QFD-based modular logistics service design

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QFD- Based Modular Logistics Service Design

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Purpose - This paper aims to develop a framework of QFD (Quality Function Deployment) -based logistics service design to integrate HOQ (House of Quality) technique and modular logic to help in designing logistics services with high quality and a large service variety.

Design/methodology/approach - Based on a literature review a conceptual research framework is built integrating QFD method and modular logic together. A case study is used to illustrate a real application in logistics service design of the third party logistics (3PL) provider.

Findings - The results shows that QFD and modularity used as design principles simultaneously can ensure service design quality at three layers (service, process, activity) in the modular logistics service platform.

Research implications - This paper provides multi-disciplinary insights for both industry and academics on how QFD/HOQ and modular logic can be integrated to systematically translate customer requirements into logistics service designs.

Practical implications - The framework proposed is directed to show how at the operational level, the service providers can transform customer requirements to customer value with modular services and develop new service modules more quickly for new customers that have not been served before.

Originality/value – The resulting framework combining QFD philosophy and modular logic, particularly integrating three level HOQs paralleled with three layers in the modular service platform adds knowledge in the research on service design, operations management and marketing.

Keywords Modularity, Platform, Service design, Quality Function Deployment, House of Quality, 3PL

Paper type Research paper

1 Introduction

With the explosive growth of the global service economy, outsourcing logistics activities to third party logistics providers (3PLs) has increased rapidly (Bask, 2001) and now becomes a common practice in many industries, which is normally driven by a company strategy of focusing on its core competency and cost benefits (Tate and Ellram, 2009). Meanwhile, the 3PLs face fierce competition, especially due to the varied, fast-changed, and customized requirements from their customers. However, the logistics industry is not amongst the most innovative industries even in developed countries like the USA and the UK. The main reason is that the logistics industry is still in the evolutionary rather than the revolutionary stage (Mena *et al.*, 2007). Consequently, effectively and efficiently designing logistics services, and providing and managing service variety to the customers with high service quality become critical success factors to 3PLs.

The purpose of this research is to apply the QFD concept and the HOQ tool to better understand and transform customer requirements into designs of service, process and activity to ensure the service quality. Another focus is to construct a logistics service platform following the modular logic within a 3PL company to provide and manage service variety to the customers. This paper expects that the QFD/HOQ applied in logistics service design would help the 3PLs to improve their performance (service quality) in effectively establishing linkages between customer requirements and service specifications (design target values). Meanwhile, the three-layer modular logistics service platform is expected to contribute on providing and managing the service variety in the 3PL company. The integration of QFD and modularity is also helpful to the 3PL to better deploy its resources to achieve higher customer service level.

For one thing, effective service design tools are urgently needed in the logistics service sector in order to ensure *service quality* to satisfy the customers. One of the essential characteristics of logistics service is that the customer critically affects the design and development of the services (Choy *et al.*, 2008). In order to achieve high service quality and customer satisfaction, the 3PLs need to better understand their customers' businesses, and then transform their requirements into service designs. The proposed QFD has been regarded as a useful method to understand customer requirements and to develop comprehensive products or service specifications (Bottani and Rizzi, 2006). Its tool named HOQ is used to define the relationships between customer requirements and the product capabilities. Considering its application in the logistics sector, Baki *et al.* (2009) present a case study to employ QFD together with different scientific methodologies to design the logistics service in a cargo company, which proves QFD is helpful in transferring strategic service quality needs of customers into cargo services. That's the reason why this paper integrates QFD in logistics service design for the 3PLs.

For another, the 3PLs have to provide various customized services to satisfy their customer needs. The capabilities of providing and managing *service variety* (Harvey *et al.*, 1997) are needed by the 3PLs, just as the capabilities of providing and managing product variety (Pil and Holweg, 2004) are required by manufacturing companies. In general, service variety is provided to the customer by delivering options via the service process (Silvestro, 1999). Hence, current research on service design is mainly focused on the design of the service process (Kindström & Kowalkowski, 2009) and the analysis of the service process (Geum *et al.*, 2009). Since the conception of *modularity* has become one of the most prevalent strategies to successfully provide and manage product variety (Campangnolo and Camuffo, 2009), this paper applies modular logic into the logistics service design, and also develops a modular logistics service platform to ensure 3PLs effectively manage service variety and create value to the customers (Pekkarinen and Ulkuniemi, 2008). While establishing a service platform has been proven to quickly (re)configure and (re)combine services to achieve service variety and to meet customized logistics needs of the customers in the industries including insurance (Meyer and DeTore, 2001), health (Meyer *et al.*, 2007), and logistics (Cambra-Fierro and Ruiz-Benitez, 2009).

This paper reviews current literature dealing with service design, quality, modularity and platform concepts to design and provide new logistics services. In this research, QFD is used as a primary tool to transform customer requirements into service targets in logistics service design. A conceptual framework of integrating QFD/HOQ tool with a modular service platform is then elaborated upon through a case study of a Chinese 3PL provider with three customers from automotive, apparel, and home appliances industry. Implications, limitations and future research directions are summarized in the conclusion part.

2 Literature Review

2.1 Modularity

Modular logic is widely employed in product design (Mikkola, 2006) in the manufacturing industry, and modularity has become one of the most prevalent strategies to support product variety (Salvador, 2007; Starr, 2010). Along with the fast growth of the global service economy, modularity is also notably being introduced into service industries.

