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The Application of Quality Function Deployment in Car Seat Industry

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Abstract **-** The research aimed to ensure the right design of new products based on customer needs and to improve competitiveness based on renewal marketing strategies and customer needs in the car seat industry. Customer satisfaction ratings were used to compare with competitors. Then, the Quality Function Deployment (QFD) was implemented for the analysis. The research used total sampling or complete enumeration. So, the sample size was the same as the population size. Based on calculations using the QFD method, it shows that the seat option has the highest percentage of technical requirements in the car seat industry around 27,39%. The second factor is material about 25,94%, and the third factor is the damping characteristic about 19,17%. For continuous quality improvement in the future, a lot of customer needs regarding the seat car need to be developed.

Keywords: Quality Function Deployment (QFD), car seat industry, customer satisfaction

I. INTRODUCTION

In line with the population's growth in Indonesia, the economic condition provides good news for economic actors. All business people consider it as a good opportunity for manufacture and service industries. One of the industrial sectors, which has a good opportunity, is the automotive industry. The demand for vehicles in Indonesia increases every year (Singapore Business Review, 2019). It has led to several companies to engage in the automotive competition to prepare for the increasing demand. One of them is the car seat industry.

To support the automotive industry, the car seat industry should be ready to take the opportunity by preparing good management to make the car seats with higher quality. The car seats are one of the main components for car interior because they come in direct contact with the driver and passengers. For many customers the car seats when buying a car, many customers try the car seats first, whether the car seats are ergonomic or not. Moreover, many customers add accessories to enhance the comfort in their car seats. Based on this condition, the industries should pay more attention to prioritize customers' desires as one of the parameters to improve the quality of their products.

By making products that follow what the customers need in the manufacturing industry, especially the automotive sector, it can increase productivity and profitability. So, business competition becomes more competitive. Car seat designs should be well prepared to be a winner in the competition. Many car seats have aspects of making passengers and drivers comfortable during the trip. The aspects are divided into three, namely primary, secondary, and tertiary. The primary aspect is comfort and ergonomic factors. For the secondary aspects, it is comfortable when the car seats are upright and reclined, and have extras for passenger and nice appearance. Then, the tertiary aspect concerns the armrest that folds right away, the car seats that do not hit the person behind when the driver recline, and others (Mandal, Maity, & Prasad, 2015).

In the middle of the 20th century, global competition began to intensify in the world (Shaik, Rao, & Rao, 2015). By looking at this phenomenon, the service and manufacturing companies need a method to make customer requirements turn into technical parameters and values. One of the approaches that can be used is Quality Function Deployment (QFD). It was first introduced by Yoji

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Akao, a Professor of Management Engineering from Tamagawa University (Büyüközkan & Çifçi, 2013). There are two important points in implementing QFD in automotive manufacturing companies. Firstly, QFD changes quality control while establishing quality control for development and design in the manufacturing process. Secondly, the QFD is as a communication tool and provides it for designers. It is a powerful tool for engineers because they find it easy to build systems for subsequent product development (Adhaye, 2013). QFD has three main objectives. First, it is a tool to prioritize the needs of customers directly, both spoken and unspoken. Second, it translates the technical characteristics and specifications based on the Voice of the Customer (VOC). Third, it provides the product or service quality and builds them by focusing on customer satisfaction (Cudney & Elrod, 2011). Some of the benefits of implementing QFD are developing new products that distinguish companies from competitors, analyzing and gathering market quality information, reducing initial quality problems, cutting development time, and expanding market share (Benner, Linnemann, Jongen, & Folstar, 2003).

As QFD is one of many methods to develop what the customers need, it can be integrated with other tools like Fuzzy (Zhang, Yang, & Liu, 2014). The integration of QFD, Kano model, and ergonomic surely will improve the quality well because it is helpful to understand what the customers want (Taifa & Desai, 2015). QFD is the best method to translate what the customers wish to (Padagannavar, 2016).

QFD can be used to improve the service in a competitive global market, QFD can be used. It has been implemented in the chemical industry (Gandara, Muri, & Purba, 2019). QFD also can be applied to determining the correct design (Hadi *et al*., 2017). For continually changing requirements from the customers, the industry needs to be prepared to start from the design. The Kano model and QFD integration can be used for ergonomic design improvement to make it happen (Hashim & Dawal, 2012).

