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Service Development using Fuzzy QFD in the banking industry

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ABSTRACT

Purpose: This paper proposes a structured approach based on Quality Function Deployment (QFD) for service development in the banking industry.

Methods: SERVQUAL is modified and adopted as a tool to understand customer requirements for the QFD. Fuzzy theory is used to resolve the subjectivity and ambiguity of customer requirements and satisfaction. This research also uses the importance- satisfaction model to construct an additional House of Quality (HOQ). A pair of houses of quality provides a confluence of results to avoid a risk of depending solely on the results of a single HOQ.

Results: A case study is introduced with three domestic banks.

Conclusion: The proposed approach effectively addresses a service development problem.

Key Words: Service Development, Quality Function Deployment, SERVQUAL, Importance-Satisfaction Model, Fuzzy Set Theory, Confluence of Results

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1. Introduction

Financial services are more complex than other services and deserve more attention (Lee et al. 2010). Customers are increasingly involved in service development, because they can choose to use or not to use services and thus have a direct impact on the success of the services (Tsai et al. 2011). Any strategy for service development is outdated and ineffective without considering potential customer patterns, needs, or backgrounds, as it fails to include critical factors that influence service success. A systematic approach is required for a financial service firm to analyze customer expectations and needs and to improve an existing financial service or to develop a new one (Gustafsson et al. 1999; Yu and Kwak 2015).

Quality function deployment (QFD) is used as a cross-functional tool for customer satisfaction (Erginel 2010). The QFD is a well-known technique as a structured framework to incorporate the "voice of the customer (VOC)" into product design (Sireli et al. 2007). The QFD can systematically transform market-based customer needs into detailed specifications for products and services.

A trouble with the QFD is that understanding customers' needs may be a challenge due to problems with capturing, understanding, and organizing these inputs (Sireli et al. 2007). Another problem is that vagueness is associated with linguistic judgments used in the QFD (Vinodh and Kumar Chintha, Suresh 2011). Human assessment and judgment on qualitative attributes are particularly subjective and imprecise. Thus, the input information of human perception can be ambiguous. Inherently vague and ambiguous are various inputs in the form of linguistic variables such as human perception, judgment, and evaluation on importance of customer requirements (Kwong et al. 2011).

SERVQUAL provides a very good tool for measuring and managing service quality. The original SERVQUAL was first proposed by Parasuraman et al. (1985) as a survey instrument. The SERVQUAL can also be used to identify customer needs and requirements, and should be modified and customized for a particular service (Paryani et al. 2010).

Fuzzy set theory helps measure the ambiguity of concepts that are associated with human beings' subjective judgments (Benitez et al. 2007). Zadeh (1965) first proposed fuzzy set theory, and Bellman and Zadeh (1970) described the decision-making method in fuzzy environments. Zadeh (1975) and Mandami and Assilian (1975) developed fuzzy logic, introducing a concept of approximate reasoning. They also showed that vague logical statements enable the formation of algorithms that can use vague data to derive vague inferences. Modeling using fuzzy sets has proven to be an effective way for formulating decision problems, in which the information available is imprecise and subjective (Zimmermann 1996). Thus, fuzzy set theory is a valuable approach to strengthen the comprehensiveness and reasonableness of the decision-making process (Benitez et al. 2007).

Ko and Lee (2000) developed a set of strategies based on a strategy formulation instrument with the Quality Function Deployment for the banking industry. The proposed strategy formulation framework integrated strategy formulation tools from both the Eastern and Western cultures and allowed intercultural adaptations for most organizations. Shih et al. (2011) used importance-performance analysis and balanced scorecard to analyze the quality gap of intellectual capital for the banking industry. They explored the gap

in the operations of intellectual capital, perceptions of employees' performances, and the emphasis placed by customers in the banking industry. Chien and Chen (2010) investigated the relationship between product development and each of customer involvement, supplier involvement, and cross-functional integration in the financial service industry. Tsai et al. (2011) diagnosed managerial strategies for reducing the gaps between customer perceptions and expectations to ensure the success of new product development in the credit card industry. Sarathy (2013) determined important factors that influence the Total Quality Management (TQM) practice in the real estate industry, by using the Analytic Hierarchy Process (AHP).

Most of the literature, however, is limited to analyzing the gaps between customer perceptions and expectations or investigating critical factors for product development in the financial service industry. A small number of studies in the financial service industry adopted the QFD as a structured framework, but did not address the vagueness associated with linguistic judgments used in the QFD.

This research proposes a systematic approach based on the QFD for service development in the banking industry. The SERVQUAL is adopted as an effective tool to understand customers' needs. The SERVQUAL is modified to provide the QFD with customer requirements and satisfaction in the banking industry. The fuzzy set theory is used to address the subjectivity and ambiguity of customer requirements and satisfaction in the QFD. This paper also uses the importance-satisfaction model for an additional QFD analysis to seek a confluence of results from a pair of houses of quality (Larose 2004). This is an effort to avoid a risk of depending solely on the results of a single HOQ.

The rest of the paper is organized as follows. The next section sequentially explains quality function deployment, SERVQUAL, and fuzzy set theory. A case study is introduced with three domestic banks in Section 3. Section 4 presents the proposed QFD approach for the banks considered. An additional QFD analysis is provided for a confluence of results in Section 5. Conclusions follow in the last section.

2. Methodologies

2.1 Quality Function Deployment

Fig. 1 shows the House of Quality (HOQ), the basis for the QFD concept. The customer requirements (CRs) or "whats" are listed in the left wing of the HOQ. Each of these requirements has an importance value elicited from customers usually through surveys, interviews, or focus groups (Sireli et al. 2007). The importance values are located in the third column of Fig. 1. The central element of the HOQ in Fig. 1 is the relationship matrix. The HOQ lists service characteristics (SCs) or "hows" horizontally along the top of the relationship matrix. The relationship matrix describes the strength of the relationship between each pair of variables CR and SC. The "roof" represents the correlation between each pair of SCs, while the far right wing of the HOQ shows the competitive evaluation of competing alternatives.

