Incorporating cost and environmental factors in quality function deployment using TOPSIS method

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Abstract: Quality function deployment (QFD) is an important tool available for organisations for efficient product design and development. Traditionally, QFD rates the design requirements (DRs) with respect to customer needs, and aggregates the ratings to get relative importance score of DRs. An increasing number of studies emphasise on the need to incorporate additional factors, such as cost and environmental impact, while calculating the relative importance of DRs. However, there is a variety of methodologies for deriving the relative importance of DRs, when several additional factors are considered. Technique for order preferences by similarity to ideal solution (TOPSIS) method is suggested for the purposes of the paper. This paper proposes TOPSIS for considering the ratings of DRs with respect to CRs, and several additional factors. Proposed method is illustrated using a step-by-step procedure. The proposed QFD-TOPSIS methodology was applied for the design of TV in Pars Electric Company in Iran.

Keywords: technique for order preferences by similarity to ideal solution; TOPSIS; multiple criteria decision making; quality function deployment; QFD; house of quality; HOQ.


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1 Introduction

Organisations that pay attention to quality and customer requirements (CRs) stay ahead of competition and survive in the modern competitive market place. A variety of tools are available to organisations in order to help them achieve this goal. Quality function deployment (QFD) is one such extremely important quality management tool that is useful in product design and development and for benchmarking.

When QFD is used for designing a product, the expectations of customers are related to the main design characteristics of the product through a matrix generally known as the ‘house of quality’ (HOQ). The HOQ matrix contains many numerical entries, including the importance of CRs, the relationships between CRs and design requirements (DRs) and the correlations between different DRs. Some of them are elicited using a semantic scale, which are later converted to numerical values. Normally, a simple weighted arithmetic aggregation procedure is employed to aggregate the ratings of DRs with respect to CRs. The resulting weights of DRs can be interpreted as in the proportion of their importance in meeting the CRs.

The QFD process does not explicitly incorporate cost and financial factors (Bode and Fung, 1998; King, 1987; Park and Kim, 1998; Tang et al., 2002). These factors are normally incorporated in further analysis. For example, Wasserman (1993) suggest that a limited budget may be allocated for the development of DRs on the basis of their relative importance. Zhang et al. (1999) given the green considerations in developing QFD matrices, DRs resulting in adverse environmental impacts could be discouraged. Lu et al. (1994) have considered the level of difficulty of implementing DRs for adjusting the relative importance of DRs. However, in general, studies have considered only one extra factor in their analysis (Bode and Fung, 1998; Lu et al., 1994; Tang et al., 2002). There was only one study that, proposed by Ramanathan and Yunfeng (2009) which used DEA for considering the ratings of DRs with respect to CRs, and several additional factors.

In this study, the technique for order preferences by similarity to ideal solution (TOPSIS) method (Abo-Sinna and Amer, 2005; Hwang and Yoon, 1981; Lai et al., 1994; Olson, 2004; Zeleny, 1982) is proposed to obtain the relative importance of DRs when several factors must be considered.

Since TOPSIS and QFD are not new to the field of operations management, this paper provides only a brief description of these techniques in the next section. Interested readers are referred to some prominent papers. The use of TOPSIS in computing an aggregate weighted score of DRs is explained in Section 3. Finally, the proposed QFD-TOPSIS procedure is applied for the design of TV for an Iranian company in Section 4.
Incorporating cost and environmental factors in quality function deployment

2 The tools: QFD and TOPSIS

2.1 Quality function deployment

QFD has been described by Sullivan (1986) as “a system to assure that customer needs drive the product design and production process”. It was originally developed in 1972 at Mitsubishi’s Kobe shipyard site (Griffin and Hauser, 1993; Nishimura, 1972) as a tool to identify and quantify customer needs, and translate these needs into technical and DRs during the design and manufacture of products and services. Over the last few decades, QFD has found a number of applications in the operations and quality management literature (Crowe and Cheng, 1996; Park and Kim, 1998; Partovi, 2006). Costa et al. (2001) and Chan and Wu (2005) review recent developments in QFD.

