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Research on Customer Satisfaction Based on Quality Function Deployment

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Abstract

Quality Function Deployment, namely QFD, is a methodology to systematically convert the customers' requirements into technical requirements with the House of Quality. Customer requirement is the difference between expected satisfaction and actual satisfaction. This paper uses QFD to analyse customer satisfaction. During the process, an integrated method of PROMETHEE II and Entropy Weight is applied for the ranking of customer requirements. Afterwards, Grey Relational Analysis is adopted to construct relation matrix. Finally, the House of Quality is established to find the key factors and put forward effective measures to improve service quality.

Keywords: *QFD, house of quality, PROMETHEE II, grey relational analysis*

1. Introduction

Customer satisfaction is viewed as the basic guarantee of a company's long-term success. Many researches have reported that customer-oriented companies can expect significantly higher profit rates [1]. Kotler proposed that customer satisfaction had a significant impact on business [2]. The competence of an enterprise has focused on understanding and satisfying customers. Customer satisfaction results from meeting customer expectations during product or service life cycle. Service quality can be regarded as the antecedent of customer satisfaction, and a higher level of service quality will increase customer satisfaction [3].Therefore, to retain customers, businesses must strive to meet customers' needs by means of understanding the importance of service, creating customer value, listening to the voices of their customers, and in the end making service quality and customer satisfaction reach their expectation.

QFD is originated in Japan, which is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production [4]. Analytic Hierarchy Process (AHP) was used to rank Customer Requirements (CRs) when construct HOQ (House of Quality) [5]. But it is unable to disclose valuable information concerning the conflicts or similarities arisen from different criteria and alternatives [6]. In QFD related literature, many techniques for prioritizing CRs have been reported, just a few of them focused on the multi-criteria decision aiding (MCDA) methods, which helped QFD teams to measure the consistency and stability in their prioritization decisions [7]. To prioritize CRs from a MCDA approach, Franceschini and Rossetto used the interactive design characteristics ranking algorithm [8]. To overcome the drawbacks mentioned above, the authors combine advantages of the Entropy Weight and PROMETHEEII methods to rank CRs. Entropy Weight method is used to analyze the

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structure of the problem and determine the weight of criteria, and PROMETHEE II method is used for final ranking. And fuzzy set theory and grey theory is used to solve the uncertain and complex relationship of Customer Requirements and Technical Requirements.

2. QFD Fundamentals

In the QFD process, a matrix called the House of Quality (HOQ) is used to display the relationship between the voice of customers (WHATs) and technical requirements (HOWs), shown as Figure 1.

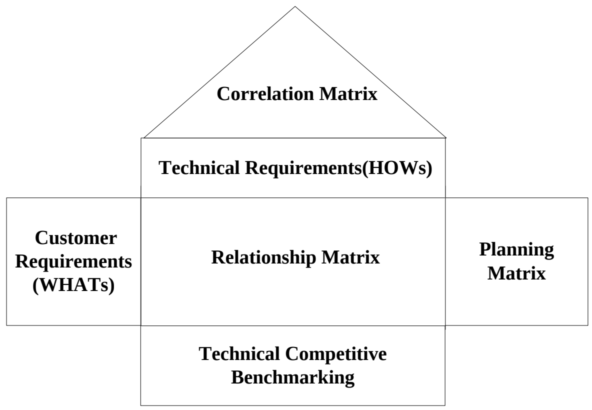

Figure 1. Framework of HOQ

Customer requirements matrix is on the left side of the HOQ, and this section illustrates the voice of customer [9-10]. It represents the "WHATS" of the system. Planning Matrix is on the right side of the HOQ matrix, and it represents the customer competitive assessment. Technical requirements Matrix lists how a company will meet the customer requirements. It is the "HOWS" of the system and represents the engineering characteristics or voice of the company. Relationship matrix occupies the middle portion of the HOQ diagram. It uses the prioritization matrix to show how well customer requirements are addressed by technical requirements. Correlation Matrix shows how the HOWs conflict with one another and this section focuses on design improvement. Technical competitive benchmarking is the final section of House of Quality matrix which summarizes the conclusions of the planning matrix. It includes two parts: technical priorities and engineering target values to be met by the new product design.