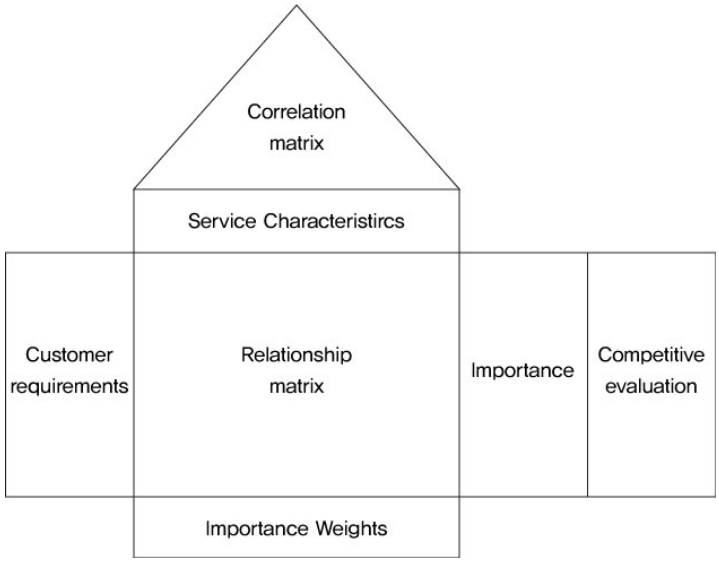


Figure 1. The house of quality

At the bottom of the HOQ are the importance weights of SCs. The importance weight of each SC for customer requirements is quantitatively computed by matrix row and column operations. Importance weight IW_j for SC_j, j = 1, 2, 3, ⋯, m, can be calculated by

$$IW_j = \sum_{i=1}^{l} W_i \cdot r_{ij} \tag{1}$$

where $W_i =$ the degree of importance for CR_i, i = 1, 2, ⋯, l,

$l =$ the number of CRs, and

$r_{ij} =$ the numerical value representing the strength of the relationship between CR_i and SC_j.

The QFD evaluates the impact values of service characteristics (SCs) on meeting customer requirements (CRs) by prioritizing the SCs based on their importance weights (Sireli et al. 2007).

The construction of the HOQ starts with customer requirements. The SERVQUAL is introduced to identify key customer requirements in the banking industry. The SERVQUAL is also used to measure customer satisfaction of bank services.

2.2 SERVQUAL

Service quality has become an important research topic, because of its relationship with costs, profitability, and customer satisfaction and retention (Buttle 1996). However, it is often challenging to measure service quality. The SERVQUAL has been used as a survey instrument to measure service quality (Sahney et al. 2004). The SERVQUAL has the following five dimensions (Buttle 1996, Park et al. 2012):

• Tangibles: The appearance of physical facilities, staff members, and equipment

- Reliability: The ability to provide the promised service accurately and dependably
- Responsiveness: The willingness to perform fast service and to help customers
- Assurance: The knowledge and courtesy of staff members and their ability to convey confidence and trust
- Empathy: Caring and individualized attention to customers

The SERVQUAL consists of 22 statements in the five dimensions. Four to five statements are used for each dimension. The survey results are collected into the five dimensions.

When the SERVQUAL is used for a specific problem, however, it should be modified based on the expectations of customers (Paryani et al. 2010). An adaptation of their scale may be desirable when a particular service is dealt with (Parasuraman et al. 1988).

2.3 Fuzzy Theory

Let the universe of discourse X be the subset of real numbers R. Fuzzy set A $=\{(\chi,\mu_A(\chi))|\ \chi\in X,\ \mu_A(\chi)\in[0,1]\}$ is a set of ordered pairs, in which $\mu_A(\chi)$ is called a membership function. The membership function can take a value from the closed interval [0,1]. The greater $\mu_A(\chi)$ is, the stronger the truth of the statement that element x belongs to set A is. The function $\mu_A(\chi)$ is defined by equation (2) with a triplet (c_1,c_2,c_3):

$$\mu_A(\chi)=\begin{cases}\dfrac{\chi-c_1}{c_2-c_1},\ c_1\le\chi\le c_2\\ \dfrac{\chi-c_3}{c_2-c_3},\ c_2\le\chi\le c_3\\ 0,\ \text{otherwise.}\end{cases}\tag{2}$$

Each linguistic term can be characterized by a triangular fuzzy number that represents its approximate value range between 0 and 7, and denoted as(c_1,c_2,c_3), where $0\le c_1\le c_2\le c_3\le 7$ (Verkuilen 2005; Benitez et al. 2007; Erginel 2010). c_1 and c_3 are the lower and upper bounds, and c_2 is the most likely value of the linguistic term, respectively.

Table 1. Triangular fuzzy numbers

Linguistic terms	very low	low	moderate	high	very high
Fuzzy number	(1,1,2)	(1.5,2.5,3.5)	(3,4,5)	(4.5,5.5,6.5)	(6,7,7)

Table 1 shows the default values of the linguistic terms used in this paper (Verkuilen 2005; Erginel 2010). The membership functions can be calculated by equation (2). Linguistic terms such as satisfaction and importance degrees can be fuzzified by triangular fuzzy numbers. For each survey statement, group opinions of n respondents are aggregated as the average fuzzy number of n triangular numbers by equation (3):

$$A = (c_1, c_2, c_3) = (\frac{1}{n}) \bullet (A_1 \oplus A_2 \oplus ... A_n) \tag{3}$$
$$= (\frac{\sum_{k=1}^{n} c_1^{(k)}, \sum_{k=1}^{n} c_2^{(k)}, \sum_{k=1}^{n} c_3^{(k)}}{n})$$

where $\bullet$ is the multiplication of a scalar and a fuzzy number, $A_k = (c_1^{(k)}, c_2^{(k)}, c_3^{(k)})$, k = 1, 2, 3..., n, and $\oplus$ is the add operation of fuzzy numbers (Bandemer and Gottwald 1995). A is the average of n responses for a survey statement. Equation (3) shows that the overall average can be represented by a new triangular fuzzy number (Buckley 1985).

