde{F} = \frac{[\max(X_{ij}) - X_{ij}]}{[\max(X_{ij}) - \min(X_{ij})]} \text{ for Non - beneficial criteria} \tag{6}$$

The crisp evaluation difference between each project and other proposed projects is calculated. The resulting matrices size will be (n × i) and apply the preference function shown in equation (7). The next step is applying the preference function to evaluate the difference for each matrix according to equation (8) and equation (9).

$$D_{in-(1 \text{ to } i)n} = \tilde{F}_{in} - \tilde{F}_{(k)n} \tag{7}$$

$$P_{in} = 0 \quad \text{if } D_{in-(k)n} \leq 0 \tag{8}$$

$$P_{in} = D_{in-(1 \text{ to } i)n} \quad \text{if } D_{in-(k)n} > 0 \tag{9}$$

Where k is project alternatives, and the total number of k = i – 1.

Criteria weight will be applied on resulted matrices using normalized criteria weights collected from experts’ opinions for each criterion according to equation (10). The resulting metrics will be aggregated in order to conclude aggregate preference function matrix that used as a major factor of project ranking using PROMETHEE part of the methodology (Macharis, 1998). This resulting matrix is a unique comparison matrix between proposed projects, revealing that each project aggregated evaluation according to all ranking criteria. Finding leaving (φ+) and entering (φ –) outranking flows is calculated next using equations (11) and (12). The alternative net outranking flow (φ) will be calculated for each project using equation (13). This ranking is performed according to variable experts’ number, individual experts’ weights, number of criteria, experts’ opinion according to ranking criteria, criteria weights, and criteria behavior, whether it is qualitative or quantitative or benefit or non–benefit criteria.

$$WP_{in} = \frac{\sum_{i=1}^i P_{in} \times Wc_n}{\sum_{i=1}^i Wc_n} \tag{10}$$

$$\varphi^+ = \frac{1}{i-1} \sum_1^i WP_{(in,(i+1)n)} \tag{11}$$

$$\varphi^- = \frac{1}{i-1} \sum_1^i WP_{((i+1)n,in)} \tag{12}$$

$$\varphi = \varphi^+ - \varphi^- \tag{13}$$

### 3. Example with real data.

To apply the proposed approach to data, six projects and four experts were used. Ranking criteria are two quantitative criteria and four qualitative criteria, which are Cr<sub>1</sub> manpower employing



(benefit criteria), Cr<sub>2</sub> project cost (non-benefit criteria), Cr<sub>3</sub> cost escalation risk (non-benefit criteria), Cr<sub>4</sub> using of local resources (benefit criteria), Cr<sub>5</sub> Compliance with environmental legislation (benefit criteria), Cr<sub>6</sub> project contribution on economic and food security (benefit criteria). The first two criteria are quantitative, with values shown in **Table 2**. Experts' evaluations of the other four qualitative criteria are shown in **Table 3** and **Table 4**, taking into consideration the symbols shown below:

Proposed projects from Pr<sub>1</sub> to Pr<sub>i</sub>  
 Criteria numbers from Cr<sub>1</sub> to Cr<sub>n</sub>  
 Experts numbers from Ex<sub>1</sub> to Ex<sub>j</sub>

**Table 2. Quantitative criteria.**

	Cr <sub>1</sub>	Cr <sub>2</sub>
Pr <sub>1</sub>	80	1,100,000
Pr <sub>2</sub>	110	1,500,000
Pr <sub>3</sub>	27	750,000
Pr <sub>4</sub>	150	2,000,000
Pr <sub>5</sub>	30	800,000
Pr <sub>6</sub>	42	1,250,000

**Table 3. Expert no.1 and Expert no.2 evaluation on qualitative criteria.**

Projects	Expert no.1				Expert no.2			
	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>
Pr <sub>1</sub>	M	VH	VH	M	M	H	VL	VL
Pr <sub>2</sub>	VH	L	VH	L	H	L	VH	VL
Pr <sub>3</sub>	M	H	VH	M	VH	M	M	H
Pr <sub>4</sub>	H	M	M	M	H	M	H	H
Pr <sub>5</sub>	VL	VL	L	VL	L	M	L	M
Pr <sub>6</sub>	M	VL	L	L	VL	M	H	M