2.1. Grey Relational Analysis

Grey relational system based on the grey system theory had been proven to be useful for dealing with poor, incomplete and uncertain information [11]. A grey forecasting model uses three basic operations (including accumulated generation, inverse accumulated generation and grey model) to build grey differential equations [12]. Grey Relational Analysis can build a relational analysis of grey quantity and accurately construct a grey forecast model for uncertain and insufficient information system [13]. This study applies Grey Relational Analysis model to construct relationship matrix.

Step 1: Normalize the original data.

The order variation of the data will result in the inaccurate grey relational grade, so the values of the original data (x_i') must be normalized as x_i. The original data are commonly normalized by mean value. In this section, n and N is the number of index factor of grey system:

$$x_i(k) = \frac{x_i^{'}(k)}{x_i^{'}(1)}, i = 0,1,\cdots n; k = 1,2,\cdots N \tag{1}$$

$$(X_0, X_1, \cdots, X_n) = \begin{pmatrix} x_0(1) & x_1(1) & \cdots & x_i(1) & \cdots & x_n(1) \\ x_0(2) & x_1(2) & \cdots & x_i(2) & \cdots & x_n(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_0(k) & x_1(k) & \ldots & x_i(k) & \ldots & x_n(k) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ x_0(N) & x_1(N) & \ldots & x_i(N) & \ldots & x_n(N) \end{pmatrix}_{N\times(n+1)} \tag{2}$$

Step 2: Calculate absolute difference matrix (Δ_{0i}).

$$\Delta_{0i}(1) = \left| x_0(k) - x_i(k) \right|, i = 1,\cdots n; k = 1,2,\cdots N \tag{3}$$

Thus, we can get the follow matrix

$$\begin{pmatrix} \Delta_{01}(1) & \Delta_{02}(1) & \cdots & \Delta_{0i}(1) & \cdots & \Delta_{0n}(1) \\ \Delta_{01}(2) & \Delta_{02}(2) & \cdots & \Delta_{0i}(2) & \cdots & \Delta_{0n}(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \Delta_{01}(k) & \Delta_{02}(k) & \ldots & \Delta_{0i}(k) & \ldots & \Delta_{0n}(k) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \Delta_{01}(N) & \Delta_{02}(N) & \ldots & \Delta_{0i}(N) & \ldots & \Delta_{0n}(N) \end{pmatrix}_{N\times n} \tag{4}$$

$$\begin{cases} \max\{\Delta_{0i}(k)\} = \Delta(\max) \\ \min\{\Delta_{0i}(k)\} = \Delta(\min) \end{cases} \tag{5}$$

Step 3: Calculate the grey relational coefficient (ξ_{0i}).

$$\xi_{0i}(k) = \frac{\Delta(\min) + \rho\Delta(\max)}{\Delta_{0i}(k) + \rho\Delta(\max)} \tag{6}$$

Where i = 1,2, . . . ,n, k = 1,2, . . . ,N, ρ is the identification coefficient, normally set $\rho = 0.5$.

$$\begin{pmatrix} \xi_{01}(1) & \xi_{02}(1) & \cdots & \xi_{0i}(1) & \cdots & \xi_{0n}(1) \\ \xi_{01}(2) & \xi_{02}(2) & \cdots & \xi_{0i}(2) & \cdots & \xi_{0n}(2) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \xi_{01}(k) & \xi_{02}(k) & \ldots & \xi_{0i}(k) & \ldots & \xi_{0n}(k) \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \xi_{01}(N) & \xi_{02}(N) & \ldots & \xi_{0i}(N) & \ldots & \xi_{0n}(N) \end{pmatrix}_{N\times n} \tag{7}$$

Step4: Calculate grey relational grade (r_{0i}).

Grey relational grade is given by the average of the grey relational coefficients as

$$r_{0i} = \frac{1}{N}\sum_{k=1}^{n} \xi_{oi}(k) \tag{8}$$

Where i = 1, 2, . . . ,n, k = 1,2, . . . ,N.

