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EDITOR: DOÇ. DR. MİHRİBAN KALKANCI

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Theory and Research in Engineering II

EDITOR

DOÇ. DR. MIHRIBAN KALKANCI

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Chapter 15

A HOUSE OF QUALITY APPLICATION BASED ON A DECISION SUPPORT SYSTEM FOR THE CREDIT CARD MONITORING UNIT OF A BANK



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1. Introduction

In an ever-increasing competitive environment, the establishment of customer relations based on loyalty providing high satisfaction levels is possible by properly perceiving clientele's expectations and delivering the proper service in a fast and effective way. Delivering services better than rival companies and adopting a customer service policy based on the voice of customers is of critical importance to establish a position in the market particularly for companies in the service sector. Finance and banking sectors have become new areas of process improvement methods. The greatest achievement in this respect will be a portfolio of the customers able to make use of fault-free and improved processes.

Quality Function Deployment (QFD) is an approach that enables the realisation of current or new products/services of an enterprise in the most effective way in line with the needs of clientele. For a self-sustainable existence of their companies, managers have to be able to meet the ever-changing needs of their clientele in a fast way while also maintaining high quality in products and services. QFD has been integrated into many services and manufacturing processes since its introduction. It essentially aims to create an optimised process in which the desires of clientele are transformed into measurable performance indicators. QFD is essentially a planning tool that aims at transforming the clienteles' wishes into points of essential quality assurance to be used in the design and production phases with a focus on customers' needs and expectations (Akao, 2003). QFD can be considered as a technique that lays great importance on the voice of customers throughout the whole phases of production and service provision. It gives the companies a competitive advantage concerning corporate structure and customer satisfaction while, at the same time, allowing companies to design their products and services. It is an effective tool that transforms customers' wishes into production/service requirements (Sivasamy et al., 2016).

On the other hand, the decisions which are taken by the managers in the finance sector are of great importance for the success of a bank. A Decision Support System (DSS) is a computer-based system that is designed to support decision-makers in decision-making processes, also shortening the decision-making time (Turban et al., 2007). There exist different QFD definitions, but features such as providing support in all phases of decision-making, enabling users to design flexible and interactive systems, and offering support to individual and group decision-makers through mathematical methods are highlighted in all. QFD is a system that supports decision-makers in semi-structured decision-making phases but does not replace the decision-makers in evaluating the decisions taken (Turban and Aronson, 1998). Decisions that are right, timely and fast help companies

keep their business moving forward in a competitive environment. DSS allow decision-makers to have easy access to decision-making models and data to give them support in semi-structured and non-structured decision-making phases. Therefore, they are effective systems in overcoming the lack of information. Hence, decision-makers in managing positions can improve the quality of their decisions and increase the possibility of making the right decisions by way of analytical models. The aim of DSS is not to impose a decision on decision-makers, but it reveals solution alternatives. In this context, DSS enables users to process both the voice of customers that defines their wishes and technical requirements that reflect the voice of employees to the benefit of the company, and can thus guide companies in a fast and right way in development processes for new products (Sahin and Demirtas, 2019). Dogan (2014) summarises the purposes of a smart DSS-based QFD framework as determining the right actions to be taken to meet the satisfaction of customers using DSS and increasing the competitive advantage of the company through analysing rival companies.

In the current study, a DSS-based House of Quality (HOQ) was developed to improve credit card monitoring unit of a bank by analysing the credit card selection behaviours of university students. The calculations in the HOQ were performed based on the proposed proportional scale. The mathematical operations such as addition, extraction, multiplication, and division cannot be defined in traditional ordinal scales. However, such operations are often used in HOQ to calculate relative weights. Besides, the DSS method also allows even those decision-makers who have limited knowledge about proportional scales to comment results by performing fast and easy calculations utilising DSS. The study provides insights into the most important customer needs as well as the most important technical requirements. To our knowledge, no study is available in the literature that has discussed a DSS-based HOQ application in the finance and banking sector. The use of proportional scale in HOQ is also unique in this sector. The second section of the study contains a literature review on QFD and DSS-based QFD. The third and fourth parts present the proposed approach and the results of the application in the bank involved in the study. The concluding part contains the results obtained in the study and recommendations.