From the perspective of service design, understanding the nature of modularity is essential to the service design and its innovation (Voss and Hsuan, 2009). In general, modularity can be implemented as a way of reducing service complexity and providing service variety (Baldwin, 2007). Furthermore, modularity can be seen as a design principle (Langlois, 2002) to simplify and rationalize service and process design for managing complexity (Araujo and Spring, 2010), and development of sub-systems (Miozzo and Grimshaw, 2005). On one hand, applying modular service platform a real challenge is that interfaces of the components within each module have to be clearly identified and standardized (Mikkola and Gassmann, 2003). On the other hand, loosely coupling through modularization allows both specialized processes performed in-house or by other units/companies and integrated in-house processes (Brusoni & Prencipe, 2001). Services grouped together loosely dependent on other groups of services are allowed to (re)use in several processes and/or by several customers (Legner and Vogel, 2007).

Concerning modularity in logistics, current research literature is limited. Pekkarinen and Ulkuniemi (2008) employed modularity in business service design for a 3PL company. A modular service platform is developed including four dimensions of service, process, organization, and customer interface. Modular platforms enable firms to perform the design process so that changes in one service module do not necessarily lead to changes in the design of other modules; 3PL companies can then extend the variety of services without correspondingly increasing in complexity of the whole system (Mikkola and Gassmann, 2003). The platform applied by the 3PL provider also could help in supply chain integration (Cambra-Fierro and Ruiz-Benitez, 2009).

A process normally can be decomposed into a number of activities (Fischer, 2006), and each activity is a piece of work that will be done by a specific people or a team based on the pilot case studies (Lin *et al*., 2010). From the view of a 3PL provider, a service defined into activity level could be helpful in activity-based costing (van Damme and van der Zon, 1999) to measure and monitor its logistics performance. Hence this research expands the four dimensions proposed in Pekkarinen and Ulkuniemi (2008) to five with an activity dimension.

2.2 Designing Services

Service design (Silvestro and Silvestro, 2003) attracts more and more attention from both academics and industry. Because of the process nature of services, a focus of vital importance in service design is how to design processes (Ramaswamy, 1996), which are regarded as the lifeblood of a service operation. The current literature puts more focus on, for example service capability (Puga-Leal and Pereira, 2007), service delivery (Mascio, 2007), and organizational issues (Stuart, 1998).

Although earlier research on service design centered on applying the classical product design methods and tools to the service sector (Pullman and Moore, 1999), a number of tools are specifically developed for service design. Service blueprint is a popular tool mapping the sequence and interaction of service events and describing essential functions of the service initially introduced as a process control technique for services (Shostack, 1984). Congram and Epelman (1995) propose a structured analysis and design technique for describing and designing the service processes. In order to reflect the customer participation perspective, fault tree analysis is applied to analyze the large-scale and complex service process and deduce useful information (Geum *et al.*, 2009). Lean service tools (Piercy and Rich, 2009) are developed to improve service design and delivery to the customers with the two integrated objectives of operational cost reduction and increasing service quality. After observing the influences of actual and speculative failure on new service design, Shulver (2005) proposed a speculative service design model considering the role of loss as an imperative for new service design. However, logistics service design and its tools are seldom mentioned in current literature.

2.3 QFD and HOQ

Service quality plays a critical role in success and survival in the fiercely competitive market (Miciak and Desmarais, 2001). For example, the service quality has a positive impact on customer loyalty to the company (Jayawardhena, 2010) and customer intentions (Spreng *et al.*, 2009). Despite the substantial advantages of current tools and approaches, the viewpoint of customers and their requirements is still lacking and the requirements are not identified and linked to the service design process.

The QFD method discussed in this paper and used to perform this task is originated in Japan in 1966 (Akao, 1990) for customer-oriented new product development under the umbrella of total quality control. QFD has been widely applied in manufacturing industries for product development (Miguel, 2005) and marketing (Lu *et al.*, 1994), and it is also employed in service industries (Ramaswamy, 1996) to help in designing and controlling service quality.

The purpose of applying QFD in logistics service design is to ensure that the eventual service designs meet the customer requirements. A key technique of QFD is HOQ. It uses a planning matrix to capture *what* the customer wants and *how* a company is going to meet those requirements (Slack et. al., 2007). As can be seen in Figure 1, HOQ includes six phases:

1. Identify customer requirements (*WHATs*) and evaluate those weights in the left wall of the house;
2. Compare the competitiveness of the service in the right wall;
3. Translate customer requirements into service design characteristics (*HOWs*) just below the roof;
4. Defines the relationship between *WHATs* and *HOWs* in the central deployment matrix or called relationship matrix;
5. Define the relationships between the various service design characteristics in the correlation matrix in the roof;
6. Design the target values of the service on the ground floor of the house, which is the absolute importance for each service design characteristic.

Take in Figure 1

2.4 Conceptual research framework

Based on the literature review, a conceptual research framework of applying the QFD method and modularity in logistics service design (Figure 2) is constructed. First of all, identifying the customer's needs is the fundamental of logistics service design. With the help of the QFD and its HOQ tool, the identified customer requirements will be transferred into design parameters and target performance to help in improving the service quality. Secondly, the designed services are expected to be categorized into a modular platform with four dimensions proposed in Pekkarinen and Ulkuniemi (2008), and a new dimension (activity) derived from literature and the pilot case studies (Lin *et al*., 2010).

