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SELECTION OF ARCHITECTURE COMPANY WITH PROMETHEE METHOD

Keywords: Architecture Firm Selection, Multi-criteria Decision Making, PROMETHEE Method

Abstract

During the design, construction and use of construction projects; it is very important to choose the right Architectural Office (Architecture Company) in order to avoid problems. Things to consider when choosing an architectural office; the type of service, technical knowledge and experience with reference projects made. The selection of an architecture firm is a multi-criteria decision making problem. In this study, it is aimed to choose the most suitable one of different architectural firms by sorting between PROMETHEE Method. First of all, alternative firms and preference criteria have been determined for this purpose. The ages of the companies, the number of technical staff they worked on, the money they returned in a year, the number of projects completed before, and the number of computer software used were taken as the main evaluation criteria. Both quantitative and qualitative considerations were taken into account in the creation of the criteria. Options as a result of the calculations are listed in PROMETHEE I and II approaches. The results obtained were analyzed on GAIA Plane. The solution for the criterion is that the weights are equal first. Then, the criteria were given by applying different weights. Expert opinions were obtained for determining criteria and weights. The two obtained sequences were compared. As a result, it has been understood that the PROMETHEE Method can be selected as an architectural firm.
1. Introduction

Architectural office; architectural services such as architectural project services, relays, restitution, restoration works, zoning planning studies, zoning plans for conservation, architectural professional control services.

When the architectural services of the architectural offices are examined; They also provide project management and consultancy services, especially design and supervision services. There are only a handful of bureaucrats who have undertaken contractual activity to provide financial gain.

Design service; up to the completion of the project drawings from the project stage. Project management, site supervision, consultancy, preparation of tender files, registration of licenses and licenses are among the areas served by the offices. When the types of buildings designed by the bureaucrats are examined, shopping centers, public use projects, office buildings, industrial buildings, commercial centers, airports, media plazas, hospitals, inquiry halls, public housing, wide open spaces, student dormitories, university campuses and religious buildings.

The PROMETHEE ranking method is seen in researches and articles that are applied in various fields in the decision making process considering more than one criterion. Keyser and Peeters (1994) pointed out the importance of using the PROMETHEE method in the decision-making process where more than one criterion should be taken, and pointed out the advantages and disadvantages of the PROMETHEE method. (9) [1]

Yilmaz and Dağdeviren (2010) have selected equipment with the PROMETHEE method, stating that the selected equipment is extremely important in establishing an efficient production system. (10) [2]

Soba (2012) used the PROMETHEE method in the selection of one of the six panelanth automobiles of the same class. It has been stated that the results are consistent and appropriate when working on six different criteria: price, fuel, maximum speed, safety, horsepower and performance. (11th) [3]

Tuzkaya, Özgen and Gülsün (2011) have chosen the most accurate material handling system with PROMETHEE method and have implemented an application on the warehouse part of a factory in Istanbul. It is stated that the results of the implementation are taken into consideration in the new investment decisions by the authorities. (12) [4]

Amponsah, Darkwah and Inusah (2012), in their research on telecommunication operators' performances, addressed four different criteria and stated that five different alternatives were ranked according to PROMETHEE ranking method and that appropriate and effective results were achieved. (13) [5]
2. Purpose

Architectural offices choice for a major construction project that will be held will be held in Turkey's Bursa province. This choice requires a very categorical decision. The methods that can be used for this purpose consist of a large number of criteria that contradict each other in evaluating the alternatives in the final number. It was decided to use the PROMETHEE method in this study. One of five major architectural firms will be selected. Expert opinions were obtained and sorted according to five different criteria. First a calculation is made without the weights of the criteria. Then the criteria were weighted by taking expert opinions. A second calculation has been made for the weighted criteria. Both rankings are compared.

3. Methodology

In this section, the PROMETHEE method –among the decision making support methods in literature which had been developed for the selection of best alternative conforming to the determined criteria- has been defined.