2. Literature Review

It has been observed that studies conducted in recent years on the QFD process have focused on different sectors, particularly on the fields of healthcare (Gündoğdu and Görener, 2017; Aktepe et al., 2018; Demirtaş and Köksal, 2018; Nursaçan and Çetinyokuş, 2020), construction (Kassela et al., 2017; Toptancı and Erginel, 2017; Moghimi et al., 2017), manufacturing (Vinodh and Kumar, 2011; Bhuvanesh and Parameshwaran, 2018; Sahin

and Demirtas, 2019) and so on. Besides these sectors, identifying the needs of customers and the studies of improvement processes are also gaining prominence day-by-day in the banking and finance sector (Shahin et al., 2016).

There have already been some applications in the banking and finance sector based on DSS. Carminati et al. (2015), for instance, developed DSS to analyse online banking fraud analysis in banking transactions. Fraud risks have been identified using data mining as well as statistical and mathematical techniques. Sarıyer (2016) developed a DSS based on fuzzy Analytical Hierarchy Process (AHP) to compare the personnel of a bank in human resources. The proposed system is effective both to compare the employees and also to categorise them. Ignatius et al. (2018) proposed a decision support tool for a credit scoring model based on multi-criteria decision-making principles. While criteria weights are generated by fuzzy AHP, Fuzzy linguistic theory is applied to describe the uncertainties and vagueness arising from human subjectivity. Finally, TOPSIS is used to rank the alternatives by least risk exposure. Gaganis et al. (2020) developed a multi-criteria decision support tool for a credit analyst. They offer a visual of a bank's judgmental analysis, by providing a holistic multicriteria decision support tool in the hands of a credit analyst and enabling a rich inferential procedure to be conducted. Within this framework, a case study was presented, which evaluated the credit risk of 55 banks based in the European Union based on their financial fundamentals.

To the best of our knowledge, this study is the first in which the proportional scale was used in all stages of a DSS-based HOQ (customer importance weights, relationship matrices, improvement factor and selling point) in monitoring credit card unit of a bank.

3. Method

QFD is a systematic approach consisting of planning and communication processes, which ensure inter-disciplinary coordination within an organisation to design, produce, and market the products or services in line with customers' wishes. In other words, it is the whole of the processes that enable the establishment of a correlation between customers' demands and company functions as well as the adaptation of customers' demands into the product or service planning system.

HOQ, which is the most important tool within QFD, transfers customers' requirements into technical requirements. In a HOQ, customers' requirements (CR1 …. CRn) are indicated in rows, and technical requirements (TR1… TRn) are shown in columns. The related technical requirements are determined by a QFD team consisting of engineers, managers, specialists, and designers (Asadabadi, 2017). The distinctive

characteristic of this technique is to evaluate the customers' requirements in integration with current possibilities, rival companies, and solution proposals.

The use of proportional scale in HOQ and the application steps of this technique are represented below:

Defining and weighting the customers' requirements: The first phase in the HOQ is the proper definition of the target market. After the target market has been defined, the requirements regarding products/services should be expressed in the customers' own words. The needs of customers can be determined by way of different methods. The methods most frequently used to better define customers' needs are focus group interviews, questionnaires, face-to-face customer conversations, communications through telephone, fax, and e-mail for wishes, complaints, and proposals as well as feedbacks after events such as exhibitions, fairs, etc.

In a HOQ, relative significance levels are indicated next to the column of customers' requirements. In the traditional approach, a five, seven or nine-point Likert scale can be used regarding customers' requirements. The number "1" in the scale represents the lowest level of importance. Arithmetic means of the customer scores for each requirement is calculated, and the relative importance weight column is formed by normalising the mean values.

