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INTEGRATION OF QFD AND DEA METHODS TOGETHER TO PRIORITISE CUSTOMER EXPECTATIONS: THE CASE OF A SERVICE ORGANISATION

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Abstract

Quality Function Deployment (QFD) is a method used to transform customer expectations into technical requirements and to identify the technical requirements that need to be improved to meet these expectations. QFD stands out as a method that has found wide application in the literature and industry in terms of its advantage in transforming relatively more abstract customer expectations into concrete product and process parameters and its ease of application. One of the most important disadvantages of the method is that in the prioritization of technical requirements related to customer expectations, criteria such as the cost of the technical requirement in question, the implementation time of the necessary improvement activities, etc., are not considered. In this study, an approach in which Data Envelopment Analysis (DEA) methods are applied together with the QFD method to take into account the costs in the prioritization of technical requirements is presented. According to the results of a sample application carried out in a cafe business to test the approach, it is concluded that taking costs into account in the prioritization process should be prioritized in order to meet customer expectations.

Keywords: *QFD, DEA, Customer Requirements*
JEL Classification: *C67, L15, M21*

MÜŞTERİ BEKLENTİLERİNİN ÖNCELİKLENDİRİLMESİNDE QFD VE VZA YÖNTEMLERİNİN ENTEGRASYONU: BİR HİZMET İŞLETMESİ ÖRNEĞİ

Öz

Kalite Fonksiyon Göçerimi (QFD), müşteri beklentilerinin teknik gereksinimlere dönüştürülmesi ve söz konusu beklentilerin karşılanabilmesi için öncelikli olarak iyileştirilmesi gereken teknik gereksinimlerin belirlenmesi amaçlı olarak kullanılan bir yöntemdir. QFD, nispeten daha soyut olan müşteri beklentilerini somut ürün ve süreç parametrelerine dönüştürme konusundaki avantajı ve uygulama kolaylığı bakımından literatürde ve endüstride geniş uygulama alanı bulan bir yöntem olarak ön plana çıkmaktadır. Yöntemin ifade edilebilecek en önemli dezavantajlarından birisi; müşteri beklentileri ile ilişkili teknik gereksinimlerin önceliklendirilmesinde, söz konusu teknik gereksinimin maliyeti, gerekli iyileştirme faaliyetlerinin uygulanma süresi vb. kriterlerin göz önünde bulundurulmamasıdır. Bu çalışmada teknik gereksinimlerin önceliklendirilmesinde maliyetlerinde hesaba katılması amacıyla QFD yöntemi ile birlikte Veri Zarflama Analizi (DEA) yöntemlerinin uygulandığı bir yaklaşım ortaya konulmuştur. Ortaya konulan yaklaşımın test edilmesi amacıyla bir cafe işletmesinde yapılan örnek uygulama sonuçlarına göre; önceliklendirme işleminde maliyetlerin de hesaba katılmasının, müşteri beklentilerinin karşılanması için öncelikli olarak ele alınması gereken teknik gereksinimlere ilişkin sıralamayı değiştirdiği sonucuna ulaşılmıştır.

Anahtar Kelimeler: *KFG, VZA, Müşteri Beklentileri*
JEL Sınıflandırması: *C67, L15, M21*

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1. Introduction

Today, when the number of enterprises supplying products or services is very high, and customer demands require the production of personalized products that meet personal expectations, the importance of applications that enable customer expectations to be met is increasing. The Quality Function Deployment (QFD) method is a systematic method that enables production and service businesses to receive and evaluate customer expectations and determine the technical requirements that need to be developed to meet these expectations. The QFD method is a method that finds wide application in both manufacturing and service businesses due to its ease of application as a voice of the customer application and its easy-to-understand but systematic approach. The QFD method has been used effectively and widely in many areas, from product design to process and product improvement activities in enterprises from different sectors. Although QFD is a widely applied method, it has been criticized for some reasons such as the difficulties that may be experienced in transforming the statements used in the process of determining customer expectations into technical requirements that need to be developed to meet expectations, the need to obtain customer expectations with complete and accurate methods, the difficulty of associating customer expectations with technical requirements for some sectors, and being very sensitive to the reliability of data in the process of obtaining customer expectations (Kılıç and Babat 2011: 97).