3.1. PROMETHEE Method

PROMETHEE method had been developed based on the difficulties in implementation phase of prioritization methods existing in literature [14] [6]. PROMETHEE method is a multi criteria decision making method by which the alternatives are assessed by realizing comparisons in pairs based on the preference functions through the determined criteria. This assessment is realizing the superiority statuses of alternatives on the basis of criteria by the combination method [1] [7]. The main features of PROMETHEE method are simplicity, clarity and balance. The method uses the preference functions while forming the ranking. For the decision maker to make her/his decision easily, it is required for all the parameters to be clearly determined. By this approach, it is possible to make both partial ranking (PROMETHEE I) and complete ranking (PROMETHEE II) on finite number of alternatives. By the PROMETHEE method, the decision making process is started through the decision matrix arising the by the alternatives (a1, a2, … , an) and criteria (q1, q2, ..., qk) [15] [8]. 2 types of information are required for the implementation of the method. These are relative significance values of the criteria (their weighs), and the values of alternatives relevant to criteria as per the preference (function) of the decision maker. The method is presenting the decision maker the results of complete and partial ranking as the result of some phases following the formation of decision matrix [16] [9]. In addition to these two approaches, there are different versions such as PROMETHEE III (ranking based on intervals), IV (status of continuous conditions), V (including constraints of segmenting) and VI (in which the human brain is taken as model).
3.1.1. Progress of PROMETHEE Method

Alternative: They are the options that may be a solution for the defined selection and ranking problems.

Criterion: The qualifications that the alternative to be selected is required to have regarding the problem. The number of criterion may vary depending on the type of problem [17] [10].

Weight of Criterion: It is determining the significance degrees of criteria – which are determined for the problem- as per each other, and depending on that, making numeric assignments to the criteria [17] [10].

Phase 1

PROMETHEE method starts the decision making process by making comparison of criterion values of alternatives in pairs. The preference function among the alternatives is as specified in equation 1.

\[ p[f(a), f(b)] = p[f(a) - f(b)] \]  \hspace{1cm} (1)

Small deviations (differences) indicate that the decision maker had made preference in between the alternatives by a small difference. If the decision maker is able to ignore this difference, then s/he doesn’t make a preference in between the two. The preference is accurate as much as the difference. These preferences are figures changing in between 0 and 1.

Phase 2

While the alternatives are being compared in pairs on the basis of criteria, one of six types of preference functions –showing the internal relation of assessment factors- should be used. The information relevant to the preference functions in subject is provided in Table 1.

Table 1. Preference functions

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Function</th>
<th>Graph, P(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Type (Ordinary)</td>
<td>-</td>
<td>[ P(x) ]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>[ \begin{align*} &amp; 0, &amp; \forall x \leq 0 \ &amp; 1, &amp; \forall x &gt; 0 \end{align*} ]</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Parameter</td>
<td>Function</td>
<td>Graph, P(x)</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>-----------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Second Type</td>
<td>l</td>
<td>$P(x) = \begin{cases} 0, &amp; x \leq 1 \ 1, &amp; x &gt; 1 \end{cases}$</td>
<td><img src="image1.png" alt="Graph" /></td>
</tr>
<tr>
<td>(U-type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Type</td>
<td>m</td>
<td>$P(x) = \begin{cases} x/m, &amp; x \leq m \ 1, &amp; x \geq m \end{cases}$</td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
<tr>
<td>(V-type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth Type</td>
<td>q, p</td>
<td>$P(x) = \begin{cases} 0, &amp; x \leq q \ 1/2, &amp; q &lt; x \leq q + p \ 1, &amp; x &gt; q + p \end{cases}$</td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td>(Level)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth Type</td>
<td>s, r</td>
<td>$P(x) = \begin{cases} 0, &amp; x \leq s \ (x - s)/r, &amp; s \leq x \leq x + r \ 1, &amp; x &gt; x + r \end{cases}$</td>
<td><img src="image4.png" alt="Graph" /></td>
</tr>
<tr>
<td>(Linear)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sixth Type</td>
<td>$\sigma$</td>
<td>$P(x) = \begin{cases} 0, &amp; x \leq \sigma \ 1 - e^{-x^2/2\sigma^2}, &amp; x &gt; \sigma \end{cases}$</td>
<td><img src="image5.png" alt="Graph" /></td>
</tr>
<tr>
<td>(Gaussian)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The parameters in here:
q: Indifference Value
p: Exact Preference Threshold
s: Defined as interim value or standard deviation in between p and q
While the q value is the largest difference value as per the decision points of
assessment factors, the p value is the smallest difference.
In here the d value is the difference in between the values of two decision
points in terms of an assessment factor [15], [8].
The PROMETHEE method doesn’t determine an internal absolute benefit
neither for all the assessment factors nor for each assessment factor either on the
basis of decision points and as independent. Instead, it performs the comparisons
in pairs of comparisons of decisions points as per assessment factors. And for
this, it uses the preference functions being defined in Table 1.