In this study, a proportional scale corresponding to the 5-point Likert was used while calculating the relative importance weights. As the arithmetical operations are undefined and invalid in the ordinal scale, a proportional scale was suggested by Demirtaş and Köksal (2018) based on the Analytic Hierarchy Process (AHP). This scale is shown in Table 1. Contrary to the ordinal scale, a fixed value is obtained all the time when the values in the proportional scale are proportioned to one another. Thus, any mathematical operation in the HOQ becomes valid.

Table 1 *Proportional versus Ordinal Scale*

Ordinal Scale	**1**	**2**	**3**	**4**	**5**
Proportional Scale	0.061	0.100	0.161	0.259	0.419

Forming the correlation matrices: In this phase, each customer requirement is translated into one or several technical requirements. At this point, several requirements can come into question from legal requirements such as security, legal regulations, quality levels, and product standards to other requirements such as machines and materials specific to the products produced, environment conditions, and company strategy. Then, the

correlation between customers' requirements and technical requirements is determined. Empty cells in the matrix indicate that no correlation exists between customer/technical requirement pairs. If any correlation exists, its degree is scored as 1 (weak), 3 (medium), and 9 (strong) in the traditional approach. Instead of numbers, relationships between customer and technical requirements can be recorded in the matrix as symbols showing the strength of the correlation (Table 2). Because the nature of the traditional 1-3-9 scale was compatible with the proportional scale, no conversion has been applied to traditional scale for technical requirements.

Table 2 *Proportional Scale for Technical Requirements*

Degree of Correlation	Strong (Θ)	Medium (O)	Weak (Δ)
Proportional Value	9	3	1

After determining the degree of correlation between customer/technical requirements, the relationship between technical requirements is investigated and the roof of HOQ is formed. Symbols are used to define the direction (positive or negative) of the correlation. While the sign (+) between two technical requirements indicates that improvement of one of the characteristics also has an improving effect on the other, the sign (-), on the other hand, indicates deterioration. It is important to take this fact into account in the improvement studies.

Forming the columns of benchmarking, improvement factor, and selling point: For effective planning, it is important to determine the importance of the requirements and the level of satisfaction with the product/service from the customers' perspective**.** In addition, it is important to determine the strengths and weaknesses of existing and competing products/services by benchmarking. It should also be determined what the selling point of the product/service will be if the customer requirements are met and how much improvement is required in the existing product compared to competing products/services. "Improvement factor" and "Selling point" columns are important for calculating the absolute and relative importance weights.

a) Improvement factor: According to the traditional approach, it can be defined as the ratio of the value targeted by firm in terms of a customer requirement to the actual performance of that company. Evaluations of the customer concerning rival companies are also taken into consideration in identifying the targets of the firm.

On the other hand, in the proposed proportional approach, four levels are identified based on the efforts to be made to reach the targeted scores:

'getting much better', 'getting better' 'remaining at the same level' and 'getting worse' when compared with the current status. For instance, while proceeding from 4 to 5 could mean 'getting much better' for a customer when considering the difficulties in business or the efforts to be made, it could mean 'getting better' in terms of another customer. Similarly, a 'worse' performance can be preferred to better focus on improvement efforts if an unjustifiable high performance comes into question in respect of the expectation of a customer. The scale in Table 3 was used to express AHP weighting of competitor level-up.

Table 3 *The proportional scale for the improvement factor*

Levels	Much better	Better	Same	Worse
Proportional Value	0.558	0.263	0.122	0.057

b) Selling point: It defines the influence of the planned improvement on the sales revenues. In the traditional approach, it is expressed in values of 1.0, 1.2, and 1.5, whereby 1.5 means 'it can considerably increase the sales potential', 1.2 means 'it can increase the sales potential' and 1.0 means 'it would have no influence'. Table 4 presents a proportional scale developed for the "selling point".

