Aalto University
School of Economics

Apply quality function deployment model in after-sales service improvements: case company X

Logistics

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Ye Tian

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Department of Business Technology
Aalto University
School of Economics

Abstract

This study is to apply the quality function deployment (QFD) model in the Chinese heavy construction equipment market to improve the after-sales service. The main objectives of this study are to find out how to translate the customers' needs into technical measurements by this QFD model for the supplier company and also to find out the priority and importance of each technical measurement to design the after-sales service model for the Chinese heavy construction equipment market.

The main literature reviews are focusing on the comparison of the differences of after-sales models in the Western and Eastern markets and how to decrease the customers' dissatisfaction of after-sales service by using the QFD model. Moreover, in this study there is a specific introduction of the QFD model and its core part, the house of quality (HOQ). And there is also an introduction of the focus group method which is used to define the research attributes in the QFD model.

After the literature review and methodology introduction, there is a case study based on the company X from China. This company is a leading company in the Chinese heavy construction equipment market. By applying the data which is collected from the company X and its customers into the QFD model, there is possibility to make the guide that how to improve the after-sales service in the Chinese heavy construction equipment market.

In this study, firstly we can know how the QFD model can be used in the service improvements, and then we can know how to improve the after-sales service by utilizing the QFD model in the Chinese heavy construction equipment market and also design the appropriate after-sales service model for this specific market.

Key words: after-sales service, Chinese heavy construction equipment market, quality function deployment (QFD), house of quality (HOQ), focus group

Table of Contents

List of figures

1 Introduction

1.1Research background

Like the automobile market in China, the heavy construction equipment market gradually became a notable market in the world and will increase more in the following several years. Because many foreign companies entered the Chinese heavy construction equipment market around 15 years ago and established the benchmark of the qualified after-sales service during the consecutive years, the Chinese local companies began to emphasize the service quality in order to catch up with their competitors and also retake the market shares.

Due to the industrial report, the after-sales service can contribute about 3/5 of the total profits in the excavator market during the product's life cycle[1]. That is to say, when sell a machine to the customer, there will be 1.5 times of the sales profits come from the after-sales service – mainly sourced from the repair, maintenance and replace and some from the information providing. Although the excavator market is one of the most profitable subdivision markets in the machinery industry, there is no big deference from other subdivisions.

Another point needs to be mentioned. The trend of heavy construction equipment production becomes homogenization. Hence the experienced customers regard the after-sales service could be the very key factor to affect their purchase decision. And there is a report made by the case company before it intended to enter the excavator market to provide some information about the homogenization phenomenon[2]. This report shows the investigation results about how the potential customers choose the products and the detail number shows nearly 1/3 of the interviewee do not consider the brand of the products as

[1] Source from the case company's internal report (1)
[2] Source from the case company's internal report (2)

the priority of the purchase standards. Especially in the experienced customers group, who has purchased any heavy construction machines before, even more than 1/2 thought the quality of the after-sales service is the key purchase factor instead of the brands images or products designs.

This condition of the heavy construction machinery market can be easy understood. Different from the automobiles, the heavy construction machines are used for production but not for enjoyment. Then the reliability and economic efficiency are the most important factors. There is another character different from the automobiles. The heavy construction machines face to be broken more frequently than the automobiles because they face more unusual operating environment. So the heavy construction machinery industry requires a high efficient and high economical after-sales service.

All the people can feel that the service is intangible. And some of the service cannot be quantified such as the manner of the service personnel. So there is necessary to find out an efficient way to improve service by the quantitative methods. The quality function deployment (QFD) model is one advisable method, although it is original used to improve the products design. And after some experiments tested by the previous researchers Fisher & Schutta, the QFD could be well applied for the non-pure service, which also delivers products together. The after-sales service is the kind that the repair work is the pure service aspect and the replace work is the spare parts delivery aspect. Then in this thesis the study is going to find out how QFD helps for service improvements.

1.2 Research process

In this thesis, the participators of the research work include the thesis writer himself and a project team from the case company X. The project team from the company X is composed of four people. They are one regional marketing manager, two local marketing workers and one regional after-sales service manager.

The whole research process contains two parts. One is the data processing part, which is taken by the thesis writer only. Another part is the data collecting and editing part, which is taken by both the thesis writer and together with a project team from the case company X. Here, the main introduction to the research process is the data collecting and editing part and the data processing part will be introduced in the case study section.

In the chart of (Figure 1-1) below, the research process map shows how the data is going to be collected and edited by the project team from the case company X.

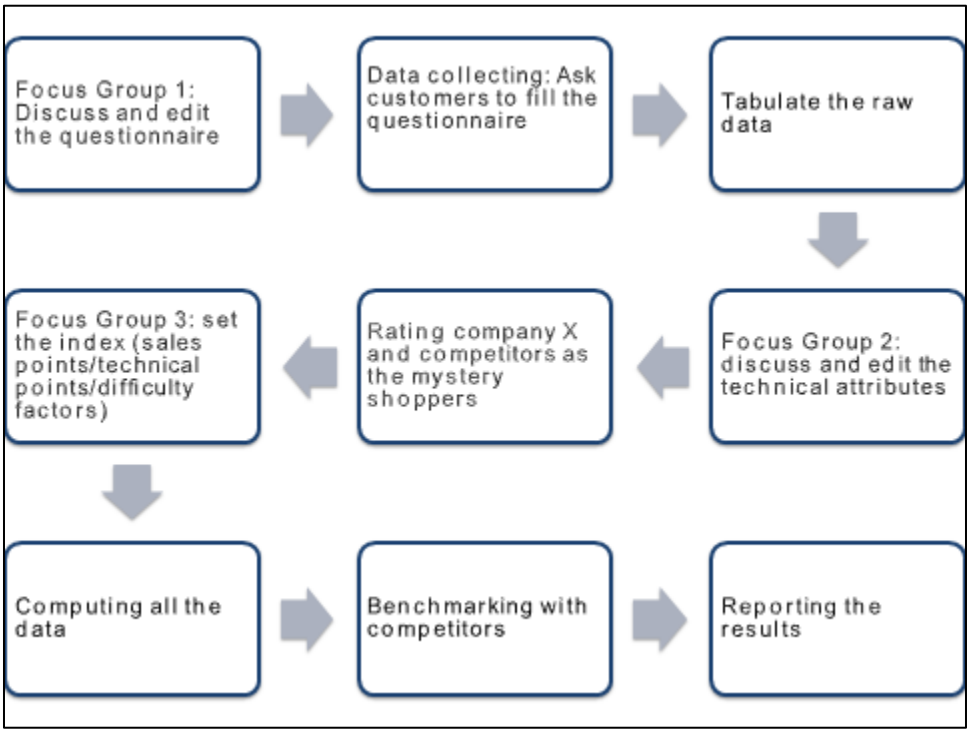

Figure 1- 1 the research process map

There are three steps are used by the "focus group" method in the whole research process. The specific introduction of the "focus group" will be stated in the methodology section of this thesis. And now here is only the brief introduction of how to apply the "focus group" method. The Focus Group 1 is to discuss what should be the main contents of the customers' requirements in the questionnaire for collecting information from customers. The Focus Group 2 is to determine the technical measurements in the Quality Function Deployment (QFD) model after receiving the raw data from the filled questionnaires. And the Focus Group 3 is to set the indexes which are used to compute the stated importance and strategic focusing for both the customers' needs and technical measurements in the QFD model calculation.

The thesis writer and the project team from the company X are the participators in the group work by using the "focus group" method. Because there is a long geographical distance from the thesis writer and the company X, the tool used for the communication will be the Instant Messaging (IM) software which is named QQ[3]. This IM tool supports the group chatting both by voice and text.

The questionnaires are going to be sent to the selected customers by the company X. They use the ways of either sending postage paid mail to customers or go to customers directly when they have the routine visiting. The questionnaire mainly asks the customers to rate the importance of each after-sales service which the supplier should provide.

And there is a special step named "mystery shopper" step in the research process which is mainly done by the project team from the company X. In this step, the project team evaluates the company X and its competitors according to the benchmarking. They would compare the every index by considering the public information and by investigating the competitors on the spot as the mystery shoppers. Although there could be somehow subjective from the project team's perspective, the whole picture was professional enough. Then we can say that the collected data are valid for applying in the QFD model.

Both the first-hand sources and the second-hand sources are used in this thesis. The main first-hand sources applied in this thesis are the collected customers' data from the

[3] http://en.wikipedia.org/wiki/QQ

questionnaires. The questionnaire is edited by the thesis writer after taking references of the project team from the case company and also from the similar cases of the automobile industry. And then the questionnaires will be sent to the selected customers by mails to get the rated feedbacks. Another first-hand source of data applied in the QFD model is collected from the benchmarking evaluation by the project team of the case company X. In the benchmarking evaluation, the project team makes the results by using the "focus group" method. And the thesis writer would also participate in the benchmarking evaluation discussion by using the IM tool named QQ for communication.

For the second-hand sources, they are mainly from the case company's documents, academic journals, books and website news and reports in the Chinese heavy construction equipment industry. In the case company's documents, there are main contents about the guidance of after-sales service and the process of the maintenance and repairing works, which could provide some suggestions for the technical measurements used in the QFD model design. The academic journals and books provide the theory basement of the application of the QFD model. It is worth to mention that the book from Fisher & Schutta (2003) is the first academic book to illustrate how to apply the QFD into service improvement. Last but not least, the websites news from the field of Chinese heavy construction equipment industry provide lots of information about the commercial activities of rival companies and also some media reports on the case company X. Moreover, from the reports of the industry, there is some forecasting comes from industrial experts on the trends of development in the Chinese heavy construction equipment industry. All of them above provide the data and suggestion to build the contents in the QFD model application and to support the results analysis.

1.3 Research objectives

There are many researches about the quality function deployment (QFD) model in the recent 30 years. But the majority of them were mainly focusing on the manufacturing aspect such as products design and products innovation. One reason to explain that is the QFD model was born due to the demanding of production in Japan. Another reason is like what Fisher & Schutta (2003) wrote in their book: the application of the QFD is more difficult for services, probably because customer needs for services are highly perceptual and harder to measure.

However, there is significance to apply the QFD model into service study just because the quality of service is intangible to be felt by customers and even by the service providers. Moreover, Fisher & Schutta (2003) successfully applied the QFD model into improve the service for a pizza house and then wrote the guide for improving service from QFD application. So in this thesis, we can follow Fisher & Schutta to test the availability of using the QFD model for improving the after-sales service.

In this thesis, there are two main study objectives. The first one is to apply the QFD model practically in order to translate the customers' needs into technical measurements for the supplier company. The second objective is to find out the priority and importance of each technical measurement and then design the after-sales service model for the specific market.

Although in this thesis there is only one case company as the study object, a couple of beneficial results for the related industries are surely brought from this study. Because the after-sales service in the machinery industry is quite similar for each subdivision industries, the principle of this research method and process can be universally used in the similar industries. Then it has the advantage to the improve after-sales service quality for all the machinery suppliers.

1.4 The thesis structure

There are five main parts in this thesis. The order of each part in the thesis is shown in the structure chart from the (Figure 1-2) below.

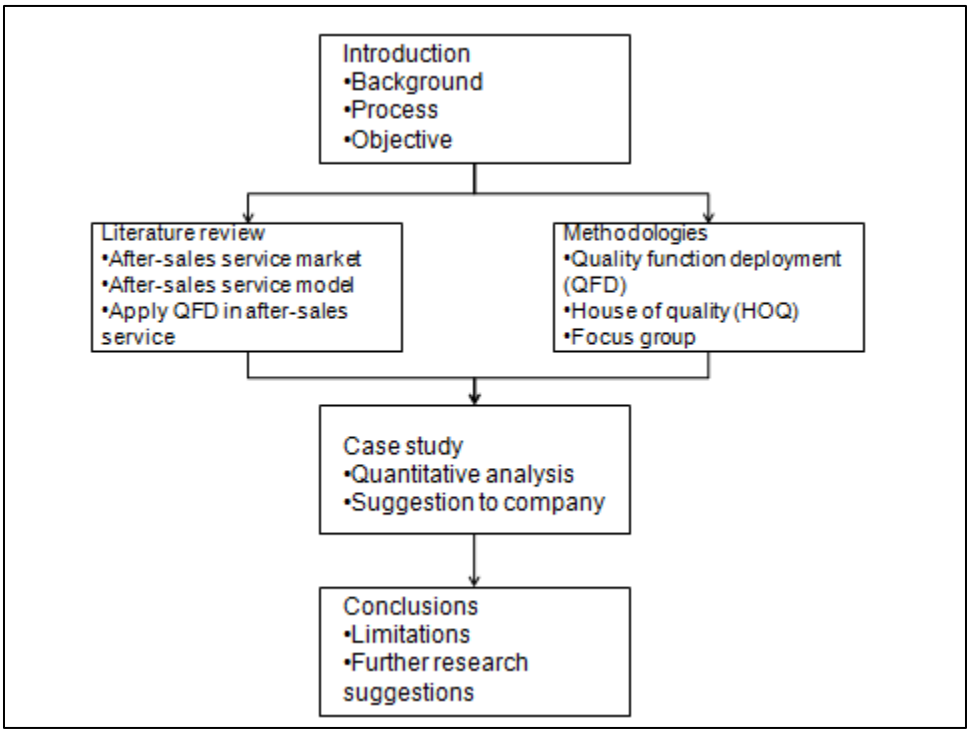

Figure 1- 2 structure of the thesis

Part one is the introduction, which gives the overview of the research background, the research process, the research objectives and the thesis structures.

The part two is the literature review. This part is the theory study part, which illustrates the previous academic research in the field of after-sales service market and the after-sales service model. Moreover, there is a discussion about how the dissatisfaction of after-sales service is decreased by applying the quality function deployment (QFD) model.

The part three is the research methodology, which explains the detail of the methods used in this thesis. In this part, there is the overview framework on the data collecting, data

tabulating, data editing, and data analyzing. The quality function deployment (QFD) model and the house of quality (HOQ) method are introduced to analysis the data. And the “focus group” method is introduced to collect the data.

The part four is the case study, which applies the theory and the methods into the real case to detect the practical performance of the QFD model. And after analyzing the results, there would be some suggestions for the case company to improve its after-sales service by adopt an optimal model. And this could evaluate the effect of applying the QFD model for the after-sales service. Moreover, it may benefit the other industries which also regard the service improvement as the priority.

The part five is the conclusion. This part summarizes the key findings of the thesis, the main results of the objectives from the case study and summarize the possible modification if re-process this study. Furthermore, there are the statement for limitation and the future study suggestions, which may be helpful for the readers who have interests on study the service improvements by applying the QFD model.

2 Literature review

2.1 The after-sales service market

Cohen, Agrawal, & Agrawal (2006) found that in the industries like automobiles, white goods, industrial machinery and information technology, companies have sold so many unites over the years that their after-sales market have become four to five times larger than the original equipment business. No doubt that the after-sales service business will be the superstar business for the industries witch listed above. Compared the marketing job which mainly focuses on selling and the promoting the current products or service, the after-sales service job takes care of the entire sold ones since the company started its business. Furthermore, after-sales service brings companies with lots of profits in high margin business. A 1999 AMR Research report from Gartner[4] stated that businesses earn 45% of gross profits from the aftermarket, although it accounts for only 24% of the revenues. Cohen, Agrawal, & Agrawal (2006) also thought that customers don't expect products to be perfect but they do expect manufacturers to fix thing quickly when they break down. This is obvious in the customer's mind. Especially in the industrial machinery industry, customers are more eager to get good performance on after-sales service.

However, it is not easy for manufactures to provide the satisfied after-sales service. Although in the early 1990s the companies in North America, Western Europe and Japan began to deliver the value to customers, there are no very effective methods to build the after-sales service supply chain as beautiful as the manufacturing supply chain. We can see the characteristics from the two chains in the compared details from (Figure 2-1).

[4] http://www.gartner.com/technology/supply-chain/amr-research.jsp

PARAMETER	MANUFACTURING SUPPLY CHAIN	AFTER-SALES SERVICES SUPPLY CHAIN
Nature of demand	Predictable, can be forecast	Always unpredictable, sporadic
Required response	Standard, can be scheduled	ASAP (same day or next day)
Number of SKUs	Limited	15 to 20 times more
Product portfolio	Largely homogeneous	Always heterogeneous
Delivery network	Depends on nature of product, multiple networks necessary	Single network, capable of delivering different service products
Inventory management aim	Maximize velocity of resources	Pre-position resources
Reverse logistics	Doesn't handle	Handles return, repair, and disposal of failed components
Performance metric	Fill rate	Product availability (uptime)
Inventory turns (the more the better)	6 to 50 a year	1 to 4 a year

Figure 2- 1 two chains compared (Cohen, Agrawal and Agrawal, 2006)

The mostly obvious difference between manufacturing supply chain and after-sales supply chain is that business cannot produce services in advance of demand. That is to say, the after-sales service supply chain is the pure demand chain. Companies can merely manufacture products or provide service only when an unpredictable event, such as a product failure, triggers a need. However, because of the products and the distributing systems have their own hierarchies; there would be another problem that companies find it difficult to decide which resources to deploy and where to deploy them due to the hierarchical spares and locations. To use the people well known computer industry as the example, the product hierarchy includes end products such as computers, models such as monitors, sub-models such as motherboards and piece parts such as semiconductors. And the geographical hierarchy has the four basic components that the central repair facility, the regional repair facilities, the field repair facilities and the stocks of spare parts on-site with customers.

Cohen, Agrawal, & Agrawal (2006) build a matrix to explain the relationship between product and geographical hierarchy and they named it "creating service products".

Looking at (Figure 2-2), we can get the information from the matrix that the quickest way for companies to meet response targets is to replace the failed products with the whole end product units that they have positioned on customers site. But this way is also the most expensive way that lots of cost from the on-site stocking and end product assembling. By contrast, the most economical way to meet a service demand is to replace from the central facility with only the broken piece parts. And this would be the slowest process because suppliers would need time to diagnose the problem and also report to the central facility.