Phase 3

The preference indices have been shown in equations (2) and (3) in terms of
determining the superiorities of both alternatives (a, b) mutually.

\[
\pi(a, b) = \sum_{i=1}^{n} w_i P_i (a, b) \quad (2)
\]

\[
\pi(b, a) = \sum_{i=1}^{n} w_i P_i (b, a) \quad (3)
\]

Phase 4

By the assistance of preference indices obtained for each alternative, the
positive and negative flows of the alternatives are obtained. The positive and
negative flows calculated by dividing the sum of preference index values of the
alternatives on their own rows and columns on the preference indices matrix to
the value (n-1) have been specified in equations (4) and (5) [18] [11].

Positive flow:

\[
\Phi^+ (a) = \Sigma \pi (a,b) \quad (4)
\]

Negative flow:

\[
\Phi^- (a) = \Sigma \pi (b,a) \quad (5)
\]
Phase 5

The decision maker, obtaining the results of PROMETHEE I by the values of positive and negative flow, may not obtain the ranking of the alternatives from best to worst option by these results. In such cases, the net flow values of PROMETHEE II are used as benefiting from equation 6.

\[ \Phi(a) = \Phi^+(a) - \Phi^-(a) \]  

The calculated net priority value \( \Phi(a) \) forms the balance of positive and negative flows. The performance of the alternative is high as much as the size of net flow. As the result of the calculated net flows, it is being possible to make a ranking in between the alternatives [18] [11]. Three possible conditions which may be encountered in this phase, in which the comparisons in pairs of negative and positive superiority values relevant to decision points are made, are superiority of a decision point to the other, indifference of decision points and inability of comparing the decision points [19] [12]. The conditions which may be encountered in the comparisons have been provided below.

1. condition: a is superior to b.
   \[ \Phi^+(a) > \Phi^+(b) \text{ and } \Phi^-(a) < \Phi^-(b) \]
   \[ \Phi^+(a) > \Phi^+(b) \text{ and } \Phi^-(a) = \Phi^-(b) \]

2. condition: a is indifferent to b.
   \[ \Phi^+(a) > \Phi^+(b) \text{ and } \Phi^-(a) > \Phi^-(b) \]
   \[ \Phi^+(a) < \Phi^+(b) \text{ and } \Phi^-(a) < \Phi^-(b) \]

3. condition: a and b cannot be compared.
   \[ \Phi(a) = \Phi^+(a) - \Phi^-(a) \]  

According to this formula, if \( \Phi(a) > \Phi(b) \) for two decision points such as a and b, then decision point a is superior to decision point b.

If \( \Phi(a) = \Phi(b) \), decision point a is indifferent to decision point b.

3.1.2. PROMETHEE Method process algorithm

Flow diagram relevant to the method is provided in Figure 1.
3.1.3. GAIA Plaine

Following the indication of alternatives on a k dimensional (at a dimension as much as the number of criterion) space, in order to be able to present the criteria and alternatives to the decision maker through a more understandable projection by using the Principal Components Analysis (PCA), a plane is formed by calculating the projections on a 2 dimensional plane from a k dimensional space. This place on which the alternatives and criteria are being indicated is called the GAIA plane. Actually this plane is corresponding to Epur which is known from design geometry. The geometric presentation of alternatives and criteria on the GAIA plane will provide a significant richness while assessing the problem. This technique is used in the decision making process especially for determining
Selection of architecture company with promethee method