Table 4 *Proportional Scale for the selling point*

Levels	Major	Minor	No
Proportional Value	0.633	0.260	0.106

After "improvement factor" and "selling point" columns were created using the proportional scale, they were normalized and used in the stage of determining the absolute weights of customer requirements.

Formulas (1-3) were used to calculate the absolute weight of customer requirements (CAWs) and relative weight of customer requirements (CRWs).

i: indices for customer's requirements

CW_i: importance weight of customer requirement i

IF_i: Improvement factor for customer requirement i

SP_i: Selling point value for customer requirement i

$\boldsymbol{CAW_i}$: *Absolute weight of customer requirement i*

$\boldsymbol{CRW_i}$: *Relative weight of customer requirement i (%)*

SCAW: Sum of the absolute weight column of customer requirements

$$CAW_i = CW_i * IF_i * SP_i \qquad \forall i \qquad (1)$$

$$\sum_i CAW_i = SCAW \qquad (2)$$

$$CRW_i = \frac{CAW_i}{SCAW} * 100 \qquad \forall i \qquad (3)$$

Technical evaluation

In this phase, the technical requirements that should be given high priority to meet customers' requirements are identified. The absolute and relative weights of each technical requirement are calculated using Formulas (4-6).

$\boldsymbol{j}$: *indices for technical requirement*

$\boldsymbol{TRAW_j}$: *Absolute weight of technical requirement j*

$\boldsymbol{TRRW_j}$: *Relative weight of technical requirement j (%)*

STRAW: Sum of the absolute weight row for technical requirements

$\boldsymbol{d_{ij}}$: the degree of the correlation between customer requirement i and technical requirement j

$$TRAW_j = \sum_i CAW_i * d_{ij} \qquad \forall j \qquad (4)$$

$$\sum_j TRAW_j = STRAW \qquad (5)$$

$$TRRW_j = \frac{TRAW_j}{STRAW} * 100 \qquad \forall j \qquad (6)$$

After the absolute and relative weights of each column were calculated, the technical requirements having higher weights were determined. In the following phase, the company that conducts the research identifies whether the testing possibility for the measurement of technical requirements is available. The QFD team makes the arrangements necessary for the test and controls. The next phase after the comparative analyses performed by engineers on rival companies is the one in which the performance targets with respect to technical requirements are identified. Comparative analyses enable us both to detect the points needed to be improved and also to identify the strong and weak points compared to competitors.

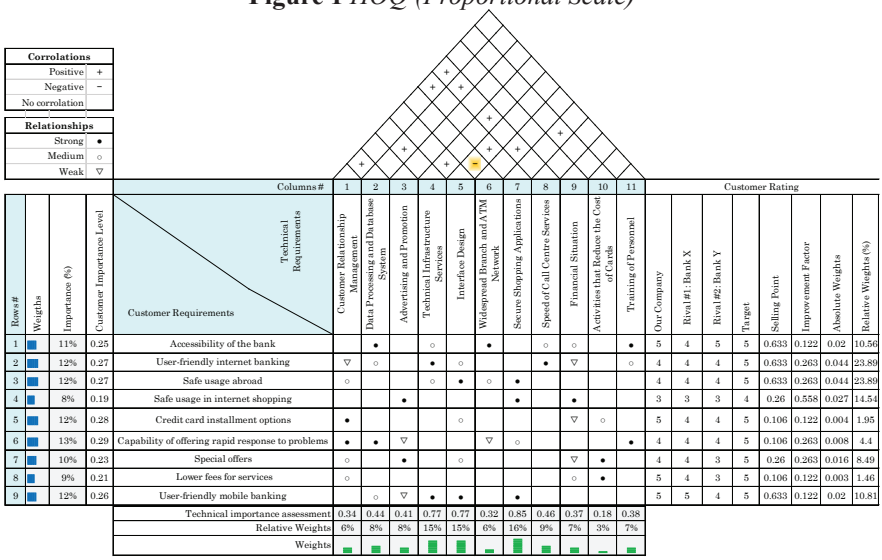
4. A case of application in the banking sector

In the banking sector application, the credit card selection procedure of university students has been analyzed. Then, a DSS has been developed to create HOQ and coded with Excel VBA. The interface developed in this way can be used in companies without the need of purchasing any new software. Even the decision-makers who have limited knowledge about this technique can easily use the Excel software.