**Table 4. Expert no.3 and Expert no.4 evaluation on qualitative criteria.**

Projects	Expert no.3				Expert no.4			
	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>
Pr <sub>1</sub>	VH	M	M	VH	VL	M	H	VL
Pr <sub>2</sub>	VH	H	L	M	M	VH	H	VL
Pr <sub>3</sub>	M	VL	VL	M	H	VH	VH	VL
Pr <sub>4</sub>	VL	VL	H	H	L	VH	L	H
Pr <sub>5</sub>	VH	H	VH	VH	VL	H	VH	L
Pr <sub>6</sub>	M	H	VH	VL	VH	M	M	VH



The triangular fuzzy number for each linguistic evaluation are shown in **Table 1**. The aggregated fuzzy project evaluations, defuzzification, and normalized criteria matrices are calculated for each expert, in addition to inputs regarding quantitative criteria taking into consideration criteria behavior are also shown in **Table 5**, **Table 6**, and **Table 7**. The difference between  $i_{th}$  project and other alternatives is shown in **Table 8** to **Table 13**. The comparison matrix is built depending on previous tables results shown in table 14 and calculate leaving, entering, and net outranking values that reveal the final project ranking, which is considered the main objective of this approach shown in **Table 15**.

**Table 5. Aggregated qualitative criteria fuzzy number evaluations.**

Project	Cr3			Cr4			Cr5			Cr6		
Pr <sub>1</sub>	2.00	2.59	3.56	2.38	3.41	4.23	2.21	2.78	3.76	1.68	1.97	2.99
Pr <sub>2</sub>	3.13	4.16	4.73	3.72	4.73	5.00	2.63	3.76	4.40	1.19	1.57	2.63
Pr <sub>3</sub>	2.63	3.66	4.47	2.83	3.87	4.47	2.38	2.94	3.76	1.86	2.45	3.56
Pr <sub>4</sub>	1.73	2.38	3.50	2.45	2.99	3.98	2.06	3.13	4.16	2.71	3.72	4.73
Pr <sub>5</sub>	1.41	1.78	2.78	1.86	2.51	3.50	2.00	3.16	3.87	1.68	2.34	3.31
Pr <sub>6</sub>	2.00	2.59	3.56	1.68	2.28	3.36	2.21	3.31	4.16	1.68	2.34	3.31

**Table 6. Fuzzification criteria evaluations.**

	Cr <sub>1</sub>	Cr <sub>2</sub>	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>
	BENEFIT	NON-BENEFIT	NON-BENEFIT	BENEFIT	BENEFIT	BENEFIT
W <sub>cn</sub> (%)	15 %	25 %	15 %	15 %	15 %	15 %
Pr <sub>1</sub>	80	1100000	2.715526	3.338852	2.919042	2.213493
Pr <sub>2</sub>	110	1500000	4.00689	4.483709	3.59777	1.79548
Pr <sub>3</sub>	27	750000	3.589042	3.724515	3.027283	2.622419
Pr <sub>4</sub>	150	2000000	2.5367	3.138847	3.117243	3.720644
Pr <sub>5</sub>	30	800000	1.991884	2.625237	3.011754	2.443964
Pr <sub>6</sub>	42	1250000	2.715526	2.441629	3.228302	2.443964

**Table 7. Normalized ranking criteria.**

	Cr <sub>1</sub>	Cr <sub>2</sub>	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>
Pr <sub>1</sub>	0.440	0.720	0.621	0.513	0.013	0.189
Pr <sub>2</sub>	0.680	0.400	0.000	1.000	0.845	0.000
Pr <sub>3</sub>	0.016	1.000	0.201	0.677	0.146	0.374
Pr <sub>4</sub>	1.000	0.000	0.707	0.428	0.256	0.871
Pr <sub>5</sub>	0.040	0.960	0.969	0.210	0.127	0.293
Pr <sub>6</sub>	0.136	0.600	0.621	0.132	0.392	0.293



**Table 8. First project difference.**

	<b>Cr<sub>1</sub></b>	<b>Cr<sub>2</sub></b>	<b>Cr<sub>3</sub></b>	<b>Cr<sub>4</sub></b>	<b>Cr<sub>5</sub></b>	<b>Cr<sub>6</sub></b>	<b>WP<sub>1n</sub></b>
<b>Pr<sub>2</sub></b>	0	0.08	0.096131	0	0	0.03257	<b>0.208701</b>
<b>Pr<sub>3</sub></b>	0.064634	0	0.065026	0	0	0	<b>0.12966</b>
<b>Pr<sub>4</sub></b>	0	0.18	0	0.014691	0	0	<b>0.194691</b>
<b>Pr<sub>5</sub></b>	0.060976	0	0	0.052418	0	0	<b>0.113394</b>
<b>Pr<sub>6</sub></b>	0.046341	0.03	0	0.065905	0	0	<b>0.142247</b>