the significance of each criterion. Moreover, by this technique, the purposes such as apprehending the preference rates on the criteria, determining the homogenous alternative groups, selecting the good alternatives from among the ones under specific criteria, determining incomparability status among the alternatives may be realized [18] [11]. As the GAIA plane presents a visual support to the decision maker as being constructed on the results of PROMETHEE method, it is bringing in an advantage to PROMETHEE method compared to other multi criteria decision making methods [1] [7]. Some significant issues regarding the indication of the data of PROMETHEE approach with the assistance of GAIA plane may be referred as follows [1]; the discriminator feature of this criterion and its significance in affecting the decision rod is as much as the length of the rod (axis) indicating the criteria. The criterion rods indicating the same direction belong to criteria showing similar features. And the criterion rods indicating different directions belong to criteria which are in conflict with each other. The alternatives having similar values are close to each other on GAIA plane. If the alternatives have a high value on a criterion, then that alternative is close to that criterion rod on the GAIA plane [20] [13]. If the discrimination power of the criteria is low, then the criterion rod will be short. Because as the criteria with low discrimination power will be more vertical to GAIA plane, their projections will be close to each other, and they will look shorter on the graphical representation [21] [14]. Against the determination of the positions of alternatives and criteria, weights are used in showing the decision rod on GAIA plane. As the weights determined by the decision maker will indicate the preferences of the decision maker, the decision rod will indicate the preference direction of the decision maker. If the decision rod is long, it indicates that there is a strong decision power. Long decision rod directs the decision maker to select the alternatives in the direction indicated by the decision rod. In this case, as the criteria in the direction indicated by the decision rod don’t conflict much, it becomes easy for the decision maker to direct to most suitable alternative(s). If the decision rod is short, there is no strong decision power. It means that the criteria conflict strongly as per these given weights, and that it becomes hard to select the most suitable alternative(s) [17] [10].

4.Application

Job descriptions for this application were reviewed, interviewed by experts, and the qualifications of a technical architect firm were assessed. By using all these data, criteria to be evaluated by candidate companies have been determined. The criteria specified are listed below. Visual PROMETHEE program is used in the application.

Criteria:
Candidate architecture firms are named A, B, C, D and E.

A decision matrix was established with the evaluations made for each company (See Table 2.)

Table 2. Decision matrix

<table>
<thead>
<tr>
<th>Criteria</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm ages</td>
<td>12</td>
<td>18</td>
<td>11</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Technical persons</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Turn overs (million TL/year)</td>
<td>1.2</td>
<td>1.4</td>
<td>0.9</td>
<td>0.8</td>
<td>0.75</td>
</tr>
<tr>
<td>Completed projects</td>
<td>12</td>
<td>14</td>
<td>8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Technical softwares</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

4.1. Determining Criterion Weights and Ordering Alternatives

At this stage of the implementation all the criteria first determined are deemed to have equal significance levels and “one” value is assigned to each criterion as the weight value. All criteria were then weighted according to expert opinion. The weights given in the second (weighted) condition are shown in Table 3.

Table 3. Criteria weights

<table>
<thead>
<tr>
<th>Criteria weights</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria weights</td>
<td>%10</td>
<td>%30</td>
<td>%30</td>
<td>%15</td>
<td>%15</td>
</tr>
</tbody>
</table>

After this step, two different calculations (weightless and weighted) were made taking into account the decision matrix and weights.
4.2. Solution with Visual PROMETHEE Program

4.2.1. Criterion Weights Equals

Data entry to program is shown in Figure 2. Criteria attributes, weights, preference functions and function parameters are entered into the interface.

<table>
<thead>
<tr>
<th>Bertrand</th>
<th>Kaç yıllık firma</th>
<th>Çalışırken te...</th>
<th>Bir yılda dön...</th>
<th>Gelirance y...</th>
<th>Kullanılan tekn...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>unit</td>
<td>unit</td>
<td>unit</td>
<td>unit</td>
<td>unit</td>
</tr>
<tr>
<td>Cluster/Group</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
<td>max</td>
</tr>
</tbody>
</table>

Fig. 2. Visual PROMETHEE data input

Positive, negative and net superiority values are calculated by evaluating alternatives. The calculated superiority values are shown in Table 6 below.
Table 4. Superior Values of Criteria (Weightless)

Subsequently, partial priorities were determined with the PROMETHEE I method and full priorities were determined with the PROMETHEE II method (see Figures 3 a and b)

![PROMETHEE Flow Table](image)

Fig. 3. a) PROMETHEE I ve b) PROMETHEE II (Weightless)
For PROMETHEE I method, Firm B is the best solution of the problem. The Second is Firm A for this method. According to PROMETHEE II method, B is the best alternative company according to the exact priority order. Candidates are listed as B, E, A, C, D at worst.