QFD can also be used combined with Analytical Hierarchy Process (AHP) in exploring customers' needs (Kumar & Garnaik, 2016). In creating House of Quality (HOQ), the Kano model is needed to adapt to the customers (Taifa & Desai, 2017). Kano model helps in the identification of customer expectations and satisfaction (Shukla, Ranganath, & Chauhan, 2017).

The viability of a product or service in the market depends upon the satisfaction that it can extend to customers through quality. QFD is a tool that gathers VOC and puts the expected features in the final product (Chaudha, Jain, Singh, & Mishra, 2011). Not all VOCs can be applied to products. However, in this case, the company should understand that by filtering the most important items applied to the product, it can have a positive impact on the market.

A company can begin QFD planning for the first time by identifying customers' needs, determining product specifications, and checking the development plans. In QFD, the process of identifying, determining specifications, and planning for development requires input and decisions made by a team of experts. Then, QFD will become a strategy to understand customers' desires with knowledge and technical requirements. It will eliminate many operating obstacles in the company during product development (Mehrjerdi, 2010).

QFD can be developed as a method to eliminate customers' complaints in the automotive industry (Azizah, Lestari, & Purba, 2018). These benefits can be applied to product and service development projects in developing strategies to achieve customer satisfaction. The research will use the QFD method to car seat products in order to create products that are expected to meet customers' needs. Car seat in Figure 1 is cushioned seats that are generally used in the vehicle as the researchers observe in the car assembly. It functions to support the body and be a shock absorber.

Figure 1 The Example of Car Seat

As mentioned previously, car seats are one of the most important components of the vehicle for customer satisfaction. It is the place where the professional driver spends most of the time, so the design should consider the sitting postures (Mandal *et al*., 2015). Moreover, the foam material for car seats needs to be well selected to make it comfortable for the driver (Patil & Patil, 2017).

The structure of passenger seats can be optimized by light-weighting material (Shahade & Sandanshiv, 2016). Another research is done in seat car design. The car-seat concept is rated well on the experienced relaxedness, even with the lack of side support. The most important findings are that hard seats with a rather high side supports are rated as sporty. However, softer seats are rated as more luxurious (Kamp, 2012). Then, ergonomic aspects and customer requirements are analyzed through VOC. Those are important factors to design a seat car (Fahma, Iftadi, & Putri, 2015).

Then, the product design specifications with market competitiveness and technical feasibility can be confirmed to propose an optimal product design strategy. It can continue the new product development process (Yang & Hsu, 2019). QFD can also be used

to investigate the normalization needed for the relationship matrix in quality (Raharjo, 2013).

The research using QFD in the car seat industry has been carried out in truck seats (Kumroni, Zahri, & Agustian, 2018). Then, the vibration of the car seat is very important to avoid discomfort in driving a vehicle (Nawayseh, 2015). Meanwhile, the weight sensor of the car seat is also a part of the quality advance to introduce to the customers through QFD (Haroglu, Powell, & Seyam, 2016).

There are two purposes of the research. First, it is to define the right design in the car seats to improve the ergonomic factor by using the QFD method. Second, it is to enhance the competitiveness based on renewal marketing strategies and customer needs such as longevity, no wrinkles, cleanliness (hard to get dirty), no flat cushion, and competitive prices.

II. METHODS

The research uses the total sampling or complete enumeration. Therefore, the sample size is the same as the population size. Then, the design concepts of the new product in the research are grouping the critical components from the seat. The primary data are collected by the observation or direct measurement and questionnaire. It includes the customers' needs, technical requirements, and critical parts. Meanwhile, the secondary data are through interviewing the Research and Development (R&D) and Technology and Production Management department in the automotive manufacturing company to collect the product types, specifications, demand rate, initial seat design, and production process.

The process of QFD starts from the identification of needs, determination of product specifications, and task development plans (Starbek & Grum, 2002). The first matrix of the QFD process usually takes the opinion of highly non-technical customers, namely VOC. It scientifically rates the importance of wants, needs, and desires, and technical links. The relationship between customers' information and technical information is checked so that the team can begin the research to determine the target value for each technical requirement. Many references explain QFD and Kano model created by the research to understand what the customer's needs such as Solanki and Desai (2017).