The DSS developed in the present study was designed also to systematise the QFD process managed by specialist employees based on the results of customer questionnaires and interviews performed in different periods. In other words, it was designed to provide decision support even when customers' wishes and weights change. It is also possible to use the DSS developed in the study in other service processes with minor modifications. The DSS process aims to provide three main advantages: analysis of survey results through access to previous and current survey reports, assessment of the proportional method in the QFD dimension, and providing target-oriented recommendations on customer needs and technical requirements.

First of all, customer needs were determined with the information obtained from meeting with experts working in the bank and one-to-one interviews with customers of bank in order to listen to customers' voices. To identify the needs of customers, 20 customers were asked in individual interviews to evaluate their needs on a five-point scale. The ''customer needs'' listed in an Excel file using the macro ''weight the customer needs'' were transferred into the HOQ and presented in the column of customer significance degree in Figure 1.

Figure 1 *HOQ (Proportional Scale)*



Correlations	
Positive	+
Negative	–
No correlation	

Relationships	
Strong	●
Medium	○
Weak	▽

Row #	Weights	Importance (%)	Customer Importance Level	Customer Requirements \ Technical Requirements	1 Customer Relationship Management	2 Data Processing and Database System	3 Advertising and Promotion	4 Technical Infrastructure Services	5 Interface Design	6 Widespread Branch and ATM Network	7 Secure Shopping Applications	8 Speed of Call Centre Services	9 Financial Situation	10 Activities that Reduce the Cost of Cards	11 Training of Personnel	Customer Rating: Our Company	Rival #1: Bank X	Rival #2: Bank Y	Target	Selling Point	Improvement Factor	Absolute Weights	Relative Weights (%)
1		11%	0.25	Accessibility of the bank		●		○		●		○	○		●	5	4	5	5	0.633	0.122	0.02	10.56
2		12%	0.27	User-friendly internet banking	▽	○		●	○			●	▽		○	4	4	4	5	0.633	0.263	0.044	23.89
3		12%	0.27	Safe usage abroad	○			○	●	○	●					4	4	4	5	0.633	0.263	0.044	23.89
4		8%	0.19	Safe usage in internet shopping			●				●		●			3	3	3	4	0.26	0.558	0.027	14.54
5		12%	0.28	Credit card installment options	●				○				▽	○		5	4	4	5	0.106	0.122	0.004	1.95
6		13%	0.29	Capability of offering rapid response to problems	●	●	▽			▽	○				●	4	4	4	5	0.106	0.263	0.008	4.4
7		10%	0.23	Special offers	○		●		○				▽	●		4	4	3	5	0.26	0.263	0.016	8.49
8		9%	0.21	Lower fees for services	○								○	●		5	4	3	5	0.106	0.122	0.003	1.46
9		12%	0.26	User-friendly mobile banking		○	▽	●	●		●					5	5	4	5	0.633	0.122	0.02	10.81
				Technical importance assessment	0.34	0.44	0.41	0.77	0.77	0.32	0.85	0.46	0.37	0.18	0.38								
				Relative Weights	6%	8%	8%	15%	15%	6%	16%	9%	7%	3%	7%								
				Weights																			

Besides, the QFD team consisting of specialist, employees identified the technical requirements (Appendix-A) that could be connected with customers' requirements. The list of technical requirements created by the same command was also transferred into the HOQ.