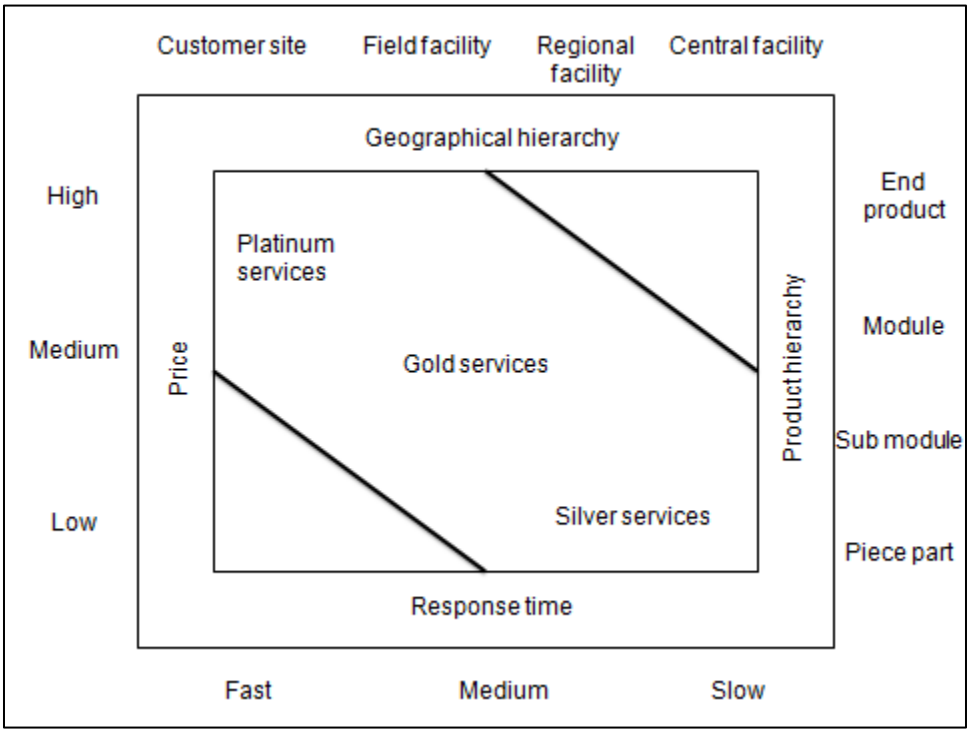

Figure 2- 2 creating service products (Cohen, Agrawal and Agrawal, 2006)

Like Cohen, Agrawal, & Agrawal (2006) illustrated, since companies cannot easily forecast the demand for resources, they must develop demand probability distributions and make allocation decisions after calculating the trade-offs of stocking different resources at different locations. So, in the following part, we will continue to discuss the two popular after-sales service models in the markets.

2.2 Two after-sales service models

The difference between the two after-sales service models in the markets is that "who is responsible to takes care of the after-sales service". More specific speaking, one is that the manufacturer or its subordinate takes care of the service work; the other is that the dealers of the manufacturer are responsible for the service work.

According to study the service in the aftermarket from Japan and the United States, Herbig & Palumbo (1993) found that the most obvious one of the service difficulties in multinational marketing is the spare parts problem, which involves (1) maintaining the expensive spare parts inventories in each spreading market and (2) incurring shipping and importation delays in receiving the spare parts from some central storage. So we can think that the spare parts management strongly affects the service quality and service efficiency.

Generally, if let the manufacturer wholly take control of the after-sales service, there is the advantage that the spare parts may have more diversity and enough inventories. By contrast, if let the dealers to take the after-sales service totally, there is the advantage that the storage way of spare parts might be more appropriate because the dealers are more familiar with the condition of the machines which they sold, then they can have a good forecasting of spare parts inventory. Moreover, the dealers have more proximity to customers, and then their response for service might be quicker. However, there is a trade-off between the service performance and service cost. So it should be balanced in the specific market.

Herbig & Palumbo (1993) researched the after-sales service market in Japan and in the United States and made the two markets as the representatives of the Eastern market and the Western market. Considering the culture difference and the affects by the culture, there are many different characteristics in the after-sales markets. They found that Japanese customers expect prompt service and availability of a full line of parts for any major purchases. That is to say, in this market the companies must carry a large and

complete inventory of parts and provide trained service personnel. Moreover, a major concern of Japanese consumers considering purchase of any imported products is the length of time it takes to have them repaired. Furthermore, Japanese customers expect the after-sales service is the part of the purchase with longer warranty periods. It means that the Japanese customers would not like to pay for the after-sales service after the initial purchase. Also, the Japanese customers feel that a qualified product should not need to be repaired frequently. So in this kind of market, let the manufacturer take care of the after-sales service could have a better performance because the manufacture has more capacity to handle any problems. And that is why in the Japanese market the mainstream is that the after-sales service is managed directly by the manufacturer itself.

Another research result made by Wilson, Boström, & Lundin (1999) also stated that customers in the Far East customers want instant service and they want it for free and customers in the North America are willing to pay in advance for the after-sales service in the form of service contracts. They still mentioned that the Western customers seem more patient if they faced the problem such as the machines failed compared with the Eastern customers. Because the phenomenon that the Western customers have the preparation of problem incurring when they purchased the products but the Eastern customers trend to require the perfect quality of both products and the after-sales service, it explained why majority of companies in the Japanese market like to control the after-sales service but most companies in the United States market prefer to ask their dealers to take care of after-sales service. No doubt that let the manufacturer wholly take care of the after-sales service would provide customers a full-scale service. However, when let the dealers to do the job, the total costs in the supply chain of this industry would decrease a lot. At least, the manufacturer could cut off its repair force and allocate those sources to focus on marketing and R&D activities.

After tracking the International Swedish firm, Wilson, Boström, & Lundin (1999) defined the after-sales service performing in the six activities when it is handled through the distribution network: Installation, Training, Routine maintenance, Emergency repair, Parts supply and Software services. Wilson, Boström, & Lundin (1999) did not

exclusively define which activity should be taken by which side. Instead, they adopted a more reasonable way to make some common suggestions for the responsibilities.

They also listed the general nature of these activities with the responsibilities in the (Figure 2-3). In this chart, they named the manufacturer as the Corp office, and named the dealers as the Distributor subsidiary. They thought that for the Training and Software service activities, the manufacturer should play the primary role and the dealers play the secondary role if needed. And they emphasized that for the Installation, Routine maintenance (including Contract and Purchase order) and Emergency repair activities, the dealers should undertake more responsibilities. However, they just stated the Parts supply activity is the partial responsibility for either manufacturer or dealers.

	Corp office	Distributor subsidiary
Installation	Specials	Normal responsibility
Training	Primary	Secondary
Routine maintenance		
Contract		Normal responsibility
Purchase order		Normal responsibility
Emergency repair		Normal responsibility
Parts supply	Partial	Partial
Software service	Primary	Secondary

Figure 2- 3 the distribution of post-sale service responsibilities (Wilson, Boström and Lundin, 1999)

By using this matrix to benchmark the after-sales service of the Swedish firm in the global market, Wilson, Boström, & Lundin (1999) found the similar results like the other study results from compassion of Western and Eastern markets. They pointed out that the Far East market has more difficult areas to service both with regards to expectations of customers and communication patterns. It is good to mention the communication patterns,

because when we are talking about the after-sales service, people mainly consider the “hard service” only, such as repairing and installing. But most of people never thought of the “soft service” such as the reservation and complaining. This is one of the points which the thesis will go to research.

2.3 Decreasing dissatisfaction in after-sales service by applying quality function deployment (QFD) model

Like the automobile market, in the heavy construction equipment market, quality and service drive everything. An article studying China heavy construction equipment market from ENR (2007) pointed out that when the manufacturers move forward, they should be careful supporting their products. If not, everyone may end up with lemons, instead of plums. There is also a typical case from the automobile market to explain how important the service is that Toyota became the market leader due to its products quality and after-sales service quality but Yugo quitted the market because of no sufficient service.

There is one book named "The Developing New Services: Incorporating the Voice of the Customer into Strategic Service Development," written by Caroline Fisher and James T. Schutta. This book deals with quality function deployment (QFD), which is the first book to guide how to develop service with a quantitative method. This book deals with the service industry. Moreover, its focus is on taking the voice of the customer, running it through the QFD process and translating it into meaningful output. In this book, there is a case of pizza shop which is applied the QFD of the whole process. And this method can be transferred to other multi-functional service market such as the after-sales service market because it also provides customers the both benefits: tangible benefits like the spare parts and intangible benefits like the delivery of service.

In order to explain how to decrease the diastisfaction of custoemrs, Fisher & Schutta (2003) made a modified Kano model firstly to illustrate the voice of customers like the picture in (Figure 2-4). In the Kano model, there are two axes. The horizontal axis means

the how much the service meet customers' requirements. And the vertical axis means how much of the feeling from the customers which reflect the service quality. Moreover, there is a critical line which is named the Performance Consequence Line. Above this line, there might be an Excitement Consequence Line which represents the relationship between degree of achieving excitement consequences and level of customers' satisfaction. By contrast, a line named Basic Consequence Line is below the Performance Consequence Line.

In the modified Kano model, Fisher & Schutta pointed out that lots of service is on the Basic Consequences Line which means if the companies do not put enough effort on the extent of meeting consequences, the attitude of customers would trend to dissatisfaction. However, if the companies strive very much to improve their service which is on the Basic Consequences Line, there will be no obvious effect to let the customers be very delight. For example, customers may be dissatisfied if the car they bought does not have the air conditioner. And they will not be crazy happy if the car have four individual-zone-controlled air conditioners. However, the car manufacturer would cost much more to install the four individual-zone-controlled air conditioners than only install the single simple air conditioner. Let's see another example in the service market. The customers will be very dissatisfied when they go to a restaurant which does not provide folks and knifes but they would not be much satisfied if the restaurant provides them the once-off table wares.

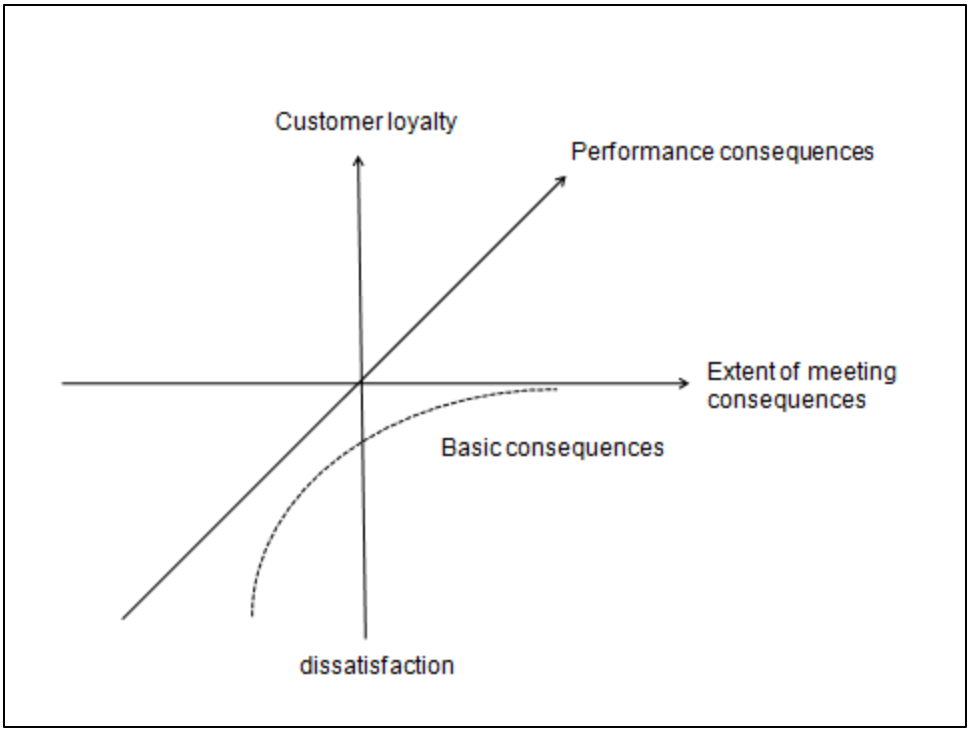

Figure 2- 4 the modified Kano model (Fisher and Schutta, 2003)

Chan & Wu (2002b) also agreed that the main use of qualify function deployment (QFD) model is to diminish the dissatisfaction of customers in their published article. They suggest using the QFD model to decrease the dissatisfaction of customers along with such guidance that "How to decrease customers' dissatisfaction?" with four subsidiary questions of (1) "Which is that customers want but we don't provide?" (2) "Which is that customers aren't eager to have but we provide?" (3) "Which is that main competitors provide but we don't?" and (4) "Which is that only we provide but not so effective?"

Like the questions listed above, the purpose of apply the QFD model into this thesis is to find the difference of after-sales service quality from the company X and its competitors and moreover, how far of the after-sales service quality between the company X's current performance and the customers' requirements. Here are the visual symbols marked on the map from (Figure 2-5).

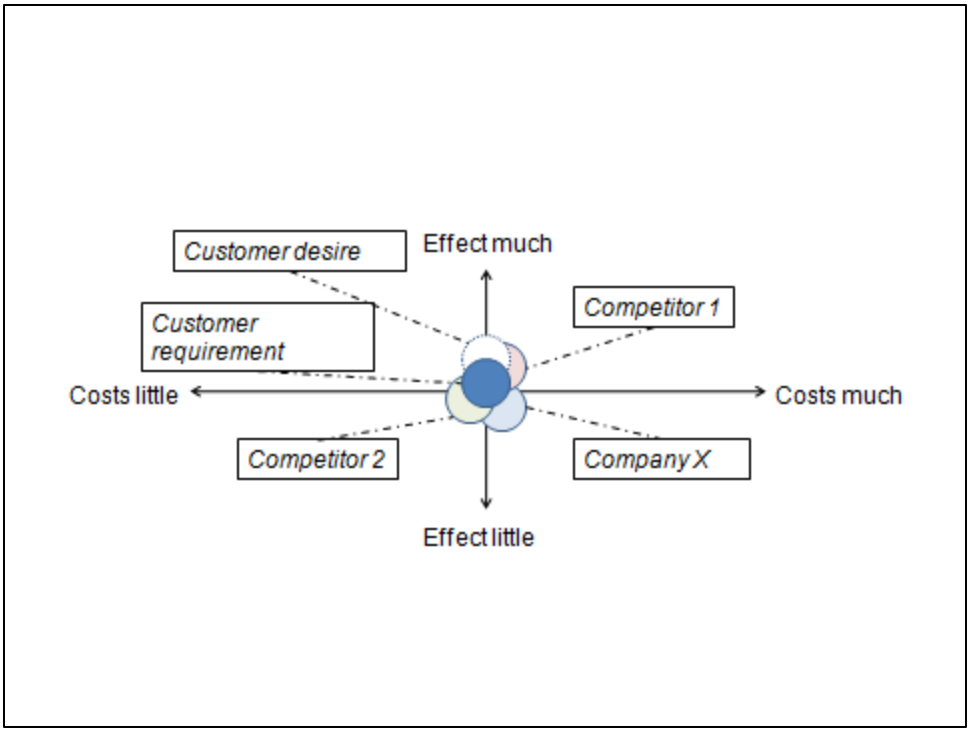

Figure 2- 5 the customer requirement and the company proving matching map 1

Another research purpose in this thesis is to detect the practical applications of service improvements. More precisely, this is to detect an optimal way to allocate the company X's capacity to build a better after-sales service. Although the better the service quality is, the bigger market share the company X may achieve, we should consider the total costs of investment on the service improvements and also consider the priority of the service which customers are asking for most. So according to the method of QFD model, the most efficient way is to set the technical requirements of service improvements into pieces and then to find the most crucial pieces after the computing by the QFD formulas. The main question is to detect "How to make the trade-off of the investments on service improving?" with two subsidiary contents of (1) "Technical and engineering requirements" and (2) "Costs analysis of the requirements"

Because the QFD model is the cross functional methods, when applying it into the real case company, more actual situation should be considered deeply. That is to say, the way to increasing the company X's competitive ability is not only to consider the customer requirements but also to think over its strategic goal to find the smart way to be the

winner in the current business campaign. Profound strategic plan could be helpful to earn the market shares by the customer desires if the customers do not only satisfy the current requirements but also expect more in the future time like the visual symbols in the (Figure 2-6). That is another trade-off which can be made a decision by the QFD model that to find out whether there is need and how imperative of the need on the service innovation or service improvements when compared competitors' actions.

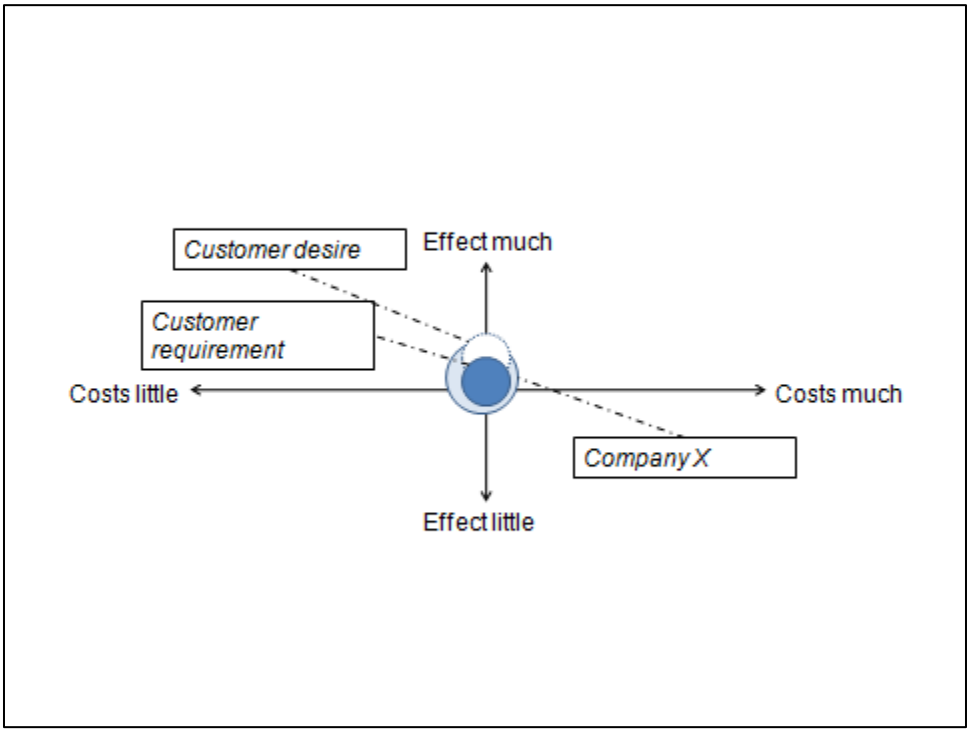

Figure 2- 6 the customer requirement and the company proving matching map 2

2.4 Summary of the literature review

After-sales service is the prompt delivery of the beneftis to customers. And it is also a manual modified work to meet the customers' needs. In the after-sales service, there are works of knowledge transfering, cost-effective maintenance, repair, and replacement. Moreover, the good after-sales service is caused by the factors of location, manufacturer and dealer supporting and service capacity.