In today's competitive conditions, production costs are of great importance for enterprises. Therefore, prioritising the technical requirements that need to be improved to meet customer expectations without taking into account their costs will limit the applicability of the QFD method. This study presents an approach in which the costs related to the improvement activities to be carried out are numerically included in the decision model. In the proposed approach, the Data Envelopment Analysis (DEA) method is used to prioritize the technical requirements after creating the quality house and associating customer expectations with technical requirements. Although there are many decision models in the literature that can be used to prioritise technical requirements, the DEA method is suitable for decision problems that require a decision based on a large number of variables with a small number of operations (Ramanathan and Yunfeng, 2009: 712). In the DEA model, the costs of technical requirements are considered as input variables, and it is aimed that the costs are decisive in the decision process.

2. Literature Review

Some of the studies in the literature where QFD and DEA methods are used together are briefly discussed below. Ramanathan and Yunfeng (2009), presented a QFD-DEA model in which additional factors such as environmental impact and cost are also considered in linking customer expectations and technical requirements. In the study, costs were also taken into account in the prioritization of technical requirements, but unlike the approach presented in this study, the relative importance ranking of cost figures was used in the model instead of cost figures. Ersöz and Aktepe (2011), presented an approach in which Analytical Network Process (ANP) and DEA methods were used together in order to prioritize technical requirements in the QFD method applied in a white goods company. Azadi and Saen (2013) presented a model in which the QFD method and a DEA model applied for data with unknown exact values are used together in an enterprise operating in the health sector. Karsak and Dursun (2014), presented an approach in which the QFD method and a DEA model applied for restricted data are used in supplier selection. In this model, the weight values of the supplier selection criteria are calculated by the fuzzy weighted average (FWA) method. Mehrjerdi et al. (2012), presented a model in which more realistic results are obtained by considering the constraints of the manufacturer as well as the relationship between customer expectations and technical requirements in calculating the relative importance weights of technical requirements in the QFD method. Zhang (2019), presented an approach in which QFD and DEA methods are applied together in user selection that will contribute to the product development process. The study also includes an application in a mobile phone manufacturing company. Li and Bao (2021), conducted a study in which QFD and a data envelopment analysis model applied for interval values were jointly applied to supplier selection problems.

3. Data Envelopment Analysis

Data envelopment analysis is a linear programming-based method that aims to measure the relative efficiency of organizational units that produce many similar inputs and outputs (Tütek et al. 2012: 223). According to the basic logic of data envelopment analysis, the efficiency score is calculated as follows:

$$\text{Efficiency} = \text{Total Weighted Outputs} / \text{Total Weighted Inputs} \tag{1}$$

Efficiency scores obtained as a result of DEA take values between "0" and "1". A low score means low efficiency. The decision-making unit with an efficiency value equal to "1" is considered efficient (Kelly et al. 2012: 65). When data envelopment models are applied to obtain the highest output with constant input, the model created is expressed as "Output-oriented," and when it is applied to obtain a certain output with the least input, the model created is expressed as "Input-oriented" (Günay 2015: 18).

Although the basic principles of data envelopment analysis were first introduced by Farrel (1957), its mathematical basis was developed by Charnes, Cooper, and Rhodes (1978) (Ayrıçay and Özçalıcı 2014: 248). Charnes, Cooper, and Rhodes developed Farrel's definition of relative technical efficiency and introduced the data envelopment model that enables the analysis of the relative efficiency of decision-making units with multiple inputs and outputs (Savaş 2015: 205). The model developed by these names and analyzing efficiency with the assumption of constant returns to scale is referred to as the CCR model, and the model developed by Banker, Charnes, and Cooper and measuring efficiency with the assumption of variable returns to scale is referred to as the BCC model (Aytekin and Kahraman 2015: 293). There are many data envelopment analysis models in the literature. Cooper et al. (2006) determined that there are many DEA models, the exact number of which varies according to the model definition, including differences according to different purposes of use (Kauppinen 2016: 97).

In data envelopment analysis, efficiency is measured over a certain time period, but in some cases, it may take a longer time for inputs to be transformed into outputs. Data envelopment analysis determines relative efficiency scores, but no conclusion can be reached regarding the absolute efficiency of decision-making units. In addition, there is no random error term in the method, so the method is highly sensitive to errors (Savaş 2015: 209).

