Chapter 6
QUALIFLEX Method

6.1 Introduction

The QUALIFLEX method was introduced by Paelinck in 1975 [35–37], which is rooted in the permutation method, introduced by Jacquet Lagreze [16, 27]. In QUALIFLEX, each possible ranking of existing m alternative is evaluated. In other words, the ranking of alternatives is evaluated to the number of $m!$ permutation, and finally, the most appropriate ones are selected for the final ranking.

Also, it is assumed that the decision matrix $D = \|f_{ij}\|$ is clear and the weights w_j are calculated for existing attributes by one of the proposed algorithms such as entropy [38, 39]. Similar to the other alternatives ranking methods, this technique is also used for airport location selection [39], the optimal site selection for the nuclear power plant [40], and supplier evaluation and selection [41]. The QUALIFLEX method has the following features:

- This technique, similar to the permutation method, is in the boundary of compensatory and non-compensatory methods;
- Attributes should be independent;
- There is no need to convert the qualitative attributes into the quantitative attributes.

The entering information of the QUALIFLEX method is as decision matrix and based on the information received from the decision maker as shown in Eq. (6.1).

$$\mathrm{X} = \begin{bmatrix} r_{11} & \cdots & r_{1j} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{i1} & \cdots & r_{ij} & \cdots & r_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mj} & \cdots & r_{mn} \end{bmatrix}_{m \times n} ; \quad i = 1, \ldots, m, \; j = 1, \ldots, n \tag{6.1}$$

A. Alinezhad and J. Khalili, *New Methods and Applications in Multiple Attribute Decision Making (MADM)*, International Series in Operations Research & Management Science 277, https://doi.org/10.1007/978-3-030-15009-9_6

In matrix of Eq. (6.1), r_{ij} displays the element of decision matrix for ith alternative in jth attribute. In addition, the decision maker provides the weight of attributes $[w_1, w_2, \ldots, w_n]$ by considering the normalized property $\left(\sum_{j=1}^{n} w_j = 1\right)$.

6.2 Description of QUALIFLEX Method

6.2.1 *The Initial Permutation of Alternatives*

The possible permutations are made up of the existing m alternative, for example, if $m = 3$, consequently, $m! = 3! = 6$.

Therefore, with the assumption of three alternatives of permutations, the alternatives are as set of Eq. (6.2).

$$\begin{aligned} \mathrm{per}_1 &= \{A_1, A_2, A_3\} \\ \mathrm{per}_2 &= \{A_1, A_3, A_2\} \\ \mathrm{per}_3 &= \{A_2, A_1, A_3\} \\ \mathrm{per}_4 &= \{A_2, A_3, A_1\} \\ \mathrm{per}_5 &= \{A_3, A_1, A_2\} \\ \mathrm{per}_6 &= \{A_3, A_2, A_1\} \end{aligned} \tag{6.2}$$

6.2.2 *The Initial Ranking of Alternatives*

At this stage, the decision matrix, provided by the decision maker, is ranked based on the strengths. The number 1 is given to an alternative which is better than the rest in an attribute, and the other alternatives are ranked similarly.

6.2.3 *The Dominant and Dominated Values*

If the permutation matches the amounts of ranking, the value is 1, and if it does not match, the value is -1. When two alternatives are identical in one attribute, the amount of zero is allocated. For example, it is assumed that the values of Eq. (6.3) to be in the hypothetical permutation and ranking of alternatives are $A_1 > A_2 = A_3$.

$$\text{per} = \{A_2, A_1, A_3\}: \tag{6.3}$$

$$A_2 < A_1 \rightarrow -1$$
$$A_2 = A_3 \rightarrow 0$$
$$A_3 < A_1 \rightarrow 1$$

In Eq. (6.3), the permutation equals to $A_2 > A_1$, but the ranking of alternatives are $A_2 < A_1$, and as this value mismatches the ranking of attributes, the value becomes -1. Further, the permutation equals to $A_2 = A_3$, and the value becomes zero. Eventually, the permutation equals to $A_3 < A_1$, but the ranking of alternatives are $A_3 < A_1$ which match each other and amount becomes 1.

6.2.4 The Permutation Values of Attributes

The values computed in the previous step are aggregated together and are calculated separately for all permutations and attributes.

6.2.5 The Permutation Values of Alternatives

The permutation value of each attribute is multiplied by its weight and is aggregated together and is introduced as the permutation value.

6.2.6 The Final Ranking of Alternatives

After determining the permutation values of alternatives, the alternative with the highest permutation value represents the best alternative.

6.3 Case Study

A refinery intends to buy a liquefied petroleum gas (LPG) bunker. A LPG bunker should be purchased among the three models (A_1, A_2, and A_3). The attributes such as price (C_1), working pressure (C_2), and capacity (C_3) are considered for decision making, and the decision matrix is as shown in Fig. 6.1.

The weight of the attributes is considered equal. It is desirable to select the best model of LPG bunker and rank the alternatives by the QUALIFLEX method.