The last step is to defuzzy the information obtained by equation (3). A fuzzy number is the result of fuzzy synthetic decision of each alternative (Tsaur et al. 2002). Thus, defuzzification is required to convert the fuzzy number into a crisp real number. The procedure of defuzzification is to locate the Best Nonfuzzy Performance (BNP) value. This research uses equation (4) for defuzzification (Chen 1996):

$$Z_A = \frac{c_1 + 2c_2 + c_3}{4} \tag{4}$$

Z_A is used to construct the HOQ in this paper. That is, Z_A is used to represent the levels of importance and satisfaction for each CR in the HOQ.

3. A Case Study

A case study was carried out with three representative domestic banks: Nonghyup, Busan Bank, and Kookmin Bank. Nonghyup is a government-invested bank, Busan Bank is a local bank in Busan, and Kookmin Bank is the largest bank in Korea, respectively.

The SERVQUAL was changed to reflect customer requirements for bank services. Survey statements were prepared considering the SERVQUAL to measure both the importance and satisfaction of the customer requirements. A total of 207 responses were collected by the survey. 7 responses were unreliable and excluded, leading to 200 responses analyzed. Out of the 200 respondents, 24.5% of the respondents used Nonghyup, 29.5% of the respondents chose Busan Bank, and 30% selected Kookmin Bank as their main banks. The remaining 16% used other banks.

4. Results

4.1 Customer Requirements (CRs)

The SERVQUAL (Parasuraman et al. 1988) was adopted and modified to construct part of the HOQ for

the banking industry based on a literature survey (Ko and Lee 2000; Shih et al. 2011; Tsai et al. 2011). The modified SERVQUAL was used as customer requirements (CRs) for the HOQ. Table 2 shows the details (Yu and Kwak 2015).

Table 2. Customer requirements

Dimension	Code	CRs
Reliability	CR1	Jobs are accurately done.
	CR2	Customers are kept posted on job progress.
	CR3	Customers' questions and requests are sincerely resolved.
	CR4	Services are provided by the time promised.
	CR5	Customers' requests are resolved right the first time.
Assurance	CR6	Employees are knowledgeable about their jobs.
	CR7	Security systems are constructed very well.
	CR8	It is convenient to use internet and phone banking.
	CR9	Employees provide customers with confidence.
Responsiveness	CR10	Prompt services are provided.
	CR11	Employees are always ready to respond to customers' requests.
	CR12	Waiting times are short.
Empathy	CR13	Individual attention is provided to customers.
	CR14	Employees kindly respond to customers.
	CR15	Employees are willing to resolve customers' requests.
	CR16	Employees understand customers' specific needs.
	CR17	Employees have customers' best interests at heart.
Tangibles	CR18	Employees are properly dressed.
	CR19	Facilities are clean and easy to use.
	CR20	The customer lounge is clean and comfortable.
	CR21	Reading materials for service are easy to read (pamphlets, brochures, etc.)
	CR22	Branches are easily accessible (short distance, many branches, etc.)

In addition to basic personal information such as gender, age, and main bank, the survey for this study had two sections: 'the level of importance for each CR' and 'the level of satisfaction for each CR.' The levels of importance represent the areas of greatest interest and highest expectations (Evans and Lindsay 2008). On the other hand, the levels of satisfaction are to measure what customers perceived from their banks. In the two sections, a 5-point scale was used for all survey statements: very low, low, moderate, high, and very high. The fuzzy set theory was introduced as an effort to resolve the subjectivity and ambiguity of customer requirements and satisfaction in the survey results. For example, even if several respondents choose the same point 'high' on the likert scale for CR1, 'jobs are accurately done,' in the importance section, there can be ambiguity in their views meaning different values even in the same choice 'high.' In addition, there is ambiguity on the border between two scale points, for instance, 'high' and 'very high (Hedayatpanah 2011).'

Table 3. Importance for each CR in fuzzy and defuzzified numbers

Customer Requirements	$A = (c_1, c_2, c_3)$	Z_A
CR1	(4.8175, 5.8075, 6.3975)	5.708
CR2	(3.9225, 4.9075, 5.7325)	4.868
CR3	(4.8375, 5.8375, 6.4225)	5.734
CR4	(4.62, 5.62, 6.27)	5.533
CR5	(4.47, 5.47, 6.155)	5.391
CR6	(4.52, 5.515, 6.2)	5.438
CR7	(5.1375, 6.1375, 6.5425)	5.989
CR8	(4.9025, 5.8825, 6.3825)	5.763
CR9	(4.825, 5.815, 6.375)	5.708
CR10	(4.825, 5.815, 6.385)	5.71
CR11	(4.75, 5.74, 6.335)	5.641
CR12	(4.4525, 5.4475, 6.0775)	5.356
CR13	(4.37, 5.35, 6.05)	5.28
CR14	(4.8125, 5.7925, 6.3875)	5.696
CR15	(4.7475, 5.7325, 6.3425)	5.639
CR16	(4.6, 5.59, 6.235)	5.504
CR17	(4.5025, 5.4925, 6.1075)	5.399
CR18	(4.2, 5.185, 5.95)	5.13
CR19	(4.545, 5.53, 6.22)	5.456
CR20	(4.545, 5.53, 6.245)	5.463
CR21	(4.1875, 5.1625, 5.9075)	5.105
CR22	(5.115, 6.1, 6.545)	5.965

When a response to CR1, 'jobs are accurately done,' was 'high' in the importance section, for example, this can be converted to fuzzy number (4.5, 5.5, 6.5) from Table 1. Next, average A can be obtained by equation (3) from 200 responses for CR1. Finally, A can be defuzzified into Z_A by equation (4). In this way, importance for each customer requirement can be obtained as in Table 3. The defuzzified figures in Table 3 are used as importance for CRs in the HOQ.