In the theory based research, Shanmugaraja, Nataraj, & Gunasekaran (2010) pointed out that the very existence of business depends on customer satisfaction. Customer expects high quality after-sales services, even willing to pay premium for better service. From a customer perspective, good after-sales service quality leads to long-term customers relationships measured by re-patronage and cross sales, also customer recommend the service to others. So if the after-sales service can clear up the customers' dissatisfaction, there would be more marketing opportunities for the company. Selen & Schepers (2001) stated that successful service design and development requires a sytematic approach that links and interfaces with a comprehensive set of customer needs, their translation into various service attributes, and the development of a properly designed service process. One of the syrtematics tools for making the above links is quality function deployment (QFD), which has been adapted for service environments. And this method is going to be used in this thesis to dectect how to build a efficient after-sales service model to achieve customers' requirements. Mazur (2008) illustrated that QFD's strength is in creating positive value and preventing negative quality before it is designed into downstream processes where it is much more expensive to correct. So I will cooperate with a project team from the case company X to work together to investigate the customers' needs and to build the QFD process. The introduction of how to collect data and how to use the QFD model will be explained in the following methodology part.

And in the case based research, Herbig & Palumbo (1993) and Wilson, Boström, & Lundin (1999) emphasized the different conditons of the after-sales markets in the Eastern and Western perspectives. It is very strange in the Eastern market in their

findings. Although the Japanese customers would not like to show their patience and are eager to have a high efficient after-sales service, most of Japanese manufacturers stick to control the after-sales service by their own departments or their own subsidiaries. By contrast that in the Western market, especially in the North American market, the manufacturers has trends to ask their dealers to process the after-sales service, though the customers seem more reasonable to accept the working slow down such as the idle time and waiting time during the service. One possible reason to explain this phenomenon is that Japan is a small place by its area of land. So the manufacturers can easily cover this market by their own capacity. For example, the manufacturer itself has enough repair force to cover the whole Japanese areas. But the North America is a huge land that if one manufacturer wants to manage the after-sales service by itself, it needs to invest and spend a lot on the service capacity.

Then look at the Chinese market, where customers are the Eastern people with the similar characters like Japanese customers but the geographical area is as big as the U.S. So the dilemma comes to the manufacturers that whether to administrate the after-sales service by themselves or let their dealers to do this business. Or in the attentive perspective from the research results of Wilson, Boström, & Lundin (1999), the after-sales service might be cut into pieces according to the functions. And there need to design an optimal way to determine the responsibilities for the service taskes. Hence, by utilizing the QFD model in the later sections, we are able to detect the details conditions of the Chinese market and also know the rational ways for developing this market.

3 Methodology

3.1 The quality function deployment (QFD)

Recorded by Akao & Mazur (2003), the quality function deployment (QFD) model was born in the environment where Japanese companies moved the mode of product development through imitation and copying to product development based on originality and then as a method or concept for new product development under the umbrella of total quality management (TQM). Akao & Mazur (2003) also stated that Akao firstly assembled the original concept and his experiences to publish an academic article about the approach of QFD in the very beginning time in 1972 and that the very first book on the topic of QFD was written by Mizuno and Akao in 1978. However, both the article and this book were written in Japanese. Until 1994, the book which written by Mizuno and Akao was translated into English by Mazur.

Hunt & Xavier (2003) pointed out that the QFD was firstly used at Mitsubishi's Kobe shipyard site in 1972 and in the following years was employed very successfully by such companies as Toyota Motors who revolutionized the process for the design of new automotive vehicles using it. This idea was accepted universally in the worldwide. But Akao & Mazur (2003) would like to correct the common mistakes that firstly the QFD was not originated at Kobe shipyard of Mitsubishi because only adopted the quality chart as a method. However, the quality chart cannot be representative of QFD, although it indeed is the core part of QFD. Secondly, the QFD was not originated with Toyota neither. Akao & Mazur (2003) stated their argue reason that the first companies under Toyota Group to try the QFD were Hino Motors, which were under Akao's guidance and Toyota Auto Body was under the guidance of Takezawa who learned the method from Akao's papers. So, we can recognize that the QFD founder was definitely Akao and the born year and place of QFD was 1967 in Japan.

According to the statistics from Chan & Wu (2002a), there are around 650 publications about quality function deployment (QFD) models in the reference bank. Prasad (1998) mentioned that the concept of QFD was introduced by the Japanese in 1967. During more than 40 years' development after born of the theory, lots of researchers have made definitions of the QFD. There are some remarkable definitions of QFD stating below.

Akao & Mazur (2003) regarded the QFD first public definition was written by Mizuno and Akao in 1972. The content of the definition is that step-by-step deployment of a job function or operation which embodies quality into their details through systematization of targets and means. Then Sullivan (1986) defined QFD as an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production. Hauser & Clausing (1988) emphasized that QFD focuses and coordinates skills within an organization, first to design, then to manufacture and market goods that customers want to purchase and will continue to purchase. The QFD founder Akao (1990) lately described QFD as a method for developing a design quality aimed at satisfying the customer and then translating the customers' demand into design targets and major quality assurance points to be used throughout the production phase. Then Eureka & Ryan (1994) gave the definition of QFD as this is a customer-driven planning process. Later, Govers (1996) continuously stated that QFD is a customer-oriented approach to product innovation which is a process that can help companies to make the key trade-offs between what the customer wants and what the company can afford to build. Between the 1970s and 1990s, the years were the golden time for the academic researchers to study the QFD model. In that time, researchers are more focusing on the QFD model theory studying. But now most of the academic articles are more related to the modified QFD models which are combined with other theories.

Nearly all the definitions about QFD model are focusing on the customer-orientated design, including the products design, processes design, manufacturing design and also service design, which is in order to satisfy the customers' requirement with a superb quality. Prasad (1998) pointed out the today's overall objective of QFD, which was quality plans deployment when introduced in 1967, is still the product's quality. However,

Fisher & Schutta (2003) emphasized that service industries could greatly benefit from the use of QFD because the QFD is one approach that directly addresses customer needs and wants, and affects customer satisfaction significantly. In this century, more and more companies do business in the developing countries began to change its business philosophy from only sell products to customers to provide the value-added service. The after-sales service one of the typical value-added services. And this thesis is going to follow Fisher & Schutta's steps to study how to apply the QFD model into the service.

Day (1993) wrote in his book with the idea that proactive product development is much more effective than reactive product development. Chan & Wu (2002b) further explained Day's idea with more details. They illustrated that the relative payback for the improvement effort made at the manufacturing, package, and delivery stages is 1:1, then the same improvement effort made at the process design stage would yield returns on a higher order of 10:1 since problem would be prevented at an earlier stage and those people downstream would never have to face these problems. Furthermore, if the same improvement effort is made at the product planning stage, the relative payback would be on the highest order of 100:1 because all the problems would be found and solved at the very beginning of the product development and fewer people have to deal with the problems at the later stages. Fisher & Schutta (2003) also agreed with that efforts to assure quality during the design phase have 100 times the impact of similar efforts during the manufacturing phase. They drew a picture in (Figure 3-1) to support Chan & Wu's explanation that when using the QFD, companies find that they make fewer changes during the development process, and those that they do make occur earlier during the process when making them is less expensive.

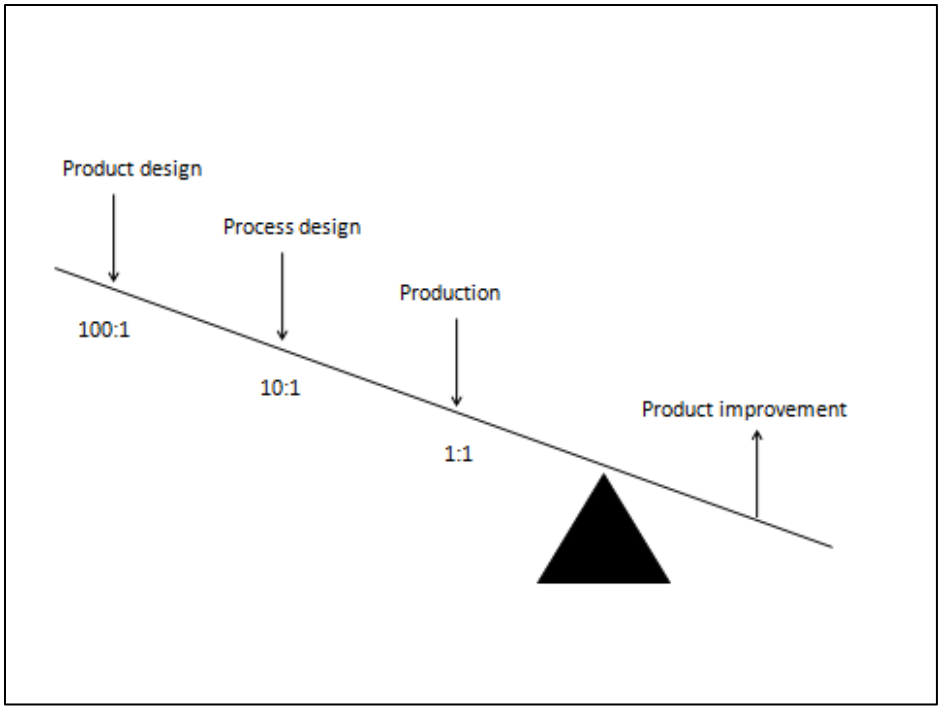

Figure 3- 1 the quality lever (Fisher and Schutta, 2003)

Govers (1996) described the using purpose of the QFD as guide product manager and design teams through the conceptualization, creation and realization process of new products". Hunt & Xavier (2003) also showed their minds in managerial level that the QFD helps to identify what is important by providing a logical system to replace emotion-based decision making. Furthermore, they found the characteristics of the QFD in the decision making view are (1) it derives from a cause-and-effect mentality where targets or objectives are translated into means in a cascading system down through the organization; (2) it is holistic in the nature and multi-functional n the application; and (3) it provides clear and measurable milestones to control implementation and self-document to facilitate review, corrective action and organizational learning. Moreover, Akao & Mazur (2003) gave more details about the purpose of using the QFD:

- Setting design quality and planned quality;
- Benchmarking competitive products;
- New product development that sets the company apart from competitors;
- Analyzing and accumulating market quality information;
- Communicating quality-related information to later processes;

- Deploying design intent into manufacturing;
- Identifying control points for the *gemba* (a Japanese term that refers to the place where source information can be learned);
- Reducing initial quality problems;
- Cutting development times;
- Reducing development costs; and
- Expanding market share.

Like what Cohen (1995) mentioned, the four-phase model is a blueprint for product development and covers basic product development steps. Later, Chan & Wu (2002b) agreed the explanation as the four-phase model divides a product development process into four phases or steps using four matrices.

The principle of the four-phase model illustrated by Hauser & Clausing (1988) was that these four linked houses implicitly convey the voice of the customer through to manufacturing. They made further explanation that if the team is truly inter-functional, we can eventually take the HOWs from the house of quality and make them as the WHATs of another house. And the process can continue to the end until a third phase as the HOWs in the stage become the WHATs in the next (nearly last) stage like the picture from (Figure 3-2).

We can see clearly from the (Figure 3-2) that in this picture the HOWs from the House of quality stage (stage 1) becomes the WHATs in the Parts deployment stage (stage 2). Since then it needs the technical requirements in the Parts deployment stage (stage 2), the Parts characters are made as the HOWs in this stage. According to the same operating, the Parts characters (HOWs in the stage 2) becomes the WHATs in the Process planning stage (stage 3). And finally, in the Production planning stage (stage 4), the WHATs of Key process operations are from the HOWs in the Process planning stage (stage 3).

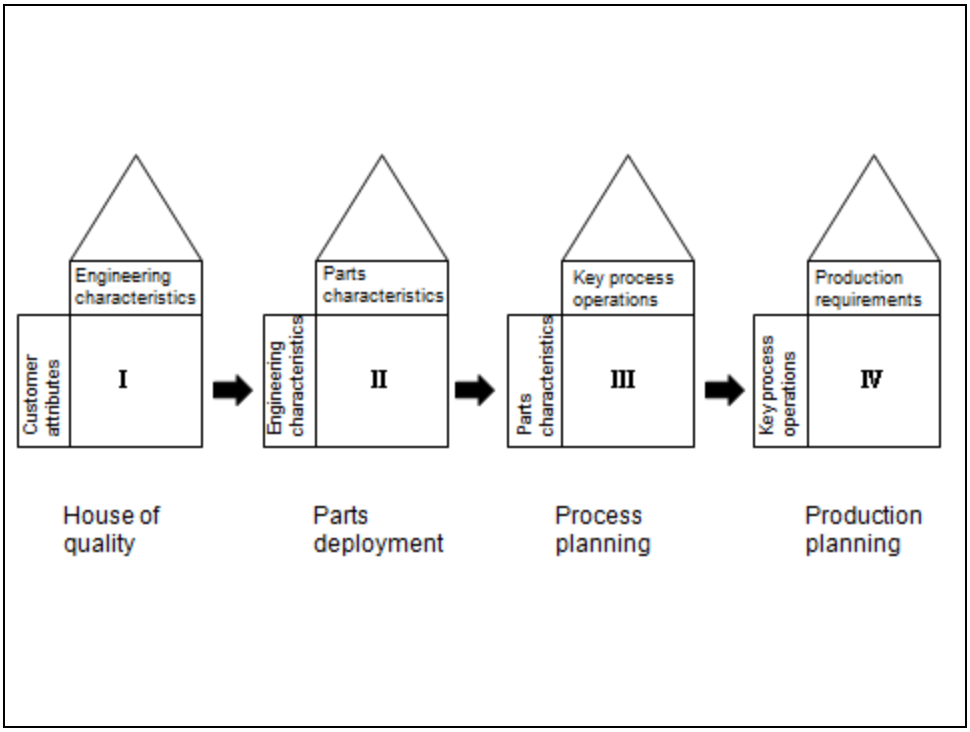

Figure 3- 2 linked houses convey the customer's voice through to manufacturing (Hauser and Clausing, 1988)

Cohen (1995) illustrated that the HOQ links customer needs to the development team's technical responses to meet these needs, which may also be called product planning. Followed by the previous theory, Chan & Wu (2002b) re-described the four-phase model with slight modification like the picture from (Figure 3-3). From Chan and Wu, the first phase of the model is used to collect customer needs for the product called WHATs (or called customer needs) which means the voice of customers. Then the next step is to transform the needs into technical measures which are called HOWs. Continually, the second phase transforms the prioritized technical measures in the first phase into part characteristics, called part deployment (or called part characteristics). The key part characteristics are transformed in the third phase, called process planning into process parameters (or called process operations) that are finally transformed in the fourth phase called production planning into operation (or called production requirements).

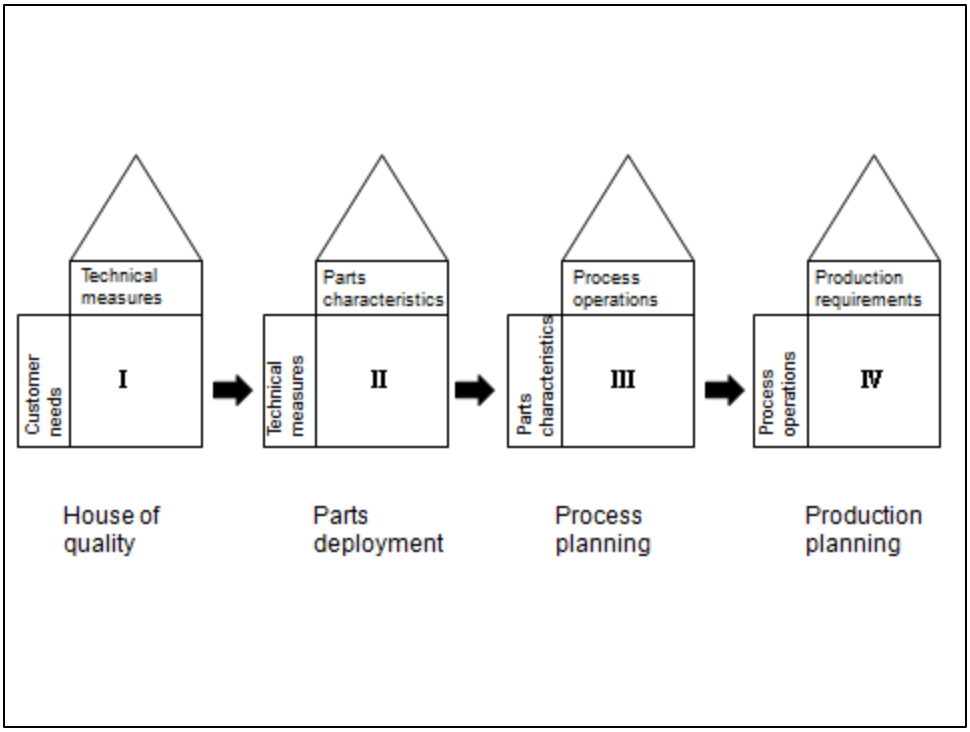

Figure 3- 3 the four-phase model of QFD (Chan and Wu, 2002b)

The notable differences between Hauser & Clausing's original four-phase model and Chan & Wu's modified model are that the later researchers emphasize more about the design of House of quality. They though in the stage 1 the QFD model users need to strongly care two things. One is that to detect the voice of customers or let's say customers' needs, which are not only from the stated customer attributes but also from the latent requirements for the company's strategic goals. Another thing is that change the valuing standards of HOWs from Engineering charcteristics to Technical measures. This is to say, when the QFD model users are designing the House of Quality, they need to think bigger and brodader that not only condider the engineering operation requiements but also relate to every technologies might be used for the service improvements. The House of Quality will be explained specificly in the next part.

