

QFD APPROACH FOR QUALITY IMPROVEMENT OF A SUSTAINABLE PRODUCT-SERVICE SYSTEM

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ABSTRACT

Increasing awareness of the importance of services has given rise to the concept of product-service system where goods and services are sold as an integrated package to customers. On the other hand, the emerging sustainability concept has escalated the demand for sustainability for industries. Consequently, it is necessary to build strategies that lead the company to achieve sustainability goals while keeping competitiveness. Drawing on the necessity service and sustainability concept in the quality improvement of the product-service system, this study aims to develop a systematic design tool by filling the gap to the previous studies. We used Quality Function Deployment (QFD) approach by considering customer requirements (VoC) and stakeholder requirements (VoSt), instead of VoC only, based on the service and sustainability dimensions. We refer to the proposed QFD approach as QFD_{SPS}. We introduce service productivity index (SPI) to measure the performance of the system. Thus, in the proposed methodology, the strategies for quality improvement were defined as subject to VoC, VoSt, and SPI. The methodology was implemented in a Javanese restaurant which meets the characteristics of a product-service system. The result shows that the proposed method can be implemented. The implications due to the implementation of the method are also discussed.

Keywords: QFD; HOQ; product-service system; sustainability; service productivity index; HOQ_{SPS}

INTRODUCTION

Today, businesses realise that services have become an integral part of modern society. Consequently, more and more companies are adding value to their core business by offering various services. These circumstances have given rise to a concept where goods and services tend to be sold as an integrated package to customers (Kim, 2011).

The three most common terms used to express service characteristics are intangibility, *uno-actu-principle* (“in one act”), and integration of external factors (Meier, Roy & Seliger, 2010). The quality of services is represented by the gap between consumer perception and consumer expectation. It is usually measured using service quality (servqual approach).

In the SERVQUAL concept, there are five dimensions of service quality namely; tangible, responsiveness, assurance, empathy, and reliability (Parasuraman, Zeithaml & Berry, 1988). Observing that services are broadly controlled by the customer, designing effective service by taking customer requirements as the focus becomes essential. In this regard, a number of approaches for effective service design have been developed and one recent approach for

designing services is Quality Function Deployment (QFD) which provides a methodology that takes costumers' requirements as the main driver in the design process. The most principal phase of QFD is the use of the House of Quality (HOQ), which translates the customer's requirements into design specifications.

On the other hand, the emerging concept of sustainable development has escalated the demand for sustainability for manufacturing and service providers. Thus, in addition to SERVQUAL dimensions, addressing the sustainability dimensions (social, environmental, and economic) in service design is a significant requirement.

In terms of environmental aspect, modified QFD is referred to as Quality Function Deployment for Environment (QFDE) (De Camillis, Raggi & Petti, 2004). QFDE aims to support the designer in the early stages of Design for Environment (DfE) of assembled goods with a high degree of freedom in design. The work of De Camillis et al. (2004) was further expanded in the context of Total Quality Management (QFDE modified version) and Total Quality Environmental Management (Comprehensive QFDE, C-QFDE). C-QFDE accommodates Life Cycle Assessment (LCA) process to progress continuously in eco-efficiency and achieve eco-label.

Lam (2015) has focussed on the modifications to QFD in terms of services and environmental aspects. The study proposed hybrid analytical approach, combining both Quality Function Deployment (QFD) and Analytical Network Process (ANP) for guiding shipping companies' design in a sustainable maritime supply chain. The ANP was used to handle the hierarchical network of interrelationships among the attributes, particularly social, environmental and economic issues.

Drawing on the necessity service concept in service design, Goldstein, Johnston, Duffy and Rao (2002) introduced the concept of service design that covers both "WHAT" (i.e. "what is to be done for customers") and HOW (i.e. "how this is to be achieved") aspects of service design. WHAT aspect deals with service design and the HOW aspect deals with the service delivery design.

Acknowledging the argument of Goldstein et al. (2002), Chowdhury and Quaddus (2016) developed a multi-phased QFD based optimization to sustainable service design. The study proposed "sustainable service concept" which considers service design and service delivery design linking them with the attainment of social, environmental and economic goals of the organization. The methodology used was the multi-phased 0–1 optimization model within the fuzzy quality function deployment (QFD) approach. The model was applied to the health service design in Bangladesh.

As described above, QFD has been progressively modified by taking environmental aspects, services, and sustainable service into consideration. Those modified QFDs are mostly concerned on customer focus, whereas, the goal is to achieve sustainability dimensions (social, environmental, and economic) which cannot be separated from stakeholder involvement. In addition, previous studies fall short of addressing the selection of appropriate strategies taking cost and performance into consideration, whereas, system performance is one of the important factors to be considered in quality improvement. To fill the gap, this study aims to modify the QFD, particularly HOQ, to be a systematic tool in the design of sustainable product-service system. By focusing on product-service system, we expect that the modified QFD could be applied more widely not only in services but also in combined

product-service system. This is done by introducing the concept of service productivity that indicates company performance, while maintaining the voices of the customer (VoC) and stakeholder (VoSt). We argue that considering service productivity index in the design phase, especially in strategy selection phase, will lead the system to reach sustainability goals while enhancing its competitiveness.