Table 4. Satisfaction for each CR in defuzzified numbers

Customer Requirements	Satisfaction	Satisfaction Nonghyup	Satisfaction Busan Bank	Satisfaction Kookmin Bank
CR1	5.064	5.061	5.076	5.2
CR2	4.225	4.01	4.208	4.479
CR3	5.034	4.98	4.877	5.292
CR4	4.75	4.684	4.75	4.683
CR5	4.586	4.49	4.665	4.629
CR6	4.78	4.622	5	4.779
CR7	4.669	3.878	5.051	4.95
CR8	5.269	5.546	5.114	5.467
CR9	4.896	4.786	4.903	5.083
CR10	4.713	4.684	4.682	4.833
CR11	4.719	4.663	4.746	4.838
CR12	3.609	3.526	3.814	3.292
CR13	4.39	4.556	4.246	4.558
CR14	5.105	5.332	5	5.188
CR15	4.909	4.893	4.903	5.021
CR16	4.583	4.495	4.614	4.679
CR17	4.419	4.321	4.542	4.483
CR18	5.258	5.179	5.411	5.304
CR19	5.28	5.219	5.225	5.454
CR20	5.278	5.286	5.148	5.421
CR21	4.63	4.628	4.521	4.65
CR22	5.183	5.745	5.424	4.971

Table 4 shows the level of satisfaction for each bank and the overall satisfaction level, both for each CR in defuzzified figures. The defuzzified figures in Table 4 are obtained by using the same procedure as in Table 3. The overall satisfaction level is derived not only from the three banks but also from the other 16% of the banks in the survey. The levels of satisfaction for each bank are used for competitive evaluation in the HOQ. In the competitive evaluation, the three banks are relatively compared on the same scale for each CR. Of the three banks considered in this study, Nonghyup turned out to be consistently weak in customer satisfaction despite its many branches as a government-invested bank.

For example, the level of satisfaction for Nonghyup is lower than those for the other two banks in CR2, 'Customers are kept posted on job progress.' Several banks use text messages for the progress of special tasks such as loan approvals that take several days or weeks. Nonghyup needs to actively consider not only text messages but also smart phone applications with a notice function to provide customers with more detailed information. Nonghyup also has very low levels of satisfaction for CR6, 'Employees are knowledgeable about their jobs, and CR9, 'Employees provide customers with confidence,' compared with the

other two banks. Nonghyup needs to reinforce training programs to boost employees' knowledge and skills. In addition, Nonghyup should establish a new evaluation system for employees and quality control methods for employees' services.

Many banks actually investigate customer satisfaction for their services. When this does not work very well, Nonghyup needs to go further to control the quality of its services more systematically. That is, Nonghyup should not only evaluate the service quality of the frontline employees who deal directly with customers, but also improve its overall service processes behind the frontline employees.

Compared with Kookmin bank, both Nonghyup and Busan Bank have low levels of satisfaction for CR11, 'Employees are always ready to respond to customers' requests.' Above all, both banks need more training programs to improve employees' attitudes towards customer service. They also need to reinforce online systems to deal with CR11. Banks have traditionally used web sites and phone services to resolve customer requests online. With smart phone applications that enable one-on-one talks, customers can contact their banks for their requests anytime anywhere. Busan Bank also has the lowest level of satisfaction for CR13, 'Individual attention is provided to customers,' compared with the other two banks. Among others, it can consider the option of an enlarged screen of automatic teller machines for elderly people. It can also introduce more facilities for disabled people. For example, web sites of the bank can be designed better for blind or visually impaired people using screen readers.

It can be said from Tables 3 and 4 that a bank with higher levels of satisfaction for important CRs can satisfy customers more efficiently. Important CRs are the ones with higher levels of importance in Table 3. Every bank has limited resources. Thus, it needs to focus on important CRs first. It is efficient to meet more important CRs than less important CRs with the same limited resources for more customer satisfaction. The more satisfied customers are, the bigger customers' loyalty and intention to continue their business are.

4.2 Relationship Matrix and Correlation Matrix

The next step is to extract service characteristics required to meet customers' requirements. Several interviews and brainstorming meetings were carried out with two financial experts in the banking industry to generate 21 service characteristics that were directly related to customer requirements. For example, CR2, 'Customers are kept posted on job progress,' is related to several SCs including computer systems and SMS notification service, and so on. CR7, 'Security systems are constructed very well,' on the other hand, is related to SCs such as modern facilities and the financial status of the bank. Computer systems, internal regulations, and customer call center were related to CR15, 'Employees are willing to resolve customers' requests.' Extracted for CRs related to physical elements were SCs such as parking facilities, branch interior, the size of the bank, automatic teller machines and so forth. Twenty one SCs were finalized in total by the two financial experts as shown in Table 5.

Based on the customer requirements and service characteristics, the relationship and correlation matrixes of the HOQ were constructed with importance weights of the SCs. The opinions of two financial ex-

perts in the banking industry were also used in this stage. Fig. 2 shows the correlation matrix that provides the correlation between any pair of SCs. Four symbols are used to represent the correlations. This research uses the symbol ▲ to denote a strong positive correlation, ◇ for a positive correlation, ● to denote a strong negative correlation, and □ for a negative correlation. For example, SC13, automatic teller machines, has a positive correlation with SC12, the size of the bank, because bigger banks have more automatic teller machines. On the other hand, the SC13 has negative correlations with SC9, workloads, and SC7, the number of employees. That is, automatic teller machines lead to reducing the number of employees or workloads.