3.2 The house of quality (HOQ)

There were diverse of formats of the HOQ models in the previous academic reports, such as the one from Govers (1996) and the one from Prasad (1998). But each format looks quite similar like others. So we just choose the typical and simple one from Govers (1996) to make the introduction of HOQ.

Govers (1996) stated that in the initial phase the scope of the project has to be established and should be communicated to and agreed upon management. Moreover, he regarded that a first project should be simple, but not trivial, and presents a real opportunity for improvement. So he drew the HOQ with simple logic and basic elements (Figure 3-4).

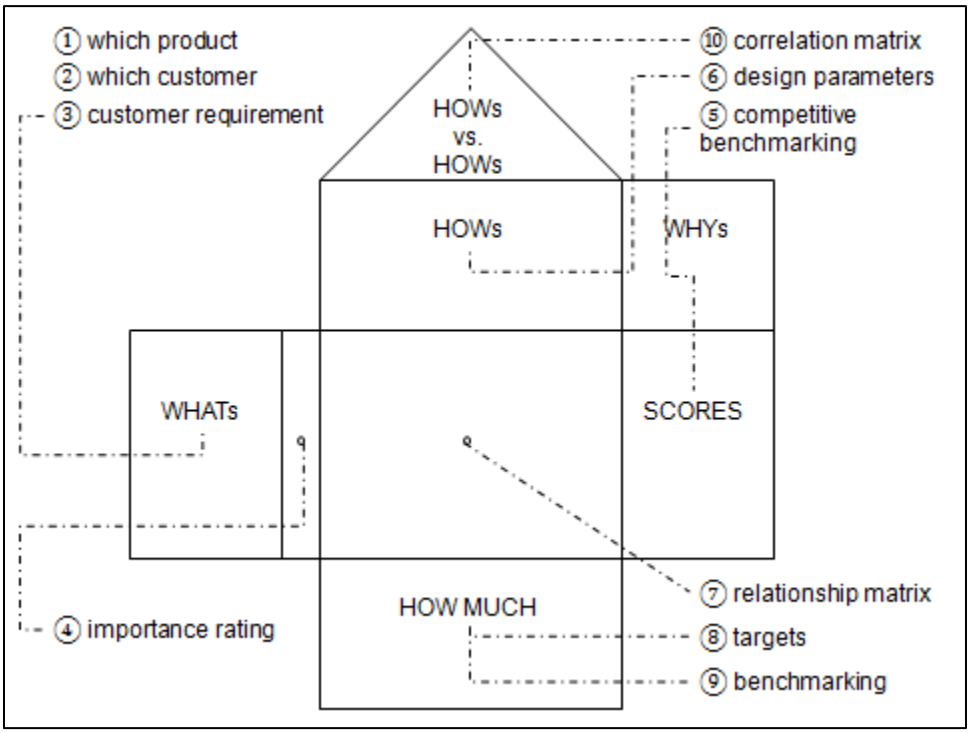

Figure 3- 4 the HOQ showing the "rooms" of the various steps in the QFD process (Govers, 1996)

From the (Figure 3-4), Govers introduced that in the left part of the HOQ picture, there are WHATs locating there. Here, we can see that three factors determine the WHATs,

which are products, customers, and customers' requirements. Moreover, there could be an importance rating, which is used to value how important the stated customers' requirements are. In the right part, there is the block of WHY. Here, we can use the competitive benchmarking method to make scores for the case company and its competitors. Then the results of WHY may provide the supporting information to set the company's strategic goals. In the upper side of this picture, there are the HOWs which is as important as the WHATs, because it is used to find the technical improvements to achieve customers' requirements. And in the middle, it is the relationship matrix which combines the WHATs and HOWs due to the formulas. In the bottom of the picture, the target and the benchmarking are used to point out the gap or differences between the case company's technical requirements and the competitors'. Both of them are the reference standards for the strategic technical improvements goals. The top part of this HOQ picture is the correlation matrix. Sometimes we can call it the roof of the quality house. It is used to show the correlation between each technical measurement and to find out the positive and negative effects from them.

And according to the purpose of the HOQ, Chan & Wu (2002b) concluded a typical HOQ comprises six main parts, which has a structured and systematic way to transform the customers' needs for service into prioritized technical measures that can be further deployed to develop process and production plans. The format made by Chan & Wu is like the picture from (Figure 3-5).

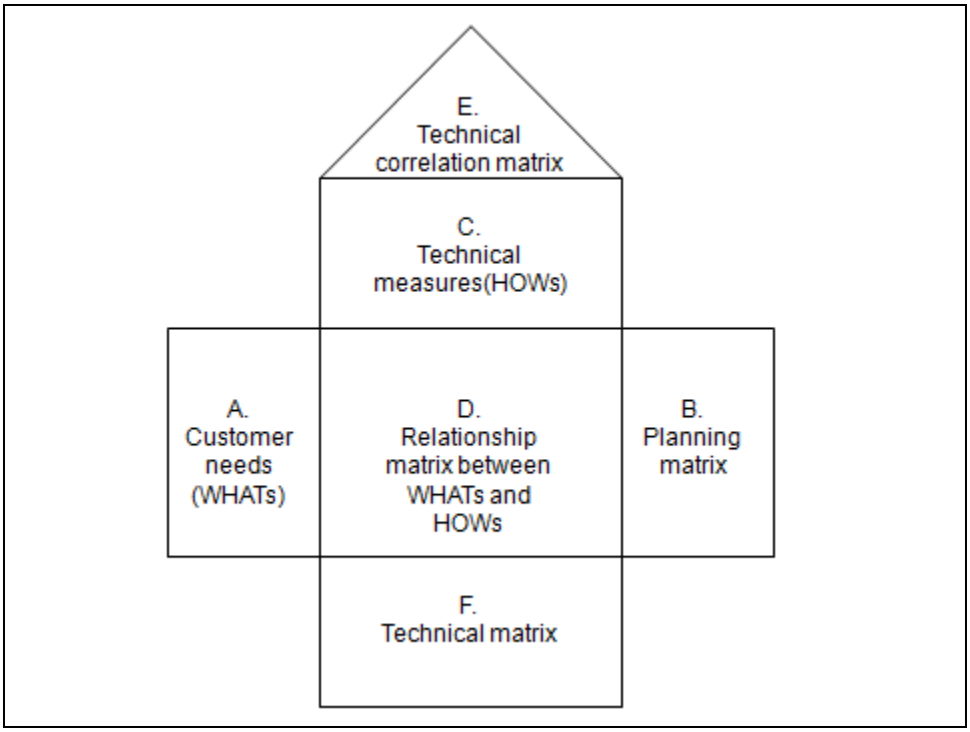

Figure 3- 5 house of quality: brief description (Chan and Wu, 2002b)

Based on the brief description of the HOQ, Chan & Wu (2002b) added sub-parts details into four of the six main parts to illustrate how the HOQ method to be used in practice. They drew another picture like in the (Figure 3-6) to how to analyze the real case by applying the details of the HOQ sections. And the details of sub-parts are introduced in the next part named the method of HOQ.

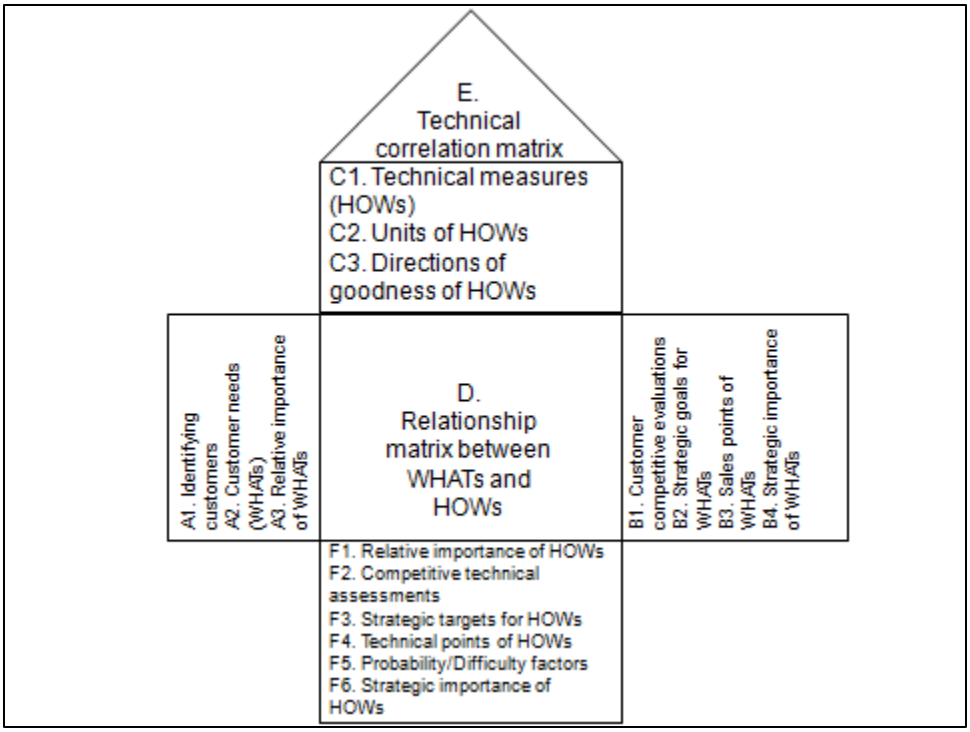

Figure 3- 6 house of quality: detailed description (Chan and Wu, 2002b)

The first step of using the HOQ is to identify the customer needs (WHATs). Chan & Wu (2002b) gave more detailed definition about the use of HOQ is that the first step for a development team of a company to build an HOQ is to identify the customers of the product, collect their needs for the product and reveal the needs' relative importance perceived by the customers. So, at the very beginning, we should identify the customer who they are.

There are three general types of customers, as American Supplier Institute (1994) defined, which are internal customers like shareholders, intermediate customers like wholesalers and ultimate customers like the ending consumers. And then, the following step is to find out what are the needs of customers for the products or service. According to the methods

listed by American Supplier Institute (1994), there are eleven main ways to explore the customer needs. The brief contents of each method are shown in the chart from (Figure 3-7) below.

Methods	Brief contents
Survey	Mail/Telephone questionnairs
Focus groups	Free discussion hold by selected customers
Individual interviewers	Get emotional side of the purchasing decision
Product in use	Clinics
Listening and observing	Adopt the "mystery shppers"
Natural field contact	Sales meetings, service calls and trade shows
Feedback	Customers gogether with employees to discuss competitors' products
Complains	Letters/Hot lines
Warranty data	Service records
Sales records	Reports
Publications	Government/Labs/Journals/Magazines

Figure 3- 7 methods for collecting customer needs (American Supplier Institute, 1994)

However, due to research from Griffin & Hauser (1993), 20-30 customers should be interviewed to obtain 90-95% of all the possible customer needs. So, we can think that use method of “focus groups” could be the most efficient way to get the approximate accurate results. Therefore, in this thesis the “focus groups” will be the only method to identify the customer needs because its efficiency and time is tight. More detailed explanation of the “focus groups” will be illustrated later in the specific section.

Chan & Wu (2002b) thought that to facilitate analysis and application, the words collected are usually organized as a tree-like needs and, according to the situation, those at a specific level are chosen as the final customer needs. This idea was an additional explanation from Griffin & Hauser (1993), who thought that customer needs can usually be structured into a hierarchy of primary, secondary and tertiary needs. Then, Chan & Wu (2002b) made an example of fried vegetable shop to support the theoretical. The details of the example are shown in the (Figure 2-9).

Primary needs	Secondary needs	Tertiary needs
Good taste	Approrite ingredients	Not too salty
		Not greasy
		Moderately soicy
		Appetizing
	Good smell	Hot
		Fresh
		Sweet smell
Good appearance	Good color	Not overcooked
		Freshness
		Jade color
	Good shape	Good-looking plate
		Not too full
		Tasteful arrangement

Figure 3- 8 the hierarchical structure of customer needs: a fried vegetable example (Chan and Wu, 2002b)

And then, customers are asked to give the relative importance ratings for each WHAT. One point should be mentioned that the relative importance comes from the absolute importance which is rating easily by customers. The usual seen rating scale is 1-10 scale, but the 5-, 7- or 9-point scale is also acceptable. In this thesis, the 1-10 scale will be chosen for the evaluation of WHATs' importance.

Secondly, the planning matrix would be considered followed by the customer needs. The Cohen (1995) mentioned that the planning matrix part is the repository for important quantitative data about the needs. Later, Chan & Wu (2002b) added that this part is customer competitive evaluations of the company's product compared with its main competitors' similar products in terms of the products' performance on customer needs. Fisher & Schutta (2003) also pointed out that the competitive analysis compares our delivery of desired consequences to that of our key competitors. In the customer competitive evaluation sub-part, Chan & Wu (2002b) stated that knowing the company's strength and constraints in all aspects of a product and in comparison with its main competitors is essential for a company if it wishes to improve its competitiveness in the relevant markets. Hence, Fisher & Schutta (2003) demonstrated that typically we use a Likert-type scale of five points to measure customer beliefs for each organization. But in this thesis, the evaluation score for the competition is the 1-10 scale because it could make the visual chart more beautiful.

After evaluating the performance of company and its competitors, the following sub-part is to establish the strategic goals for the WHATs. Chan & Wu (2002b) illustrated that the goals must be set realistically taking into account of program timing, resources, cost objectives and available technology. According to American Supplier Institute (1994), the goals setting includes four main aspects that (1) improve through QFD implementation, (2) hold (i.e., retain the current position), (3) copy a competitor and (4) degrade.

The next sub-part is about the sales points of WHATs, which is described by Cohen (1995) that should contain such information that characterizes the company's ability to sell the product based on how well each customer need is met. And according to American Supplier Institute (1994), numerically, 1.5, 1.25 and 1 are assigned to strong, moderate and no sales point respectively. There will be the practical application for the sales points in the case study to explain it more precisely.

The last sub-part in the planning matrix is to calculate the strategic importance of WHATs. In this sub-part, Chan & Wu (2002b) highlighted that customer needs with high

final importance ratings indicate high potential business benefit to the company and thus should be prioritized.

Thirdly, the quantitative information collected from the first step and second step is transformed into the technical measures (or called HOWs). The technical measures will determine the further analysis and deployment of the house of quality (HOQ). Moreover, the technical measures are the combination of the first phase of the QFD and the next phase. More importantly, the technical measures are the way to meet the corresponding attributes desired by the customers. Fisher & Schutta (2003) mentioned that we must match each customer needs by specific capabilities to meet those needs. Here, we also use the method of "focus group" to determine the technical measures.

Units and directions should also be defined to associate the HOWs. Chan & Wu (2002b) pointed out that it is better to give these units explicitly. Fisher & Schutta (2003) suggested to always asking how you can measure it before settling on the technical requirement. And they gave an elaborate 5-class measurement to identify the directions of HOWs. The symbols and meanings of the 5-class measurement are shown below from (Figure 3-9). But Cohen (1995) explained that as for improvement directions, three possible definitions may be adopted for different HOWs: (1) the more the better (to increase), (2) the less the better (to decrease) and (3) target is best (to close to). So in order to make the competing process more efficient and the result easier to understand, we just use the 3-class measurement in the case study. The difference of Cohen's measurements from Fisher & Schutta's are there are only the front 3 symbols from the later authors'. And it is sufficient in the simple application for the case without huge data.

Symbol	Meaning
○	Meeting a define target is better
↑	Bigger, faster, heavier, more or longer is better
↓	Smaller, shorter, lighter, slower, or less is better
○↑	Target is best but higher is better than lower
○↓	Target is best but lower is better than higher

Figure 3- 9 Directions of HOWs (Fisher and Schutta, 2003)

Fourthly, there is need to build the relationship matrix between WHATs and HOWs. According to Chan & Wu (2002b), the relationship matrix of WHATs vs. HOWs is a systematic means for identifying the degree of relationship or linkage between each WHAT and each HOW. Fisher & Schutta (2003) made the similar statement that the relationship matrix of the customer WHATs versus the technical HOWs is a systematic means for identifying the degree of the relationship or linkage between each consequence/WHAT and each technical requirement/HOW. Moreover, the relationship matrix always is tagged with visual symbols. Due to the guidance from American Supplier Institute (1994), usually there are four relationship levels, i.e., no relationship, weak relationship, moderate relationship and strong relationship. The most usual measurement scale is 0, 1, 3 and 9, respectively. When filling the relationship matrix, Chan & Wu (2002b) pointed out that filling in the relationship matrix in a HOW-wise fashion works better, since usually the development team defines the HOW once and then established if it helps to satisfy each of the WHATs. Then Fisher & Schutta (2003) showed their idea in another perspective that a rule of thumb is to have the ratio of technical requirements to customer consequences be between 1 and 3. Because if there is less than 30% of cells are filled, the result may be lack of customer satisfaction. Furthermore, if there is more than 60% of cells are filled, it could cause too many technical requirements leads to difficulty designing the service process and overly expensive services. Not at all, the symbols must be scattered throughout the matrix.