QFD can be utilized more than a design tool. There are several steps for implementing the QFD method (Erdil & Arani, 2019). First, it is to capture the basic needs of the customer (what). In identifying the requirements, a quantity of market research is essential to know the competitive position of the product in terms of customer satisfaction. In addition, it evaluates the importance of their requirement as expressed by the customers. Then, the design attributes that can fulfill their needs is carried out. Second, it translates VOC to the technical attribute. Third, the appropriate and feasible relationship between customers' attributes and technical attributes is established with the help of HOQ metrics.

HOQ of quality matrix is considered as the most recognized and widely utilized tool for product or service design. It translates customers' requirements, based on marketing exploration and benchmarking data, directly into an appropriate range. It is associated with involving engineering targets to get a new product or service design. It is carried out by a multidisciplinary staff representing marketing, design, manufacturing engineering, and any kind of other functions considered to be essential by the company. HOQ continues to be widely used in the industry. With the correct way of implementation, HOQ will have a big impact on the company. It is a methodology that will provide the right information collectively, efficiently meet customers' requirements, and facilitate better decision making. It promotes cross-functional teamwork which usually reduces the uncertainty associated with the product and process design (Shrivastava, 2016).

The design flow of HOQ consists of customer attributes a portion of matrix (horizontal), engineering characteristics matrix (vertical), customers' competitive evaluation, relationship matrix between (central portion), co-relationship matrix (triangular-shaped roof), competitive technical analysis and, absolute importance, as well as relative importance and target. With the mentioned design flow, the researchers describe the HOQ steps. First, it identifies what the customer wants or needs. Second, it identifies how the product or service will fulfill the customers. It refers to figuring out specific product characteristics, functions, or attributes and demonstrating how they will fulfill customers' wants. Third, it identifies human interactions with several questions. Fourth, it develops significance ratings. It refers to utilizing the customer's importance evaluations and weights from the particular relationships within the matrix to compute the importance rankings. Fifth, it evaluates the competing products or services. A question is asked (how well do competitive products meet customer wishes or needs?). This activity has established a base on research. Sixth, it determines the typically desirable technical attributes. With this step, the performances of the company with the competitor are identified and compared.

III. RESULTS AND DISCUSSIONS

For QFD functions, HOQ are used on customer products to manage and identify design tradeoffs. It involves studying customer requirements that can be in the form of a marketing survey that has been targeted towards specific marketing. Usually, the purpose of this survey is to find out what the customers want from the producer. HOQ serves as a good match between the customer requirements and the engineering variables. The simple word on it can be translated to what the customer through the technical language.

The first level of the QFD is definition phase. The phase translates the customers' requirements for design. If it has been completed, it can move to the next stage. The early stages concerns finding out what the customers want in the product. Then, the researchers move to develop engineering characteristics that can be used to assure customer satisfaction. The next stage involves correlating the two previous steps by highlighting the conflicting characteristics and setting target values. During the setting of target values, it becomes clear that the researchers do not know enough about some aspects of the design, such as the back seat and seat pan profiles. This is one of the strengths of QFD. It highlights areas of weakness that are important for customers. Once the problem is identified, it can be tackled. This point comes up again during the final stages. The analysis of the chart shows the areas of importance that must be addressed. However, QFD does not solve engineering problems. It is a forum for gathering and organizing all relevant data for design. It focuses on what the customer wants and sets target values for engineering characteristics to assure customer satisfaction. In this context, QFD shows what to do, not how to do it.

A large amount of effort is put into preparing the first-level study. An equal commitment should be made to solve the highlighted engineering problems. The best problem-solving techniques should be employed. The use of designed experiments is strongly recommended. Two other benefits of QFD may not be so obvious. Firstly, it acts as a facilitator for a multi-discipline team approach to product design. Secondly, it is an excellent documentation medium for recording options and decisions made during product design. The mentioned terms can be developed with QFD as a popular tool used for the new products, as seen in Figure 2.