**Table 9. Second project difference.**

	<b>Cr<sub>1</sub></b>	<b>Cr<sub>2</sub></b>	<b>Cr<sub>3</sub></b>	<b>Cr<sub>4</sub></b>	<b>Cr<sub>5</sub></b>	<b>Cr<sub>6</sub></b>	<b>WP<sub>2n</sub></b>
<b>Pr<sub>1</sub></b>	0.036585	0	0	0.084095	0.15	0	<b>0.27068</b>
<b>Pr<sub>3</sub></b>	0.10122	0	0	0.055766	0.126079	0	<b>0.283064</b>
<b>Pr<sub>4</sub></b>	0	0.1	0	0.098786	0.106197	0	<b>0.304983</b>
<b>Pr<sub>5</sub></b>	0.097561	0	0	0.136513	0.12951	0	<b>0.363585</b>
<b>Pr<sub>6</sub></b>	0.082927	0	0	0.15	0.081653	0	<b>0.31458</b>

**Table 10. Third project difference.**

	<b>Cr<sub>1</sub></b>	<b>Cr<sub>2</sub></b>	<b>Cr<sub>3</sub></b>	<b>Cr<sub>4</sub></b>	<b>Cr<sub>5</sub></b>	<b>Cr<sub>6</sub></b>	<b>WP<sub>3n</sub></b>
<b>Pr<sub>1</sub></b>	0	0.07	0	0.028329	0.023921	0.031862	<b>0.154112</b>
<b>Pr<sub>2</sub></b>	0	0.15	0.031105	0	0	0.064431	<b>0.245537</b>
<b>Pr<sub>4</sub></b>	0	0.25	0	0.04302	0	0	<b>0.29302</b>
<b>Pr<sub>5</sub></b>	0	0.01	0	0.080747	0.003432	0.013904	<b>0.108083</b>
<b>Pr<sub>6</sub></b>	0	0.1	0	0.094234	0	0.013904	<b>0.208138</b>

**Table 11. Fourth project difference.**

	<b>Cr<sub>1</sub></b>	<b>Cr<sub>2</sub></b>	<b>Cr<sub>3</sub></b>	<b>Cr<sub>4</sub></b>	<b>Cr<sub>5</sub></b>	<b>Cr<sub>6</sub></b>	<b>WP<sub>4n</sub></b>
<b>Pr<sub>1</sub></b>	0.085366	0	0.013312	0	0.043803	0.11743	<b>0.259911</b>
<b>Pr<sub>2</sub></b>	0.04878	0	0.109443	0	0	0.15	<b>0.308224</b>
<b>Pr<sub>3</sub></b>	0.15	0	0.078338	0	0.019881	0.085569	<b>0.333788</b>
<b>Pr<sub>5</sub></b>	0.146341	0	0	0.037727	0.023313	0.099473	<b>0.306855</b>
<b>Pr<sub>6</sub></b>	0.131707	0	0.013312	0.051214	0	0.099473	<b>0.295706</b>

**Table 12. Fifth project difference.**

	<b>Cr<sub>1</sub></b>	<b>Cr<sub>2</sub></b>	<b>Cr<sub>3</sub></b>	<b>Cr<sub>4</sub></b>	<b>Cr<sub>5</sub></b>	<b>Cr<sub>6</sub></b>	<b>WP<sub>5n</sub></b>
<b>Pr<sub>1</sub></b>	0	0.06	0.053869	0	0.02049	0.017957	<b>0.152316</b>
<b>Pr<sub>2</sub></b>	0	0.14	0.15	0	0	0.050527	<b>0.340527</b>
<b>Pr<sub>3</sub></b>	0.003659	0	0.118895	0	0	0	<b>0.122553</b>
<b>Pr<sub>4</sub></b>	0	0.24	0.040557	0	0	0	<b>0.280557</b>
<b>Pr<sub>6</sub></b>	0	0.09	0.053869	0.013487	0	0	<b>0.157356</b>