Take in Figure 2

3 Methodology

3.1 Case study approach

The main purpose of this research is to build a framework of QFD-based modular logistics service design. The research questions are focused on 'How':

Q1: How to integrate QFD/HOQ and modularity into logistics service design for better service quality?

Q2: How to construct a modular logistics service platform for providing and managing service variety?

A case study is adopted in this research to build better understanding of the nature and complexity of the research phenomenon (Voss *et al.*, 2002). The case study also enables in-depth research revealing the real domain of logistics service design and its performance (Aastrup and Halldórsson, 2009).

As the focus is on the broad view of modular logistics service design by applying QFD and modularity, the case study defined in this research includes a focal case company and its three customers. Firstly, to address the two research questions, the focal company chosen is company A, who is a top ten 3PL in China with 65 years of experience offering a wide range of logistics services (warehousing, transportation, information management, system integration, and so on) to customers from various industry context, including automotive, apparel, food, cargo, electric power, steel and home appliances. With its recent strategy, providing high quality service and variety to satisfy customers has become the highest strategic priority. Secondly, due to the customer highly involved into the service design process, three customer companies (from industries of automotive, apparel, and home appliance) are selected to better understand their requirements and feedbacks on the service design within the 3PL. These three companies are the best in their respective industries. Choices of the focal case company and these three customers all satisfy the requirements of significance for case selection (Dubois and Araujo, 2007), and all are closely relevant to the conceptual research framework.

3.2 Data collection

Data were collected through multiple sources and methods, including field visits and semi-structured interviews to obtain information both from the focal case company and its three customers as well as secondary documentation, which can achieve data triangulation (Voss *et al.*, 2002) in the case research.

The primary data were collected from two types of semi-structured interviews. In-depth interviews with twelve top level managers were conducted with average length of six hours per person. The main purpose was to extract their personal opinions on how QFD and modularity can help in logistics service design. Secondly, the focused interviews with nineteen middle level managers were designed to identify how the 3PL actually applies QFD/HOQ and modular logic in the logistics service design, and to collect the feedbacks from the customers. Detailed interview information is summarized in Table 1.

Table 1. Interview summary

Company	**Interview type and average time (AT) (hrs)**						**Total time (hrs)**
	In-depth			**Focused**			
	No	Top managers	AT	No	Middle managers	AT	
A (3PL)	4	CEO	5	6	Two logistics managers responsible for customers from automotive, apparel, and home appliance industry	4	44
		Vice president responsible for automotive industry customers	**7**		Two QFD engineers	5	
		Two logistics executive managers	8		Two regional logistics manager	3	
B (Automotive)	2	Vice president responsible for supply management	4	4	Supply manager	2	24
		Vice president responsible for inbound logistics	6		Two logistics operations managers	4	
					Logistics planning manager	4	

C (Apparel)	3	Vice president responsible for material inventory, warehousing and finance management	4	4	Supply manager	2	28
		Two vice presidents responsible for supply and inbound logistics	5		Two logistics operations managers	4	
					Logistics planning manager	4	
D (Home appliance)	3	Vice president responsible for purchasing management	4	5	Supply manager	2	34
		Two vice presidents responsible for supply and inbound logistics	6		Two logistics operations managers	4	
					Two logistics planning managers	4	
Total	12		63 hrs	19		67 hrs	130 hrs

The questions addressed in the interviews are listed in Table 2, which is included into a pre-designed case study protocol in order to enhance the reliability (Yin, 1994) of this research. All the interviewees are familiar with QFD/HOQ and modularity logics. In particular in company A, two QFD engineers are interviewed to extract the in-depth personal experiences and opinions on the QFD application in the modular logistics service design. Moreover, as a result of the training courses on QFD and modularity operated by company A, most of the managers from the customers B, C and D are familiar with QFD and modular technology used in company A.

Table 2. Interview question list

For 3PL provider (company A)	*For Customers (company B, C, D)*
· Describe the normal logistics operations process in your company (department) for customers from different industry context. · How to identify the customer requirements and how to evaluate its priorities? · How to transfer customer requirements into service design following QFD logic and HOQ tool? · How to define the service modules and how it constructed into the service platform? · How to satisfy the customer with the designed service modules? · How is customer's response and feedback on the modular services designed and delivered to them?	· Describe the normal logistics processes in your company (department) · Describe the normal logistics services and processes delivered by your 3PL provider. · Describe your main requirements on logistics services, and rank it. · How your company (department) collaborates with the 3PL provider, in particular during the service design stage? · How your logistics needs are satisfied by the modular services provided by your 3PL? · Describe your experience and opinions on the modular service and QFD technology used in your 3PL provider.

3.3 Data analysis

Following the propositions in the conceptual research framework, the data collected through the interviews and from other resources were coded and then analyzed with the guidelines of Miles and Huberman (1994). The framework of QFD-based modular logistics service design platform presented in this paper has shaped the collection and analysis of the data for providing research results. The second analytical strategy adopted in this research is to develop a case description framework. With the pre-designed descriptive framework, it is more effective to well-organize the case study within the research team (Yin, 1994).