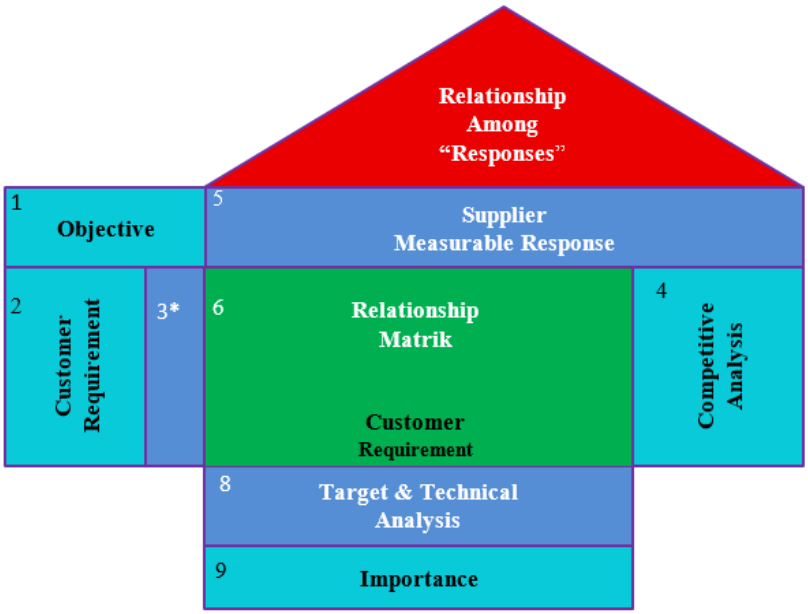
By using HOQ, the researchers apply the scale of weight for customer needs for car seats. The scale of weight is 1−5, with 5 is as highest priorities as shown in Table 1. After getting the customer's needs weight, the next step is putting the results on HOQ. The HOQ can be seen in Figure 3.

Table 1 The Weight of Customer Needs

Customer Needs	Weight
Comfort in all conditions	5
Long lifetime for the car seats	2
No wrinkle on the car seat	3
Car seat's cleanliness (hard to get dirty)	4
No flat cushion	5
Competitive prices	2

The calculation of improvement factor, overall weight, and the percentage of weight uses Equation (1).

$$Improvement\ Factor = [(Plan\ CS\ Rating - Existing\ CS\ Rating)0,2] + 1 \quad (1)$$



* = Requirements Characterization and Verification (Typical, Kano Weight and Classification)

Figure 2 The Basic Construct of HOQ Model

Then, the sales point or strategic marketing factor is placed in the planning matrix. Several sales points about 1 to 1,5 are used to emphasize customer needs. It is an estimate of the marketing importance of the need for the promotion of the new right product. It is used along with customer importance and improvement factor in the calculation for the overall weight in the customers' needs. The calculation of overall weight is based on customer importance, improvement factor, and sales point. The equation used is as follows:

$$\textit{Overall weight} = \textit{Customer importance} \times \textit{Improvement factor} \times \textit{Sales point} \quad (2)$$

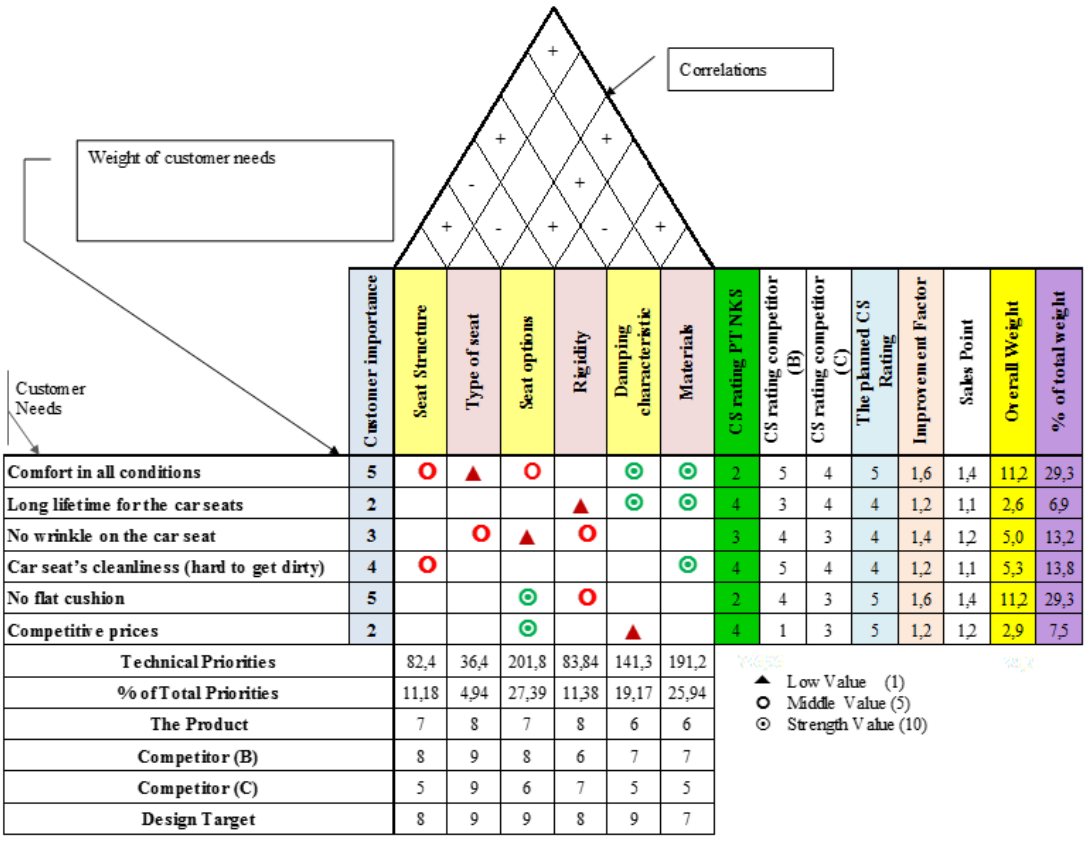
After that, it converts the overall weight to percentages to understand how much the design or improvement effort should be put on each customer's need (Goetsch & Davis, 2014). The percentage of total weight can be calculated with Equation (3).