This paper is organised as follows. The next section presents the literature review in the QFD area, followed by the conceptual development and its application sections. Next, the results are presented with a discussion whereby theoretical and managerial implications are stated. Finally, the paper ends with conclusions of the study.

LITERATURE REVIEW

Sustainability in Services

The concept of sustainable development was introduced in the ‘Brundtland Report’ of the World Commission on Environment and Development (WCED) as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. The three pillars of sustainable development include economic development, social development, and environmental protection (WCED, 2002). In other words, sustainability can also be regarded as a system that is economically effective, environmentally sustainable and socially fair (Busset, 2014; Douallea, Medina, Bouchera & Laforesta, 2015). To achieve the goal of sustainable development, sustainability is therefore used as a driver for industries to produce more sustainable goods and services. Consequently, in addition to cost and quality, sustainability criteria must be considered since the very beginning of product or service development.

According to Hallstedt and Thompson (2011) and Hallstedt, Thompson and Lindahl (2013), there are eight key elements for successfully implementing a strategic sustainability perspective. The basic concept of the strategy is applying sustainability responsibilities in every phase of the product development, in terms of product innovation process, procurement, product life cycle, product assessment, and organisational support. In businesses perspective, sustainability means sustaining and expanding economic growth, shareholders’ value, prestige, corporate reputation, customer relationships, and the quality of products and services (Szekely & Knirsch, 2005).

At the beginning, the implementation of the concept of sustainability in the industry was mostly focused in the manufacturing sector. In this case, sustainable manufacturing strategies were developed for company levels and industrial levels, such as Design for Sustainability, Design for Environment, and Eco-Industrial Park. The implementation of sustainability in services has brought out the concept of sustainable services, which refers to “the service offering the tasks embedded with economic, social and environmental protection elements that are so far still non-existence especially to the existing traditional, conventional and competing offers in the market” (Tseng & Huang, 2016).

The increasing awareness of the importance of services as a complement of a product gave rise to the concept of product-service system (PSS) which tends to increase not only market share, but also customer satisfaction (Beuren, Ferreira & Miguel, 2013). In fulfilling customer needs while meeting sustainability criteria, Goedkoop, Van Hellen, Te Riele and Rommens

(1999) defined the PSS as “product(s) and service(s) combined in a system to deliver required user functionality in a way that reduces the impact on the environment”. Hence, PSS can be a potential strategy to deliver social well-being and economic prosperity while reduces environmental impact. With regard to PSS assessment, Doualle et al. (2015) analysed methods and tools that guide stakeholders of the PSS throughout a life cycle perspective. In addition, a wide range of studies in PSS involving design, production, and consumption perspectives have been done (Chowdhury & Quaddus, 2016; Mylan, 2015; Maxwell, Sheate & Van Der Vorst, 2006; Paulo & Miguel, 2016).

Quality Function Deployment

Quality function deployment (QFD) is an overall concept that gives an understanding to translate customer requirements into technical language at every step of product development. QFD aims to transform customer requirements of a product into engineering characteristics, process specifications, and production requirements. The QFD can be implemented through four phases, i.e. product planning, product development, process planning, and production planning (Pahl, Wallace & Blessing, 2007).

QFD was first implemented in Japan in the late 1960s and early 1970s (Chan & Wu, 2002). At that time, QFD was used to improve process planning of an item in a manufacturing industry. Stages in the QFD method are as follows (Cross, 1994):

- 1) Identifying customer and producer requirements for attributes of a product that will be developed.
- 2) Determining relative importance of each attribute.
- 3) Evaluating attributes on a competitor's product.
- 4) Describing product attributes matrix on engineering characteristics.
- 5) Identifying relationship between engineering characteristics and product attributes.
- 6) Identifying relevant relationships between engineering characteristics.
- 7) Setting targets to be achieved on engineering characteristics

Because of its widespread applicability to determine suitable strategies, QFD has been used in various area of design. With regard to service characteristics, Mazur (1993) developed a comprehensive QFD for service industries to support service organization. Another modified QFD was for logistics service design, which is called fuzzy QFD, has been developed by Battani and Rizzio (2006). However, Aurich, Fuchs and Wagenknecht (2006) revamped QFD for designing technical product and service system. In the area of sustainable product design QFD has been adapted especially for ecological design of product and service (Wolniak & Sędek, 2009; Sakao, Watanabe & Shimomura, 2003; An, Lee & Park, 2008).

House of Quality

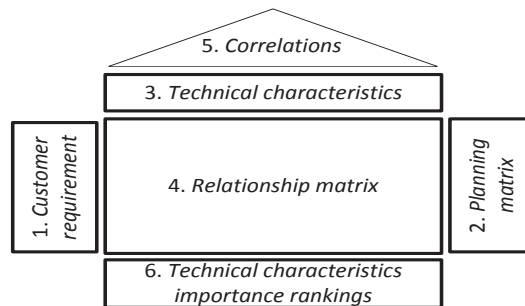
The main tool used for most of the QFD phases is ‘house of quality’ (HOQ). The HOQ transfers the degree of importance in the customer requirements (CRs) (the WHATs) into design requirements (DRs) (the HOWs).