Step 5: Rank the grey relational grade.

The grey relational grades (r_{oi}) of the different compared sequences provide a ranking in which a higher value indicates stronger correlation.

2.2. Entropy Weight and PROMETHEE II Method

We use a hybrid Entropy Weight and PROMETHEE II to highlight the problem of ranking CRs in the first step of the HOQ process. Entropy Weight is used to calculate weights of index factors (refer to experts, managers and tourists in Table 6), and PROMETHEE II is applied for deciding prioritization of CRs. At present, the information entropy method has been widely used to determine the weight index in natural hazards, environmental, integrated assessment of natural processes such as debris flow, drought, sandstorm, *etc.* [14].

Step 1: Construct an evaluation matrix for the raw data.

The original evaluation matrix is constructed as shown in Eq. (9).

$$D = [X_{ij}]_{n\times m} = \begin{matrix} & C_1 & C_2 & \cdots & C_m \\ & \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (9)$$

Where i = 1, 2, . . . ,n, j = 1,2, . . . ,m.

Step 2: Normalize the original evaluation matrix.

Because the original data for the index factors may be measured by different units, the original matrix must be normalized to create an objective baseline for the various index factors. The normalized original evaluation matrix ($P = [p_{ij}]_{n\times m}$) can be obtained using Eq. (10) where p_{ij} is the performance rating.

$$p_{ij} = \frac{x_{ij}}{\sum_{p=1}^{n} x_{pj}} \quad (10)$$

Where i = 1, 2, . . . , n, j = 1, 2, . . . ,m.

Step 3: Calculate the entropy value of index factors (E_j).

$$E_j = -k \sum_{i=1}^{m} \ln p_{i,j} \quad (11)$$

Where $K = (\ln n)^{-1}$ is a constant that guarantees $0 \le E_j \le 1$.

Step 4: Calculate the weights of index factor (W_j).

$W_j (j = 1,2, \ldots, m)$ Can be calculated using Eq. (12), in which $V_j = 1 - E_j$ is the degree of divergence of the average intrinsic information associated with each criterion. The more divergent the performance ratings $p_{ij} (i = 1,2, \ldots, n)$is, the higher V_j and the greater W_j will be.

$$w_j = \frac{V_j}{\sum_{i=1}^{m} V_j} \quad (12)$$

PROMETHEE II provides a complete ranking on a finite set of feasible alternatives from the best to the worst. The central principle of PROMETHEE II is based on a pair-wise comparison of alternatives along with each recognized criterion [15]. For each criterion, the preference function translates the difference between the evaluations obtained by two alternatives into a preference degree ranging from zero to one. This paper uses the usual criterion for the implementation of PROMETHEE II:

Step 1: Determine of deviations based on pair-wise comparisons

$$d_{ir} = x_{ij} - x_{rj}$$

(13)

Where d_{ir} denotes the difference between the evaluations of a and b on each criterion i= 1,2, . . . ,m, r = 1,2, . . . ,m, j = 1,2, . . . ,n.

Step 2: Application of the preference function (use usual type preference function)

$$P_j(d_{ir}) = F_j[d_j(d_{ir})] = \begin{cases} 0 & d_{ir} = 0 \\ 1 & d_{ir} \neq 0 \end{cases} \quad (14)$$

Where $P_j(a,b)$, as a function of $d_j(d_{ir})$, denotes the preference of alternative a with regard to alternative b on each criterion.

Step 3: Calculation of a global preference index

$$\pi(X_i, X_r) = \sum_{j=1}^{n} w_j . P_j(d_{ir}) \quad (15)$$

Where $\pi(X_i, X_r)$ of X_i over X_r is defined as the weighted sum of $P_j(d_{ir})$ for each criterion, and w_j is the weight associated with j the criterion, j = 1,2, . . . ,k.