Pattern-matching and exploring the data of 31 in-depth and focused interviews (Yin, 1994) are adopted as the major techniques for data analysis. Firstly, the empirical patterns derived from the case evidence are compared with the patterns embedded in the conceptual research framework. The coincidence of the patterns would enhance the internal validity of the case study. Secondly, building a case explanation to analyze the collected data would help in refining the results. Data from the focal case company A leads to the key results to address the research questions. While the data collected from the customers contribute to refine the results with the opinions and feedbacks on the service design approach implemented in the 3PL company A. Furthermore, their service requirements are directly part of the house of quality.

4 Findings

4.1 Logistics service design using QFD

The recent corporate strategy of company A is to achieve a high level of customer satisfaction through providing high quality logistics services to the customers. One of the major tasks is to quickly design high quality logistics services to meet customer requirements.

In order to design and deliver high quality logistics services to the customers, company A applies QFD to transfer the customer requirements into service designs as visualized with HOQ in Figure 1. Therefore, a QFD team is organized consisting of three QFD engineers, two logistics operations managers, and one logistics planning managers.

Following the QFD logic, customer requirements are firstly identified and transferred into service designs in the level 1 HOQ, the service design attributes are transferred into process elements in the level 2 HOQ, and then the activity parameters in the level 3 HOQ (Figure 3).

Take in Figure 3

1) Level 1 HOQ: Services

The first step of applying QFD is to understand and define the customer requirements and its priorities, to compare with competitors' performance, and then to define the service to meet customer needs, which construct the level 1 HOQ.

First of all, the most important task is to collect information from the customer, and to identify and weigh the importance of customer requirements. These compose the left side wall of the houses in Figure 3 to show *What* the customer wants and its *weights.* For example, the requirements identified with customers from the apparel industry are summarized and coded in the left wall of the level 1 HOQ (see Figure 4).

Take in Figure 4

After the customer requirements are weighted using AHP technique (AHP (Analytic Hierarchy Process, Lu *et al.*, 1994) on the left wall, the potential services in form of *service designs* are developed which constitutes the roof of the house, which shows *Hows* (see Figure 3) to satisfy the customer requirements. Based on the requirement analysis, company A designs 5 services to respond to the customer's needs which are shown in the roof of HOQ in Figure 4. The correlations (the top roof of the HOQ in Figure 4) among these services are analyzed, which helps in clearly identifying the boundaries and better designing the interfaces between each service.

The competitiveness of each service provided by company A is compared with two benchmarking companies (the right wall of the HOQ in Figure 4). The Likert scale of 1 to 5 shows the competitiveness from very weak to very strong. The numbers in the body (called Service Design Attribute Matrix) are the relevance between customer requirements and service designs, which shows the impact of each service on satisfying the requirements. Finally, design targets of the service are deployed to satisfy customer requirements, and these service targets are the principal results of the level 1 HOQ process.

2) Level 2 HOQ: Processes

Service designs are visible to the external customers, and company A needs a process view internally on how to complete the services. Therefore, company A furthers the QFD implementation into the operational level. As a result, the level 1 HOQ is expanded into level 2 and level 3 HOQs separately for processes and its activities.

In the second stage of QFD implementation, *How*s (service designs) in the level 1 HOQ are transformed into *What*s (service design requirements) in the level 2 HOQ (see Figure 3), and the service design targets are assigned as the weights for each service design requirements. Following the same logic constructing the level 1 HOQ, processes are designed with weighted targets to satisfy the service design requirements.

Level 3 HOQ: Activities

At the third QFD stage, company A tries to divide the processes into activities in detail, which helps them better auditing the logistics costs and monitoring the logistics operations performance. The main outputs of level 3 HOQ are the activities with performance targets to complete the service processes in the level 2 HOQ.

Through the construction of HOQs, customer requirements are finally transformed into the services provided to the customer, the processes to complete the services, and the activities composed for the process. By implementing QFD logic and HOQ tool, company A improves its service quality both in service design and service delivery.

Furthermore, according to the interview results with the customers, company A improved its capability of better understanding customer needs with an increased customer satisfaction and the customization level.

4.2 Development of the modular service platform

Another major task of company A is to manage the service variety to meet different customer requirements; hence company A categorizes its QFD design results into a modular service platform. Due to the services are defined in detail with processes and activities in three levels, the modular logistics service platform developed in company A correspondently includes three layers with service modules, process modules, and activity modules separately.

One of the services designed in level 1 HOQ in Figure 3 is information management, which is categorized into the 'information management' module in the service layer (see Figure 5). The boundaries between each module are clearly clarified following the modular logic. The information management service includes modules such as inventory records management, order processing, and order tracking, which constitutes the process layer. The order processing module subsequently consists of several activity modules, such as order receiving, order scheduling, and order picking, in the activity layer.

Take in Figure 5

Within this platform, each module is linked to an organizational dimension (see Figure 5, a box in right top). The reason is that company A is a group company consisting of several subsidiary companies. Each service, process, or activity could be performed by specific team(s) and department(s) in the sub companies. As a result, the service module in the first layer is a combination of companies and services. Each service module consists of several process modules in the second layer, which accomplishes the logistics function to achieve the service performance targets.

The process module is defined as a combination of processes and departments in the process layer, and it includes fundamental and supportive ones. The fundamental process modules are the main logistics functions that directly satisfy customer needs, while the support processes such as human resource management, financial management, and IT management, enable the fulfillment of the fundamental logistics processes. The department or sub-company executing these processes is the organizational dimension at the second layer.