The structure of genuine HOQ is composed of several parts that can be seen in Figure 1. Each part of HOQ can be explained as follows:

- 1) Customer requirements (WHATs), provides an overview of the exact specifications based on consumer requirements. It is divided in two columns. The first column is for the

customers' requirements and the second is for the coefficient that reflects the importance of each customer requirement.

- 2) Planning matrix, contains information about relative importance of customer requirements and the level of customer satisfaction.
- 3) Technical or engineering characteristics (HOWs), is the adjustment of valuable qualitative consumer requirements that are translated into quantitative values.
- 4) Relationship matrix, is an indication level of engineering characteristics that influence customer satisfaction for each customer requirement.
- 5) Correlations matrix, illustrates the interdependence between engineering characteristics and to capture the opportunities among the various engineering parameters.
- 6) Technical characteristics importance ranking, is a priority on the engineering characteristics by providing information to produce innovation of a product design or new systems.



(Source: Bergquist & Abeysekera, 1996; Yang, Khan, Sadiq & Amyotte, 2011)

Figure 1: House of Quality

CONCEPTUAL DEVELOPMENT

We then developed QFD, particularly extending the HOQ phase, for sustainable product-service system. The modified HOQ is presented in Figure 2 and is referred to it as HOQ_{SPS}. The approach is made up of fifteen steps. In Figure 2, the areas with dark background indicate the modifications to the original HOQ.

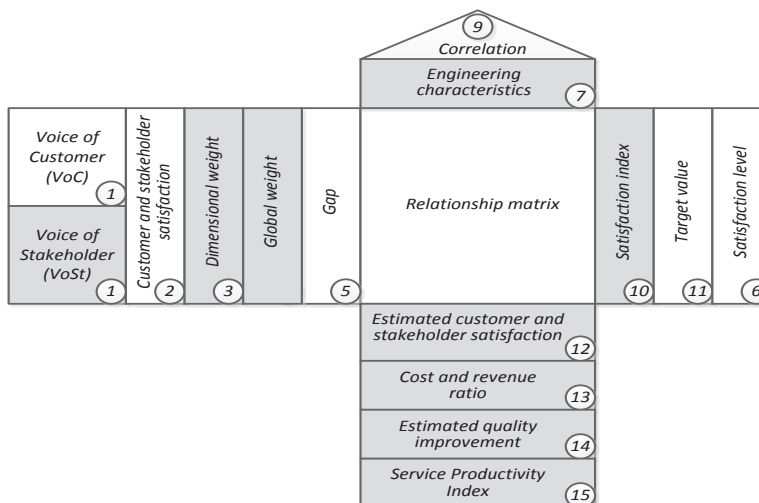


Figure 2: Modified HOQ for Sustainable Product-Service System

The steps for constructing HOQ_{SPS} are specified as follows:

- Step 1. Identify voice of customer (VoC) and voice of stakeholder (VoSt).
- Step 2. Determine customer and stakeholder satisfaction (S_i) of each attribute (using Likert scale).
- Step 3. Determine the dimensional weight (Wd_i) of VoC and VoSt.
Dimensional weight denotes the capability of each dimension.
- Step 4. Determine the global weight (Wg_i).
The global weight of each attribute indicates its position so that strategies to improve the quality of the system can be defined.
- Step 5. Determine the gap of each attribute.
A gap occurs when the ideal situation expected by the customer is not met. The gap is defined as the difference between perception and expectation of service.
- Step 6. Determine the importance level of each attribute (AI_i).
The value of AI_i is a weighted S_i and represents the degree of interest of each attribute.
- Step 7. Determine alternative solutions (engineering characteristics).
Alternative solutions are defined based on the gap and importance level and structured as an engineering characteristics matrix. Once the attribute is selected, the alternative solutions to improve the quality of the attribute can be determined.
- Step 8. Develop VoC-VoSt relationship matrix.
In this step, the engineering characteristics will be linked to the selected attributes in the area of VoC and VoSt.
- Step 9. Develop correlation matrix that shows the relationship among alternative solutions.
- Step 10. Determine customer and stakeholder satisfaction index (SI_i).
Based on VoC-VoSt relationship level, the customer and stakeholder satisfaction index is estimated and expressed as a new matrix. Satisfaction index of selected attribute i is estimated using the following equation:

$$SI_i = Wg_i \cdot t \dots\dots\dots (1)$$

where t is numerical value based on the strength of the relationship.

- Step 11. Determine target value (TV_i).
Target value is a management policy that describes the expected quality improvement of the selected attributes when an alternative solution is implemented. The target value of selected attribute i can be calculated as follows:

$$TV_i = (1 + \Delta m_i) \cdot S_i \dots\dots\dots (2)$$

where Δm_i is the expected quality improvement of attribute i (proportional to the current value of S_i).