Though QFD is a very popular tool and has found a variety of applications, the terminologies used by different authors in QFD literature vary widely (Chan and Wu, 2002a). In this note, customer needs are called CRs (also called WHATs in the literature) and the technical characteristics of the product as DRs (also called HOWs). A matrix called the HOQ with CRs as its rows and DRs as its columns is developed in the QFD process.

In general, a typical HOQ comprises six main parts (Matrices A–F) as shown in Figure 1 (Chan and Wu, 2002b). The needs of customers are identified and their relative importance as perceived by the customers estimated in Matrix A. Park and Kim (1998) suggest that the relative importance may be obtained using simple methods such as direct rating, or more complex ones such as the swing method. Saaty (1980) suggest that the analytic hierarchy process (AHP) may be used for the purpose and also Partovi (2006) suggest that the analytic network process can be used.

The DRs are listed in Matrix B, and the degree of relationship between CRs and DRs are measured in Matrix C. The relationship is usually captured using four levels – no relationship, weak/possible relationship, medium/moderate relationship, and strong relationship – and is usually captured using symbols similar to the ones described in the legend of Figure 1. The symbols are converted into numbers using a measurement scale (0, 1, 3, 9), however (0, 1, 3, 5) is also used in the QFD literature.

The technical correlation Matrix D is needed because some of the DRs are interrelated. The degree of the interrelations are captured using a symbolic scale, similar to the one used for Matrix C.

When there is a significant interrelation between the DRs as shown by entries of Matrix D, this information should be used to normalise the entries of Matrix C.

The following normalisation procedure suggested by Wasserman (1993) is usually employed for this purpose.

\[
R_{ij}^{\text{norm}} = \frac{\sum_{k=1}^{N} R_{ik} R_{kj}}{\sum_{j=1}^{N} \sum_{k=1}^{N} R_{ik} R_{kj}}
\]

\[
I = 1, 2, 3, \ldots, K \quad j = 1, 2, 3, \ldots, N
\]

where \( R_{ik} \) is an element of the Matrix C represents the relationship between CR, and \( DR_{i} \), and \( k \) is an element of the technical correlation Matrix D representing the interrelation between \( DR_{i} \) and \( DR_{j} \). K is the number of CRs, and N is the number of DRs. \( R_{ij}^{\text{norm}} \) forms the entries of the normalised Matrix C, which can be denoted as \( C^{\text{norm}} \). Note that \( C^{\text{norm}} \)
needs to be calculated only when there are significant interrelations among DRs; otherwise Matrix C can be directly used.

The absolute and relative importance of DRs are calculated in Matrix E. Matrix F is used for benchmarking.

**Figure 1** HOQ matrix

![HOQ matrix diagram](image)

Source: Chan and Wu (2002a)

In this paper, we concentrate on calculating the entries of Matrix E. The usual procedure is to use weighted arithmetic aggregation rule. Thus, given the symbols of Figure 1, if there is no significant correlation in the Matrix D the absolute importance of DR1 is calculated as: 
\[
[(0.3 \times 9) + (0.1 \times 1) + (0.05 \times 1) + (0.4 \times 1) + (0.15 \times 1)] = 3.4
\]

These absolute importance values, when normalised, yield relative importance measures. Thus, the relative importance of DR1 is 
\[
3.4/(3.4 + 1.45 + 1.90 + 0.35) = 0.4789 \text{ or } 47.89\%.
\]