Each process module has its own detailed structure or chain of activities, which are identified as activity modules at the third layer. The activity module is described as a combination of activities and teams. The activities are completed by different teams in the department or sub-company.

With this platform, company A can quickly combine selected modules to satisfy different customers' logistics requirements, which ensure company A maintaining their competitive advantages in fast-changing customization environments without losing cost efficiency and flexibility in service design and operations. In particular, the organizational dimension combined with the service, process and activity, helps company A quickly organize necessary resources to deliver required logistics services to the customers, and also helps in monitoring performance of each organization.

5 Discussion

5.1 Framework of QFD-based modular logistics service design

The research results illustrate how QFD/HOQ and modularity can be applied to 3PL provider in designing and managing logistics services. With the case study results, the proposed conceptual model (see Figure 2) has been refined as a framework of QFD-Based Modular Logistics Service Platform for the 3PL company (see Figure 6).

Take in Figure 6

The left part of Figure 6 shows how three-level HOQ is constructed to design services following the QFD philosophy, and the right part shows how the modular logistics service platform is configured to provide and manage service to the customers following the modular logic. These two parts are interlinked, that is to say that the QFD philosophy and the modular logic are integrated to ensure both the service quality and the service variety.

5.2 Three-level HOQ for logistics service design

The results state that the QFD approach can enable 3PLs quickly transfer customer requirements into services, processes, and then activities. Following the QFD process, three levels of HOQ are constructed to design the logistics services to meet the customer requirements (see Figure 6). The level 1 HOQ can be expanded into level 2 and 3 HOQs. The research results also shown that the sequence of building the three level HOQs helps better deploying the resources in the 3PL company to deliver high quality logistics services to the customers. This three level HOQs show the sequence of HOQ applied in the logistics service design from services to processes, and to activities.

The logistics services provided to the customer are a combination of services in the level 1 HOQ, each service consists of several processes in the level 2 HOQ, and each process is accomplished through one or a combination of activity designed in the level 3 HOQ. By implementing HOQ tool and QFD logic in the logistics service design, the logistics services can be divided into processes and then activities in operational details. Each level has the performance targets, which helps the 3PL to easily measure the service quality to the customers and to monitor the internal operational performance.

5.3 Three-layer modular logistics service platform

The HOQs in three levels are correspondently linked with the three layers in the modular logistics service platform. In fact, the three layers reflect the structural nature of the modular platform. In this platform, each layer consists of two dimensions: module dimension and organization dimension. While module dimensions include service, process, and activity, the organization dimensions include company, department, and team which correspondently accomplish the performance targets of service, process, and activity.

By selecting and combining service modules and companies at the first layer, the 3PL provider can offer customized services or solutions with a number of module variations to meet individual customer's requirement. When facing a new service requirement or developing new services, it is also easier for 3PL providers to design new modules in these three layers and reintegrate the modules to satisfy the current or new customers.

Due to the visibility of service modules to the customers, it helps the customers to specify their own service needs, to evaluate the quality of service, and to identify the costs of the services (Ulkuniemi and Pekkarinen, 2011). Consequently, the interface (See Figure 6) between 3PL and the customers is the key to the service design quality, and it helps to maximize customer satisfaction and loyalty (Pekkarinen and Ulkuniemi, 2008). Compared with the first layer of service modules, the second and third layers of the platform are in some extent less visible to the customers as the processes and activities cannot always be observed directly by the customers.

5.4 Concurrent process of QFD and modular service design

One interesting aspect of this research is that transforming customer requirements into services/processes/activities and establishing the modular logistics service platform are concurrent processes for the 3PL provider. That means that the QFD and the modularity used as design principles in this research are inter-linked, and this concurrent nature ensures the design quality for these three layers in the modular logistics service platform.

In Figure 6, the arrows ongoing from HOQs to modules reflect the transformation of customer requirements to service/process/activity, while the arrows from modules to HOQs represent feedbacks from modular design process and customers (on satisfaction and service quality), which are used to re-design or optimize the service design characteristics, process elements, and activity parameters.

On one hand, during constructing the three level HOQs, the output of services, processes, and activities can be simultaneously categorized into correspondent modules at the three layers within the logistics service platform following the modular logic. On the other hand, when considering the interfaces among different service modules following the modular logic, the HOQ results sometimes need to be simultaneously revised and redesigned to make sure that the right interface and right modules are developed between these service modules. Based on this concurrent process, these two techniques are integrated within the proposed framework.

6 Conclusions

6.1 Theoretical contributions

As 3PL companies play increasingly critical roles in the economy in general and in supply chains, particularly efficient and fast service design is essential to the success of 3PLs.

This paper proposes a framework for logistics service design, which is based on modularity logic and QFD/HOQ tools regularly used in product design. The QFD-Based Modular Logistics Service Platform shows how the quality function deployment approach with HOQ tool and modularity can be integrated into the design of logistics services. The results shows that QFD and modularity used as design principles simultaneously can ensure service design quality at three layers (service, process, activity) in the modular logistics service platform.

The platform proposed in this research is an extension of the modular service platform proposed by Pekkarinen and Ulkuniemi (2008), which includes three modular elements: service offering, modular process, and modular organization. Whilst in the platform presented in this paper, services, processes, and activities are categorized into three layers, and each layer is attached with an organizational dimension. The process module is defined as a sub-system of the platform comprised of a number of processes (Pekkarinen and Ulkuniemi; 2008). In this paper, the process module is further expanded into activity modules in the third layer.