Step 4: Calculation of outranking flows and partial ranking

$$\phi^+(X_i) = \frac{1}{m-1} \sum_{r=1}^{m} \pi(X_i, X_r) \quad (16)$$

$$\phi^-(X_i) = \frac{1}{m-1} \sum_{r=1}^{m} \pi(X_r, X_j) \quad (17)$$

Where $\phi^+(X_i)$ and $\phi^-(X_i)$ denote the positive out ranking flow and the negative outranking flow for each alternative, respectively.

Step 5: Calculation of net outranking flow and complete ranking

$$\phi(X_i) = \phi^+(X_i) - \phi^-(X_i) \quad (18)$$

Where $\phi(X_i)$ denotes the net outranking flows for each alternative.

3. The QFD Model of Tourist Satisfaction

3.1. Left Wall, Ceiling, Room of HOQ

The HOQ model of Yuntai Mountain is shown in Figure 2. The left wall of HOQ describes tourists' requirements. We used questionnaires, interview and observations to obtain tourists requirements of Yuntain Mountain, and gathered 100 valid questionnaires (80 from tourists and another 20 from referrals and internet groups). The questionnaires and survey provided many tourists requirements. After extraction of tourists' requirements, we use Affinity Diagram Method (KJ) and induction to build a three-level quality factors hierarchy as shown in Figure 2. Then, organize the CRs to the left wall of HOQ. Technical requirements related to 12 CRs were drawn up by a design team, consisting of tourist experts in using the HOQ for different kinds of products. The number of technical requirements in the House of Quality was limited to five: Y_i ={policy, budget, the infrastructure construction, management, service quality}, i =1,2,3,4,5.These technical requirements were chosen because they were thought to affect the user's comfort.

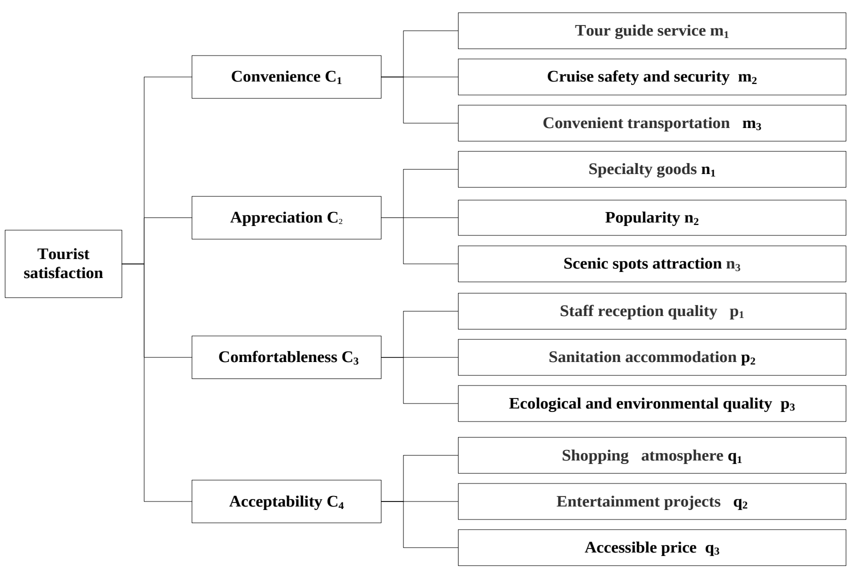

Figure 1. Hierarchical Structure

Table 1. Initial Value Matrix of Entertainment Relations (m_1)

	Y_1	Y_2	Y_3	Y_4	Y_5	Reference
m_{11}	9	6	8	5	2	7
m_{12}	10	5	7	3	1	5
m_{13}	9	7	4	7	3	6
m_{14}	8	8	7	6	1	7

According to the formula (2), we can get normalized value matrix of m_1, see in Table 2.

Table 2. Normalized Value(m_1)

	Y_1	Y_2	Y_3	Y_4	Y_5	Reference
m_{11}	1.000	1.000	1.000	1.000	1.000	1.000
m_{12}	1.111	0.833	0.875	0.600	0.500	0.714
m_{13}	1.000	1.167	0.500	1.400	1.500	0.857
m_{14}	0.889	1.333	0.875	1.200	0.500	1.000

Using Eq. (3), the absolute difference matrix was obtained, see in Table 3.