The technical correlation matrix graphically looks like the roof of the house of quality. Cohen (1995) pointed out that the technical correlation matrix is the most underexploited part of the QFD. And Chan & Wu (2002b) concluded that the technical correlation matrix is the development team's assessments of which HOWs are interrelated and how strong these relationships are, which can be obtained through engineering analysis and experience. Fisher & Schutta (2003) illustrated that this process helps us in the analysis of trade-offs between the technical requirements by considering the interactions between the technical process parameters. Due to the guidance from American Supplier Institute (1994), usually five types of technical correlations or impacts are identified in the QFD: strong positive impact, moderate positive impact, no impact, moderate negative impact

and strong negative impact. A set of symbols like "✓ ✓, ✓, <blank>, ×, ××" and "＋＋, ＋, <blank>, －, －－" are used usually.

The last and the most important part is technical matrix. Chan & Wu (2002b) concluded that the technical matrix contains much technical information that is liked to both customer needs and parts characteristics in the QFD's second phase. Fisher & Schutta (2003) then added statement that the technical matrix causes the trade-offs which can be determined to optimize the entire process to fulfill the consequences of the customer.

In this technical matrix part, there are six sub-parts. The first one is the relative importance of HOWs, which is described by Chan & Wu (2002b) as a comprehensive measure indicating the degree to which the HOW is related to all the WHATs. It should be mentioned that here the relationship is between each HOW with all the WHATs.

The second sub-part is to conduct the competitive technical assessments, which is used to compare the company's technical performance against the competitors' technical performance. This one is quite a subjective evaluation. Chan & Wu (2002b) thought that this step can be done through marketing but is a difficult task in applying the QFD since not all technical parameters and know-how of the competitors' products can be easily obtained. And Fisher & Schutta (2003) suggested that the testing performed is actually observing and using the service by the mystery shopper to visit your competitors – playing the role of a customer.

Then the third one is the strategic target of HOWs, which is conducted base on the relative importance of HOWs and competitive technical assessments. Chan & Wu (2002b) emphasized that it should be noted that performance targets are different from design specifications because the target of HOWs represents the performance directly compared with the competitors'.

The fourth one is technical points of HOWs, which are used to assist the assessment of strategic goals. This one has the same function like the sales points used in the WHATs assessment. Chan & Wu (2002b) agreed that theses points should be incorporated into the determination of the HOWs' final strategic importance.

The fifth one is the difficulty factors of HOWs. The difficulty factors are used to mark the difficulty of achievement for each performance target through technical and financial analysis. And this is important to be used in the difficulty analysis which is usually applied in the case study.

The last sub-part is the strategic importance of HOWs, which is measured by the similar method from strategic importance of WHATs. It is worth to mention that the final importance of HOWs determines the new WHATs in the next phase of the QFD model. Chan & Wu (2002b) explained that those HOWs of higher final importance are moved to phase 2 of the QFD, then are translated into parts characteristics (new HOWs) and then analysis can also be done to complete the new phase by using part C – F in the phase 1.

3.3 The benefits of QFD

There were many discussions about the qualitative benefits of the QFD model. Sullivan (1986) emphasizes that the QFD can bring tremendous efficiency to companies because misinterpretation and need for changes are minimized. Bossert (1991) pointed out that the benefits of the QFD are grouped into four areas: customer orientation, reduction of implementation time, promotion of teamwork and provision of documentation. Govers (1996) listed the benefits of successful applications of the QFD for a wide variety of industries: (1) decreased startup problems; (2) competitive analysis became possible (improved market research); (3) control points clarified (reduced development time; better planning); (4) effective communication between divisions (departments); and (5) design intent is carried through to manufacturing (quality is built in "upstream"). Hunt & Xavier (2003) concluded the several research reports in the 1990s and tabulated the benefits of the QFD below:

- They develop collaboration between individuals and departments.

- They facilitate the development of a sense of ownership through the involvement of many individuals. This ownership then drives the strategy implementation process.
- They identify customers and their needs with regards to the strategic formulation process.
- They enforce a methodical and comprehensive analysis of all relevant relationships.
- The matrices provide a comprehensive document of all the data used and decisions taken in the strategic decision process.
- Emotions and politics are to a large degree removed from the strategic process.
- The completed matrices can be reused dynamically to allow a rapid refocusing of strategy if circumstances change.
- They maintain consistency with the firm's capabilities.
- The techniques lead decision-makers through complex decisions and provide a structured view of fuzzy "issues".

And Chan & Wu (2002b) cared more about the intangible benefits of the QFD model. They summarized the contents of the benefits by using a structured table to state. The table is shown in the (Figure 3-10) below.

QFD benefits	***Enhanced customer-orientation***	•Structuring "the voice of the customer" •Creation of focus on customer needs •Effective use of competitive information •Identification of areas to be acted upon •Improved customer-company relationship •More satisfied/delighted customers
	Effective product development	•Lower start-up and product costs •Shorter design cycles •Fewer midstream design changes •Limiting post-introduction problems •Avoiding future development redundancies •Identifying future application opportunities
	Improved communications & teamwork	•Involvement of every function and everyone •Provision of a common language •Decrease of cross-functional barriers •Provision of working procedures and focuses •Living documentation for future applications •Improved company management and culture

Figure 3- 10 the qualitative benefits of using QFD (Chan and Wu, 2002b)

3.4 Focus Group: the method for determining WHATs and HOWs

In this thesis, the research method of exploring the customers' needs and technical measurements is the Focus Group. According to the definition by Morgan (1998), Focus groups are group interviews. And a moderator is needed to guide the interview while a small group discussed the topics that the interviewer raises. And he also described the using purpose of the Focus Group, which is to guide group discussions to generate a rich understanding of participants' experiences and beliefs.

By using this Focus Group method to identify the WHATs and HOWs in the QFD model, I organized a project team from the case company X. In this team, there are staffs from different departments such as marketing department and service department. Hence, we can utilize their intelligence from the very professional fields to discuss the same topic but with deferent perspectives.

Because the interviews process of this thesis is organized by the tale-interviews due to the far distance, an applicable method is required. This method must have the characteristics of high efficiency and full coverage in diverse perspectives. So the Focus Group method was chosen. Another reason for using this method is that in this thesis research, the study object is very professional in the specific industry. The appropriate way to combine my theoretically managerial view with the practically operational view is to organize a project team from the case company to hold a discussion together. Moreover, the project team must contain participants from various departments of the company. Then we can design the case study process and the details of questionnaires for investigating the customers and markets.

Morgan (1998) emphasized the Focus Group method in the book that focus groups are fundamentally a way of listening to people and learning from them. Focus groups create lines of communication. This is most obvious within the group itself, where there is continual communication between the moderator and the participants, as well as among the participants themselves. Here, I was the moderator to guide the project team from case company (participants) to discuss along with the research purpose.

Morgan (1998) also mentioned the strengths of using Focus Group in the qualitative research. Focus groups draw on three of the fundamental strengths that are shared by all qualitative methods: (1) exploration and discovery, (2) context and depth, and (3) interpretation. And in this thesis, the main research steps are following to the Focus Group guide that to discover the possible problem, then to find the context and finally to interpret the problem to tabulate the WHATs and HOWs. Because this study of how to optimize the sources for after-sales service is the very fresh question which the case company never had a deep thought. And also there were no ready-made industry standards available. Then I and the project team from the case company had to do the research step by step with our original ideas to inspect the feasibility of developing after-sales service by QFD model. It’s obvious that the Focus Group method increase the efficiency of research by only organizing discussion with professionals.

4. Case study

4.1 Introduction to company X

The company X was founded in the beginning of 1990s, which is a hi-tech public company with registered capital of around 2 billion Chinese Yuan (RMB) and nearly 20,000 employees. With a sound corporate governance structure and good faith for the concept of enterprise culture system, company X is recommended as the "typical one of the listed companies operated under modern enterprise system" by the China Securities Regulatory Commission and State Economic and Trade Commission.

At present, production bases locate in Central China, Southern China and Eastern China as well as Southern Europe and Latin America. There are 9 industrial parks with a total area of nearly 3,000,000 square meters. The company X has the international management systems of technical development, manufacturing processes and logistics, as well as strong sales network and perfect service system covering the whole domestic market and extending to the oversea market. China market and other three oversea markets (North America, Latin America and Africa) are the four sophisticated markets. Followed by that the Russia market, India market and Europe market are the new target markets for company X.

The company X is one of the best manufacturers of concrete equipment and crane equipment. And it has more than 50 dealers for selling its concrete equipment and crane equipment in China. From the year 2009, the company X began to sell its excavator products in the China market and planned to make the excavator products as one of its core business.

4.2 Introduction to company X' competitors

Although company X's has the world's most complete product chain in the construction machinery business, with completely independent intellectual property rights of concrete machinery, mobile cranes machinery, environmental and sanitation machinery, construction hoisting machinery, road machinery, earth working machinery, port machinery, special vehicles and so on, it is a fresh hand in the excavator industry. Started from 2009, company X entered the excavator industry and it had to face the very dynamic competition with the global leaders such as Caterpillar and Komatsu and also the domestic expert Sany. So the company X has a very long journey to go and catch up with the first class players in the China excavator market.

In the excavator market of China, there are more than 20 brands are competing in this market. According to the report from 2009 Excavator Sales Report[5], Japanese and Korean brands shared about 60% of the market, European and American brands shared about 20% of the market, and the Chinese local brands shared the rest of the market, amount to 20%. Among the Chinese local brands, we can find the Sany is the most competitive one and the first Chinese brand. Moreover, it is the 6th player in the Chinese excavator market in 2008, followed by the Caterpillar. So we chose the Sany and Caterpillar as the representative benchmark cases for Chinese local brand and European and American brand. Although from the 1st one to the 4th one are all the Japanese and Korean brands, we only chosen the Japanese giant Komatsu as the benchmark case, which is the 1st one in the 2009 due to its markets share.

[5] 2009 Excavator Sales Report is the statistic data edited by the company X

The introduction to Caterpillar:

Caterpillar is also known as "CAT", designs, manufactures, markets and sells machinery and engines and sells financial products and insurance to customers via a worldwide dealer network[6]. Caterpillar is the world's largest manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines. With more than US$7 billion in assets, Caterpillar was ranked number one in its industry and number 44 overall in the 2009 Fortune 500. Caterpillar stock is a component of the Dow Jones Industrial Average.

Caterpillar traces its origins to the 1925 merger of the Holt Manufacturing Company, the inventor of the crawler tractor, and the C. L. Best Tractor Company, creating a new entity, the California based Caterpillar Tractor Company. In 1986, the company re-organized itself as a Delaware corporation under the current name, Caterpillar. Caterpillar's headquarters are located in Peoria, Illinois, United States.

Caterpillar's Asia & Pacific headquarter moved from Tokyo and now is located in Beijing, the capital city of China. Since 1995, Caterpillar has entered China market by establishing a joint-venture with a Chinese construction equipment company XCMG. During the 14 years developing in the China market, Caterpillar has achieved the 4th place in the China excavator market in 2008[7]. And in the June of 2010, Caterpillar has completed the purchasing of the joint-venture company from XCMG and made it into the wholly subsidiary. The strategic purpose of that acquisition is to broaden the market share of China excavator market.

In the China excavator market, Caterpillar has 5 dealers spreading in the five main regions such as Northeastern China, Northwestern China, Southeastern China, Southwestern China and Taiwan. All of the 5 dealers of Caterpillar are not Mainland Chinese owned companies. More precisely, they are WesTrac which is from Australia and is doing business in Northeastern China market, China Engineers which is from Malaysia and is mainly focusing on Northwestern China market and minor Southeastern

[6] Most resources are from Wikipedia: http://en.wikipedia.org/wiki/Caterpillar_Inc.
[7] 2008 Excavator Market Report (from 2009 Annual report of China Construction Machinery)

China market including Hong Kong, ECI—Metro which is originally from Thailand and is managing business in Southwestern China market, Lei Shing Hong which is from Hong Kong and is operating in Southeastern China market, and the last one is Capital Machinery which is also from Hong Kong and is managing the Taiwan market.

The introduction to Komatsu:

Komatsu is a multinational corporation that manufactures construction, mining, and military equipment, industrial equipment such as press machines, lasers, and thermoelectric generators[8].Its headquarters is at Tokyo, Japan. Its name was taken after the current city of Komatsu, Ishikawa at the company's foundation there in 1917.

Komatsu is the world's second largest manufacturer of construction equipment and mining equipment after Caterpillar. However, in some areas (Japan, China), Komatsu has a larger share than Caterpillar. It has manufacturing operations in Japan, Asia, Americas and Europe. It is worth to mention that in the year of 2010, Komatsu surpasses Doosan to be the 1st seller in the China excavator market according to the market share[9].

In the China excavator market, Komatsu has 33 dealers spreading in this market[10]. Due to the administrative division of China, there are 32 provinces and special governance cities (including Hong Kong, Macau and Taiwan). That is to say, averagely each dealer could cover one of the 32 regions in China market. And Komatsu won the "best after-sales service provider awards" in the 2009 from the China Engineering Machinery Magazine by its superb quality of after-sales service. Moreover, Komatsu always has the good words of mouth in the China excavator market.

[8] Most resources are from Wikipedia: http://en.wikipedia.org/wiki/Komatsu_Limited
[9] 2010 Excavator Market Report
[10] 2009 China Excavator Market Operating Report

The introduction to Sany:

Sany was established in 1989 in Hunan, China. 20 years ago, Sany began as a small welding material factory, but has now grown into a global corporation with 8 domestic manufacturing facilities, 4 production factories in U.S., Germany, India and Brazil and 26 support centers around the world. Currently, Sany employs over 40,000 people in more than 120 countries with the sales revenue of 30.6 billion of Chinese Yuan (RMB) in 2009.

According to Sany's belief of "Quality changes the world", each year it invests 5%-7% of sales revenue into the R&D and it has also developed a program for continuing education where talent is nurtured for the benefit of the corporation and for society.

After becoming one of the most successful enterprises in China, Sany is the world's largest concrete machinery manufacturer and in the Top 15 of Global Construction Machinery Manufacturers. Besides constantly striving to improve the products, Sany is doing its best to provide customers in over 150 countries with the most comprehensive and efficient service.

Like Komatsu, Sany also has 33 dealers in China market. But some of the dealers are directly operated by the Sany company itself. Although the first excavator production of Sany started from 2000, Sany has achieved the 6th place in the China excavator market in 2010[11] and has been the first Chinese brand since 2008.

[11] 2010 Excavator Market Report

4.3 Benchmarking of WHATs

In this questionnaire, there were 30 customers were asked to fill in the form with the question that "How do you rate on the priority of requirements". Then the collected data were tabulated in the sheet and calculated the average score of each requirement (WHAT). After that, by using the round-off function from the MS Excel, the final ratings of the WHATs were born out in the (Figure 4-1).

WHATs	Rating	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AVG.
Appearance of dealer shop	4.00	5	4	4	4	5	5	5	5	5	5	4	5	4	4	4	4	5	5	4	4	4	5	5	4	4	4	4	4	4	5	4.43
Facility of dealer shop	7.00	7	8	7	8	8	8	6	6	7	6	7	7	7	6	6	7	6	6	6	8	7	8	6	8	8	6	7	8	8	7	7.00
Spare parts price	8.00	9	9	8	7	7	7	8	9	8	7	7	7	7	7	8	8	8	9	9	7	8	8	9	8	9	9	7	8	7	9	7.93
Repair price	9.00	10	9	10	9	9	10	10	9	9	9	9	9	10	9	9	9	10	10	9	9	9	9	9	10	9	9	9	10	9	9	9.30
Maintenance price	10.00	10	10	10	9	10	9	9	9	9	9	9	10	10	10	10	10	9	10	10	9	9	10	10	10	10	9	10	10	10	9	9.60
Quick response	9.00	9	9	9	9	9	9	9	9	10	9	10	9	10	9	9	10	9	10	10	10	9	9	9	10	10	9	10	10	10	9	9.40
Repair efficiency	10.00	9	10	9	9	10	10	9	10	9	10	9	10	10	9	10	9	10	9	9	10	10	10	10	9	10	10	9	9	9	9	9.50
Maintenance effect	9.00	9	9	10	10	8	8	10	9	9	8	10	9	9	8	10	8	10	9	9	10	10	10	9	8	10	8	9	8	10	8	9.07
Appearance of personnel	6.00	6	6	6	6	7	7	5	5	7	6	6	5	7	6	5	7	7	6	5	6	6	5	7	6	5	6	7	5	5	5	5.93
Manner of personnel	7.00	8	8	6	6	7	8	7	7	6	7	6	8	7	7	7	7	8	6	7	8	8	6	7	6	6	8	6	6	6	6	6.87
Ways to order	5.00	4	5	4	4	5	5	5	4	5	4	4	4	4	5	5	4	4	5	5	4	5	5	4	5	5	4	5	5	4	4	4.50
Ways to pay	4.00	4	4	4	5	5	5	5	4	4	4	4	4	5	5	5	4	5	4	4	4	5	5	4	5	4	4	4	5	5	4	4.43
Ways to complain	6.00	5	5	5	6	6	5	6	6	6	5	5	5	6	7	6	5	7	7	7	6	5	6	5	6	6	5	5	6	7	5	5.73
Periodic information	7.00	7	7	7	6	7	6	7	7	7	7	6	6	7	7	8	8	8	6	7	7	6	7	7	6	7	8	7	8	8	6	6.93
Periodic inspection	8.00	9	9	7	8	7	8	9	9	8	9	8	8	7	8	7	9	9	9	8	9	9	7	7	7	7	7	7	8	7	9	8.00

Figure 4- 1 customer questionnaire feedback

Then the next step is to calculate the relative importance of WHATs based on the rounded average rating of WHATs. In this step the formula is that:

$$\text{Relative importance of WHAT}_{(i)} = \text{Rating of WHAT}_{(i)} / \sum(\text{Rating of WHAT}_{(i)}) * 100\%$$

The following step is the customer competition evaluation, which required a project team of company X played as the mystery shoppers to investigate their competitors. In this thesis, we selected three main competitors of the company X, which are the representative of the best player from United States, Japan and China. More precisely, they are namely Caterpillar, which is the biggest giant in the industry equipment market, Komatsu, which is the quality and service leader and the second biggest player, and Sany, which is the leading company in China and the third world counties market and also one of the top 10 player in the industry equipment market. The selected benchmarking competitors are from the perspectives of International background, Asian background and

also the local characteristics. So although the benchmarking companies are only three but they have already covered the mainstream characters.