The modular logistics service platform developed by Pekkarinen and Ulkuniemi (2008) is more of a strategic management tool to identify, design, and choose the most successful platform for each customer's needs. To some extent, the QFD-based modular logistics service platform contributed in this paper is more directed to show how at the operational level, customer requirements are transformed to customer value with modular services.

Baki *et al.* (2009) applied QFD in the logistics sector to transfer customer service attributes into HOQ. Different from the one level HOQ used to make recommendations on the development of service quality in a Turkey case company (Baki *et al.*, 2009), there are three level HOQs developed in this research. Furthermore, Baki *et al.* (2009) integrated Servqual and Kano model with QFD in the case study, and the former two techniques are used to evaluate service quality and deep understand customer needs and expectation. While in this paper, QFD and modularity are integrated in order to focus on improving the service design quality by using QFD/HOQ, and managing service variety through the modular logistics service platform.

The resulting framework contributes to academic research on how to integrate quality issues operationally into service design. The paper also argues that modularity logic is helpful for the establishment of a cost-efficient and flexible service platform and the development of new logistics services. With the proposed framework and tools, it is also possible to extend the research results to other business services, e.g. industrial and professional services.

6.2 Managerial implications

The results show that QFD philosophy and HOQ method are useful for the creation of customized logistics services with high quality. By selecting and combining components in the modular logistics service platform, the managers can design logistics services/solutions based on individual customer requirements and deliver designed services cost-effectively and flexibly. The research results also shown that how QFD and modularity can be used to develop new service modules more quickly for new customers from new industries that have not been served before.

This framework proposed in this paper could help the 3PL providers systematically transforming customer requirements into service characteristics, processes and activities. Through identifying customer requirements and generating of a comprehensive and modular logistics service platform, 3PLs could competitively offer customized services and solutions not only to new customers from new industries, but also to existing customers with new service needs.

6.3 Limitations and future research

This paper conducts a case study with one 3PL provider and its three customer companies. Hence, further case studies are needed to enrich the findings, to facilitate its industrial applications, both in logistics and other business services with varying and dispersed customer needs.

The other branch in this field should focus on the interfaces among the modules at different levels, in particular within the context of serving several customers from different industries with the same platform. As the key input of the HOQ, customer requirements are the critical factor to effective service design, and the voice of the customer and how it is identified, specified and collected are the fundamental capabilities the service providers need to have to ensure the success of the logistics service design. As a result, the tools and approaches to capture and understand knowledge of the customers will become one of the most important fields in future research on logistics service design.

The framework integrating QDF (with HOQ tool) into the modular service platform is very complex and requires multi-disciplinary professional skills from managers and designers. Therefore, there is also a need to develop a simpler tool for the smaller 3PLs to develop new customer-driven services.