**Table 13. Sixth project difference.**

	Cr <sub>1</sub>	Cr <sub>2</sub>	Cr <sub>3</sub>	Cr <sub>4</sub>	Cr <sub>5</sub>	Cr <sub>6</sub>	WP6n
<b>Pr<sub>1</sub></b>	0	0	0	0	0.068347	0.017957	<b>0.086304</b>
<b>Pr<sub>2</sub></b>	0	0.05	0.096131	0	0	0.050527	<b>0.196658</b>
<b>Pr<sub>3</sub></b>	0.018293	0	0.065026	0	0.044426	0	<b>0.127744</b>
<b>Pr<sub>4</sub></b>	0	0.15	0	0	0.024544	0	<b>0.174544</b>
<b>Pr<sub>5</sub></b>	0.014634	0	0	0	0.047858	0	<b>0.062492</b>

**Table 14. Projects comparison matrix.**

	Pr <sub>1</sub>	Pr <sub>2</sub>	Pr <sub>3</sub>	Pr <sub>4</sub>	Pr <sub>5</sub>	Pr <sub>6</sub>	$\varphi+$
<b>Pr<sub>1</sub></b>	0	0.208701	0.12966	0.194691	0.113394	0.142247	<b>0.157738</b>
<b>Pr<sub>2</sub></b>	0.27068	0	0.283064	0.304983	0.363585	0.31458	<b>0.256149</b>
<b>Pr<sub>3</sub></b>	0.154112	0.245537	0	0.29302	0.108083	0.208138	<b>0.168148</b>
<b>Pr<sub>4</sub></b>	0.259911	0.308224	0.333788	0	0.306855	0.295706	<b>0.250747</b>
<b>Pr<sub>5</sub></b>	0.152316	0.340527	0.122553	0.280557	0	0.157356	<b>0.175551</b>
<b>Pr<sub>6</sub></b>	0.086304	0.196658	0.127744	0.174544	0.062492	0	<b>0.107957</b>
<b><math>\varphi-</math></b>	<b>0.184665</b>	<b>0.216608</b>	<b>0.166135</b>	<b>0.207966</b>	<b>0.159068</b>	<b>0.186338</b>	

**Table 15. Leaving, entering and net outflow, and project ranking.**

	$\varphi +$	$\varphi -$	$\varphi$	Ranking
<b>Pr<sub>1</sub></b>	<b>0.157738</b>	<b>0.184665</b>	<b>-0.02693</b>	<b>5</b>
<b>Pr<sub>2</sub></b>	<b>0.256149</b>	<b>0.216608</b>	<b>0.039541</b>	<b>2</b>
<b>Pr<sub>3</sub></b>	<b>0.168148</b>	<b>0.166135</b>	<b>0.002013</b>	<b>4</b>
<b>Pr<sub>4</sub></b>	<b>0.250747</b>	<b>0.207966</b>	<b>0.042781</b>	<b>1</b>
<b>Pr<sub>5</sub></b>	<b>0.175551</b>	<b>0.159068</b>	<b>0.016483</b>	<b>3</b>
<b>Pr<sub>6</sub></b>	<b>0.107957</b>	<b>0.186338</b>	<b>-0.07838</b>	<b>6</b>

#### 4. CONCLUSIONS

Project ranking is a strategic process for each organization and individual. Most of the project ranking methods are based on economic measures and risk of vagueness. A hygiene approach consists of two main stages: the first stage is based on fuzzy logic using triangular fuzzy numbers to deal with qualitative criteria depending on experts' evaluations. Preference Ranking Organization Method for Enrichment of Evaluations PROMETHEE II method deals with criteria weights, behavior, and first-stage outputs to rank the proposed projects.

The proposed approach gives the ability to deal with a variety of ranking criteria, a committee of expert opinion, criteria weights, and overcome the barriers of ranking boundary conditions associated with the project's ranking process.



The proposed methodology depends on comparing projects according to all ranking criteria. These comparisons will produce a matrix that has dimension (no. of projects  $\times$  no. of criteria) for each project and can reveal the strength and weaknesses of each project relevant to each specific criterion. Currently, adopting a project ranking system in a large number of governmental authorities is based on points methodology that majority of proposed projects have the same degree of importance. These classical systems need to be updated in order to optimize all available resources and allocate budget usage, which in turn meet more end-user requirements in minimum time. More attempts need to be performed with other optimization methods.

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