- Step 12. Estimate customer and stakeholder satisfaction (ES_u).
Given the alternative solution be applied to the system for quality improvement, it is necessary to estimate how far the level of satisfaction can be perceived by customers and stakeholders. One activity is possible to solve some problems. Hence, the estimated customer and stakeholder satisfaction of a strategy is the sum of satisfaction index of the influenced attributes.

- Step 13. Determine cost and revenue ratio (C/R).
Cost and revenue ratio is calculated using the following equation:

$$C/R = \frac{C_o + \Delta C}{R_o + \Delta R} \dots\dots\dots (3)$$

where:

- C_o : current operating cost
- ΔC : strategy implementation cost
- R_o : current income

ΔR : additional income due to the implemented strategy.

The lower the ratio value the more efficient the system.

Step 14. Estimate quality improvement (EQ_i).

The estimation of quality improvement is used to predict how much quality can be improved due to the implementation of the strategies. The value of (EQ_i) is the sum of TV_i influenced by the strategy.

Step 15. Determine Service Productivity Index (SPI).

Productivity is defined as the ratio between output and inputs. As argued by Fornell (2003), productivity should be predicted to identify a way to improve the quality of goods and services. In this study, we refer to Indrianti (2012a), hence the SPI is calculated as follows.

$$\text{Service Productivity Index (SPI)} = \frac{\text{effectiveness}}{\text{efficiency}} = \frac{\text{customersatisfaction}}{\text{costs/revenue}} \quad (4)$$

The higher the value of SPI the more effectively and efficiently the system.

METHODOLOGY: MODEL APPLICATION

To examine the HOQ_{SPS} that was developed in this study, we used a restaurant as a case study. We chose a restaurant since it meets the characteristics of product-service system. We selected a Javanese restaurant located in Sleman District, Yogyakarta Special Region, Indonesia. The restaurant provides traditional Indonesian food such as grilled chicken, grilled fish, and Indonesian vegetable.

Referring to the previous section, the HOQ_{SPS} was developed through the following steps:

Step 1. The attributes that served as voice of customers and voice of stakeholders were defined based on Indrianti (2012b). We selected the attributes with the number of respondents who provided important votes of more than 50%. The attributes is shown in Table 1 below. It can be seen that sustainability aspects were taken into account.

Table 1 : Voice of Customers and Voice of Stakeholders

	Dimension	No	Description		Dimension	No	Description
Voice of customer	Tangible	VoC-T1	Food presentation and plating tools	Voice of customer	Assurance	VoC-A4	Taste
		VoC-T2	The availability of room for special purposes (meeting room, etc.)			VoC-A5	Cleanliness of dining and kitchen supporting facilities
		VoC-T3	The beauty of the environment		Empathy	VoC-E1	Entertainment
		VoC-T4	Art and creativity for food display			VoC-E2	Hospitality
		VoC-T5	Room lighting		Reliability	VoC-R1	Order (size) flexibility
		VoC-T6	Cleanliness of serving utensils			VoC-R2	Menu variety
		VoC-T7	Completeness of supporting facilities for personal needs (toilet, sink, nursery, prayer rooms, etc.)			VoC-R3	Variations in the way for ordering food
		VoC-T8	Completeness of serving utensils		Voice of stakeholder	Tangible	VoSt-T1
Responsiveness	VoC-R1	Responsiveness (time and ease to order)	Empathy	VoSt-E1		Noise level	
Assurance	VoC-A1	Parking area	VoSt-E2	Social responsibility program			
	VoC-A2	Comfort (room layout, the ventilation system)	Assurance	VoSt-A1	Parking area		
		VoC-A3	Quality of raw material				

Modified from Indrianti (2012b)

The attributes were then used for the other steps, particularly to determine the satisfaction level of each attribute. The data was obtained by distributing a set of questionnaires. Customer respondents were determined using non-probability sampling, while the stakeholder respondents were determined using convenience

sampling. We selected 5 residents who live near the restaurant as stakeholder respondents. Assuming 95% confidence level and 10% of sampling error, the minimum required sample size is 97 (Fitzsimmons & Fitzsimmons, 2004).

Step 2. We used 5-Likert scale to determine customer and stakeholder satisfaction of each attribute (S_i). Score 1 means very bad and 5 means very good. Statistical tests included validity and reliability tests using SPSS 20. Validity test resulted in $r_{calculated} > r_{table}$ for each item in the questionnaire, so the questionnaire instrument are valid.

Questionnaire reliability was tested using Cronbach's value of alpha (α). The calculation resulted in 0.928 of Cronbach's alpha value. According to Nunnaly, (1978), the test with value of alpha (α) 0.7 and above is usually acceptable. Thus, the set of questionnaires used this study was reliable.

Step 3. The dimensional weight (Wd_i) of VoC and VoSt were calculated based on the results of step 2.

Step 4. The global weight (Wd_i) was calculated based on the results of step 2.

Step 5. In this step, we considered '5' as the ideal expectation of service.