Because of this normalisation, the sum of the relative importance values of all DRs will be equal to 1 or 100%. These relative importance values provide the ranking of DRs with respect to CRs, and the DR that has the highest relative importance should be given the highest attention while designing the product. Often, in QFD, these relative importance values are used for further analysis. For example, Wasserman (1993) suggest that they can be used to decide the allocation of limited budgetary resources devoted developing for the DRs. Chan and Wu (2002) suggest that the relative importance of DRs can be used as input in another HOQ matrix, by treating the DRs of one HOQ as the CRs of the next stage HOQ in a four-phase model. The QFD process described above has been
criticised as technically one-sided as it considers only customer satisfaction and not other important factors such as cost (Bode and Fung 1998; King, 1987). Incorporating factors other than the relationships of DRs with CRs, such as cost, environmental impacts, ease of implementation of the DRs, extendibility, and manufacturability, have been considered important in the evolution of QFD process (Bode and Fung, 1998; Karsak et al., 2002; Lu et al., 1994; Partovi, 1999; Zhang et al., 1999). As suggested in Wasserman (1993) and Park and Kim (1998), a linear programming model with the relative importance of DRs as the coefficient of objective function, and constraints on resource availability has been used to incorporate financial factors in QFD. Bode and Fung (1998) have shown that such a mathematical programming problem attempts to allocate limited budgetary resources according to decreasing ratio of weights to costs of DRs. For example, suppose that the costs of implementing the four DRs are given by the values shown in Figure 1, which also shows the ratio of relative importance to cost. Thus, the DRs in the descending values of the ratio are DR1, DR2, DR3, and DR4. As suggested in Wasserman (1993) and Bode and Fung (1998), when a limited cost budget (of say $35,000, which is less than the total cost for all the DRs, say $41,000) is available to develop the DRs, the mathematical programming model will allocate the available resources to DR1 first, followed by DR2, DR3, and DR4. Naturally, when the resources are limited, DRs with lower values of the ratio may not receive the required quantities. Albeit there are a few studies that consider additional factors after computing the relative importance of DRs, most of them consider only one additional factor. For example, Lu et al. (1994) consider only ease of implementation; while Bode and Fung (1998) and Tang et al. (2002) use only cost to adjust the relative importance of DRs. Ramanathan and Yunfeng (2009) using DEA to comprehensively consider the ratings of DRs with respect to CRs, and several additional factors simultaneously.

Table 1 Relative importance of DRs using DEA model

<table>
<thead>
<tr>
<th>DR1 (DMU 1)</th>
<th>DR2 (DMU 2)</th>
<th>DR3 (DMU 3)</th>
<th>DR4 (DMU 4)</th>
</tr>
</thead>
</table>

Matrix C

<table>
<thead>
<tr>
<th>Ratings of DRs with respect to CRs</th>
<th>DR1</th>
<th>DR2</th>
<th>DR3</th>
<th>DR4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR1 (output 1)</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CR2 (output 2)</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>CR3 (output 3)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>CR4 (output 4)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>CR5 (output 5)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Dummy input</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Relative importance of DRs using DEA model</td>
<td>1.000</td>
<td>0.426</td>
<td>0.559</td>
<td>0.103</td>
</tr>
</tbody>
</table>

Matrix F

| Cost (in cost units) (input factor) | 4   | 5   | 7   | 7   |
| Relative importance of DRs using DEA model | 1.000 | 0.341 | 0.319 | 0.027 |
| Ease of implementation (output factor) | 5   | 1   | 9   | 1   |
| Adverse environmental impact (input factor) | 1   | 7   | 3   | 9   |
| Relative importance of DRs using DEA model | 1.000 | 0.341 | 1.000 | 0.052 |

Note: See Figure 1.

Source: Ramanathan and Yunfeng (2009)
In their method, since the DRs were the DMUs, hence, their relative importance must be estimated. The efficiency score of a DR is equal to its relative importance. Thus, a DR with a higher efficiency score should be considered more important value.

Their study has two problems:

1. Does not consider the matrix F and also the relative importance of CRs in their calculation (see Table 1).
2. In their model, ratios for several DRs equal to 1. These ratios confuse decision makers in the DRs selection (see Table 1).

Therefore, in this study it is assumed that TOPSIS could be used to comprehensively consider the ratings of DRs with respect to CRs, and several additional factors simultaneously. The methodology is explained in the next subsection.