Table 3. Absolute Difference Matrix(m_1)

k	Δ_{01}	Δ_{02}	Δ_{03}	Δ_{04}	Δ_{05}
1	0.000	0.000	0.000	0.000	0.000
2	0.397	0.278	0.042	0.275	0.100
3	0.143	0.167	0.667	0.900	0.100
4	0.111	0.444	0.458	0.325	0.700

According to table3, we obtain $\Delta(\max) = 0.9$, $\Delta(\min) = 0$.Using Eq. (6) and ρ =0.5, calculate the grey relational coefficients ($\xi_{0i}(k)$), see in Table 4.

Table 4. Grey Relational Coefficient(m_1)

k	ξ_{01}	ξ_{02}	ξ_{03}	ξ_{04}	ξ_{05}
1	1.000	1.000	1.000	1.000	1.000
2	0.531	0.618	0.915	0.621	0.818
3	0.759	0.729	0.403	0.333	0.818
4	0.802	0.503	0.496	0.581	0.391

Then the correlation degree between entertainment projects and technology requirements of m_1 was derived using Eqs. (7) and (8): r_{0i} ={0.773，0.713，0.703，0.634，0.757}. With the same method, the rest correlation degree ($m_2, m_3, p_1 \cdots q_3$) was calculated, see in Table 5. Thus, we got the room of HOQ.

Table 5. Incidence Matrix

Items	Y_1	Y_2	Y_3	Y_4	Y_5
m_1	0.773	0.713	0.703	0.634	0.757
m_2	0.497	0.502	0.515	0.782	0.780
m_3	0.557	0.674	0.754	0.823	0.632
n_1	0.742	0.683	0.512	0.532	0.654
n_2	0.547	0.648	0.734	0.589	0.652
n_3	0.683	0.746	0.739	0.515	0.697
p_1	0.793	0.653	0.714	0.689	0.711
p_2	0.501	0.755	0.612	0.578	0.728
p_3	0.683	0.690	0.715	0.637	0.641
q_1	0.790	0.633	0.794	0.812	0.733
q_2	0.798	0.732	0.689	0.746	0.715
q_3	0.744	0.751	0.516	0.522	0.688

3.2. The Right Wall Ranking of CRs

This paper used a integrate method of entropy and PROMETHEE II to rank customer requirements. Before we used PROMETHEE II to rank customer requirements, we should get the weight first. In this case, we get the evaluation of CRs from experts, managers and tourists, and we use entropy method to calculate the evaluation weight of experts, managers and tourists. We invited experts, managers and tourists to score 12 CRs based on their experiences and preferences, then average each group's score, and standardize these scores. The higher the score is, the more important the degree is. The score show and normalized matrix using Eq. (10), show as Table 6.

The entropy value E and weights W of experts, managers and tourist were obtained with Eqs. (11) and (12）:

$E = \{1.305645, 1.30679, 1.300921\}$

$W = \{0.333166, 0.333708, 0.333126\}$

Table 6. Sore Matrix and Normalized Matrix

Items	experts	managers	tourists	Items	experts	managers	tourists
m1	85	90	85	m1	0.293369	0.304158	0.288177
m2	87	85	90	m2	0.300271	0.287261	0.305129
m3	85	89	88	m3	0.293369	0.300779	0.298348
n1	80	86	75	n1	0.276112	0.29064	0.254274
n2	85	88	85	n2	0.293369	0.297399	0.288177
n3	75	80	80	n3	0.258855	0.270363	0.271225
p1	89	86	90	p1	0.307174	0.29064	0.305129
p2	90	88	92	p2	0.310626	0.297399	0.311909
p3	88	89	80	p3	0.303723	0.300779	0.271225
q1	80	78	80	q1	0.276112	0.263604	0.271225
q2	75	80	86	q2	0.258855	0.270363	0.291567
q3	83	85	89	q3	0.286466	0.287261	0.301738

Then, calculate the fuzzy relations with PROMETHEE II method according to formula (13)-(15), see in Table 7.This study uses the usual type preference function for CRs.