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Figure Captions

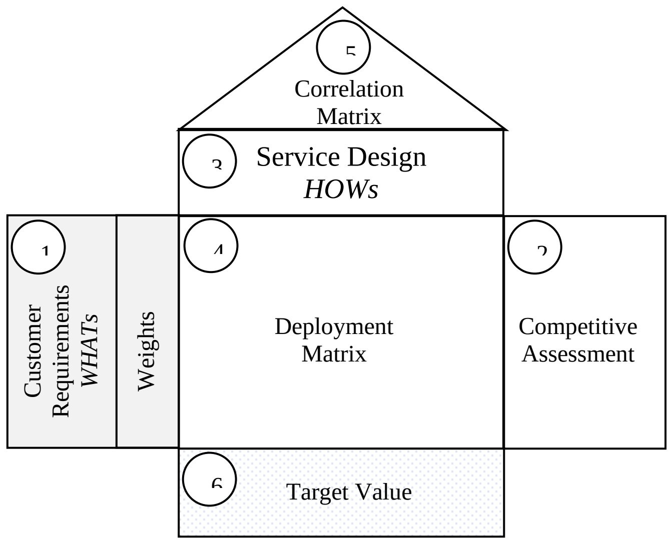


Figure 1

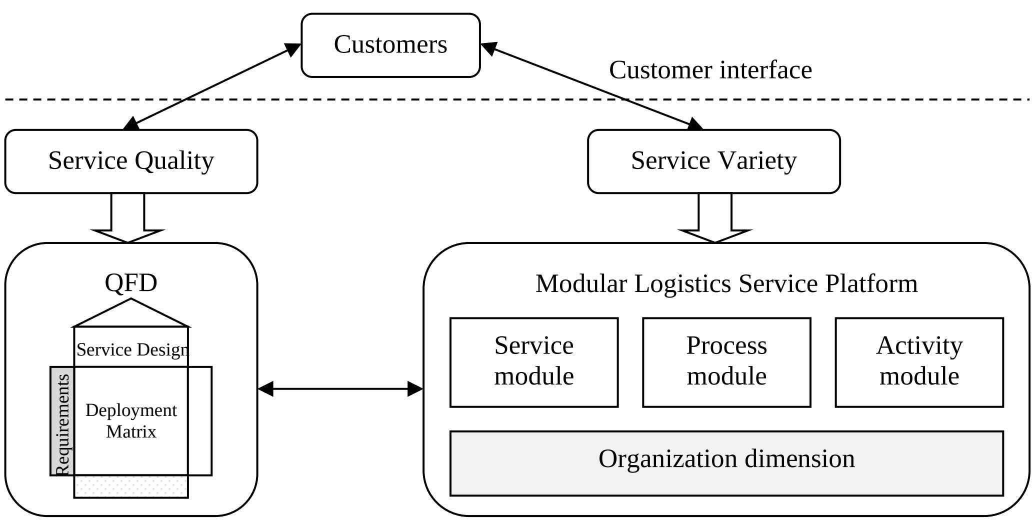


Figure 2

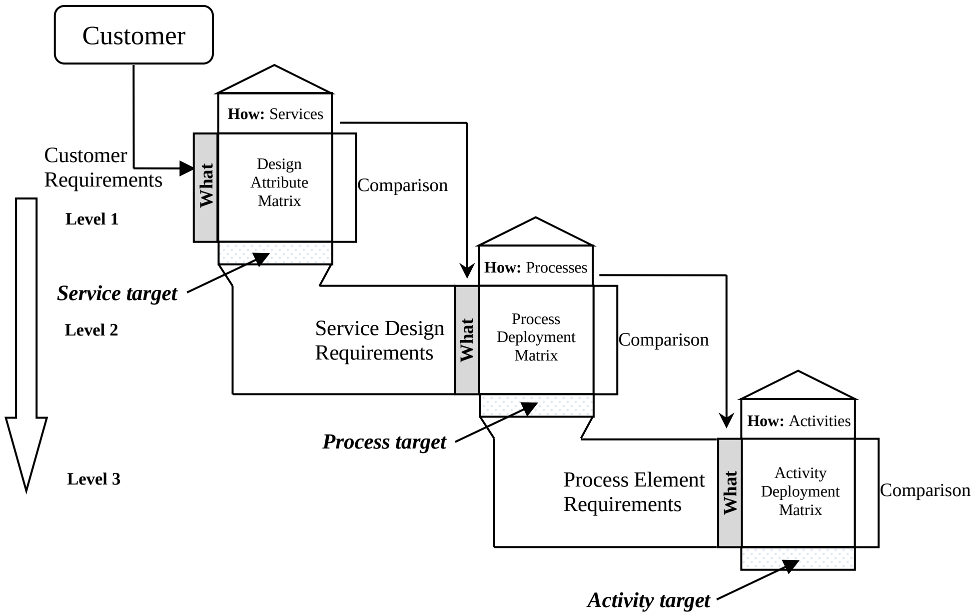
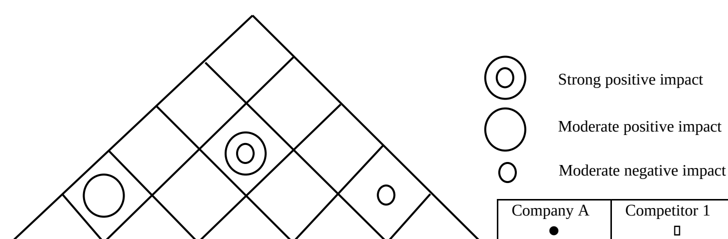


Figure 3



	Customer requirements	Weight	Service 1	Service 2	Service 3	Service 4	Service 5
1	Shorter order process cycle	0.385	2	4	9		2
2	Inventory record accuracy	0.292	9	7		4	
3	Real time information sharing	0.106	7				8
4	Reasonable price	0.066	7	6			
5	Inventory availability	0.151	3	4		6	
		Target	0.323	0.266	0.155	0.146	0.110