2.2 TOPSIS method

Decision-making is the process of finding the best option from all of the feasible alternatives. In almost all such problems the multiplicity of criteria for judging the alternatives is pervasive. These criteria usually conflict with each other so there may be no solution satisfying all criteria simultaneously. That is, for many such problems, the decision maker wants to solve a multiple criteria decision-making (MCDM) problem. An MCDM problem with finite possibilities can be concisely expressed in matrix format as shown in Table 2. In this Table, \(A_1, A_2, \ldots, A_m\) are possible alternatives among which decision makers have to choose, \(C_1, C_2, \ldots, C_n\) are criteria with which alternative performance are measured, \(x_{ij}\) is the rating of alternative \(i\) with respect to criterion \(j\), \(w_j\) is the weight of criterion \(j\).

There are several methods for solving MCDM problems (Hwang and Yoon 1981; Zeleny, 1982). One of them is TOPSIS presented by Hwang and Yoon (1981). In this method the rank of units depends on the distance from ideal and anti-ideal solutions. There exists a large amount of literature involving TOPSIS theory and applications. For example, Lai et al. (1994) applied the concept of TOPSIS on MODM problems. Abo-Sinna and Amer (2005) extended TOPSIS methods for solving multi-objective large-scale non-linear programming problems.

**Table 2** A typical multiple attribute decision problem

<table>
<thead>
<tr>
<th>Alternative 1</th>
<th>(x_{11})</th>
<th>(x_{12})</th>
<th>(x_{13})</th>
<th>(x_{1n})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2</td>
<td>(x_{21})</td>
<td>(x_{22})</td>
<td>(x_{23})</td>
<td>(x_{2n})</td>
</tr>
<tr>
<td>\vdots</td>
<td>\vdots</td>
<td>\vdots</td>
<td>\vdots</td>
<td>\vdots</td>
</tr>
<tr>
<td>Alternative m</td>
<td>(x_{m1})</td>
<td>(x_{m2})</td>
<td>(x_{m3})</td>
<td>(x_{mn})</td>
</tr>
</tbody>
</table>
Moreover, Olson (2004) used the weights and some other norms to measure these distances. Also, Shih et al. (2007) has extended TOPSIS for group decision making. Some researchers have been published on the applications of TOPSIS method with fuzzy data (Chen and Hwang, 1992; Chen and Tsao, 2008; Zeleny, 1982; Zhang et al., 2005). In this paper, we propose that TOPSIS could be used to comprehensively consider the ratings of DRs with respect to CRs, and several additional factors.

The procedure of TOPSIS can be expressed in a series of steps:

1. Calculate the normalised decision matrix. The normalised value \( n_{ij} \) is calculated as
   \[
   n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}} \quad \text{for} \quad i = 1, 2, \ldots, m \quad \text{and} \quad j = 1, 2, \ldots, n.
   \]

2. Calculate the weighted normalised decision matrix. The weighted normalised value \( v_{ij} \) is calculated as
   \[
   v_{ij} = w_i n_{ij} \quad \text{for} \quad i = 1, 2, \ldots, m \quad \text{and} \quad j = 1, 2, \ldots, n.
   \]
   where \( w_i \) is the weight of the \( i \)th attribute or criterion, and \( \sum_{i=1}^{n} w_i = 1 \). These weights can be introduced by a decision maker.

3. Determine the ideal and anti-ideal solution
   \[
   A^+ = \left( \{v_{1}^+, v_{2}^+, \ldots, v_{n}^+\} \right) = \left( \{\max v_{ij} \mid i \in O\}, \{\min v_{ij} \mid i \in I\} \right)
   \]
   \[
   A^- = \left( \{v_{1}^-, v_{2}^-, \ldots, v_{n}^-\} \right) = \left( \{\min v_{ij} \mid i \in O\}, \{\max v_{ij} \mid i \in I\} \right)
   \]
   where \( O \) is associated with benefit criteria, and \( I \) is associated with cost criteria.