Table 7. Fuzzy Relation Matrix

Item	m_1	m_2	m_3	n_1	n_2	n_3	p_1	p_2	p_3	q_1	q_2	q_3
m_1	0	0.3337	0.3337	1	0.3337	1	0.3337	0.3337	0.668	1	0.6669	0.6669
m_2	0.6663	0	0.6663	0.6663	0.6663	1	0	0	0.3331	1	1	0.6663
m_3	0.3331	0.3337	0	1	0.6668	1	0.3337	0.3337	0.3331	1	1	0.6669
n_1	0	0.3337	0	0	0	0.6669	0	0	0	1	1	0.6669
n_2	0	0.3337	0	1	0	1	0.3337	0	0.3331	1	0.6669	0.6669
n_3	0	0	0	0.3331	0	0	0	0	0	0.3337	0	0
p_1	0.6663	0.6669	0.6663	0.6663	0.6663	1	0	0	0.6663	1	1	1
p_2	0.6663	1	0.6663	1	0.6663	1	1	0	0.6663	1	1	1
p_3	0.3332	0.6669	0.3332	1	0.6669	0.6669	0.3337	0.3337	0	0.6669	0.6669	0.6669
q_1	0	0	0	0.3331	0	0.3332	0	0	0	0	0.6663	0
q_2	0.3331	0	0	0.3331	0.3331	0.3331	0	0	0.3331	0.6668	0	0
q_3	0.3331	0	0.3331	0.6663	0.3331	1	0.3337	0	0.3331	1	1	0

Table 8. Net Outranking Flow and the Complete Ranking of CRs

Items	m_1	m_2	m_3	n_1	n_2	n_3	p_1	p_2	p_3	q_1	q_2	q_3
$\phi^+(m_i)$	0.606	0.055	0.636	0.212	0.485	0.061	0.727	0.879	0.576	0.121	0.212	0.485
$\phi^-(m_i)$	0.303	0.334	0.273	0.727	0.394	0.818	0.243	0.091	0.333	0.818	0.758	0.515
$\phi(m_i)$	0.303	-0.28	0.364	-0.52	0.091	-0.76	0.485	0.788	0.243	-0.70	-0.55	-0.03
w	7	9	4	3	5	12	10	1	8	2	11	6

After calculating the fuzzy relations, we can get the result of the complete ranking with PROMETHEE II for 12 CRs with the formula (14-16), see in Table 8. The experimental results from the real-world data sets are encouraging in terms of the classification performance obtained by the PROMETHEEII. In Table 8, 'w' indicates the relative emphasis of these CRs, and we get 'w' from the value of $\phi(m_i)$. The bigger $\phi(m_i)$ is the bigger w is. At the same time, the bigger w means the more important of CR. The alternatives scenic spots attraction n_3, staff reception quality p_1 and entertainment projects q_2 are preferred from the multi-criteria viewpoint, respectively, whereas sanitation accommodation p_2 and shopping atmosphere q_1 are selected the worst alternatives. The higher score is, the more important the tourist requirement is. Thus, the rank of the CRs can be completed, and organize them in the right wall of HOQ.

We invited the experts scoring the current situation of Yuntai Mountain. Among them, experts set specialty goods, scenic spots attraction, ecological and environmental quality4 point, entertainment projects 2 point, others 3 point, see U_i in Table 9. At the same time, experts also set target quality score specialty goods, scenic spots attraction, ecological and environmental quality 5 point, others 4 point. Experts forecasted Point-of-sale score, and the higher the score, the better the sales. Tour guide service Cruise safety and security are 5 point, signify with ◎, Convenient transportation Scenic spots attraction Ecological and environmental quality Entertainment projects 3 point, signify with○, others are 1 point, signify with△, see S_i in Table 9. We can calculate the rate of improvement, absolute weight and relative weight; see R_i, I_{ai}, I_i in Table 9, with routine calculation methods of HOQ.