The linear input-oriented CCR model, also called the multiplier model, is shown as follows (Tütek et al. 2012: 233).

Objective Function

$$Maks\ \eta_k = \sum_{r=1}^{s} \mu_r y_{rk} \tag{2}$$

Subject to:

$$\sum_{i=1}^{m} w_i x_{ik} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} w_i x_{ij} \leq 0 \qquad (j = 1 \dots . n)$$

$$\mu_r, w_i \geq \varepsilon > 0 \quad (r = 1 \dots . . s)\ ve\ (i = 1 \dots . m)$$

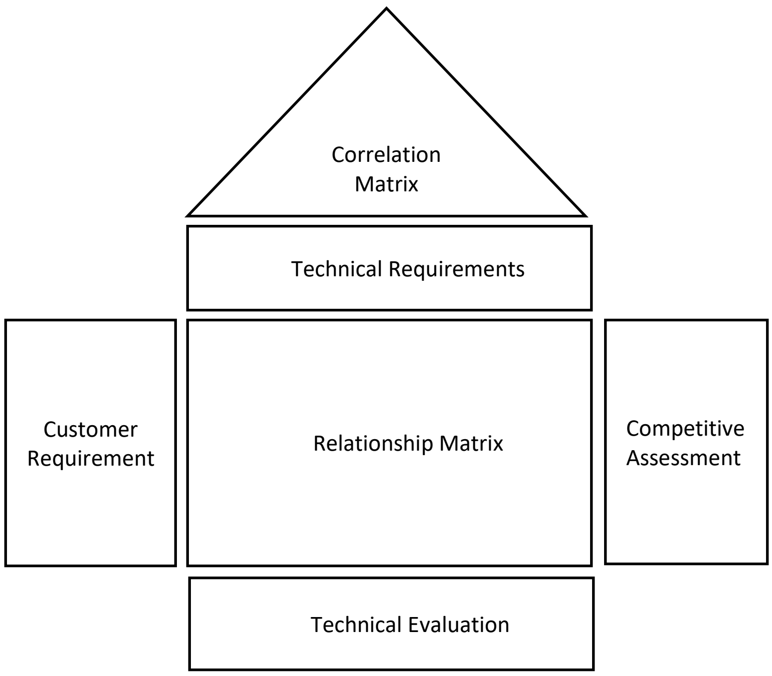
The ε value in the last constraint in the model is accepted as a value such as 10^{-5} or 10^{-6} and is used to ensure that the weights take a value higher than zero in the sign restriction (Tütek et al. 2012: 233).

4. Quality Function Deployment

The QFD method was introduced by Akao in 1966 and first applied in 1972 in the Kobe shipyard of Mitsubishi and is a method based on meeting customer expectations (Kılıç and Babat 2011: 94). The QFD method has found a wide range of applications in product development, service quality, marketing, distribution, etc., as a method that enables the voice of the customer to be transformed into production output. QFD aims to determine customer expectations, to transform these customer expectations into technical requirements, and produce customer satisfaction-oriented products and services (Yıldız and Baran: 2011: 60). QFD is defined as a systematic tool that transforms customer expectations into measurable products and process parameters through a quality matrix (Pakdil et al. 2012: 1398).

In the QFD method, the matrix in which customer expectations are transformed into technical specifications is also called the quality house since it resembles a house in shape (Gündoğdu & Görener 2017: 130). The general structure of the quality house used in the QFD method is shown in Figure 1 (Delice and Güngör 2008: 187).

Figure 1: **General Structure of the Quality Function Deployment Method Quality House**



In QFD applications, customer expectations are determined by collecting the voice of the customer. In the second stage, a QFD matrix also called the quality house, is created to transform customer expectations into technical requirements and to prioritize technical requirements by revealing the relationship between customer expectations and technical requirements (Delice and Güngör, 2008: 187). In QFD applications, customer requirements are taken in the first step, and the importance levels of these customer requirements are determined. In the next step, the technical requirements that must be met in order to fulfill customer expectations are determined, and the relationship between technical requirements and customer expectations is determined. When determining the importance levels of customer expectations, scale values containing numerical scales in different scales can be used. In the next step, the situation of the company in terms of customer demands compared to its competitors is analyzed, and improvement targets for technical requirements are determined. In the last step, the priority weight of each technical requirement is calculated by multiplying the importance levels of customer requirements and the relationship coefficient between technical requirements and customer expectations, and technical requirements are ranked according to their priority weight values (Erdil and Arani, 146). In addition to providing a systematic approach for understanding the voice of the customer and transforming customer expectations into technical requirements, the quality house provides a source of information that will enable a clearer and easier understanding of the situation of the business in competitive conditions compared to its competitors (Delice and Güngör, 187).