4. Calculate the separation measures, using the \( n \)-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as
   \[
   d_j^+ = \left[ \sum_{i=1}^{n} (v_{ij} - v_{ij}^+) \right]^{\frac{1}{2}} \quad \forall j.
   \]
   Similarly, the separation from the anti-ideal solution is given as
   \[
   d_j^- = \left[ \sum_{i=1}^{n} (v_{ij} - v_{ij}^-) \right]^{\frac{1}{2}} \quad \forall j.
   \]

5. Calculate the relative closeness to the ideal solution. The relative closeness of the alternative \( A_j \) with respect to \( A^+ \) is defined as
   \[
   R_j = \frac{d_j^-}{d_j^+ d_j^-} \quad \text{for} \quad j = 1, 2, \ldots, m.
   \]
   Since \( d_j^+ \geq 0 \) and \( d_j^- \geq 0 \) then clearly \( R_j \in [0,1] \).

6. Rank the preference order. For ranking alternatives using this index, we can rank them in decreasing order. The basic principle of the TOPSIS method is that the chosen alternative should have the ‘shortest distance’ from the ideal solution and the ‘farthest distance’ from the anti-ideal solution. The TOPSIS method introduces two ‘reference’ points (Jahanshahloo et al., 2009).
3 Incorporating additional factors in QFD using TOPSIS

In this paper, TOPSIS method provides a useful tool for considering the ratings of DRs with respect to CRs and other additional factors such as cost, environmental impact, level of difficulty, etc. in estimating the relative importance of DRs. In this paper, the DRs are the alternative and the additional factors are the criterion.

3.1 Step-by-step procedure for integrating QFD-TOPSIS

When TOPSIS is used for calculating the relative importance values of DRs, the following step-by-step procedure should be applied.

Step 1 List all the CRs, DRs, and other factors to be considered in deciding the relative importance values of DRs.

Step 2 Obtain the degree of relationship between CRs and DRs (i.e., Matrix C in Figure 1), the technical correlation Matrix D and the ratings of DRs in terms of additional factors using the regular procedures employed in any QFD exercise. Then the benchmarking Matrix F is fulfilled. For example, the level of relationships mentioned in Figure 1 could be used for the purpose.

Step 3 Assign appropriate numerical values to the entries of Matrices C and D. When there is significant interrelation between the DRs as shown by entries of Matrix D, the normalised Matrix Cnorm should be computed.

Step 4 The entries of Matrices A, F, C (if there is no interrelations among DRs), or Cnorm (if there is significant interrelations), and the ratings of DRs with respect to the additional factors are used to obtain relative importance of DRs.

Step 5 Without considering the values of relative importance of DRs in Step 4, \( R_j \) for each of DRs with respect to additional factors is obtained. Then each of \( R_j \)s are multiplied by relative importance of DRs. Now, we can rank the DRs based on the highest score.

4 Case study

The proposed QFD-TOPSIS procedure has been applied for the design of TV for Pars Electric Company in this section. The company is one of the major producers of TV and monitor in Iran, employing about 500 employees.

This company has faced some problems in the current design of LCD. In order to meet CRs and to develop a more competitive design, the company was looking for an effective tool to improve its product development process. The proposed QFD-TOPSIS procedure is applied here.

The calculations for the case study are explained in terms of the step-by-step procedure outlined in Section 3.1.
Incorporating cost and environmental factors in quality function deployment

**Figure 2** HOQ matrix for the case study

<table>
<thead>
<tr>
<th>Customer Needs</th>
<th>Design, Development</th>
<th>Manufacturing</th>
<th>Quality Assurance</th>
<th>Support</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>3</td>
<td>1.6</td>
<td>3</td>
<td>1.77</td>
<td>6.34</td>
</tr>
<tr>
<td>Reliability</td>
<td>3</td>
<td>1.6</td>
<td>3</td>
<td>1.77</td>
<td>6.34</td>
</tr>
<tr>
<td>Durability</td>
<td>3</td>
<td>1.6</td>
<td>3</td>
<td>1.77</td>
<td>6.34</td>
</tr>
<tr>
<td>Maintainability</td>
<td>3</td>
<td>1.6</td>
<td>3</td>
<td>1.77</td>
<td>6.34</td>
</tr>
<tr>
<td>Cost</td>
<td>3</td>
<td>1.6</td>
<td>3</td>
<td>1.77</td>
<td>6.34</td>
</tr>
</tbody>
</table>