3.3. Floor of HOQ

The floor of the HOQ describes the importance of technical requirements and target value. We calculate the important degree with quality planning matrix and the relationship matrix. The process of technical requirements importance is shown as follows.

$$H = \sum r_{ij} \times I_i \quad (19)$$

Thus, we can set the goal based on the important degree, and the higher score represent the more important the technical requirement is. Among them, r_{ij} refers to relation matrix value, I_i refers to relative importance, i refers to the number of customer demands, j refers to the number of technical requirement. According to formula (18), calculate the important degree of technical requirement: funding budget, infrastructure construction, service personnel quality and the government management policies, see H in Table 9.

Table 9. House of Quality of Tourist Satisfaction

Items	Y_1	Y_2	Y_3	Y_4	Y_5	Planning Quality						
						W	U_i	T_i	R_i	S_i	I_{ai}	I_i
m_1	0.773	0.713	0.703	0.634	0.757	7	3	4	1.33	◎	59.85	0.249074
m_2	0.497	0.502	0.515	0.782	0.780	9	3	4	1.33	◎	33.25	0.138374
m_3	0.557	0.674	0.754	0.823	0.632	4	3	4	1.33	○	39.9	0.166049
n_1	0.742	0.683	0.512	0.532	0.654	3	4	5	1.25	△	5	0.020808
n_2	0.547	0.648	0.734	0.589	0.652	5	3	4	1.33	△	9.31	0.038745
n_3	0.683	0.746	0.739	0.515	0.697	12	4	5	1.25	○	3.75	0.015606
p_1	0.793	0.653	0.714	0.689	0.711	10	3	4	1.33	△	14.63	0.060885
p_2	0.501	0.755	0.612	0.578	0.728	1	3	4	1.33	△	15.96	0.06642
p_3	0.683	0.690	0.715	0.637	0.641	8	4	5	1.25	○	30	0.124849
q_1	0.790	0.633	0.794	0.812	0.733	2	3	4	1.33	△	2.66	0.01107
q_2	0.798	0.732	0.689	0.746	0.715	11	2	4	2	○	18	0.074909
q_3	0.744	0.751	0.516	0.522	0.688	6	3	4	1.33	△	7.98	0.03321
H	0.682818	0.671539	0.665824	0.679334	0.717139						240.29	1
goal	1	2	3	4	5							

◎5 Strong ○3 Medium △1 Weak

3.4. The HOQ of Tourist Satisfaction

We achieved HOQ through regularly calculations, as shown in Table 9. Based on the competition analysis, the relative weight of the scenic spots attraction and the entertainment project occupy the most proportion. In the analysis of technical requirements important degree, service quality and management are the most important reasons that could drive customer satisfaction. Thus, we should consider the service quality methods first, and then improve management.

4. Conclusion

This paper proposes an integrated approach that combines QFD, Entropy Weight, PROMETHEE II and Grey Relational Analysis to study customer satisfaction. The methodology is a sound alternative in an unstructured, conflicting, multi-criteria environment. These combined methods are reasonable in using QFD to solve problems. Once the QFD model is completed, all of the functional areas can use the same approach.

In order to rank CRs in the stage of HOQ process, this paper summarized the valuable experiences gained by applying a hybrid entropy weight and PROMETHEE II approach. This function is used to compute the degree of preference associated to the best action in case of pair wise comparisons; PROMETHEE II gives decision makers considerable strengths, by the Yuntai Mountain, to visualize the decision problem and to understand the conflicts; PROMETHEE II also eliminates the scaling effects completely and reduces the number of in comparability. The results showed that PROMETHEE II has a great potential to be considered as an effective MCDA method for overcoming drawbacks with ranking CRs in the QFD planning. Furthermore, PROMETHEEII offered the QFD team distinct advantages in understanding the structure of decision problem and is a powerful graphical tool in analyzing conflicts, or similarities among criteria and alternatives. The study indicates that such an approach can provide a useful tool for the complicated multiple objective decision-making to obtain scientific and reasonable results for decision makers. Furthermore, this approach can also be applied to other fields in regard to the optimization of complicated multi-objective decision-making problems. Compared with the grey evaluation model which only concerns with proximity or similarity, this approach would be the future researching trend includes both proximity and similarity in this model.