5. Application

This study conducted a sample case to implement the proposed model. The application was carried out in a cafe business operating in Şırnak province. 50 customers were asked the question 'List three problems that need to be improved in order to increase the service standard of our business' and customer requirements were determined by evaluating the answers. In the next step, the service conditions that need to be improved in order to meet customer expectations were determined as technical requirements. As a result of the evaluations made with the business manager, it was decided to use a mobile ordering device to follow the orders and to make the account transactions accurately. A call system will be placed on the desks in order to shorten order times and minimize customer waiting times. It was decided to employ two additional staff to minimize customer waiting times and to have a staff member to greet customers arriving at the café, In addition, it has been decided to increase the variety in the menu in line with customer expectations and to subject the personnel to periodic training by experts to provide better service in line with all customer expectations. Customer expectations, technical requirements, the relationship matrix, and the quality house matrix, which show the importance levels of customer expectations, are provided in Table 1. The values in the relationship matrix section in Table 1 were determined according to the QFD method relationship scale. Accordingly, "9" indicates a strong relationship between a technical requirement and a customer expectation, "3" indicates a medium-level relationship, and "1" indicates a low-level relationship. Cells without assigned values indicate no relationship between the technical requirement and the customer expectation at any level. According to the QFD method, the importance values for the service requirements that need to be improved to meet customer expectations and the target values determined for the business in terms of competition were obtained as shown in Table 1. The importance values for the technical requirements in Table 1 were obtained by summing the products of the importance levels for customer expectations and the values in the relationship matrix. For example, the priority value for "Purchase of mobile ordering device" was calculated by performing (3*4) + (9*3) = 39.

After prioritizing the technical requirements to meet customer expectations with the classical QFD application, the improvement costs related to these technical requirements were determined to prioritize the technical requirements by considering the cost values required for improvement. The cost of installing mobile ordering devices was determined as 15.000 TL, the cost of installing a call system on the tables was determined as 20.350 TL for 37 tables, the monthly salary for 2 additional personnel was determined as 36.000 TL for the employment of sufficient personnel, no additional cost was foreseen for increasing the diversity in the menu, and similarly, no cost was foreseen for the training of the personnel since it was considered as in-house training even if a trainer from the relevant field was invited from the university. In the input-oriented CCR model established for the prioritization of technical requirements, the importance levels calculated according to the classical QFD procedure for technical requirements and the competition coefficient of the enterprise for the technical requirement in question are considered as output variables since they are considered values to be maximized. The competition coefficient of rival cafes and the cost items related to technical requirements are considered input variables since they are considered values to be minimized. The input and output variable values used for the input-oriented CCR model are given in Table 2

Table 1: **Quality House Matrix for Cafe Business**

	Purchase of mobile ordering device	Placing a call system on the table	Employment of sufficent number of	Incrasing Diversity in the menu	Training of employees	Important Level	Cafe	Competitor Cafe	Target Value
Don't let orders arrive late.	3		9		3	4	4	4	4
Orders should be taken as soon as possible.		9	9		3	4,3	4	5	5
Someone should greet and show customers to their seats when they enter the cafe.			3		3	3,3	3	5	5
Avoid confusion and delay in account payment transaction	9					3	4	2	4
The menu should include a variety of flavors.				9		3,3	4	3	4
Employess should be friendly and attentive			1		9	4,7	3	4	4
Importance Value	39	39	90	30	77				
Cafe	48	36	84	36	60				
Competıtor Cafe	30	45	100	27	78				
Target Value	48	45	100	36	78				

Table 2: **Input and Output Variable Values for Input-Oriented CCR Model**

		Purchase of mobile ordering device	Placing a call system on the table	Employment of sufficent number of employees	Incrasing Diversity in the menu	Training of employees
OUTPUT	Importance Value	39	38,97	89,62	29,97	76,92
	Cafe	48	36	84	36	60
INPUT	Target Value	48	45	100	36	78
	Cost	15.000	20.350	36.000	0	0

To prioritize the technical requirements using the input and output variable values given in Table 3, the input-oriented CCR model for the first technical requirement is constructed as follows.