**Relative Importance of CSBs**

<table>
<thead>
<tr>
<th>Design, Development</th>
<th>Manufacturing</th>
<th>Quality Assurance</th>
<th>Support</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.14</td>
<td>1.13</td>
<td>1.11</td>
<td>1.18</td>
<td>1.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design, Development</th>
<th>Manufacturing</th>
<th>Quality Assurance</th>
<th>Support</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.14</td>
<td>1.13</td>
<td>1.11</td>
<td>1.18</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**Score Matrix**

- **Quality**: 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0
- **Reliability**: 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0
- **Maintainability**: 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0
- **Cost**: 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0

**Relative Importance**

- **Design, Development**: 1.14
- **Manufacturing**: 1.13
- **Quality Assurance**: 1.11
- **Support**: 1.18

**Score**

- **1.04**
Step 1  The case study involved several meetings with marketing and engineering staff. A detailed list of CRs and DRs were prepared during the meetings, and is used to find a list of six CRs and four DRs, listed in Figure 2.

Step 2  The relative importance of CRs were obtained through direct rating. Degree of relationship between CRs and DRs and the degree of interrelationships among the DRs were obtained similarly.

Now, complete the Matrix F. In this step, the product of the Pars Electric Company is compared with the product of the one rival company. The Pars Electric finds its position and so designs programme for improving its competitiveness.

Ratings of DRs in terms of the three additional factors, namely cost, ease of implementation, and adverse environmental impact were also obtained using direct rating. To prevent bias, all such information were obtained from ten responsible officials of the company.

Step 3  Figure 2 shows the ratings for Matrices C and D. There are not significant interrelationships among DRs as reported in Matrix D, so this information does not need to normalise the entries of Matrix C.

Step 4  Using the entries of Matrices A, B, C, D and F, we can obtain relative importance of DRs.

Step 5  In this step \( R_j \) should be obtained for each of DRs with respect to additional factors. Then each of \( R_j \)s is multiplied by relative importance of DRs. Now we can rank the DRs based on the highest score (Figure 2).

In the Figure 2 the absolute importance of CRs are calculated as (important of CR * ratio improvement * sale point). The important of CRs equal to: (5, 5, 5, 4, 3, 5, 3). So the absolute importance of image clearness is calculated as \((1.25 * 1.5 * 5) = 9.37\).

The relative importance of screen is calculated as \([(0.173 * 9)/54.28] = 0.103\). At the next step, \( R_j \) should be obtained for each of DRs with respect to additional factors. Importance of DRs is calculated with Shannon entropy method. Then, the \( R_j \) for each DRs are calculated with respect to the step-by-step procedure outlined in Section 2.2.

Final score for screen is calculated as \((0.7385 * 0.103) = 0.0761\) or 7.61%.

5 Conclusions

QFD involves simple calculations for estimating the relative importance of DRs, primarily using the ratings of DRs with respect to important customer needs. However, the simple procedure cannot be employed when the relative importance of DRs have to be computed based not only on the ratings with respect to customer needs but also other additional factors such as cost, ease of implementation, environmental impacts, etc. In this paper, TOPSIS method suggested to compute the relative importance of DRs when several additional factors need to be considered. The proposed procedure applied for the design of TV in Pars Electric Company. The ratings were obtained from ten company officials. By applying the procedure, it was found that ‘screen’ received the highest importance by all the ten respondents. For better modelling the problem and making the
results more applicable, recommended that researchers apply this concept in fuzzy environment.

References


