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SERVICE QUALITY ASSESSMENT OF FREE TRADE PORT ZONE USING MULTILAYER QUALITY FUNCTION DEPLOYMENT: AN EMPIRICAL STUDY IN TAIWAN

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Key words: Free trade port zone, Service quality, Quality function deployment (QFD), Multilayer QFD.

ABSTRACT

The aim of this paper is to improve the service quality of Taiwan's free trade port zone (FTPZ), which is the key facilitator for trade activities and economic growth. However, high service quality is important to satisfy FTPZ's users, investors, and other stakeholders. This study evaluates the service quality of the FTPZ using the multilayer quality function deployment (QFD) technique. Many previous studies on the FTPZ only focused on the points of view of manufacturers, logistics companies, and cargo owners, whereas a service provider (such as the Maritime Port Bureau) has a different viewpoint. To fill this gap, we evaluate the FTPZ's service quality by proposing a multilayer QFD analysis that considers both the customer's and the service provider's perspectives, with results nearly similar to the actual service quality. By completing the house of quality (HoQ), the voice of the customer and voice of the service provider may be transformed into technical solutions to enhance service quality. The results offer three important technical solutions: "Strengthening information and technology systems," "Coordination and unified regulations," and "Constructing automated road and regulation systems." The study offers practical implications for policymakers, business practitioners, and other FTPZ stakeholders in Taiwan.

I. INTRODUCTION

Global trade is the key engine that supports a nation's economic growth and business activities (Cheng, 2004). Maritime transport is critical to the world's economy, and over 90% of world trade relies on ocean transportation. Taiwan is surrounded by ocean, and the country's economic growth and trade activities heavily depend on importation and exportation (UNCTAD, 2015). Moreover, the competitiveness of the free trade port zone (FTPZ) plays an important role in supporting Taiwan trade and economic activities (Tiefenbrum, 2013). According to a report from Taiwan's government in 2014, the FTPZ helped strengthen this traditional function through "shop onsite and factory offsite" operations, with the aim of accelerating the country into joint regional trade blocs such as the Regional Comprehensive Economic Partnership. With the emergence of East Asian FTPZs in China and Korea, Taiwan's FTPZ has encountered serious competition and pressure from its neighbors (Wan et al., 2014; Yan and Wang, 2016). In 2015, the total value of trade handling cargo in US dollars in Taiwan's FTPZ decreased by 4% annually as compared to the equivalent figure for 2012. The major causes of the decline include service quality, the customs process, efficiency, and policy factors (Zeng, 2015). With competition from the FTPZ that directly influences economic activities and foreign investment, the FTPZ has focused on providing high service quality to customers and stakeholders, and this has become an important managerial issue in attracting foreign investment and staying competitive(WTO, 2010; Aggarwal, 2012) .

An FTPZ is a designated area that provides value-added service for cargo owners and enterprises. These services include bonded storage, manufacturing functions, consolidation, and packaging (Papadopoulos, 1985; Lu, 2004). Moreover, an FTPZ also offers integrated functions for customers by handling complicated customs and administrative procedures. In Taiwan, the major services of the FTPZ are providing customers with one-stop window service, a quick cargo flow process, a flexible labor source, tax exemptions, and other value-added services. FTPZ customers include manufacturers,

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logistics companies, and cargo owners. Service providers include the Taiwan International Ports Corporation, Ltd. (TIPC) and the Maritime and Port Bureau (MPB). The customer's point of view regarding FTPZ service may be different from the service provider's point of view. Improving FTPZ service quality to attain customer satisfaction is important for increasing Taiwan trade activities (Akbari et al., 2018). Therefore, this paper aims to evaluate the service quality of Taiwan's FTPZ based on the customer's and service provider's perspectives.

The primary role of an FTPZ is to support a nation's economic growth and provide diverse logistics trans-shipment services (Yang et al., 2013). To improve the competitiveness of global supply chain management, streamline FTPZ functions, and provide excellent quality of service, governments must efficiently satisfy key stakeholders such as customers and service providers. Previous studies focus on improving service quality via logistics services, regulation restrictions, flexible policymaking, hinterland planning, customs efficiency, tax exemptions, and other value-added services. However, these papers evaluate the service quality issue only from the customer's perspective, proposing good service quality strategies for an FTPZ. The considerations of key stakeholders such as the service provider should be included when evaluating service quality. To the best of our knowledge, very few studies consider both customers and service providers. Therefore, this paper aims to fill this research gap by evaluating Taiwan's FTPZ service quality from key stakeholders' perspectives. To deal with this research problem, multilayer QFD is a suitable technique for combining the voices of multi-stakeholders.