Table 5. Service characteristics

	SCs
SC1	Computer systems
SC2	SMS notification service
SC3	Internet banking/phone banking
SC4	Customer call center
SC5	Employee training
SC6	Knowledge sharing among employees
SC7	The number of employees
SC8	Continuous customer management
SC9	Workloads
SC10	Internal regulations
SC11	The financial status of the bank
SC12	The size of the bank
SC13	Automatic teller machines
SC14	The number of branches
SC15	Parking facilities
SC16	Modern facilities
SC17	Branch interior
SC18	Branch layout
SC19	Interest rates
SC20	A variety of financial products
SC21	Fees

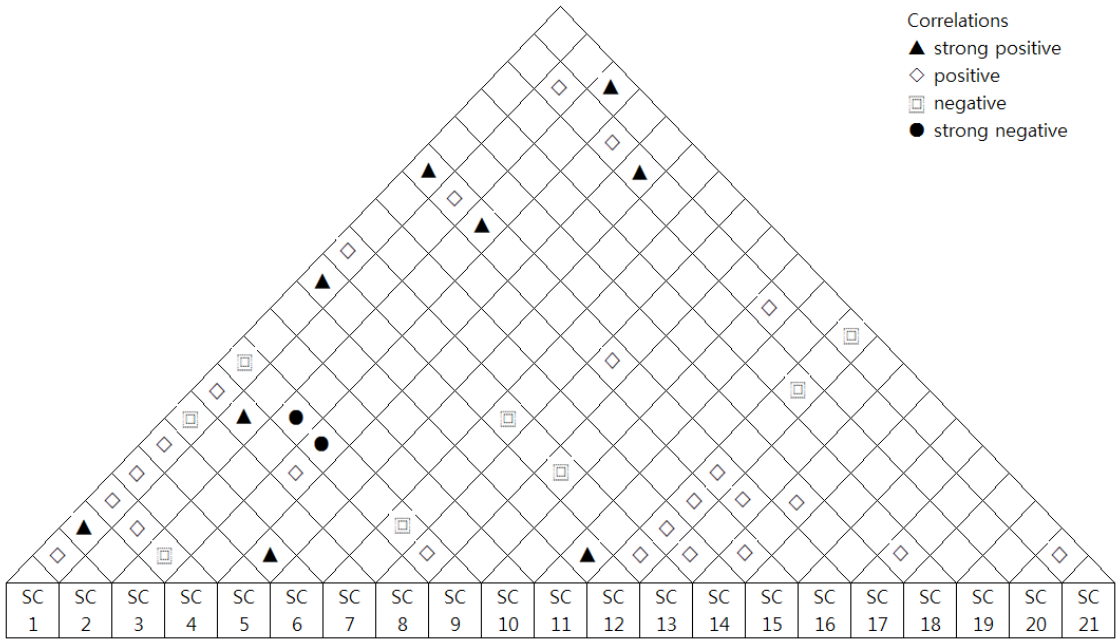


Figure 2. Correlation matrix

Fig. 3 presents the relationship matrix between CRs and SCs. The symbol △ indicates a weak relationship with 1 point, O denotes a medium relationship with 3 points, and ◎ represents a strong relationship with 5 points. For example, CR6, 'employees are knowledgeable about their jobs,' has a medium relationship with SC10, internal regulations, with 3 points. The CR6 has strong relationships with SC5, employees training, and SC6, knowledge sharing among employees, all with 5 points.

The degree of importance for each CR is provided in Table 3. The degrees of importance for CRs are combined with the values of the relationship matrix to calculate importance weights. The importance weight for each SC can be calculated by equation (1). The results obtained by equation (1) are presented at the bottom of Fig. 3 and in Table 6. In addition, normalized importance weights are calculate and added into Fig. 3 and Table 6. The normalized importance weights are calculated by setting the maximum value to 100, the minimum value to 0, and intermediate values to relative values between 0 and 100. SC5, Employee training, received the highest points, 505, followed by SC8, Continuous customer management, with 490 points, SC9, Workloads, with 422 points, and SC4, Customer call center, with 360 points. The importance weights in Table 6 can be used to determine the priority of quality improvements for service characteristics in the process of service development. The normalized importance weights are used to catch the relative differences of the importance weights better.

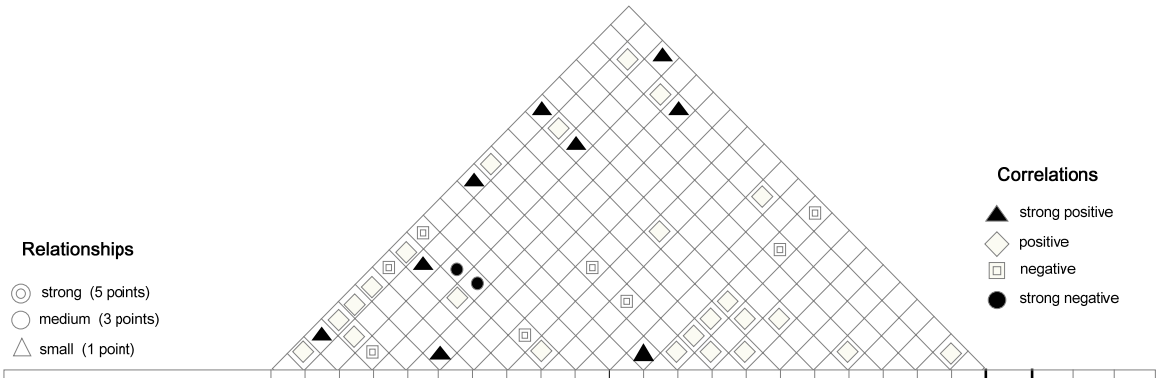
Relationships ◎ strong (5 points) ○ medium (3 points) △ small (1 point) Service Characteristics (SCs) / Customer Requirements (CRs)	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6	SC 7	SC 8	SC 9	SC 10	SC 11	SC 12	SC 13	SC 14	SC 15	SC 16	SC 17	SC 18	SC 19	SC 20	SC 21
CR1	◎	○	○	◎	◎	◎	◎	◎	◎	○	△	△	△	○		○		△		△	
CR2	○	◎	△	◎	◎	○	○	○	○	△		△		△		○		△			
CR3	○	○	○	◎	◎	○	◎	◎	◎	○		△		△		△	△	△			
CR4	◎	◎	○	◎	◎	○	◎	◎	◎	○			○	○	○	○		△			
CR5	◎	○	○	◎	◎	◎	◎	◎	◎	△			○	○		○			○	○	○
CR6	○	△	△	△	◎	◎	○	◎	◎	○			△							○	
CR7	◎	○	◎	○	○	△	△	△	○	○	△	○	○	○		○	△	△			
CR8	◎	○	◎	○	○	△	△	○	○	△	△	◎	○	○		○					
CR9	○	△	△	◎	◎	◎	○	◎	◎	△		△	○	△		○	△	△	○	○	○
CR10	◎	△	◎	○	◎	○	◎	◎	◎	△		△	○	◎	△	○	△	△			
CR11	○	○	○	○	○	○	○	◎	○	△			○	○		○	△	△			
CR12	○	△	◎	○	◎	○	◎	○	◎	△		○	◎	◎		◎					
CR13	△	△	△	◎	◎	△	◎	◎	◎	△				○	△	△	○	○			
CR14	△	△	○	○	◎	○	○	◎	◎	△			○	○		○		○			
CR15	△	△	○	◎	◎	◎	◎	◎	◎	○			△		△	△					
CR16		△	△	◎	◎	◎	△	◎	◎	○		△		△	△	△					
CR17			△	△	◎	△	△	○	△	△	○	○	△	△	△	△	△	△	◎	◎	◎
CR18					◎		△	◎	△	◎		○		○							
CR19	○	△	○			△		○	△	△		○	◎	○	◎	◎	◎	◎			
CR20	△				◎	◎		◎	△	○		△	△	△	△	○	◎	◎			
CR21					○	○		○		○		◎				△	◎	◎		△	
CR22	△	△	△									◎	◎	◎	◎	◎	◎	◎			
Importance Weights	313	210	287	360	505	353	332	490	422	236	34	205	248	285	107	301	160	193	60	87	60
Normalized Importance Weights	59	37	54	69	100	68	63	97	82	43	0	36	45	53	15	57	27	34	6	11	6