Objective Function:

Max: $39\mu_1 + 48\mu_2$

Constraints:

$$48w_1 + 15.000w_2 = 1 \quad (3)$$

$39\mu_1 + 48\mu_2 - (48w_1 + 15.000w_2) \leq 0$

$38{,}97\mu_1 + 36\mu_2 - (45w_1 + 20.350w_2) \leq 0$

$89{,}62\mu_1 + 84\mu_2 - (100w_1 + 36.000w_2) \leq 0$

$29{,}97\mu_1 + 36\mu_2 - (27w_1 + 0w_2) \leq 0$

$76{,}92\mu_1 + 60\mu_2 - (78w_1 + 0w_2) \leq 0$

$\mu_r , \quad w_i \geq \varepsilon \geq 0$

After the input-oriented CCR model for the first technical requirement was created by changing the objective function and the first constraint for all technical requirements, the efficiency values obtained by solving the models and used for ranking the technical requirements, and the ranking values determined according to these efficiency values, are given in Table 3. According to the data in Table 3, since the efficiency value for the first two ranked technical requirements was calculated as "1," the results were obtained by creating a super-efficiency model for ranking purposes.

Table 3: **Efficiency Values and Ranking Values for Technical Requirements**

Technical Requirements	Efficiency Values	Ranking
Purchase of mobile ordering device	0,985	3
Placing a call system on the table	0,9145	5
Employment of sufficent number of employees	0,9364	4
Incrasing Diversity in the menu	1,089	2
Training of employees	1,0985	1

6. Conclusion

QFD is a method that enables the transformation of customer expectations into technical requirements to gain a competitive advantage and to determine the technical requirements that need to be developed first to meet these customer expectations. Although the QFD method is widely used in industry and academia, there are different criticisms about the method in the literature. One criticism is that determining factors of technical requirements, such as cost, are not taken into consideration in the prioritization of technical requirements. However, for example, in today's conditions where the importance of costs for businesses is increasing day by day, healthier results can be obtained for the industry by taking into account the costs in the prioritization of technical requirements that need to be improved to meet customer expectations.

In this study, a sample application in which technical requirements are prioritized by the DEA method to consider costs in the prioritization of technical requirements in the QFD method is presented. In the sample application carried out in a cafe business, it was seen that the ranking obtained by the QFD method and the ranking obtained by the approach where the costs of technical requirements are also considered by the QFD and DEA methods differ. According to the results obtained with the QFD method, the first two technical requirements that need to be improved are "Employment of sufficient number of employees" and "Training of employees," respectively. In the method where QFD and DEA methods are applied together, and costs are also considered, the first two technical requirements to be prioritized are determined as "Employee training" and "Increasing the diversity in the menu," respectively. As in the study conducted by Ramanathan and Yunfeng (2009), where the relative importance ranking of the costs of technical requirements was also taken into account, a different ranking was obtained from the ranking in the classical QFD method in this study, where cost figures were directly considered.

This study is based on the assumption that to obtain more realistic results in the QFD method, the costs of technical requirements, environmental impacts, implementation time, etc., should be considered in the prioritization of technical requirements that need to be improved to meet customer expectations. The sample application made within the framework of the study has revealed that the priority values change when the costs of technical requirements are considered in determining the priorities using the DEA method. The result obtained has led to the opinion that it will be possible to obtain more applicable results for enterprises by considering more factors such as the costs of technical requirements, implementation time, etc., in industrial applications. Prioritisation of technical improvements to be made to meet customer expectations in industrial applications without considering factors such as cost, time, environmental impact, etc. may prevent the achievement of feasible, logical, technically correct results. Therefore, prioritising the technical requirements in academic studies and industrial applications by taking into account the above-mentioned criteria such as implementation time, cost, environmental impact, ease of implementation, etc. and analysing the effect of each criterion on the ranking can contribute to the field.

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