In the second phase, the significance scores were defined in the values of the proportional scale shown in Table 1, combined with geometric means, and transferred into the customer significance column in the HOQ.

The next step involves the identification of the correlation between customers' and technical requirements. The term correlation refers to the influence of a technical requirement indicated in each column on meeting the customer requirement shown in each row. After the transfer of the weight values and other information regarding customer needs, the user is forwarded to the Excel page of HOQ. The input of data concerning the correlation between customers' and technical requirements is easily done using ''the dropdown list'' displayed by clicking on the cells on the page.

Within the framework of the specialist team's views and experiences, a strong correlation was detected between the accessibility of the bank and its data processing and database system, and widespread branch ATM network. The study also reveals a strong correlation between the accessibility of the bank and training of personnel. For example, it ensures fast execution of operations in the branch with the training given to the personnel and personnel who can solve potential problems quickly. The study results indicate a strong correlation between safe usage in internet shopping and advertisements, and promotions. Specialists underlined, in this respect, promotion of any security application is as much important

as the application itself. A weak correlation was detected between the capability of rapid response to problems and advertisements and promotions. Through advertisements, the customers are contacted not direct, but indirectly. It is suggested that while a strong correlation exists between user-friendly mobile banking and interface design, there exists a medium correlation between lower service fees and financial situation. The stronger the financial strength of a bank, the more likely its customers is to pay lower fees for the services they receive. Other correlations between technical requirements and customer requirements are shown in symbols in the HOQ.

The correlation on the roof matrix, on the other hand, is the part in which the effects of technical requirements on one another are discussed. This matrix aims to identify whether technical requirements affect each other negatively or positively (Kelesbayev, 2016). The study suggests that while a negative correlation exists between interface design indicating the user-friendly feature of mobile applications and widespread branch and ATM network, the results indicate the existence of a positive correlation between technical infrastructure services and interface design.

Thereafter, two rival banks with considerable market share were selected to observe the fields where rival companies had a better market position and accordingly take the necessary steps for the future. Apart from that, the customers were asked to evaluate the bank involved in the study and its rivals, as a result of which the QFD team defined the bank's target values for each customer request. Thus, the columns of improvement requirements and sales potential were created using the macro based on the projected and realised performance.

All the calculations in the HOQ (absolute and relative weights for customers' requirements, and absolute and relative weights for technical requirements) were performed in accordance with the proportional scale. In other words, the macro "Calculate According to the Proportional Scale'' performed the calculations in all the cells in the HOQ based on the values that correspond to the ones of the proportional scale. The macro ''Interpret'' was used to evaluate the values calculated. The results of the analysis were presented to the customers utilising the inference mechanism available in the dimensions of ''customer needs'' and ''technical requirements'' in the DSS. Upon activation of the ''Interpret'' macro, customer wishes and technical requirements were ranged by relative weight values, and the technical requirements with the highest significance degree were displayed. Additionally, target values for technical requirements were extracted from the database created based on the views of the specialists in the QFD team and presented to decision-makers through the same macro. As it is, the system provides essential proposals to end-users.

The results obtained in the calculations performed in the DSS-based HOQ are discussed in the following paragraphs:

The customer wishes with the highest relative weight according to the proportional scale were ‘’user-friendly internet banking’’ and ‘’secure usage abroad’’ with 23.89%, followed by ‘’secure usage in internet shopping’’ with 14.54%, and ‘’user-friendly mobile banking’’ with 10.81%. The relative weight values of other customer wishes are presented in Figure 1. The technical requirement with the highest relative weight was ‘’secure shopping applications’’ with 16%, followed by ‘’technical infrastructure services’’ and ‘’interface design’’, both with a weight value of 15%, and ‘’speed of call centre services’’ with a weight value of 9%. To enhance these applications, “expanding the 3-D secure shopping domain’’ was identified as the target value. ‘’Providing individual services using artificial intelligence applications’’ was identified as the target to enhance the technical infrastructure services. The target defined for interface design was ‘’Providing a tailored interface based on the transactions frequently used by users’’. The target identified to enhance the service quality in this respect was ‘’being able to access to the call centre in less than two minutes’’.