Previous studies mainly evaluated the service quality issue from a customer's perspective (Xiao, 2016). To understand the stakeholder's voice, this paper aims to combine the customer's and the service provider's perspectives. Combining stakeholders' opinions to evaluate service quality may generate suitable technical solutions. Therefore, this paper applies multilayer QFD to combine two key stakeholders' voices in order to explore key technical solutions. This paper aims to contribute to the existing literature in two ways. First, this study explores FTPZ service quality, stakeholder considerations, customers, and service providers. Second, it provides technical practical solutions for policymakers and practitioners for improving FTPZ service quality.

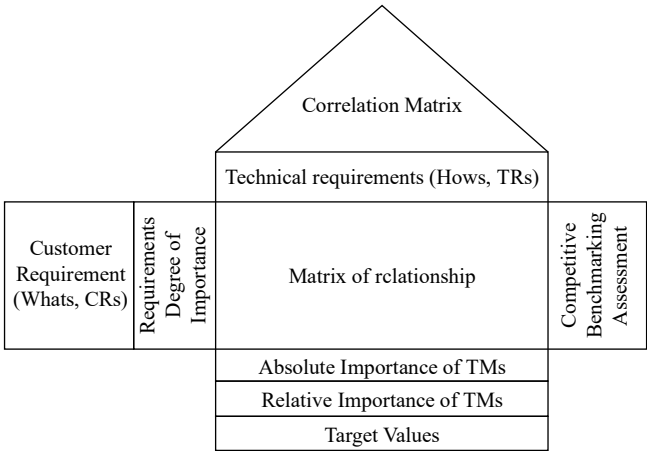
II. FTPZ TAIWAN LITERATURE REVIEW

Numerous studies have discussed the importance of FTPZs, including service quality, efficiency, policy making, and other value-added strategic functions (Yŏn'guwŏn, 2005; Chaudhuri and Yabuuchi, 2010; Pak and Majd, 2011; Irshad and Xin, 2014; Peng and Fei, 2017; Tseng et al., 2017). Chiu and Wang (2009) stressed that additional government incentives and supportive policies may facilitate Taiwan's FTPZ operations, based on the enterprise perspective. Thus, the key shipping and logistics functions, such as multi-country consolidations, regional repair centers, global supply chain management, and regional auction centers, should be strengthened. Cheng and Tsai (2009) explored factors that influence shippers into using multiple-country consolidation services. Yang (2009) explored Taiwan's FTZ port hinterland functions and compared them with the Korean status quo. The author pointed out that Taiwan's terminal faces a serious land shortage problem, which may require overall layout re-planning. Moreover, FTZ functions are well-coordinated with local industrial development, as there is still room to improve the customs inspection regulation process to ensure the freedom of FTPZ operation activities. Feng and Hsieh (2010) studied FTPZ core value-added criteria in Taiwan, stating that the selected core industries in FTZ should be electrical equipment and machinery component enterprises, the toy and game industry, and the clock and watch industry, based on value-added service perspectives. Important service quality attributes have also been revealed. Chiu et al. (2011) used Importance-Performance Analysis (IPA) to analyze FTZ business operations in Taiwan. The top five key factors selected for the analysis were were government efficiency, cheap rates and charges, simplified customs procedures, a clear regulation policy, and free tax measures. Meanwhile, Chen et al.(2016) used fuzzy IPA analysis to explore strategies to increase the international competitiveness of the FTPZ in Taiwan. Key improvement strategies are (a) to establish an interdepartmental coordination mechanism, (b) to integrate the free trade port zone, bonded zones and logistics park into a special economic area, (c) to positively join the regional free trade organization, and (d) to expand supply goods, introduce a famous logistics service provider, and build a public warehouse to develop a multi-country consolidation system. Table 1 summarizes the previous studies in terms of study aims, study approaches, and key findings.

Table 1 classifies the previous studies on FTPZ in Taiwan. The approaches of these studies vary between statistical analysis, IPA models, and empirical methods or comparison with other nations. These studies recommended improving FTPZ operations through a value-adding process, custom efficiency, government incentive policy, and other supportive measures for streamlining operations. Most of the previous studies evaluated service from the customer's perspective, whereas some studies evaluated service from a service provider or government perspective. The literature review shows that few papers simultaneously combine customer and service provider perspectives in evaluating service issues. However, both the voice of the customer and the voice of the service provider are important in determining technical solutions for service. This paper is motivated by this gap and aims to consider the two "voices" in exploring the service issue. Compared with prior studies, the major contribution of this paper is to combine the voices of customer and service provider to explore technical solutions in the FTPZ. The next section details the methodology.

Table 1. Summary of previous studies on FTZ in Taiwan.