Step 6. To determine the importance level of each attribute we used 4-Likert scale ranging from 1 (very unimportant) to 4 (very important). We invited 127 customer respondents and 93 stakeholder respondents. Afterwards, normalization into 5-scale was done in order to have similar scale used in previous steps.

The results of step 2 to 6 can be seen in Table 2.

Table 2 : Satisfaction Level, Gap, and Importance Level of Each Attribute

	Dimension	No	Satisfaction level	Dimensional weight	Global weight	Expectation	Gap	Level of importance (4 scale)	Normalization	Importance priority
Voice of customer	Tangible	VoC-T1	3.938	0.126	0.0158	5	-1.062	2.890	3.612	17
		VoC-T2	3.711	0.119	0.0149	5	-1.289	1.425	1.781	23
		VoC-T3	4.227	0.136	0.0169	5	-0.773	3.189	3.986	10
		VoC-T4	3.639	0.117	0.0146	5	-1.361	2.417	3.022	21
		VoC-T5	3.763	0.121	0.0151	5	-1.237	2.622	3.278	19
		VoC-T6	3.876	0.124	0.0155	5	-1.124	3.575	4.469	5
		VoC-T7	4.000	0.128	0.0160	5	-1.000	3.575	4.469	6
		VoC-T8	4.021	0.129	0.0161	5	-0.979	2.969	3.711	16
	Responsiveness	VoC-R1	3.866	1.000	0.1250	5	-1.134	3.591	4.488	4
	Assurance	VoC-A1	3.773	0.195	0.0244	5	-1.227	2.984	3.730	15
		VoC-A2	3.990	0.206	0.0258	5	-1.010	3.488	4.360	8
		VoC-A3	3.804	0.197	0.0246	5	-1.196	3.567	4.459	7
		VoC-A4	3.794	0.196	0.0245	5	-1.206	3.803	4.754	2
		VoC-A5	3.979	0.206	0.0257	5	-1.021	3.803	4.754	3
	Empathy	VoC-E1	3.268	0.450	0.0562	5	-1.732	1.984	2.480	22
VoC-E2		4.000	0.550	0.0688	5	-1.000	3.811	4.764	1	
Reliability	VoC-R11	3.825	0.332	0.0414	5	-1.175	2.567	3.209	20	
	VoC-R12	3.866	0.335	0.0419	5	-1.134	3.157	3.947	14	
	VoC-R13	3.845	0.333	0.0417	5	-1.155	3.409	4.262	9	
Voice of stakeholder	Tangible	VoSt-T1	4.000	1.000	0.1250	5	-1.000	3.189	3.986	11
	Empathy	VoSt-E1	4.000	0.556	0.0694	5	-1.000	3.165	3.956	12
		VoSt-E2	3.200	0.444	0.0556	5	-1.800	2.835	3.544	18
	Assurance	VoSt-A1	4.000	1.000	0.1250	5	-1.000	3.165	3.956	13

Step 7. With regard to the previous results presented in Table 2, the alternative solutions were defined by interviewing the restaurant manager. Table 3 shows the alternative solutions of each selected attributes. It is shown that not all of attributes were important and needed to be improved. On the other hand, one alternative solution could influence more than one of the attributes. The replacement of serving equipment did not become prioritized strategy as it only influenced one attribute.

Table 3 : Selected Attribute for Quality Improvement

Priority	No	Description	Alternative solutions
1	VoC-T2	The availability of room for special purposes	Develop meeting room
			Develop production house
2	VoC-T1	Food presentation and plating tools	Employee training
3	VoC-R1	Responsiveness (time and ease to order)	Employee training
4	VoC-A2	Room comfort	Develop meeting room
			Develop production house
5	VoC-A3	Quality of raw material	Develop production house
			Employee training
6	VoC-A4	Taste	Develop production house
			Employee training
7	VoC-A5	Cleanliness of serving utensils	Replacement of serving equipment
			Employee training
8	VoC-RI2	Menu variety	Develop production house
			Employee training
9	VoC-T3	The beauty of the environment	Develop production house

Step 8. We developed VoC-VoSt relationship matrix. The correlations were classified into strong, middle, and weak relationships.

Step 9. We determined the correlation matrix among the proposed strategies.

Step 10. Satisfaction index was determined based on the relationship matrix and global weight. The relationship level was translated into numerical value as follows: 1 is for “may have relationship”, 3 is for “middle relationship”, and 9 is for “strong relationship”. For example, satisfaction index for VoC-T2 is $(0.0149 \times 9) + (0.0149 \times 9) = 0.26$.

Step 11. The management wished to get increasing quality of 20%. The calculation results of satisfaction index and target value of each selected attribute is presented in Table 4

Table 4 : Satisfaction Index and Target Value of Selected Attributes

	Dimension	No. Atribut	Satisfaction Index	Target Value
Voice of customer	Tangible	VoC-T2	0.268	4.454
		VoC-T4	0.044	4.367
	Responsiveness	VoC-R1	1.125	4.639
	Assurance	VoC-A2	0.103	4.788
		VoC-A3	0.295	4.565
		VoC-A4	0.098	4.553
		VoC-A5	0.309	4.775
Reliability	VoC-RI2	0.251	4.639	
Voice of stakeholder	Tangible	VoSt-T1	0.375	4.800

Step 12. The estimation of customer and stakeholder satisfactions were done based on the influencing strategies. The result is shown in Table 5.