Fig. 4. GAIA Plane (Weightless)

When the GAIA Plane is considered, the criterion with the most disintegrating feature is the paradise they rotate in one year (turn over). The situation of the alternatives according to the criteria is also shown in this graphic (Fig.4.). The preference vector also represents A alternative. These results does not overlap with PROMETHEE I and PROMETHEE II methods’ results.
4.2.2. Condition Weighted by Criteria

Using the criterial weights given in Table 4, the data is entered into the interface as shown in Fig. 5.

![Fig. 5. Data Entry with Different Criteria Weights](image)

Positive, negative and net superiority values are calculated by evaluating alternatives. Calculated superiority values are shown in Table 5. below.
Table 5. Superior Values of Criteria (Weighted)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Car</th>
<th>Phi</th>
<th>Phi+</th>
<th>Phi-</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>0.0371</td>
<td>0.3454</td>
<td>0.3083</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>0.0329</td>
<td>0.3517</td>
<td>0.3187</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>0.0246</td>
<td>0.3629</td>
<td>0.3383</td>
</tr>
<tr>
<td>4</td>
<td>E</td>
<td>0.0100</td>
<td>0.3375</td>
<td>0.3275</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>-0.1046</td>
<td>0.2379</td>
<td>0.3425</td>
</tr>
</tbody>
</table>

Fig. 6. a) PROMETHEE I ve b) PROMETHEE II (Weighted)
When weights given to the criteria, it is the best alternative B company according to the exact priority order found by PROMETHEE I method. The same applies to the PROMETHEE II method. (see Fig. 6a and b)

Fig. 7. GAIA Plane (Weighted)

When the GAIA plane is examined (see Figure 7), it shows an alternative to the preference vector A. In this case the results do not overlap with PROMETHEE I and PROMETHEE II.
5. Results

Decisions made in the construction sector are becoming more and more complex and there are a number of criteria that affect a decision. Given the wrong decisions can cause high costs. At this stage, new computer-aided approaches have been developed to help decision-makers. One of these approaches is the PROMETHEE approach. This approach is based on a weighting of the criteria that affect this decision when it makes a decision among various options. The most important advantage of the approach is that it is possible to change the weight points initially given within the decision making process.

Some decisions may require that benchmark values in high numbers be combined with benchmark values in low numbers. PROMETHEE is one of the multi-criteria decision-making methods that allow examination of values in opposite structures together. However, as in most of the multi-criteria decision-making methods, the measurement units of the evaluation criteria differ in the PROMETHEE approach.

The PROMETHEE ranking technique is one of the most effective and easiest methods in the solution of multi-criteria problems. By setting more than one criterion in the process of decision making, these criteria are assigned weights according to their importance, and the ranking among the alternatives can easily be realized thanks to the computer software as in this study.

The most important reason for preferring the PROMETHEE method in studying is; to define individual scores for each criterion and to evaluate the criterion in itself, in this way both healthier and more reliable interpretations can be made. In practice, comparisons are made according to the binary comparison method and all the latest alternatives are evaluated at the same time.

Architectural office selection with PROMETHEE has two important advantages in addition to other ranking methods. One of these advantages is that a different preference function can be used for each factor used in the evaluation of alternative architectural firms; and the second is to obtain partial and complete sequences of alternatives. In this way, it is ensured that decision makers are able to rescue each criterion in a similar way. Thanks to these advantages, the effectiveness and correctness of the architectural office selection process has been increased.

Since the PROMETHEE approach is easy to understand and simple to use, it can be easily applied to similar problems, and other criteria can be used to select organizations that offer different types of services in the construction industry, such as when choosing an architectural office. In other studies, it is possible to make comparative analyzes with different methods using PROMETHEE method.
Table 6. Best companies for every method

<table>
<thead>
<tr>
<th>Weightless</th>
<th>Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROMETHEE I</td>
<td>PROMETHEE II</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

The companies that received the first order as a result of the calculations made are given in Table 6. In case the criteria are weightless (equal weight), company B is the best firm according to PROMETHEE I and II methods. GAIA Plane analysis with no weight; A company as the best company. In the case where the criteria are weighted (different weight), the best firm according to PROMETHEE I and II methods is again B firm. GAIA Plane analysis with no weight; also shows A as the best company. It would be appropriate to focus on B and A firms for decision makers for the best solution.

It has been seen that the results obtained are consistent and appropriate.

REFERENCES