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References

[1] A. M. Karakitsiou, A. Migdalas and A. Tsiakali, "Customer Satisfaction Evaluation in the Tourism Industry: the Case of Chana", Foundations of Computing and Decision Sciences, vol. 2, no. 32, **(2007).**
[2] A. Chaudha, R. Jain, A. R. Singh and P. K Mishra, "Integration of Kano's Model into Quality Function Deployment (QFD)", International Journal of Advanced Manufacturing Technology, vol. 8, no. 53, **(2011).**
[3] X. B. Liu, Y. Ma and J. P. YANG, "Incremental Multi-Process Planning for Special Steel Industry Based on Quality Function Deployment", Computer Integrated Manufacturing Systems, Springer-Verlag, China, **(2009)**.
[4] D. Feng and P. Xuning, "Information Systems Risk Evaluation Based on the AHP-Fuzzy Algorithm", International Conference on Networking and Digital Society, **(2009)** May 30-June 1, Guiyang, China.
[5] N. Hamzah, A. Ramly, H. Salleh and N. M. Tawil, "The Importance of Design Process in Housing Quality", 2nd International Building Control Conference, **(2011)** July 11-12, Penang, Malaysia.
[6] Y. Z. Chen, Z. H. Ren and B. C. Wang, "Research on Optimization Model based on House of Quality Fuzzy Theory in Industrial Environment", Advanced Materials Research, Trans Tech Publications, vol. 1042, **(2010)**.
[7] S. Q. Kuang, J. Y. Tao and D. G. Yang, "Evaluation of Experimental Teaching Quality based on Multi-level Grey Relational Analysis", 3rd International Conference on Intelligent System Design and Engineering Applications, **(2013)** January 16-17, Hong Kong, China.
[8] T. J. Liu, X. G. Ma and T. J. Liu, "Performance Evaluation Research on Supply Chain based on AHP and Modified Grey Relational Analysis", 2012 IEEE International Conference on Computer Science and Automation Engineering, **(2012)** May 25-27, Hunan, China.
[9] S. Y. Kim, "Hybrid Forecasting System based on Case-based Reasoning and Analytic Hierarchy Process for Cost Estimation", Journal of Civil Engineering and Management, Vilnius Gediminas Technical University, vol. 6, no. 19, **(2013).**
[10] C. Dragan, D. Đorđević and Z. Sajfert, "Acceptance of Customer Satisfaction Concept: An Exploratory Study in Serbian Companies", Metalurgia International, Editura Stiintifica F. M. R.., Romania, vol. 2, no. 44, **(2011).**
[11] J. R. Sharma, "Linking Voice of Customer to Product Development through Quality Function Deployment (QFD)", International Journal of Advanced Operations Management, vol. 1, no. 3, **(2011).**
[12] J. Shi, Z. H. Ding, W. J. Lee, Y. P. Yang and Y. Q. Liu, "Hybrid Forecasting Model for Very-Short Term Wind Power Forecasting Based on Grey Relational Analysis and Wind Speed Distribution Features", IEEE TRANSACTIONS ON SMART GRID, vol. 1, no. 5, **(2014).**
[13] E. Fernandez and J. Navarro, "Computer-based Decision Models for R&D Project Selection in Public Organizations", Foundations of Computing and Decision Sciences, vol. 2, no. 30, **(2005).**

[14] F. Cadier, G. Coppin and P. Lenca, "From Cognitive Models to Multiple Decision Makers Support Systems", Foundations of Computing and Decision Sciences, vol. 4, no. 33, **(2008)**, pp. 317-49.
[15] J. Stefanowski, "Classification and Decision Supporting based on Rough Set Theory", Foundations of Computing and Decision Sciences, vol. 3, no. 18, **(1993),** pp 371-380.

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