Table 5 : Estimated Customer and Stakeholder Satisfaction

No.	Strategy	Affected attributes	Satisfaction Index	Estimated customer and stakeholder
1	Training for all employees	VoC-T4	0.044	2.122
		VoC-R1	1.125	
		VoC-A3	0.295	
		VoC-A4	0.098	
		VoC-A5	0.309	
		VoC-RI2	0.251	
2	Replacement of serving equipment	VoC-A5	0.309	0.309
3	Development of production house	VoC-T2	0.268	1.015
		VoC-A2	0.103	
		VoC-A3	0.295	
		VoC-A4	0.098	
		VoC-RI2	0.251	
4	Development of meeting room	VoC-T2	0.268	0.746
		VoC-A2	0.103	
		VoSt-T1	0.375	

Step 13. The data used for calculating cost and revenue ratio was collected by interviewing the restaurant's manager. Table 6 shows cost estimation of the proposed strategies.

Table 6 : Cost Estimation Components

No.	Technical strategies	Cost estimation		Description	Product life cycle
		Implementing strategy (Rp)	Monthly additional income		
1	Conducting training for all employee	1 x 10 ⁶	15%	<ul style="list-style-type: none"> for 50 employees conducted 2 times a year conducted outside office hours 	6 months
2	Replacing serving equipment	5 x 10 ⁶	10%	Applied for inappropriate and dangerous equipment, both for visitors and employees	1 year
3	Developing production house	9 x 10 ⁶	10%	<ul style="list-style-type: none"> Including land and physical building about 200m² Separated from dining area 	10 years
4	Developing meeting room	450 x 10 ⁶	20%	<ul style="list-style-type: none"> Estimated capacity 150 people Building area of approximately 200m² 	10 years

Operating cost is approximately Rp250 million per month with average visitors of 300 people a day. Net profit is 15%. Assuming the average cost per visitor Rp50.000,00, the average monthly profit is Rp450 million. Calculation of C/R was done using Equation (3). The C/R calculation obtained 0.48 for employee training, 0.51 for serving equipment replacement, 0.52 for developing production house, and 0.47 for developing meeting room.

Step 14. Quality improvement due to strategy implementation was defined. The result is shown in Table 7.

Table 7 : Estimated Quality Improvement of Each Strategy

No.	Selected solutions	Affected attributes	Target Value	Estimated quality improvement
1	Training for all employee	VoC-T4	4.367	27.538
		VoC-R1	4.639	
		VoC-A3	4.565	
		VoC-A4	4.553	
		VoC-A5	4.775	
2	Replacing infeasible serving equipment	VoC-A5	4.775	4.775
3	Building production house	VoC-T2	4.454	22.999
		VoC-A2	4.788	
		VoC-A3	4.565	
		VoC-A4	4.553	
		VoC-R12	4.639	
4	Building additional meeting room	VoC-T2	4.454	14.042
		VoC-A2	4.788	
		VoSt-T1	4.800	

Step 15. Service Productivity Index(SPI) was calculated using Equation (4). The result is presented in Figure 3.