Figure 3. Relationship matrix

Table 6. Importance weights for service characteristics

	SCs	Importance weights	Normalized importance weights
SC1	Computer systems	313	59
SC2	SMS notification service	210	37
SC3	Internet banking/phone banking	287	54
SC4	Customer call center	360	69
SC5	Employee training	505	100
SC6	Knowledge sharing among employees	353	68
SC7	The number of employees	332	63
SC8	Continuous customer management	490	97
SC9	Workloads	422	82
SC10	Internal regulations	236	43
SC11	The financial status of the bank	34	0
SC12	The size of the bank	205	36
SC13	Automatic teller machines	248	45
SC14	The number of branches	285	53
SC15	Parking facilities	107	15
SC16	Modern facilities	301	57
SC17	Branch interior	160	27
SC18	Branch layout	193	34
SC19	Interest rates	60	6
SC20	A variety of financial products	87	11
SC21	Fees	60	6

Fig. 4 shows the constructed HOQ. The HOQ presented in Fig. 4 indicates that employee training and close human relationships with customers should be emphasized, while workloads for each employee need to be reduced to boost service quality for customers. Such a result should be considered for maximum customer service under limited resources.



Service Characteristics (SCs) / Customer Requirements (CRs)	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6	SC 7	SC 8	SC 9	SC 10	SC 11	SC 12	SC 13	SC 14	SC 15	SC 16	SC 17	SC 18	SC 19	SC 20	SC 21	Importance	Nonghyup	Busan Bank	Kookmin Bank
CR1	◎	○	○	◎	◎	◎	◎	◎	◎	○	△	△	△	○		○		△		△		5.708	3.73	3.75	3.82
CR2	○	◎	△	◎	◎	○	○	○	○	△		△		△		○		△				4.868	3	3.15	3.33
CR3	○	○	○	◎	◎	○	◎	◎	◎	○		△		△		△	△	△				5.734	3.67	3.61	3.88
CR4	◎	◎	○	◎	◎	○	◎	◎	◎	○			○	○	○	○		△				5.533	3.47	3.53	3.47
CR5	◎	○	○	◎	◎	◎	◎	◎	◎	△			○	○		○			○	○	○	5.391	3.33	3.47	3.43
CR6	○	△	△	△	◎	◎	○	◎	◎	○			△							○		5.438	3.43	3.69	3.53
CR7	◎	○	◎	○	○	△	△	△	○	○	△	○	○	○		○	△	△				5.989	2.92	3.73	3.65
CR8	◎	○	◎	○	○	△	△	○	○	△	△	◎	○	○		○						5.763	4.08	3.78	4.03
CR9	○	△	△	◎	◎	◎	○	◎	◎	△		△	○	△		○	△	△	○	○	○	5.708	3.53	3.63	3.75
CR10	◎	△	◎	○	◎	○	◎	◎	◎	△		△	○	◎	△	○	△	△				5.71	3.47	3.47	3.57
CR11	○	○	○	○	○	○	○	◎	○	△			○	○		○	△	△				5.641	3.45	3.53	3.57
CR12	○	△	◎	○	◎	○	◎	○	◎	△		○	◎	◎		◎						5.356	2.67	2.9	2.52
CR13	△	△	△	◎	◎	△	◎	◎	◎	△				○	△	△	○	○				5.28	3.39	3.19	3.38
CR14	△	△	○	○	◎	○	○	◎	◎	△			○	○		○		○				5.696	3.92	3.69	3.82
CR15	△	△	○	◎	◎	◎	◎	◎	◎	○			△		△	△						5.639	3.61	3.63	3.7
CR16		△	△	◎	◎	◎	△	◎	◎	○		△		△	△	△						5.504	3.35	3.44	3.47
CR17			△	△	◎	△	△	○	△	△	○	○	△	△	△	△	△	△	◎	◎	◎	5.399	3.22	3.39	3.33
CR18					◎		△	◎	△	◎		○		○								5.13	3.82	3.98	3.9
CR19	○	△	○			△		○	△	△		○	◎	○	◎	◎	◎	◎				5.456	3.84	3.85	4
CR20	△				◎	◎		◎	△	○		△	△	△	△	○	◎	◎				5.463	3.88	3.8	3.98
CR21					○	○		○		○		◎				△	◎	◎		△		5.105	3.43	3.37	3.45
CR22	△	△	△									◎	◎	◎	◎	◎	◎	◎				5.965	4.22	4	3.67
Importance Weights	313	210	287	360	505	353	332	490	422	236	34	205	248	285	107	301	160	193	60	87	60				
Normalized Importance Weights	59	37	54	69	100	68	63	97	82	43	0	36	45	53	15	57	27	34	6	11	6				

Figure 4. The first house of quality

5. Additional Analysis with the Importance-Satisfaction Model

5.1 Importance Satisfaction Model and New HOQ

The importance satisfaction model maps the area for improvement to focus on the key attributes where a company should make its efforts to improve the service quality, as in Fig. 5 (Yang 2003). For example, an item with low importance does not need to be improved earlier than other items with high importance. As a result, time and cost can be efficiently spent to meet customer requirements and boost service quality in new service development.