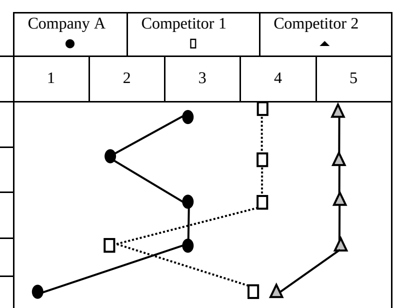


Figure 4

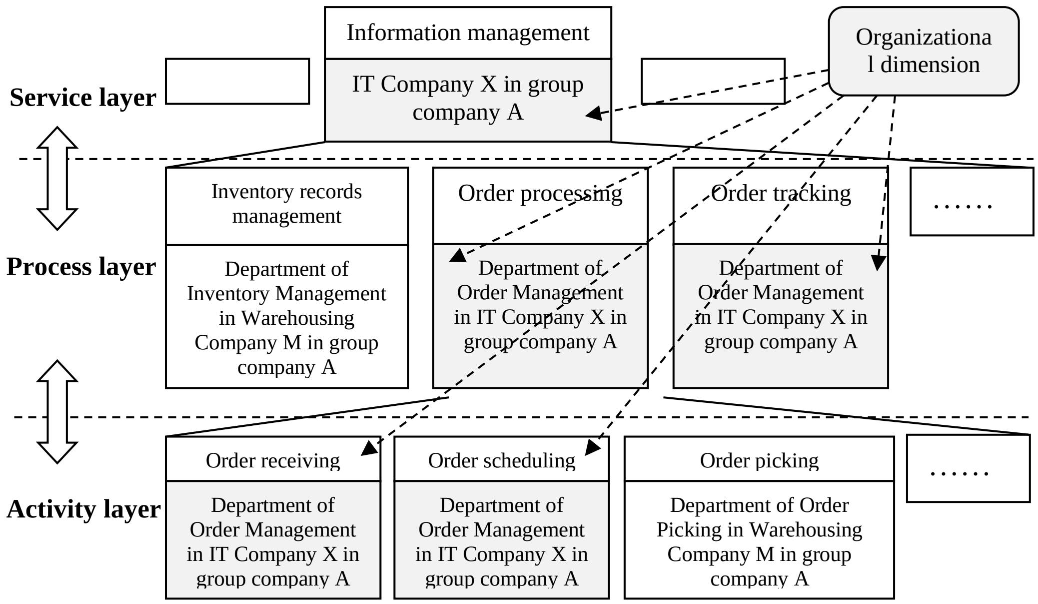
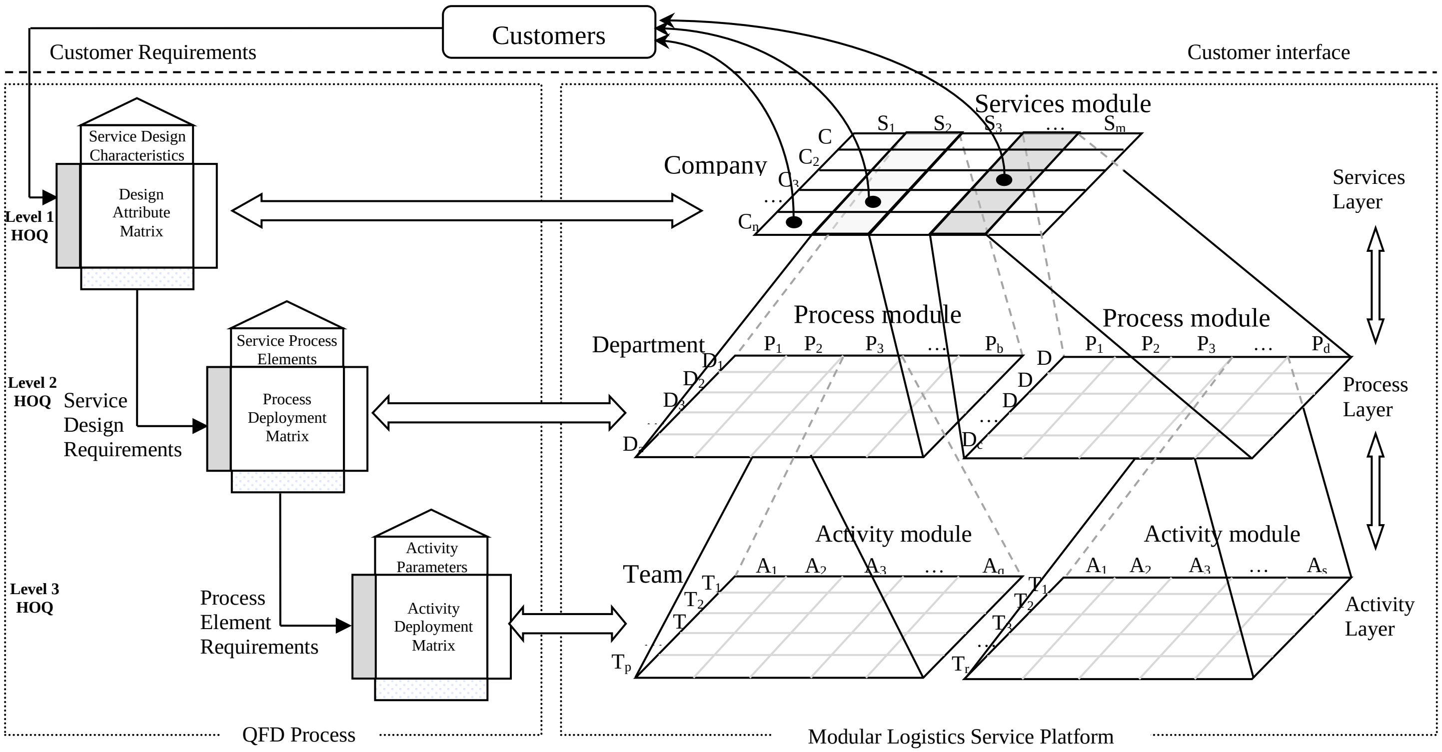

Information management
IT Company X in group company A
Organizational dimension
Service layer
Process layer
Activity layer
Inventory records management
Department of Inventory Management in Warehousing Company M in group company A
Order processing
Department of Order Management in IT Company X in group company A
Order tracking
Department of Order Management in IT Company X in group company A
……
Order receiving
Department of Order Management in IT Company X in group company A
Order scheduling
Department of Order Management in IT Company X in group company A
Order picking
Department of Order Picking in Warehousing Company M in group company A
……

Figure 5



Customers
Customer Requirements
Customer interface
Service Design Characteristics
Design Attribute Matrix
Level 1 HOQ
Service Process Elements
Process Deployment Matrix
Level 2 HOQ
Service Design Requirements
Activity Parameters
Activity Deployment Matrix
Level 3 HOQ
Process Element Requirements
QFD Process
Services module
Company
Services Layer
Process module
Process module
Department
Process Layer
Activity module
Activity module
Team
Activity Layer
Modular Logistics Service Platform

Figure 6