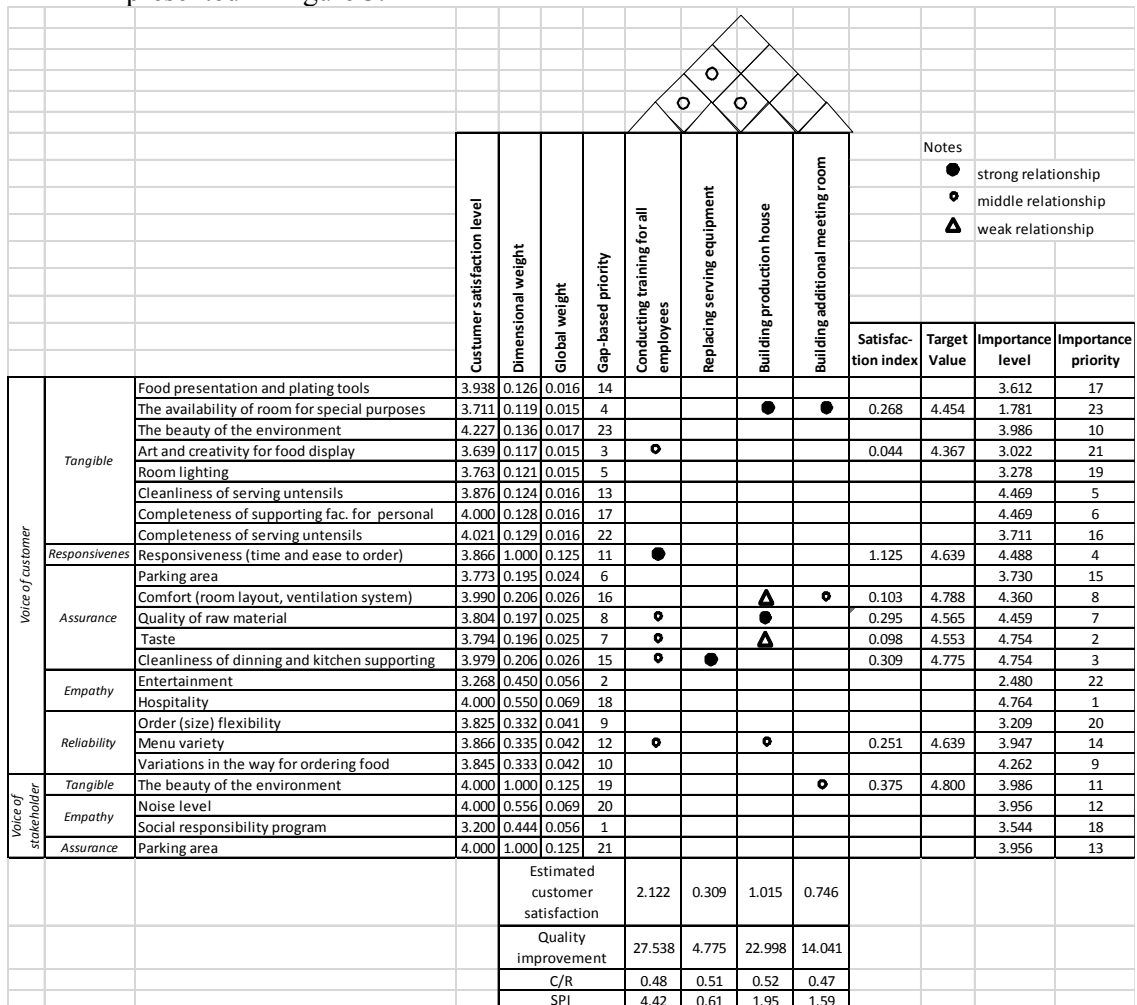


Figure 3: HOQSPs for Quality Improvement

DISCUSSION

In this study we introduce service productivity index as an important criteria to determine strategy for quality improvement in product-service system. Based on the case study presented, the strategies for improving quality include: (1) conducting training for all employees, (2) replacing unfeasible serving and cooking tools, (3) building production house which is located in a separated area, and (4) building additional meeting room. The calculation obtained 0.56 of cost and revenue ratio which represents current efficiency level of the restaurant. The value of C/R from the implementation of each strategy compared to current condition can be seen in Figure 4. The figure shows that strategy 4 has the lowest C/R . This means that strategy 4 has the highest efficiency level. In contrast, strategy 3 has the lowest efficiency level.

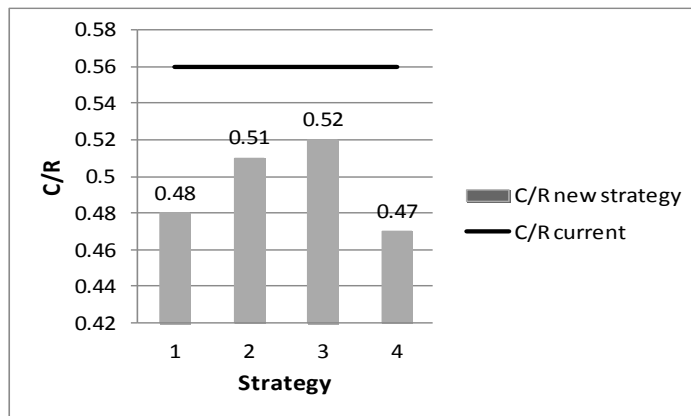


Figure 4: Current C/R Compared to Expected C/R

The value of C/R shows efficiency level of the implementation of a strategy in the view point of financial aspect, without showing the performance of overall system. System performance, however, is represented by SPI value. High customer satisfaction value and low C/R value will result in high system performance. Comparison between SPI, C/R , and customer satisfaction (C_s) can be seen in Figure 5 and 6.