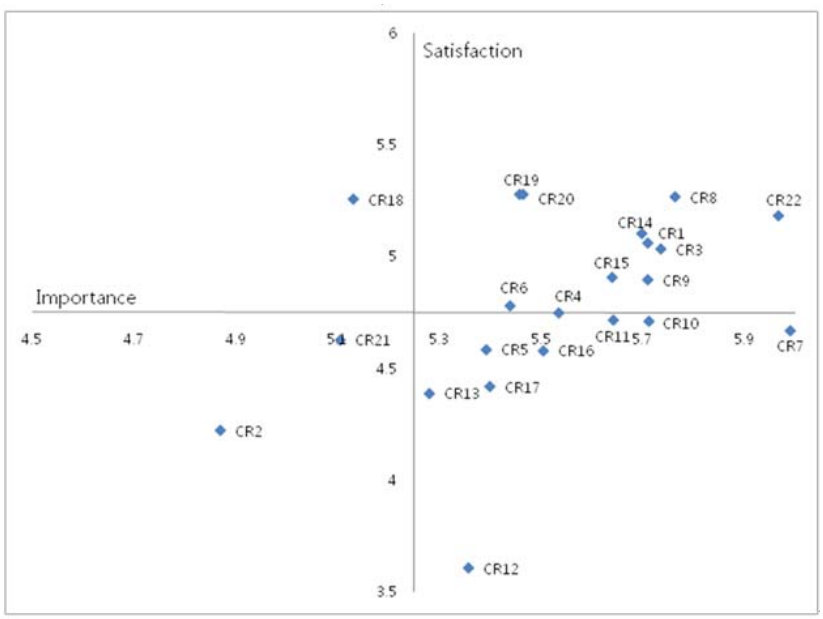
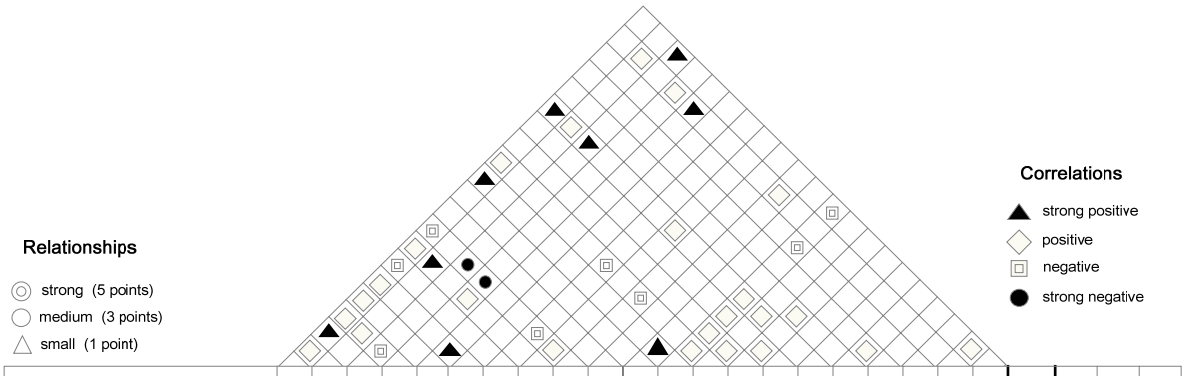


Figure 5. Importance-satisfaction Model

The X-axis indicates importance, and the Y-axis represents satisfaction in the importance satisfaction model as shown in Fig. 5. Starting from the upper right quadrant, the numbering goes counter-clockwise from the first quadrant up to the fourth quadrant. The importance satisfaction model is used to locate the area for improvement that corresponds to the fourth quadrant in Fig. 5. Fig. 5 plots 8 CRs in the area: CR5, CR7, CR10, CR11, CR12, CR13, CR16, and CR17. For example, CR7, 'Security systems are constructed very well,' has the highest degree of importance, 5.989, while the CR7 remains at a relatively low level of satisfaction, 4.669. The 8 CRs mean that, although customers consider them very important, their overall service quality remains low. Thus, service quality should be improved urgently in the 8 CRs.



Service Characteristics (SCs) / Customer Requirements (CRs)	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6	SC 7	SC 8	SC 9	SC 10	SC 11	SC 12	SC 13	SC 14	SC 15	SC 16	SC 17	SC 18	SC 19	SC 20	SC 21	Importance	Nonghyup	Busan Bank	Kookmin Bank
CR5	◎	○	○	◎	◎	◎	◎	◎	◎	△			○	○		○			○	○	○	5.391	3.33	3.47	3.43
CR7	◎	○	◎	○	○	△	△	△	○	○	△	○	○	○		○	△	△				5.989	2.92	3.73	3.65
CR10	◎	△	◎	○	◎	○	◎	◎	◎	△		△	○	◎	△	○	△	△				5.71	3.47	3.47	3.57
CR11	○	○	○	○	○	○	○	◎	○	△			○	○		○	△	△				5.641	3.45	3.53	3.57
CR12	○	△	◎	○	◎	○	◎	○	◎	△		○	◎	◎		◎						5.356	2.67	2.9	2.52
CR13	△	△	△	◎	◎	△	◎	◎	◎	△				○	△	△	○	○				5.28	3.39	3.19	3.38
CR16		△	△	◎	◎	◎	△	◎	◎	○		△		△	△	△						5.504	3.35	3.44	3.47
CR17			△	△	◎	△	△	○	△	△	○	○	△	△	△	△	△	△	◎	◎	◎	5.399	3.22	3.39	3.33
Importance Weights	124	73	135	154	198	121	143	176	176	67	22	61	100	133	22	111	39	39	43	43	43				
Normalized Importance Weights	58	29	64	75	100	56	68	87	88	26	0	22	45	63	0	51	9	9	12	12	12				