Authors (reverse the order of these authors)	Study aims	Study approach	Findings
Chen *et al.,* (2016)	Explore key factors that can increase FTZ competitiveness in Taiwan	Combining IPA analysis and fuzzy theory	Five key improvement strategies to increase FTZ competitiveness in Taiwan.
Chiu *et al.,* (2011)	Analyze FTZ business operation	IPA analysis	Five important factors to improve the business operation of FTZ.
Feng and Hsieh (2010)	Core value-added criteria of FTPZ in Taiwan.	Empirical study and visit	Electrical equipment and machinery suppliers are the core industry in FTPZ based on the value-added perspective.
Yang (2009)	Explore FTZ in Taiwan from port hinterland perspectives	Comparing Taiwan operation with Korea status quo	Terminal layout and customs efficiency may be enhanced.
Chiu and Wang (2009)	Explore FTZ operation and policy	An empirical study of FTZ in Taiwan	Additional government incentives and supportive policies to streamline FTZ operation in Taiwan.



Source: Hauser and Clausing (1988)

Fig. 1. Framework of House of Quality.

III. METHOD

1. Multilayer QFD method

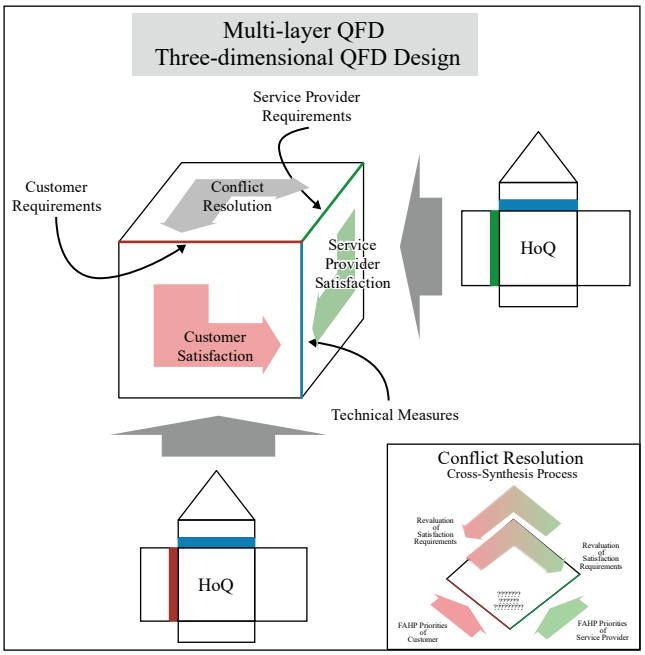
The concept of QFD methodology was initially established by Akao (1992) intended to help understand the features of products based on customer feedback. The most important QFD structure is the House of Quality (HoQ), which was primarily used in the Kobe Shipyard of Mitsubishi Heavy Industries for advancing a new oil tanker shipbuilding project. Akao introduced the application of QFD for the shipbuilding industry, and its popularity shortly became widespread among different industries. The HoQ is useful in allocating possible improvements for customer requirements. However, the service provider can maximize customer satisfaction by executing alternative improvements. The basic structure of HoQ is presented in Fig. 1 (Hauser and Clausing, 1988). The relationship matrix is the key part of HoQ, with relationships represented by three symbols: strong relationship ('■' corresponding to 9), moderate relationship ('▲' corresponding to 5), and low relationship ('●' corresponding to 1), as shown in Table 4, Table 5, and Table 6. The elementary background of the QFD method has been well defined using the following phases (Huang et al., 2015):

Phase 1. Indicate dimensions of customer requirements for measuring service quality
Phase 2. Accurately calculate the degree of importance of each customer requirement
Phase 3. Accurately calculate the degree of satisfaction of each customer requirement
Phase 4. Completely assess the priorities of the customer requirements
Phase 5. Demonstrate related service management requirements to indicate technical requirement management.
Phase 6. Carefully create the central relationship matrix to attribute customer service requirements to technical requirements
Phase 7. Determine the relationship strength of each customer requirement and technical requirement
Phase 8. List the level of the technical requirement to categorize the requirement priority, satisfy overall customer requirements, and maximize overall service quality.

2. Multilayer QFD framework

The key criticism of the traditional QFD procedure is that it lacks budget assessment and only takes account of the voice of the customer. Duru suggested multilayer QFD methodology to cope with the customer satisfaction issue in the dry bulk shipping industry (Duru et al., 2013).

The customer's voice and the service provider's voice are transformed into key technical solutions. Following Duru's approach, Huang used multilayer QFD to evaluate the service quality of container terminals by combining the voices of the customer and the service provider (Huang et al., 2016). Bulut



Source: Duru *et al.,* (2013).

Fig. 2. Framework of multilayer QFD model.

et al.(2018) applied multilayer QFD to evaluate the service quality of Kansai International Airport in Japan by combining the passengers' and airline's considerations. Final technical solutions were provided for the airport authority to improve the service quality of Kansai Airport.