By comparing the benchmarking scores from company X and its three competitors, we set the strategic goals of the future development. The way to set the strategic goals is that ask the project team from company X use the "focus group" method to rating the overall evaluation of WHATs for company X (column 4 in Figure 4-2) and its three competitors (column 5-7 in Figure 4-2). And then the project team went on to set the goal score (column 8 in Figure 4-2) by considering the original rating score of company X and its competitors. The strategic goals are basically close to the mainstream scores of the competitors. And there are still some exceptions. If the gap between company X and its competitors is too big, the strategic goals setting are conservative because of the current capability and the available resources predict.

WHATs	Rating of WHATs	Relative improtance of WHATs	Customer Competitive Evaluation				Strategic goals	Sales point	Planned improvement	Stated importance	Strategic focus of WHATs
			Company X	Caterpillar	Komatsu	Sany					
Appearance of dealer shop	4	3.67%	6	7	8	6	7	1	0.17	3.14%	2.65%
Facility of dealer shop	7	6.42%	6	7	9	6	7	1	0.17	5.49%	4.64%
Spare parts price	8	7.34%	7	6	7	9	8	1	0.14	6.27%	4.54%
Repair price	9	8.26%	7	5	6	9	8	1.25	0.14	8.82%	6.39%
Maintenance price	10	9.17%	7	6	7	8	8	1.25	0.14	9.80%	7.10%
Quick response	9	8.26%	6	7	8	6	8	1.5	0.33	10.59%	17.89%
Repair efficiency	10	9.17%	7	9	8	6	8	1.5	0.14	11.76%	8.52%
Maintenance effect	9	8.26%	7	8	8	7	8	1.25	0.14	8.82%	6.39%
Appearance of personnel	6	5.50%	6	7	8	5	7	1	0.17	4.71%	3.98%
Manner of personnel	7	6.42%	6	6	7	7	7	1	0.17	5.49%	4.64%
Ways to order	5	4.59%	7	7	7	8	8	1	0.14	3.92%	2.84%
Ways to pay	4	3.67%	6	7	6	7	7	1	0.17	3.14%	2.65%
Ways to complain	6	5.50%	7	8	7	6	8	1	0.14	4.71%	3.41%
Periodic information	7	6.42%	5	7	6	9	7	1	0.40	5.49%	11.13%
Periodic inspection	8	7.34%	6	8	7	6	8	1.25	0.33	7.84%	13.25%

Figure 4- 2 voice of customer benchmarking

Followed by the strategic goals setting, the next one is the sales points setting (column 9 in Figure 4-2). In this step, the strong sales point is represented by 1.5, which means the related attribute will strongly increase the sales of the product/service if it improves well. Same to the strong sales point, medium sales point is represented by 1.25, this means there will be lightly affection from the related attribute. And the normal sales point is represented by 1, which is to say there is no effect on the sales no matter how much the related attribute improves.

And then the planned improvements (column 10 in Figure 4-2) are calculated. In order to keep the relativity of each row, the planned improvements are not formed from the subtraction between benchmarking scores of company X (column 4 in Figure 4-2) and its strategic goals (column 8 in Figure 4-2). Instead, the formula is established by the proportion:

Planned improvement $_{(i)}$ = (Strategic goal $_{(i)}$ – Score of company X $_{(i)}$) / Score of company X $_{(i)}$

Usually if the score of planned improvements is beyond to 0.2, it may be paid attention to. In this case although only a few of them are more than 0.2, some of the rest are very near to 0.2. So they also need to be considered seriously.

The next step is to calculate the stated importance of the WHATs (column 11 in Figure 4-2). It is worth to mention that the stated importance just reflects the priority which directly comes from the customers' perspectives. That is to say, the stated importance is the objective importance of the WHATs because it is not considered with the affect from competition. We can use the formula to calculate the stated importance of WHATs that:

Stated importance of WHAT $_{(i)}$ = Relative importance $_{(i)}$ * Sales point $_{(i)}$ / $\sum$ (Relative importance $_{(i)}$ * Sales point $_{(i)}$) * 100%

The last step of the voice of customer benchmarking is the strategic importance of WHATs (column 12 in Figure 4-2) or we can call it strategic focus of WHATs. This means how important each attribute related to the company's strategic objective. In this

step, we have to consider both the importance of customer requirements and the planned improvement from the competition. So the formula is set like that:

Strategic focus of WHAT = Stated importance of WHAT $_{(i)}$ * Planned improvement $_{(i)}$ / $\sum$ (Stated importance of WHAT $_{(i)}$ * Planned improvement $_{(i)}$) * 100%

In the critical analysis of WHATs, the chart is shown in (Figure 4-3). Here, we sorted the WHATs by the score of stated importance from the biggest to the smallest. Moreover, we used the Pareto statistics method to summarize the score of the stated importance of WHATs. Then we can clearly see that the most important attributes which occupy the top 30% of the Pareto statistics are composed by Repair efficiency, Quick response and Maintenance price. And the least important attributes which occupy the last 30% are composed by 7 pieces. We also can find the crucial figures that the each most important stated importance is around the 10% and the each least important stated importance is no more than 5.5%. That is to say, the most important ones are nearly the twice of the least important ones. So we can think that the most important attributes dominantly affect consumption decision of customers and the least one can hardly affect customers' decision making.

WHATs	Pareto statisitcs	Stated importance	Strategic focus of WHATs
Repair efficiency	11.76%	11.76%	8.52%
Quick response	22.35%	10.59%	17.89%
Maintenance price	32.16%	9.80%	7.10%
Repair price	40.98%	8.82%	6.39%
Maintenance effect	49.80%	8.82%	6.39%
Periodic inspection	57.65%	7.84%	13.25%
Spare parts price	63.92%	6.27%	4.54%
Facility of dealer shop	69.41%	5.49%	4.64%
Manner of personnel	74.90%	5.49%	4.64%
Periodic information	80.39%	5.49%	11.13%
Appearance of personnel	85.10%	4.71%	3.98%
Ways to complain	89.80%	4.71%	3.41%
Ways to order	93.73%	3.92%	2.84%
Appearance of dealer shop	96.86%	3.14%	2.65%
Ways to pay	100.00%	3.14%	2.65%

Figure 4- 3 the critical analysis of WHATs

Looking at the strategic focus of WHATs, the most crucial ones are respectively Repair efficiency, Quick response, Periodic inspection and Periodic information. It is not surprising that the most important stated importance attributes have high importance of strategic focus. Although the Maintenance price is not belong to the first class (above 33%) and second class (above 67%), it is the highest one among the rest. However, Periodic information has the first class importance in the strategic focus though it is not so important in the stated importance. And this situation also happened on the Periodic inspection. So, we may find the problem that although customers clearly require characteristics of fast, quick and economical, they also have the potential demand of instant care.

4.4 Benchmarking of HOWs

In the benchmarking of HOWs, there is a prioritization matrix used to establish the correlation between WHATs and HOWs and then calculate the relative importance of HOWs. The chart of the correlation is shown in (Figure 4-4).

The symbols used on the prioritization matrix are defined as shown in the chart. The set of available symbols includes the standard QFD 1-3-9 symbols, where 9 means strong level correlation, which has the symbol of red rhombus; 3 means some or medium correlation, which as the symbol of yellow triangle; and 1 means possible or weak correlation, which has the symbol of green dot. And if there is no obvious correlation, we just let the column to be blank. Moreover, there is need to explain that the level number of 3 (symbol of medium correlation) only means the correlation is moderate but does not mean that it is the medium value between 1 and 9. This is the thesis writer's understanding for this method, which is used by Fisher & Schutta (2003) in their book named Developing New Service.

Furthermore, the optional symbols for documenting negative correlations are also available. They can be used to document negative side effects of improving the HOWs.

But in the standard QFD model, those side effects are documented in the HOQ (House of Quality) "roof" matrix that when wish to skip the "roof" matrix then those symbols may be used. The negative symbols have the same principles as the positive symbols with the 1-3-9 scales but only with the negative numbers. However, in this thesis only the positive symbols are used in the correlation matrix.

In the calculation of the relative importance of HOWs, there are two steps. The first one is to get the results of the weighted value of HOWs from the correlation matrix. We can use the formula like that:

Weighted value of HOW $_{(i)}$ = Relative importance of WHAT $_{(i)}$ * matrix relation value between WHATs and HOW $_{(i)}$

Then we can calculate the proportion of each weighted value of HOWs and then to know the relative importance of HOWs. The formula is like below:

Relative importance of HOW $_{(i)}$ = Weighted value of HOWs $_{(i)}$ / $\sum$ (Weighted value of HOW $_{(i)}$)

Relative improtance of WHATs		Percentage of native speaking personnel	Average serving experience of personnel	Annual training times of personnel	One-time solve problem	Spare parts sticker price	Repair fee	Maintenance fee	Numbers of emergency assistant	Numbers of personnel	Numbers of service cars	Service distance	Numbers of safety inventory	Assignment completion on time	Service warranty time	Rare parts ordering time	Waiting time after ordering service	Feedback after complaining	Variety of emergency inventory	Brochure providing	Using original factory spare parts
3.67%	Appearance of dealer shop										1		1						3		
6.42%	Facility of dealer shop								3	9	9	3		1					3		
7.34%	Spare parts price					9															9
8.26%	Repair price			3			9			3	3	3									
9.17%	Maintenance price			3				9		3	3	3									
8.26%	Quick response								3	3	3	3	3				9		3		
9.17%	Repair efficiency		9	9	9				3					9							
8.26%	Maintenance effect		3	3				3							9						3
5.50%	Appearance of personnel			1																	
6.42%	Manner of personnel	3	1	1														3			
4.59%	Ways to order												3			9	3				3
3.67%	Ways to pay					1	1	1													1
5.50%	Ways to complain																	9			
6.42%	Periodic information																			9	
7.34%	Periodic inspection									3	3	3									
	Weighted value	0.19	1.14	1.72	0.83	0.70	0.78	1.11	0.72	1.57	1.61	1.18	0.42	0.89	0.74	0.41	0.88	0.69	0.55	0.58	1.08
	Relative importance	1.08%	6.40%	9.65%	4.64%	3.92%	4.39%	6.24%	4.02%	8.82%	9.03%	6.66%	2.37%	5.01%	4.18%	2.32%	4.95%	3.87%	3.10%	3.25%	6.09%

Figure 4- 4 correlation matrix of WHATs and HOWs

Then the project team from the company X discussed the critical index of the HOWs and listed into the sheet below in (Figure 4-5).

	HOWs	Units	Directions	Relative importance	Competitive technical assessments				Strategic targets	Technical point	Difficulty factors
					Company X	Caterpillar	Komatsu	Sany			
	Percentage of native speaking personnel	%	↑	1.08%	60	50	50	80	70	1	4
	Average serving experience of personnel	Years	↑	6.40%	2.8	3.3	3.6	2.4	3	1.5	5
	Annual training times of personnel	Units	↑	9.65%	1	2	4	1	2	1	5
Effect	One-time solve problem	%	↑	4.64%	80	90	90	70	90	1.5	7
	Spare parts sticker price	Avg. Yuan	↓	3.92%	5000	7000	5500	4500	5000	1	8
	Repair fee	Avg. Yuan	↓	4.39%	5000	8000	7000	3000	4500	1.25	6
Prices	Maintenance fee	Avg. Yuan	↓	6.24%	2200	2800	2500	1800	2000	1.25	6
	Numbers of emergency assistant	Units	↑	4.02%	1	1	2	2	2	1	7
	Numbers of personnel	Units	↑	8.82%	9	13	10	10	10	1	6
	Numbers of service cars	Units	↑	9.03%	3	5	4	3	4	1	6
	Service distance	Kilometers	↑	6.66%	300	400	300	300	350	1	5
Capability	Numbers of safety inventory	Units/Kind	↑	2.37%	2	4	4	1	3	1	6
	Assignment completion on time	%	↑	5.01%	85	90	95	80	90	1	8
	Service warranty time	Days	↑	4.18%	30	45	60	30	45	1.25	8
	Rare parts ordering time	Days	↓	2.32%	5	3	3	7	5	1	7
	Waiting time after ordering service	Days	↓	4.95%	3	2	2	5	2	1.5	7
Efficiency	Feedback after complaining	Days	↓	3.87%	7	5	5	10	5	1	4
	Variety of emergency inventory	Units	↑	3.10%	20	35	30	15	25	1	6
	Brochure providing	Units/Year	↑	3.25%	6	12	24	0	12	1	5
Materials	Using original factory spare parts	%	↓	6.09%	70	90	80	60	60	1	7

Figure 4- 5 critical to quality 1-1

We can see from the sheet that each HOW has its computation unit to quantize the value in the benchmarking. In the direction column (column 4 in Figure 4-5), the symbol of ↑ means "the more the better" and the symbol of ↓ means "the less the better". There may be the symbol of ○ which means the "exact", but no one is marked with that in this thesis due to the case condition. Like the sales points, the technical points (column 11 in Figure 4-5) are also used to show how much it can increase the market share if the related HOWs (technical measurements) improves. And the technical points use the similar 1-1.25-1.5 scales.

Then, the project team from the company X also used the "focus group" method to get the difficulty factors (column 12 in Figure 4-5) after the group discussion. We use 1-10 scales value to show how difficult each HOW is. It is worth to mention that when the difficulty factor is above or equal to 8, we marked it as the red flag, which means very difficult to make a breakthrough. And we marked the ones with less difficulty as the green flag, with means there is no technical bottleneck for the related HOW to make an improvement. And the yellow flag is reprehensive of the medium one.

After those setting work, the project team from the company X played the roles as the mystery shoppers to investigate and how the competitors did in the same market. It is the strongly objective observation to know the exact doing of competitors in each index with details. However,

some figures of the investigating results were processed to the rounded-off number. We made the current index of the company X in the (column 6 in Figure 4-5) and made the index of the three benchmark competitors in the (column 7-9 in Figure 4-5).

Now using the collected data and setting index, we can calculate the stated importance of HOWs and the strategic focus of HOWs. The details of the chart are in the (Figure 4-6).

	HOWs	Directions	Relative importance	Planned improvement	ABS of PI	Stated importance	Strategic focus of HOWs
	Percentage of native speaking personnel	↑	1.08%	0.17	0.17	0.97%	0.53%
	Average serving experience of personnel	↑	6.40%	0.07	0.07	8.59%	2.00%
	Annual training times of personnel	↑	9.65%	1.00	1.00	8.64%	28.10%
Effect	One-time solve problem	↑	4.64%	0.13	0.13	6.24%	2.54%
	Spare parts sticker price	↓	3.92%	0.00	0.00	3.51%	0.00%
	Repair fee	↓	4.39%	-0.10	0.10	4.91%	1.60%
Prices	Maintenance fee	↓	6.24%	-0.09	0.09	6.99%	2.07%
	Numbers of emergency assistant	↑	4.02%	1.00	1.00	3.60%	11.72%
	Numbers of personnel	↑	8.82%	0.11	0.11	7.90%	2.86%
	Numbers of service cars	↑	9.03%	0.33	0.33	8.08%	8.77%
	Service distance	↑	6.66%	0.17	0.17	5.96%	3.23%
Capability	Numbers of safety inventory	↑	2.37%	0.50	0.50	2.12%	3.46%
	Assignment completion on time	↑	5.01%	0.06	0.06	4.48%	0.86%
	Service warranty time	↑	4.18%	0.50	0.50	4.68%	7.61%
	Rare parts ordering time	↓	2.32%	0.00	0.00	2.08%	0.00%
	Waiting time after ordering service	↓	4.95%	-0.33	0.33	6.65%	7.21%
Efficiency	Feedback after complaining	↓	3.87%	-0.29	0.29	3.46%	3.22%
	Variety of emergency inventory	↑	3.10%	0.25	0.25	2.77%	2.25%
	Brochure providing	↑	3.25%	1.00	1.00	2.91%	9.47%
Materials	Using original factory spare parts	↓	6.09%	-0.14	0.14	5.45%	2.53%

Figure 4- 6 critical to quality 1-2

The stated importance (column 7 in Figure 4-6) shown the critical degree of HOWs when considered the technical points (column 11 in Figure 4-5) from the company's perspective. We used the formula like below:

Stated importance of HOW $_{(i)}$ = Relative importance of HOW $_{(i)}$ * Technical point $_{(i)}$ / $\sum$ (Relative importance of HOW $_{(i)}$ * Technical point $_{(i)}$) * 100%

To calculate the planned importance (column 5 in Figure 4-6), we can calculate the difference between the strategic target (column 10 in Figure 4-5) and the current index of the company X (column 6 in Figure 4-5). The formula is shown below:

Planned improvement $_{(i)}$ = (Strategic target $_{(i)}$ – Current index of company X $_{(i)}$) / Current index of company X $_{(i)}$

Because some directions of HOWs are set as "the less the better", then the strategic targets of them are possible less than their current index. That is to say the planned importance of HOWs

could be the negative number. So we use the absolute value of planned improvement (ABS of PI) in order to make it easier to compare the strategic focus of HOWs. The formula to calculate the ABS of PI (column 6 in Figure 4-6) is below:

ABS of PI $_{(i)}$ = | Planned improvement $_{(i)}$ |

And then we calculated the strategic focus of HOWs (column 8 in Figure 4-6) by using the formula that:

Strategic focus of HOW $_{(i)}$ = Stated importance of HOWs $_{(i)}$ * ABS of PI $_{(i)}$ / $\sum$ (Stated importance of HOW $_{(i)}$ * ABS of PI $_{(i)}$) * 100%

In the critical analysis of HOWs shown in (Figure 4-7), we can obviously know that the most important attributes which occupy the top 30% of the Pareto statistics are composed by Annual training times of personnel, Annual serving experience of personnel, Numbers of service cars and Numbers of personnel. And the least important attributes which occupy the last 30% are composed by 11 pieces. We also can find the crucial figures that the each most important stated importance is around the 8% and the each least important stated importance is no more than 5%. That is to say, the most important ones are roughly the 1.5 times of the least important ones. So we could get the conclusion that the most important attributes are with high priority to improve the after-sales service quality according to customers' demanding and the least ones seemed not so urgent if the company X wants to improve its after-sales quality under the limited resources.