$$\textit{\% of total weighting} = (\textit{Overall weight}/\textit{Sum of overall weight}) \times 100\% \quad (3)$$

The car seat is divided into several parts. Those are seat frame, pad, spring back, trim cover, spring cushion, recline, sliding seat, and slide adjustment. The seat frame, spring back, recline, and sliding seat are made from metal. It supports other seat components, such as pad and trim cover. To make the spacious rear seats more comfortable, it must be equipped with the reclining systems. The ability to slide the seats (forward 70 mm.) and raise the seats (upward 20 mm.) ensures a comfortable position all the time. After the completion, the seat is checked visually whether there is any defect or not. This process does not use the machine or equipment, so the accuracy of workers is needed. Besides visual checks and following up by function test the seat, it is done by 100% manual checking of the car seat function.

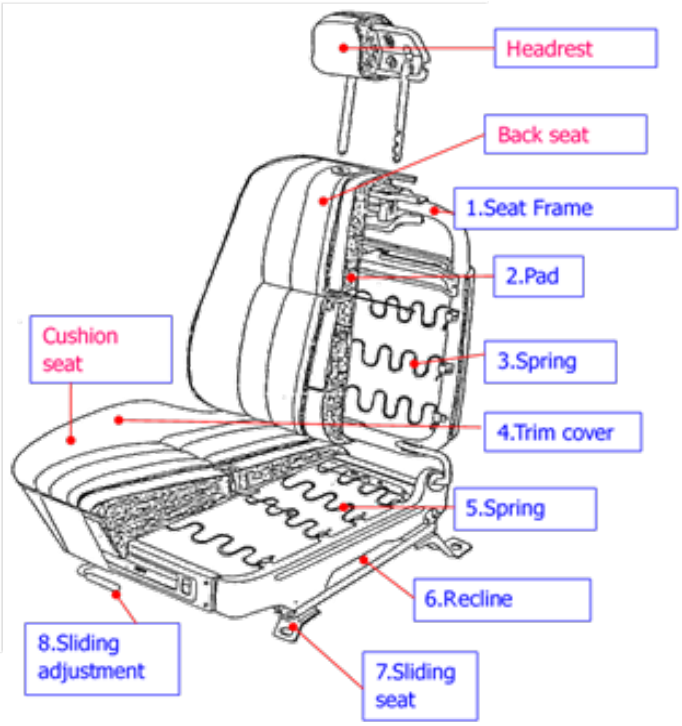
The details of car seat parts are described as in Figure 4. It is designed by PT NHK KBU Seating (NKS) for PT Mitsubishi Motor Krama Yudha Indonesia (MMKI). PT NHK KBU Seating (NKS) is one of the companies located in Cikarang, engaged in the manufacturing of car accessories (car seats). The attribute of QFD in an automotive manufacturing company for car seats becomes the priority to improve service quality (comfort in all conditions, long lifetime, no wrinkles, clean, no flat cushion, and competitive prices). It can be a suggestion for a marketing strategy.