Figure 6. The second house of quality

Fig. 6 shows a new HOQ constructed with the 8 CRs from Fig. 5 and all 21 SCs. The correlation matrix of Fig. 6 is the same as that of Fig. 4. The relationship matrix of Fig. 6 is exactly the same as the 8 rows for the 8 CRs of Fig. 4. However, the importance weights for the 21 SCs are newly calculated by equation (1) with the 8 CRs only in Fig. 6.

5.2 Comparison between the first and second HOQs

Table 7 presents two lists of the top 5 service characteristics based on the importance weights from the two HOQs of Fig. 4 and Fig. 6. Table 7 shows that SC5, employee training, is most important in both the first and second HOQs. In addition, SC8, continuous customer management, SC9, workloads, and SC4, customer call center, are included in both lists with different rankings. However, SC6, knowledge sharing among employees, in the first list is excluded from the second list, while the second list newly includes SC7, the number of employees, that is in 6th place in the first HOQ.

Table 7. Top five service characteristics

	The first HOQ	The second HOQ
1	Employee training	Employee training
2	Continuous customer management	Workloads
3	Workloads	Continuous customer management
4	Customer call center	Customer call center
5	Knowledge sharing among employees	The number of employees

Table 7 leads to the final list of service characteristics requiring urgent quality improvements through 'a confluence of results' from a pair of houses of quality. That is, employee training, continuous customer management, workloads, and customer call center should be considered urgently to improve service quality. Knowledge sharing among employees and the number of employees can be taken into account additionally in the final list, because they are included in either of the two top five lists. The final list can be used as a managerial guideline when managers make their strategic decisions in the process of service development, because the results from a pair of houses of quality provide a bigger support for their decisions than depending solely on the results of a single HOQ. This is an effort to boost customer satisfaction and enhance competitive strength by improving service quality under limited resources.

6. Conclusions

This paper presents a structured approach based on the QFD for service development in the banking industry. The QFD is typically used to define customer needs and translate them into specific plans for products or services. However, it is often a challenge to capture, understand, and organize customer needs. The QFD also uses linguistic variables that are characterized by subjectivity and ambiguity. Thus, this research adopts and modifies SERVQUAL as an effective tool to understand customer requirements in the banking industry. In addition, fuzzy set theory is used to deal with the subjectivity and ambiguity of the customer requirements and satisfaction used in the QFD. This paper also applies the importance-satisfaction model to an additional QFD analysis for a confluence of results from a pair of houses of quality to avoid a risk of depending solely on the results of a single HOQ. The proposed approach is illustrated with three representative domestic banks.

According to the first QFD for the three banks, critical factors for bank services are employee training, continuous customer management, workloads, customer call center, and knowledge sharing among employees. The second QFD lists employee training, workloads, continuous customer management, customer call center, and the number of employees as important factors. Through a confluence of results, a conclusion can be made that the most important factors for service quality are employee training, continuous customer management, workloads, and customer call center. Knowledge sharing among employees and the number of employees can be considered additional factors, when resources allow.

Nonghyup has the lowest levels of satisfaction for many CRs compared with the other two banks.

Nonghyup is a representative government-invested bank in Korea that may lack efforts to maximize efficiency by nature. Such an organizational culture possibly affects poorer customer service. Nonghyup should reform its human resource management as well as its training programs for customer services. Nonghyup has its advantage as a government-invested bank, that is, the largest number of branches nationwide as of 2011 (Korea Federation of Banks 2013). Despite such an advantage, Nonghyup is consistently weak in most of the CRs, including even physical requirements such as CR18 to CR22. This indicates that Nonghyup has a huge problem even in efficient resource allocation.

Local banks provide financial services and loans for regional residents and companies. Nationwide banks determine the number of branches and the amount of budgets for each local city, considering the size of economy and population in the city. They also have the same or similar nationwide standards for financial services and loans. On the other hand, local banks have more information on local economies, companies, and residents, and customized standards for financial services and loans. As a local bank, Busan Bank should maximize its advantages in the regional areas. That is, it needs to accumulate information on local customers to manage them systematically and continuously by customized services. Such information should be shared by all employees, and customer contacts should be boosted by keeping customers posted on job progress and by providing useful information regularly.

Overall, Kookmin Bank has the highest levels of customer satisfaction, as the largest bank in Korea. However, it has the lowest level of satisfaction for CR12, 'Waiting times are short.' Private banks typically pursue maximizing profits by minimizing the number of employees, resulting in heavy workloads for individual employees. This may work very well for short-term profits, but may cause negative effects on customer services in the long term. Kookmin Bank needs to boost the use of automatic teller machines and phone and internet banking to lighten employee workloads. Above all, Kookmin Bank should seek an optimal policy on the number of employees, considering a trade-off between profitability and service quality.

This research proposes a systematic approach based on fuzzy set theory, QFD, and SERVQUAL for direct interactions with customers in service development. This paper effectively attacks a case study in the financial service industry based on the SERVQUAL. A service development problem is newly addressed in the banking industry by using fuzzy QFD and the importance-satisfaction model. The fuzzy set theory addresses the subjectivity and ambiguity of customer requirements and satisfaction very well by nature. This approach will help banks make strategic decisions to improve service quality in real situations under limited resources. This research, however, has a limitation in that the improvement achieved by the fuzzy set theory is not quantitatively measured. Continued research is necessary for this issue.

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