5. Results

In this study, QFD technique was used and improvement suggestions were presented for banks to meet the expectations of university students, who have an important place in the market share. The present study provides a HOQ based on the DSS developed through a proportional scale, which is relatively new used. This proposed method was implemented in the process of determining the technical requirements concerning the wishes and expectations of clientele for credit cards. The aim was to help the decision-making team managing the process to develop fast responses utilising DSS. The study has provided the target values regarding the wishes/expectations of the clientele, and the technical requirements that should come into focus. The DSS based HOQ aimed to enhance customer satisfaction through properly analysing the customers’ voice. In the proposed interface with Excel VBA support, ease of use and access for decision makers who are not experts in quality techniques are at the forefront. The mechanism that supports decision-makers in taking fast and proper decisions also enables users to take into account customer expectations in different periods using integrating survey data into the system. Thus, information regarding customers’ and technical requirements can also be easily transferred into the HOQ using the macros. In order to overcome the disadvantages of the traditional scale, absolute and relative weights are easily calculated for customers’ and technical requirements with the newly proposed proportional scale, so decision maker is supported in the

interpretation of the results. In addition, assistance is available on what the target values will be for key technical requirements.

When the importance weights of customer requirements are evaluated, convenient internet banking applications and safe usage in internet shopping abroad have come to the fore. It was followed by handy mobile banking. Nowadays mobile banking has gained importance thanks to the widespread usage of mobile phones. Providing special offers and discount to mobile banking users has become an important factor for banks to attract students in credit card selection decisions. The results regarding the relative weights of technical requirements show that secure shopping is the most important one, followed by technical infrastructure services, interface design, and speed of call centre services.

Customer satisfaction can be enhanced using customer-tailored service delivery when the services of a bank regarding technical infrastructure reach an adequate level. Interface design is another requirement that is important for students. Interface design is also important for students to enable them to complete the transactions in a shorter time both in mobile applications and internet banking.

Ultimately, call centre services are also very important concerning meeting the customers' expectations and solving their problems, because customers always prefer to have access to services in the most rapid way. Advertisements and promotion are important factors as well, but it has been observed that students lay less importance on these factors than other technical requirements. As a result of the rapid increase and change in the amount of data and customer requests, it is thought that the possible benefits of the predictability of customer expectations will spread the DSS-based QFD process. In future studies, it is possible to work on the DSS-based QFD process that can be integrated with mathematical modelling in order to optimize the target values.

Conflict of Interest

The authors have no conflicts of interest to declare.

Appendix-A. The list of technical requirements

Customer Relationship Management refers to the proper guidance of all the units in a bank to meet the expectations of customers and ensure the satisfaction.

Data Processing and Database System refer to the technical requirement that aims to provide and develop the necessary infrastructure for transactions and storing the database throughout the bank.

Advertising and Promotion refer to take part in the printed and

visual media to catch the attention of customers and awake curiosity in customers.

Technical Infrastructure Services refer to the strengthening and enhancing of a bank's security system using state-of-art technology.

Interface Design refers to the design and usefulness of mobile and online banking applications used today.

Widespread Branch and ATM Network refers to the number of branches and ATMs of a bank.

Secure Shopping Applications refer to the work of banks with companies in order to provide card security for the customers' credit card payments, especially in online shopping.

Speed of Call Centre Services refers to the waiting time in queue, fast processing time and fast services of call centre.

Financial Situation refers to the financing allocated to the bank by the holding or capital owner behind the bank.

Activities that Reduce the Cost of Cards refer to creating advantages to reduce the cost of the card reflected on the customer.

Training of Personnel refers to the requirements that involve the training given to the employees concerning essential banking services, human relations, and training programmes regarding customers.

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