Fig. 6.1 Decision matrix of buying LPG bunker

$$\begin{array}{c} \\ \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{ccc} - & + & + \\ C_1 & C_2 & C_3 \\ \end{array}$$

$$\begin{array}{c|ccc} & C_1 (-) & C_2 (+) & C_3 (+) \end{array}$$

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{bmatrix} 1.200 & 18 & 32000 \\ 2 & 23 & 24000 \\ 2 & 15 & 25000 \end{bmatrix}$$

❖ **Solution**

(A) **The initial permutation of alternatives**

There are six permutations for three alternatives as follows:

$$\begin{aligned} \text{per}_1 &= A_1 > A_2 > A_3 \\ \text{per}_2 &= A_2 > A_1 > A_3 \\ \text{per}_3 &= A_2 > A_3 > A_1 \\ \text{per}_4 &= A_3 > A_2 > A_1 \\ \text{per}_5 &= A_3 > A_1 > A_2 \\ \text{per}_6 &= A_1 > A_3 > A_2 \end{aligned}$$

(B) **The initial ranking of alternatives**

Here, the first attribute is negative. In other words, lower number leads to a better attribute. In addition, the other two attributes are positive, that is, the higher the better. Therefore, ranking alternatives is based on the attributes as shown in Fig. 6.2.

(C) **The dominant and dominated values**

For instance, the dominant and dominated values are obtained for firth permutation:

$$\begin{aligned} &\text{Per}_1 = A_1 > A_2 > A_3 \,\text{for}\, \text{C}_1: \\ &A_2 < A_1 \rightarrow 1 \\ &A_2 = A_3 \rightarrow 0 \\ &A_3 < A_1 \rightarrow 1 \end{aligned}$$

Fig. 6.2 Initial ranking of alternatives

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 3 \\ 2 & 3 & 2 \end{bmatrix} \end{array}$$

Table 6.1 Permutation values

	C_1	C_2	C_3
per_1	2	1	1
per_2	0	3	−1
per_3	−2	1	−3
per_4	−2	−1	−1
per_5	0	−3	1
per_6	2	−1	3

$$\begin{aligned}
&\text{Per}_1 = A_1 > A_2 > A_3 \text{ for } C_2: \\
&A_2 > A_1 \rightarrow -1 \\
&A_2 > A_3 \rightarrow 1 \\
&A_3 < A_1 \rightarrow 1
\end{aligned}$$

$$\begin{aligned}
&\text{Per}_1 = A_1 > A_2 > A_3 \text{ for } C_3: \\
&A_2 < A_1 \rightarrow 1 \\
&A_2 < A_3 \rightarrow -1 \\
&A_3 < A_1 \rightarrow 1
\end{aligned}$$

Accordingly, the values are obtained for other attributes.

(D) **The permutation values of attributes**

Table 6.1 indicates the permutation values of attributes.

(E) **The permutation values of alternatives**

The permutation values of alternatives are as follows:

$$\begin{aligned}
\text{per}_1 &= 1.333 \\
\text{per}_2 &= 0.667 \\
\text{per}_3 &= -1.333 \\
\text{per}_4 &= -1.333 \\
\text{per}_5 &= -0.667 \\
\text{per}_6 &= 1.333
\end{aligned}$$

(F) **The final ranking of alternatives**

According to the permutations of alternatives, the permutations of 1 and 6 are selected:

$$\begin{aligned}
\text{per}_1 &= A_1 > A_2 > A_3 \\
\text{per}_6 &= A_1 > A_3 > A_2
\end{aligned}$$

As a result, the first model of LPG bunker (A_1) is chosen as the best alternative.

6.4 Conclusion

Paelinck could present the QUALIFLEX method as one of the precise techniques for ranking alternatives using the permutation method. Considering the independent and compensatory features of this technique, the permutation of attributes is determined, due to the use of the dominant and dominated property of alternatives based on the attributes. Accordingly, it is possible to find the most ideal alternative, and actually, this process has differentiated the QUALIFLEX method in comparison to the other methods. Fig. 6.3 indicates the process of determining the best alternative, now used in various papers with different applications.

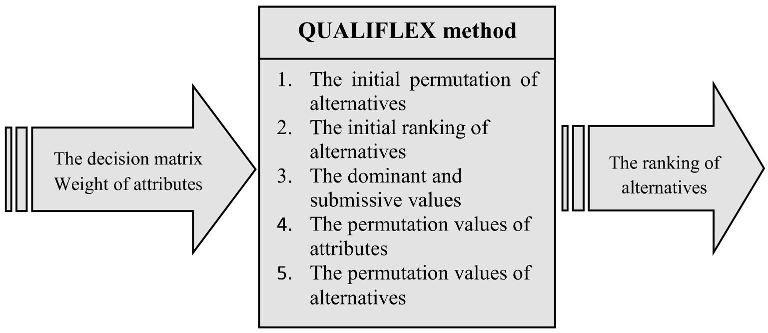

Fig. 6.3 A summary of QUALIFLEX method