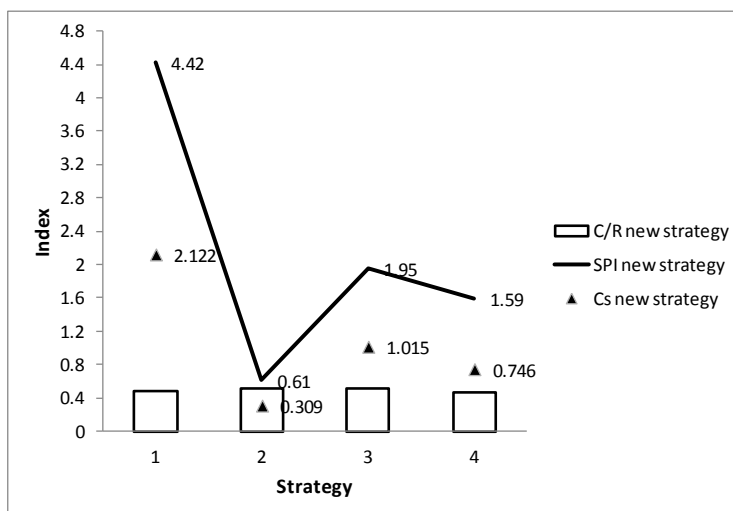


Figure 5 : C/R , SPI, and Customer Satisfaction of Each Strategy

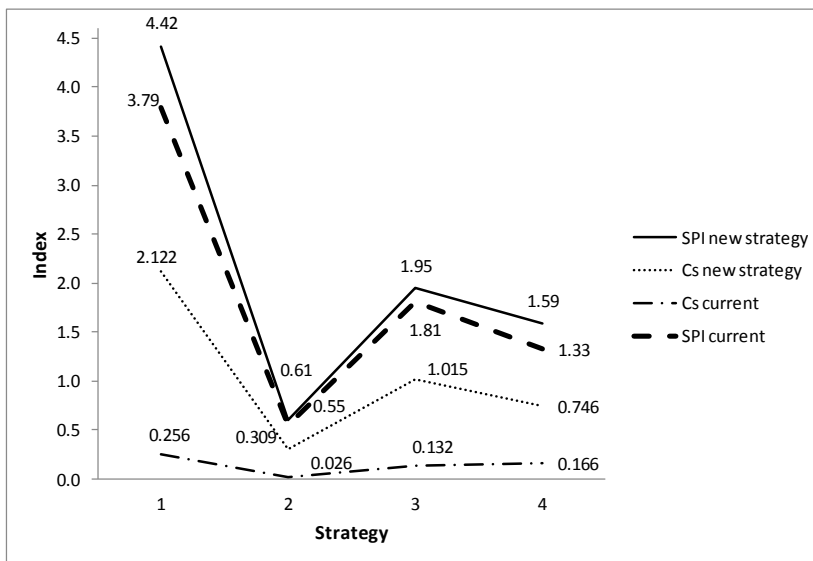


Figure 6 : SPI of Each Strategy

Low cost does not always result in low quality or vice versa. According to Figure 6, it can be seen that strategy 1, which has the lowest implementation cost, could improve customer satisfaction (*Cs*) from 0.256 to 2.122 (1.866) and SPI from 3.79 to 4.42 (0.63). The rise of *Cs* at this strategy is significant enough. Strategy 3, which is the strategy with the highest cost, could increase *Cs* by 0.884 and SPI by 0.14. This means that although strategy 3 has the highest cost but it resulted in increasing *Cs* and SPI far below strategy 1. The third strategy based on SPI value is strategy 4. It yielded increasing *Cs* from 0.166 to 0.746 and SPI from 1.33 to 1.59. The last priority is strategy 2, which could improve *Cs* from 0.026 to 0.309 and SPI from 0.55 to 0.61.

The theoretical contribution of this study lies in our QFD approach of sustainable service concept by considering customer and stakeholder requirements and introducing service productivity index in the strategy selection phase. Methodologically, we have shown how our approach can be operated and applied.

In terms of the managerial implications, the model developed in this study will therefore, help the management to decide and implement the portfolio of strategies that consider three-dimensional sustainability aspects of the social, environmental and economic goals within the limited budget. It is worth noting that . to estimate quality improvement, it should be based on the historical data. With the aid of strong data, the estimation of strategy impact will be more accurate. In addition, the implementation of a new strategy requires serious monitoring as it is used for evaluating the impact of the implementation of the strategy. Monitoring can be done periodically using questionnaires distributed to customers and stakeholders.

Besides monitoring, evaluation is also necessary to do. This can be performed periodically after monitoring activity. The evaluation result can be used as a basis to conduct an assessment to determine the strengths and weaknesses of the company. In addition, it can be used for clustering strategy implementation, particularly for short term, middle term, or long-term goals.

CONCLUSION

We have modified QFD, particularly developing HOQ for a sustainable product-service system, named HOQ_{SPS}. The purposes of modification are to determine strategies for improving product-service system to achieve sustainability goals while keeping competitiveness. The concept is performed by implementing strategies to improve the quality of services, with regard to sustainability aspects and the implementation cost. In this case, we have selected strategies based on customer and stakeholder requirements and applied the concept of service productivity index to measure the performance of the system.

HOQ_{SPS} that was developed in this study has been implemented in a Javanese restaurant located in the province Yogyakarta Special Region. We found that the high-cost strategy did not necessarily provide a significant impact on customer satisfaction and SPI. The result of the case study showed that the model could be implemented with some managerial implication such as monitoring and evaluation during the strategy implementation. The management should also keep the data of improvement trends due to strategy implementation. This is because the prediction of system improvement will be based on the historical data or company experiences.

Regarding environmental aspect as one of the sustainability pillars, this study can be further developed by considering environmental performance of the system. Hence, there should be an integrated performance index taking services and environmental aspects into consideration.

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