HOWs	Pareto statisitcs	Stated importance	Strategic focus of HOWs
Annual training times of personnel	8.64%	8.64%	28.10%
Average serving experience of personnel	17.23%	8.59%	2.00%
Numbers of service cars	25.31%	8.08%	8.77%
Numbers of personnel	33.21%	7.90%	2.86%
Maintenance fee	40.20%	6.99%	2.07%
Waiting time after ordering service	46.85%	6.65%	7.21%
One-time solve problem	53.09%	6.24%	2.54%
Service distance	59.05%	5.96%	3.23%
Using original factory spare parts	64.50%	5.45%	2.53%
Repair fee	69.41%	4.91%	1.60%
Service warranty time	74.08%	4.68%	7.61%
Assignment completion on time	78.57%	4.48%	0.86%
Numbers of emergency assistant	82.17%	3.60%	11.72%
Spare parts sticker price	85.68%	3.51%	0.00%
Feedback after complaining	89.14%	3.46%	3.22%
Brochure providing	92.05%	2.91%	9.47%
Variety of emergency inventory	94.83%	2.77%	2.25%
Numbers of safety inventory	96.95%	2.12%	3.46%
Rare parts ordering time	99.03%	2.08%	0.00%
Percentage of native speaking personnel	100.00%	0.97%	0.53%

Figure 4- 7 the critical analysis of HOWs

Looking at the strategic focus of HOWs, the most crucial ones are respectively Annual training times of personnel, Numbers of emergency assistant, and Brochure providing. From the data we can know that in the first class (above 33%) and second class (above 67%) of stated importance of HOWs, company X did normally except the Annual training times of personnel. In this index, there is 28.10% of strategic focus occupation which is far more than others' occupation and even more than twice of the second highest one. Besides this, the Numbers of emergency assistant and Brochure providing should be pay more attention by company X, although the two technical measurements are belong to the third class of the stated importance. One reason for the urgent improving is that the competitors of company X did quite better in these two technical measurements. And another reason is that considering the strategic focus of WHATs, the instant information providing will make company X a big competitive advantage.

However, besides the strategic focus with extreme priorities, there are two technical measurements are also suggested to care a lot. They are Numbers of service cars (8.77%) and Waiting time after ordering service (7.21%). Moreover, if sum the occupation of them with the

previous three most prior ones, the total occupation would be 65.27% which could be the dominants to decide how well the service is been improving.

4.5 Difficulty analysis

The difficulty analysis is the quantitative analysis method to find out the bottleneck for the technical measurements by visual symbols. Although in the quality function deployment (QFD) and house of quality (HOQ) literature review there is no introduction for this method, one QFD software company named Qualica[12] has applied this method in the QFD analysis process. And we found it is useful to show the levels of the difficulties for the technical measurements.

In the difficulty analysis, there are two axes. The horizontal one is representative of the importance of the HOWs (technical measurements). And the vertical one is representative of the objective difficulty of the HOWs. And there are two critical lines in the horizontal axis and vertical axis respectively. Either critical value of the critical lines is 33%.

In the difficulty analysis, the main purpose is to detect the results which technical measurements have the higher priority to achieve to satisfy the customers and win the market share. We can use four blocks to show where each technical measurement is positioning according to the two standards: the horizontal one is the importance and the vertical one is the difficulty. The details are shown in the (Figure 4-8). The meanings of the four colored boxes are listed below:

1. The Critical Zone (Red): these are the potential problems causing bottlenecks later in the process because they are not only difficult but also important.
2. The Quick Wins Zone (Orange): these are the quick wins which have the characters that important to customers but easy to achieve.
3. The Low Value Added Zone (Blue): these technical measurements should be reconsidered since that they are not important to customers but hard to achieve.

[12] http://www.qualica.de/software.html

4. The Non Critical Zone (Green): these have low importance and low difficulty that somehow they are supposed not emergent to be achieved.

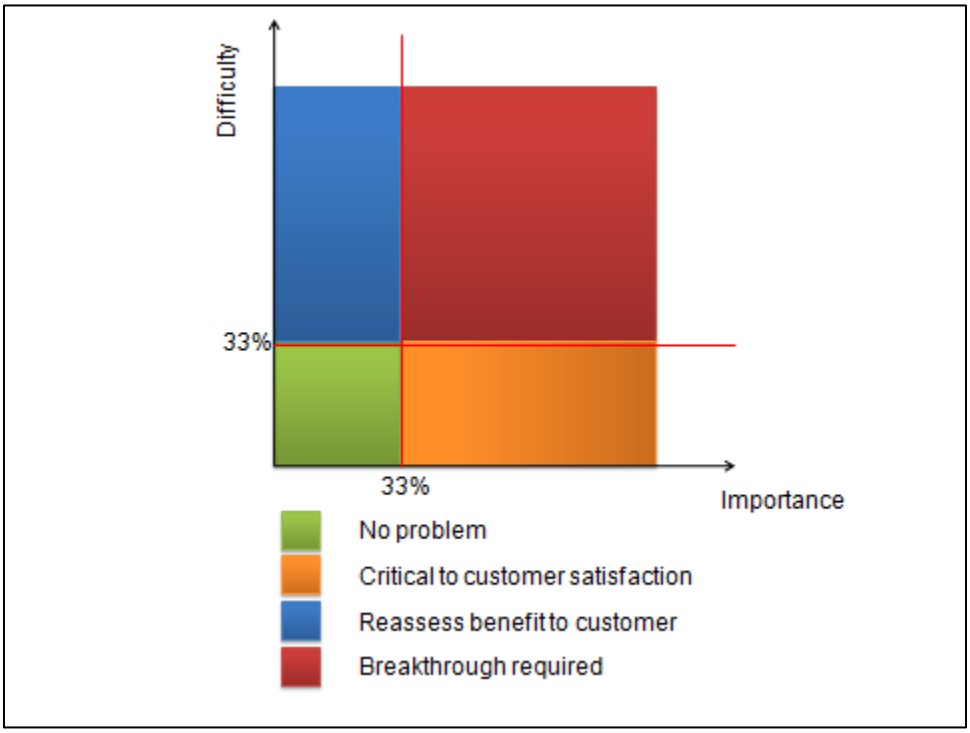

Figure 4- 8 difficulty portfolio

Now, let's look at the HOWs from the collected data. Every HOW has its difficulty factor and 100-times of stated importance in the chart from (Figure 4-9). The difficulty factor is from the chart of critical to quality 1-1 (column 12 in Figure 4-5). The 100-times of stated importance comes from the stated importance of HOWs (column 10 in Figure 4-5) multiplying 100. Multiplying the stated importance of HOWs with 100 is to match the format of the difficulty factors and to let both of the indexes in the same numerical level.

HOWs	Difficulty	Stated importance * 100
Percentage of native speaking personnel	4	0.97
Average serving experience of personnel	5	8.59
Annual training times of personnel	5	8.64
One-time solve problem	7	6.24
Spare parts sticker price	8	3.51
Repair fee	6	4.91
Maintenance fee	6	6.99
Numbers of emergency assistant	7	3.60
Numbers of personnel	6	7.90
Numbers of service cars	6	8.08
Service distance	5	5.96
Numbers of safety inventory	6	2.12
Assignment completion on time	8	4.48
Service warranty time	8	4.68
Rare parts ordering time	7	2.08
Waiting time after ordering service	7	6.65
Feedback after complaining	4	3.46
Variety of emergency inventory	6	2.77
Brochure providing	5	2.91
Using original factory spare parts	7	5.45

Figure 4- 9 difficulty analysis

And then we can plot the difficulty factor of each HOW as the y-coordinate, and plot 100-times of stated importance of each HOW as the x-coordinate to show how the HOWs are spreading in the difficulty portfolio map. The difficulty portfolio map is shown in the (Figure 4-10) below.

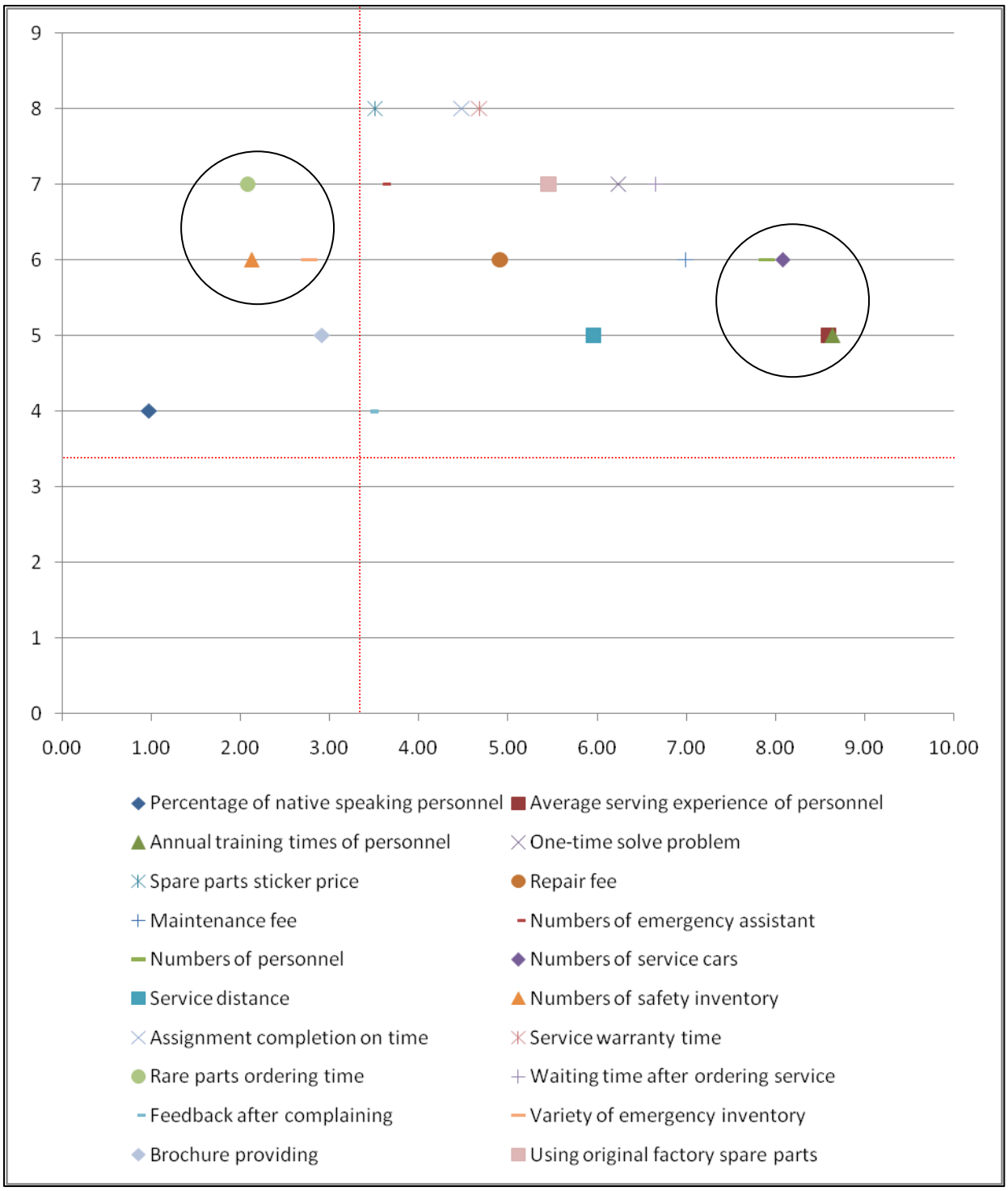

Figure 4- 10 HOWs difficulty portfolio map

However, there is no HOW plotted in the Non Critical Zone (Green Zone) nor in the Quick Wins Zone (Orange Zone). That is to say, every HOW looks more or less important to customers for company X to achieve the service development goal when comparing with its competitors. And

among the 20 HOWs, 5 of them belong to the Low Value Added Zone (Blue Zone) and 15 of them belong to the Critical Zone (Red Zone) like the picture shown in (Figure 4-11).

In the Critical Zone group, there are four HOWs are the most important ones, which are tagged with ☆ as the suggestion of extremely focusing. They are Average serving experience of personnel, Annual training times of personnel, Numbers of personnel and Numbers of service cars. Since these three HOWs have the very strong importance for customers but have relative lower difficulty index for improvement, they should be seriously focused on.

By contrast to that, in the Low Value Added Zone there are three HOWs should be neglected al all, which are tagged with ≠as the suggestion of entirely neglecting. They are the Rare parts ordering time, Numbers of safety inventory and Variety of emergency inventory. Since there attributes are too difficult to be improved but not be considered as important as others by customers, it is not necessary for them to consume lots of resources of the company X but only to get the very limited achievement.

HOWs	Difficulty	Stated importance * 100	Suggestions
Percentage of native speaking personnel	4	0.97	
Average serving experience of personnel	5	8.59	☆
Annual training times of personnel	5	8.64	☆
One-time solve problem	7	6.24	
Spare parts sticker price	8	3.51	
Repair fee	6	4.91	
Maintenance fee	6	6.99	
Numbers of emergency assistant	7	3.60	
Numbers of personnel	6	7.90	☆
Numbers of service cars	6	8.08	☆
Service distance	5	5.96	
Numbers of safety inventory	6	2.12	≠
Assignment completion on time	8	4.48	
Service warranty time	8	4.68	
Rare parts ordering time	7	2.08	≠
Waiting time after ordering service	7	6.65	
Feedback after complaining	4	3.46	
Variety of emergency inventory	6	2.77	≠
Brochure providing	5	2.91	
Using original factory spare parts	7	5.45	

Figure 4- 11 the distributing of HOWs in the difficulty portfolio

4.6 Comparison against competitors

In the comparison against competitors, the main comparable index is the relative strength. And the formula for calculating the relative strength is shown below:

Relative strength $_{(i)}$ = (Current norm of company X $_{(i)}$ – Current norm of competitor A) / Current norm of company X $_{(i)}$ * Relative importance of HOWs $_{(i)}$ * 100%

When company X compared its after-sales service with Caterpillar in the China market, there are only 4 HOWs with positive strength, which are Percentage of native speaking personnel, Rare parts ordering time, Feedback after complaining and Waiting time after ordering service and 1 HOW with equal point which is Numbers of emergency assistant. They are shown in the (Figure 4-12). Not to be surprised, the company X's total relative strength compared with Caterpillar is below zero, which is -37.64%. This is to say, there is a huge gap of the after-sales service quality between the company X and Caterpillar.

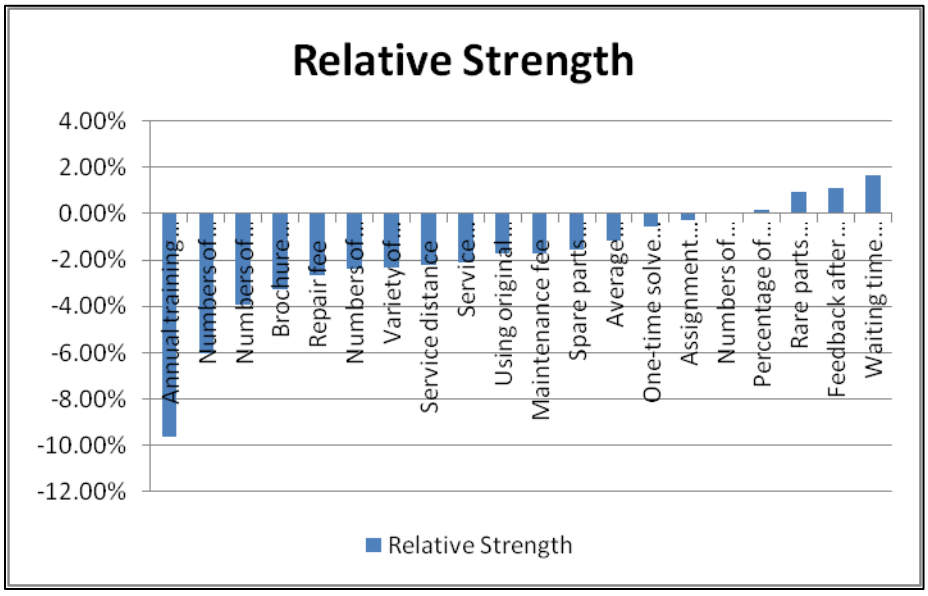

Figure 4- 12 relative strength compared with Caterpillar

When company X compared its after-sales service with another main competitor Komatsu in the China market, there are also only 4 HOWs with positive strength and 1 different equal point HOW from the comparison with Caterpillar. These advanced HOWs are Percentage of native

speaking personnel, Rare parts ordering time, Feedback after complaining and Waiting time after ordering service and the equal one is Service distance. They are shown in the (Figure 4-13). Worse result than the previous comparison, the company X's total relative strength compared with Komatsu is farer below zero, which is -57.81%. In another word, this provides the details reasons why Komatsu could be the after-sales service quality leader in the China excavator market.