The final result of the research is conducted at PT NHK KBU Seating (NKS) with the QFD. It can be concluded that to improve the quality of car seats, priority attributes and technical requirements are obtained, namely, seat structure, seat type, seat options, stiffness, damping characteristics, and materials. From Figure 3, it can be seen that the highest priority for improvement is seat option (27,39%), material (25,94%), and damping characteristic (19,17%). The details can be seen in Table 2.



Customer Needs	Customer importance	Seat Structure	Type of seat	Seat options	Rigidity	Damping characteristic	Materials	CS rating PT NKS	CS rating competitor (B)	CS rating competitor (C)	The planned CS Rating	Improvement Factor	Sales Point	Overall Weight	% of total weight
Comfort in all conditions	5	O	▲	O		⊙	⊙	2	5	4	5	1,6	1,4	11,2	29,3
Long lifetime for the car seats	2				▲	⊙	⊙	4	3	4	4	1,2	1,1	2,6	6,9
No wrinkle on the car seat	3		O	▲	O			3	4	3	4	1,4	1,2	5,0	13,2
Car seat's cleanliness (hard to get dirty)	4	O					⊙	4	5	4	4	1,2	1,1	5,3	13,8
No flat cushion	5			⊙	O			2	4	3	5	1,6	1,4	11,2	29,3
Competitive prices	2			⊙		▲		4	1	3	5	1,2	1,2	2,9	7,5
Technical Priorities		82,4	36,4	201,8	83,84	141,3	191,2								
% of Total Priorities		11,18	4,94	27,39	11,38	19,17	25,94								
The Product		7	8	7	8	6	6								
Competitor (B)		8	9	8	6	7	7								
Competitor (C)		5	9	6	7	5	5								
Design Target		8	9	9	8	9	7								

Figure 3 The HOQ Matrix



	Part	Materials
1	Seat Frame	Metal
2	Pad	Urethane foam
3	Spring back	Metal
4	Trim cover	fabric, vinyl, leather
5	Spring cushion	Metal
6	Recline	Metal
7	Sliding seat	Metal
8	Sliding adjustment	Metal

(Source: PT NHK KBU Seating (NKS))
Figure 4 Virtual Seat Design

Table 2 The Customers' Important Priority

Customer Importance (attributes)	Priority (%)
Seat option	27,39
Material	25,94
Damping characteristic	19,17
Rigidity	11,38
Seat structure	11,18
Type of seat	4,94

The company should consider on the three customers' important attributes to improve or design new products by adding seat option, material, and damping characteristic to get a more comfortable car seat. Therefore, in all conditions, the seat has a long lifetime, competitive price, and no flat cushion. It is also not easy to wrinkle and dirty. From these results, it is expected to assist companies in the development of service and product quality following the needs of customers.

IV. CONCLUSIONS

The attributes of car seat design are based on the customer needs. It consists of six variables, namely the comfort in all conditions, long lifetime, no wrinkles, clean, no flat cushion, and competitive prices. The process of alternative product design and planning is done by approaching the concurrent technology team by implementing new product development. Then, the conceptual design step is done by using QFD to identify the importance of the weight of seat design and part characteristics. The approach of applying the QFD method in the manufacturing seat industry can analyze customer needs, know what to do by the company, and apply it to the product and manufacturing process. Based on a calculation using the QFD method, it shows that seat option has the highest percentage of technical requirement in seat car industry about 27,39%. The second factor is material about 25,94%. The third factor is the damping characteristic about 19,17%. From the results of the research, it can be concluded that implementing and improving the process of seat manufacturing can be done by using seat structure, type of seat, seat option, rigidity, damping characteristic, and material. It can be an excellent tool for planning and controlling the development process before production, especially in the car seat industry.

Further discussion is needed to maintain what has been successfully achieved. The recommendations for future researchers are to make it better. It is highly recommended to make revisions and adaptations with new tools and technology, such as using Six Sigma program before implementing the QFD concept. Six Sigma performance is always the long-term goal for a company quality system, so it will be more accurate to justify establishing the improvements. The future researchers can also use another method such as

Multi-Criteria Decision Making (MCDM), Analytical Network Process (ANP), or Analytical Hierarchy Process (AHP) to combine with QFD.

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