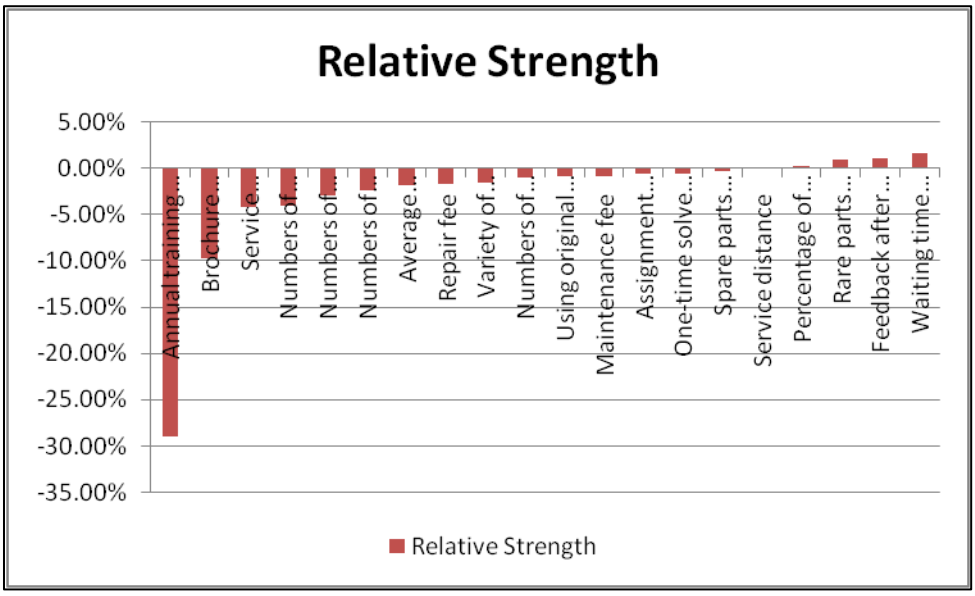

Figure 4- 13 relative strength compared with Komatsu

And when company X compared its after-sales service with a Chinese local competitor Sany in the China market, there are 10 HOWs with positive strength and there are 4 HOWs with the equal strength. It's worth to mention that in such field company X did not perform better than its local competitor although it did better than the two International giants: Numbers of emergency assistant, Waiting time after service ordering, Feedback after complaining, Numbers of personnel, Rare parts ordering time and Percentage of native speaking personnel. They are shown in the (Figure 4-14). However, the company X's total relative strength compared with Say is also below zero but without big difference, which is -0.10%.

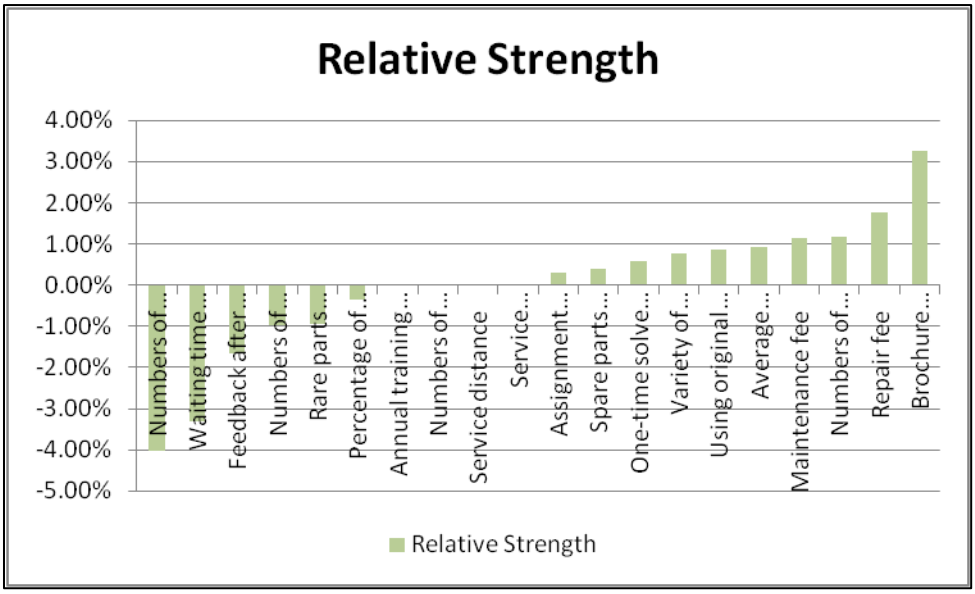

Figure 4- 14 relative strength compared with Sany

4.7 Comparison of results

In the conclusion of the HOWs comparison, we can see the details figures in the chart below from (Figure 4-15). Here, we can find that company X has the advantage of HOWs in the fields of Percentage of native speaking personnel, Rare parts ordering time, Waiting time after ordering service and Feedback after complaining. And the attributes of these HOWs have the features that they are based on the local service capability. However, another Chinese local player Sany has a superior performance in these HOWs. Then we can see that the after-sales service of company X is too medium that not too much focusing on the higher global standards (like Komatsu's training system) nor too much focusing on the local service capability (like Sany's customers relationship management).

HOWs	Relative importance	Relative Strength			Difficulty portfolio	Strategic focus
		V.S Caterpillar	V.S Komatsu	V.S Sany		
Annual training times of personnel	9.65%	-9.65%	-28.95%	0.00%		
Numbers of service cars	9.03%	-6.02%	-3.01%	0.00%		
Numbers of personnel	8.82%	-3.92%	-0.98%	-0.98%		
Service distance	6.66%	-2.22%	0.00%	0.00%		
Average serving experience of personnel	6.40%	-1.14%	-1.83%	0.91%		
Maintenance fee	6.24%	-1.70%	-0.85%	1.14%		
Using original factory spare parts	6.09%	-1.74%	-0.87%	0.87%		
Assignment completion on time	5.01%	-0.29%	-0.59%	0.29%		
Waiting time after ordering service	4.95%	1.65%	1.65%	-3.30%		
One-time solve problem	4.64%	-0.58%	-0.58%	0.58%		
Repair fee	4.39%	-2.63%	-1.75%	1.75%		
Service warranty time	4.18%	-2.09%	-4.18%	0.00%		
Numbers of emergency assistant	4.02%	0.00%	-4.02%	-4.02%		
Spare parts sticker price	3.92%	-1.57%	-0.39%	0.39%		
Feedback after complaining	3.87%	1.11%	1.11%	-1.66%		
Brochure providing	3.25%	-3.25%	-9.75%	3.25%		
Variety of emergency inventory	3.10%	-2.32%	-1.55%	0.77%		
Numbers of safety inventory	2.37%	-2.37%	-2.37%	1.19%		
Rare parts ordering time	2.32%	0.93%	0.93%	-0.93%		
Percentage of native speaking personnel	1.08%	0.18%	0.18%	-0.36%		
Total	100.00%	-37.64%	-57.81%	-0.10%		

Figure 4- 15 strategic analysis of HOWs

Moreover, most of the results clearly suggested what should company X to do in the near future from the strategic analysis of HOWs chart.

Firstly, company X would be better to invest more money on its after-sales service network building because customers require more skilled personnel and sufficient capability of the service personnel and equipment. Not only of that, according to the difficulty portfolio and the strategic focusing, should company X improve such situation that there is an obvious gap between it and its main competitors in the basic service capability side although company X also thinks these HOWs are critical to it. But time flies and the slower guy would be the loser in the emerging market.

Secondly, company X could make some strategic abandoning because it has to allocate its resources (finance resource and human being resource) in the most effective and efficient way. For example, for the HOWs such as Number of safety inventory, Rare parts ordering time and Percentage of native speaking personnel, customers do not very strongly demand the performance of them. Moreover, concerning of the competitor, company X's competitors seem not care such HOWs very much. Although it looks that if company X does better in such field than its competitors the company X will be the outstanding one in the market, the company X has to balance its resources distributing and do the most prior improvement firstly.

Thirdly, although the formula and metric of the QFD model tells a lot, we cannot make the decision only depending on the results of figures. For instance, the HOW of Average serving experience of personnel belongs to the breakthrough requirements in the difficulty portfolio and also has high strategic focus demanding, but we may think this HOW is not the priority for the company X. one reason is that although some of the rivals of company X did better, there is not a big difference. Another reason is that if the company X wants to improve this HOW very soon, it has to hunt some service personnel from the rivals' company because in the job market there is not so many potential employees to match the requirements. Then the company X will spend a lot of money on the recruitment and this is really a tough work.

Fourthly, sometimes we should consider the strategic focus of WHATs when analyzing the results of HOWs improving. For example, look at the HOW attribute of Brochure providing, the one is categorized into the Low Value Added Zone and it looks that there is no necessary for company X to take strong strategic focusing on it. However, let's look back on the chart of the critical analysis of WHATs from (Figure 4-3), the WHAT attribute of Periodic information has a relatively higher score in the strategic focus of WHATs. This phenomenon figured out that "providing continuous information to customers" cannot increase the market share in a very short time but this measure will bring the company a long-term benefit and help the company to win the market share in a profound way.

4.8 Summarize and managerial suggestions

This study based on the company X shown that the customers in the Chinese heavy construction equipment market consider the time consuming seriously (both processing time and waiting time). Followed by time consuming, they also seriously take the long-term costing as the judgments of good after-sales service. Although the sticker price of the spare parts is important for these customers, it is not the very critical factor. According to the interview of the company X's staff from after-sales service department, a truth told that some economical customers preferred to choose the spare parts which are made from small factories. That is to say, the customers have the

channel to find the substitutes of the products from original factory and would like to decrease the alternative products if there is a big difference of costs.

However, when take thinking on the company side there would be a lot of operational costs on increasing the number of service personnel and the amount of spares parts stocked in the dealer shop, although the service capacity and service ability are both the very critical technical factors for company X to win the market share.

Then new kind of after-sales service model is strongly asked for. This new model could be the medium way from the previous two models, which are the manufacturer response one and the dealer response one. And this new model divided the service capability such as service personnel and service equipment into two parts, one part are permanently belonged to the company X and the other parts are separately belonged to the spreading dealers in the China markets. Borrowed the advantages from the manufacturer response one and the dealer response one, this new model has the characteristics of that (1) sufficient recourses are available, (2) with proximity to local customers (3) flexibility to dispatch service resources (personnel and equipment) to the nearby regions (4) emergency problem solution responsible and (5) cut off the total operating costs for all the participators including company X, dealers and the possible third-party services such as transports service provider.

Like Cohen, Cull, Lee, & Willen (2000) researched the best after-sales service model operated by the brand of Saturn. They used the “pooling group” to build the hundreds of dealers into the service network. In the “pooling group” system, a group of nearby Saturn retailers organized by Saturn for inventory pooling purpose to see if it is available there. Based on but developed from this model, there is a suggestion to the company X that to build the whole after-sales service into the “pooling group” not only focusing on the inventory. That is to say, to make the dealers in the four main regions of the China market to establish the closed-loop or a cross network, which depend on the geographic situation on the map from (Figure 4-16). They can freely borrow the service personnel, equipment and also the spare parts inventory from each other in the nearby regions. And if the resources of the service capacity and service ability are not available in the “pooling group”, then they can be ordered from the regional distribution center or directly from the company X head quarter.

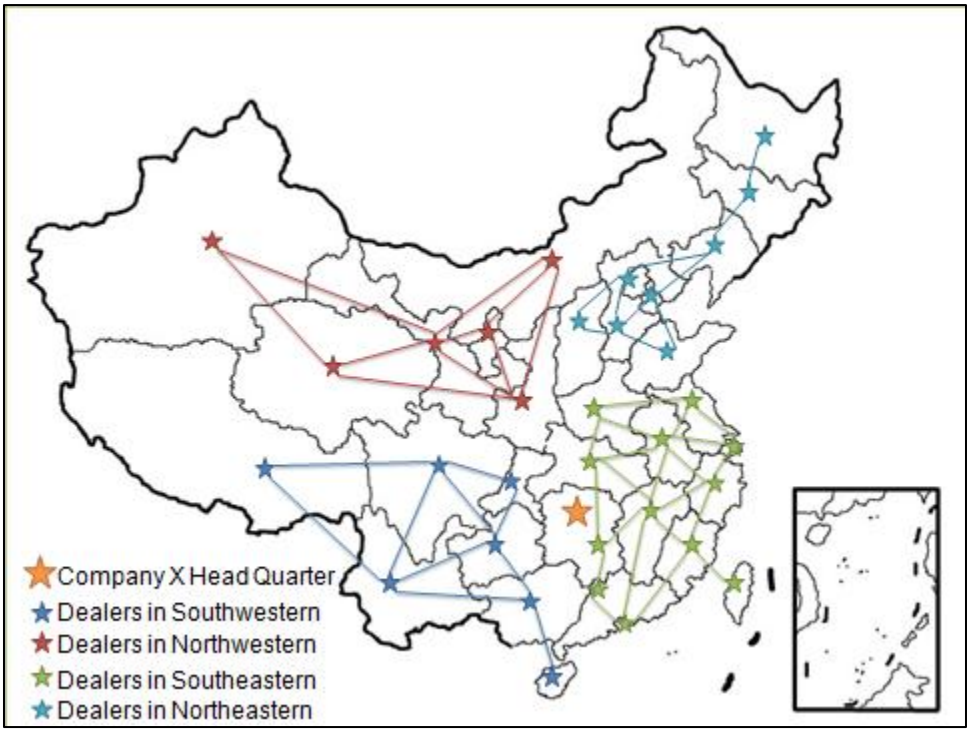

Figure 4- 16 pooling group of after-sales service

5. Conclusions

5.1 Goals and findings

In this thesis, the two main study goals are achieved. The one is to successfully apply the QFD model in the after-sales service. In this goal, the achievements are not only to translate the customers' needs into technical measurements for the supplier company but also to find out the priority and importance of each technical measurement. This helps a lot for understanding the customers well and also comprehending the market competition better.

Another study goal is to design the after-sales service model for the Chinese heavy construction equipment market. Following the case study, I get the advisable results for designing the "pooling group" network for the after-sales service in the Chinese heavy construction equipment market. Currently, this method is the most economical and efficient one for doing after-sales service in the target market.

Followed the way from Fisher & Schutta, I can get the way how to practically use the QFD model in the service improvements. I found that the QFD model is a very efficient way to decrease the customers' dissatisfaction. One side is that in the house of quality (HOQ) phase, I can design the customers' requirements and also benchmark these attributes with the competitors. Then I can get the qualitative results of the difference between the after-sales service my study object can provide and the service its competitors have. This could give me a guide with the marketing perspective.

In another side, I could translate the customers' needs into the technical measurements and then according to the quantitative benchmarking with the competitors' technical capacity I can know the details of the gap from competitors in each technical measurement. And this could give me a guide with the technical perspective.

Besides this above, in this thesis, I showed that the QFD model can well be applied in the service improvements although this model is originally invented to improve the production. If the every

detail steps of the service can be quantified, and if the customers' requirements can be divided from the general view into very specific demanding pieces, the QFD model will be optimally used for improving the service. So I could conclude that the good way to use the QFD model has the key points of know well the voice of customers and design well the related technical measurements.

5.2 Results of the research

From the results of this thesis, there are some advisable points can be used for other companies in the Chinese heavy construction equipment industry or in the similar machinery industries.

First of all, as for the Chinese heavy construction equipment industry, other companies may adopt the QFD model as the research method to improve the after-sales service. In this industry, the qualified after-sales service is strongly required. However, in such industry the marketing people are usually working separately from the service people. Then, the marketing activities might be not so suitable for the customers' demanding. And also, the service activities might be the passive ones but not the active ones. In order to provide customers a better after-sales service based on the current sources and costs, there is necessary to apply this QFD model to make a cross-functions effort. It is worth to mention that the QFD model could directly translate the customers' requirements into the technical measurements. In one side, the marketing people could have a full-scale picture to see where there is the marketing opportunity. In another side, the service people could have a clear view about what are the technical differences from the competitors' service. One more notable advantage of using this model is that it doesn't need more extra sources to improve the service. Instead of that, this model helps to adjust the strategic goals and reallocate the current sources to make them to be used optimally.

As for the similar machinery industries, the QFD model also could be a very effective method to improve the after-sales service. As long as such the industries mainly need to get rid of the dissatisfaction from the customers, the QFD model is the appropriate way. Moreover, if the service contains more quantified technical measurements, the QFD model will be more useful to match the service to customers' demanding.

5.3 Limitations

Due to the limited time and limited sources, the results in the thesis are not so perfect. In this thesis, there are two limitations. One is from the methodology aspect and another is from the data aspect.

In the methodology aspect, the limitation is that the technical correlation matrix (part E in Figure 3-6) is not used in the thesis because I do the case study only based on the house of quality (HOQ) which is the first phase of the four-phase quality function deployment (QFD) model. And the technical correlation matrix (or we can call it the roof of the quality house) is more important to use if there are continuous phases to be researched. So I just get rid of this step in the data processing and then apply the HOQ without the "roof".

In the data aspect, the main limitation is that the collected data is limited. Because only a few interviewees are available during this study period, I only collected 30 samples from the questionnaires to make the data. And these collected data were from the same regional market, so there may be some slight bias in the investigation that these interviewed customers cannot totally be preventative of the all the customers in the whole Chinese heavy construction equipment market.

However, the framework of this thesis is well organized. Then it can still give the readers a basic view of how to apply the QFD model to improve the after-sales service. Moreover, this study is based on the after-sales service of excavator products from the case company X. And it still can be useful for studying the after-sales service of the heavy construction equipment in the China market. But I would like to state some further research suggestions in the following section.

5.4 Further research suggestions

Here, I would like to list three main further study suggestions. I hope they may be useful for the readers who are interested in studying the after-sales service, especially in the Chinese heavy construction equipment market.

Firstly, the sample of the questionnaires for customers' requirements should be bigger. Because China has a broad area, the geographic environment is quite different from the North China to the South China. For example, in the winter time, the North China always snows but the South China rarely snows. Then the weather affects the construction process in the specific market and also determines the customers' needs for after-sales service in a certain degree. So if the sample can cover all the representative customers in the Chinese heavy construction equipment market, the study results from the QFD model would be more advisable.

Secondly, it is necessary to ask the customers to participate the design of questionnaires. Although the project team from the case company X is composed by the marketing expert and service expert, they did not entirely understand the customers' needs. So some parts of the results in this study are not so clear to be explained. Then I suggest doing the pre-survey for a small group of customers for the feedback and then modified the formal questionnaire with an improvement.

Thirdly, there is a more accurate way to rate the customers' requirements. In this thesis, I just adopted the simple method to average the relative importance of WHAT (Figure 4-1) from the 30 samples. However, there is a more scientific method to value the data, which is named Analytic Hierarchy Process (AHP). By using this method, users can do pair-wise comparisons to rate each WHAT according to the absolutely objective evaluation. So if the research requires very accurate data, the researchers may consider the AHP method to get the rating of the relative importance of WHAT as the advisable option.

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