These three papers modified traditional QFD by proposing multilayer QFD analysis for the voice of both the customer and the service provider. In this paper, multilayer QFD is applied to evaluate FTPZ service quality by combining customer and service provider considerations. The final outcome is defined by synthesizing the priority requirements and their cross-correlation. The outline of the multilayer QFD framework is shown in Fig. 2.

3. Cross-synthesis analysis

Cross-synthesis analysis is an important aspect of the multilayer QFD framework in terms of resolving the conflict of interest between the customer and service provider. The relationship matrix between these requirements proves that the resolutions are correlated and support/oppose each other. The relative weight of the requirements is well defined, based on the importance and satisfaction calculation. Previously, the relationship matrix and the relative importance of the counterparty served to estimate the relative rank of the counterparty. The synthesis is completed by averaging the relative rank of a party and the inferred relative importance of the counterparty (Duru et al., 2013).

Let R_i^s and R_j^c be the requirements of the service provider and customer, respectively. i (I = 1, 2, …, k) is the number of service provider requirements and j (j = 1, 2, …, l) is the number of customer requirements. The relative rank of the requirements is w_i^s (Eq. (2)) and w_j^c (Eq. (3)), for the service provider and customer, respectively. The relationship grade between the requirements is r_{ij}: 9 for a strong relationship, 5 for a moderate relationship, 1 for a low relationship, and 0 for no relationship. The relationship matrix, A_{ij}, is obtained in (Eq. (1)):

$$A_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1l} \\ r_{21} & r_{22} & \cdots & r_{2l} \\ \vdots & \vdots & \vdots & \vdots \\ r_{k1} & r_{k2} & \cdots & r_{kl} \end{bmatrix} \quad \text{(Eq.1)}$$

The adjustment of relative rank is achieved in two steps. First, the cross importance–weighted value of relative rank is added. Then, the simple average of cross-priority weighted and raw relative rank degrees indicates the mid-position between parties. The sum of the products of the relationship degree and the relative rank is determined using the following formula (Huang et al., 2016):

$$w_i^s = \sum_{i=1}^{k} w_i^s r_{ij} \quad \text{(Eq.2)}$$

for representing customer requirements, j, and

$$w_j^c = \sum_{j=1}^{l} w_j^c r_{ij} \quad \text{(Eq.3)}$$

for service provider requirements, i. The simple average of the normalized cross-priority weighted and raw relative rank degrees provides the combined relative weights:

$$\omega_j^c = \frac{\dfrac{\sum_{i=1}^{k} w_i^s r_{ij}}{\sum_{j=1}^{l}\sum_{i=1}^{k} w_i^s r_{ij}} + w_j^c}{2} \quad \text{(Eq.4)}$$

for the relative rank of customer requirements after the cross-synthesis, ω_j^c (Eq. (4)), and

$$\omega_i^s = \frac{\dfrac{\sum_{j=1}^{l} w_j^c r_{ij}}{\sum_{i=1}^{k}\sum_{j=1}^{l} w_j^c r_{ij}} + w_i^s}{2} \quad \text{(Eq.5)}$$

for the relative rank of service provider requirements after the cross-synthesis, ω_i^s (Eq. (5)). The increased relative rank of

Table 2. Customer requirement.

Row No.	Customer requirement	Description	Source
1.	Access to highway and port	FTPZ's convenience for connecting with other transportation modes	Lu and Yang (2007)
2.	Local market capabilities	Local FTPZ's ability to accommodate enough cargo operations (Import and export potential)	Yang *et al*., (2009)
3.	Infrastructure completeness	Sufficient logistics and warehouse facilities for operations	Chiu *et al*., (2011)
4.	Stevedoring efficiency	Shipping and logistics efficiency for facilitating FTPZ operation	Lu and Yang (2007)
5.	Management flexibility	Users may have more flexibility to operate in the FTPZ	Lu and Yang (2007)
6.	Smooth cargo planning	A clear process of cargo flow within the FTPZ	Chiu *et al*., (2011)
7.	Simple custom clearance procedure	The user requires a simple and fast custom process in the FTPZ	Chiu *et al*., (2011); Chen *et al*., (2016)
8.	One-stop shop functions	One-stop window to handle user's requirements within the FTPZ	Chiu *et al*., (2011)
9.	Tax exemption	Users may enjoy lower taxes or exemptions in the FTPZ	Chiu *et al*., (2011)
10.	Lower rent cost	Users may utilize the land of the FTPZ at lower prices	Yang *et al*., (2009)
11.	Flexible labor regulations	Users may hire cheaper foreign employees under the FTPZ's regulations	Yang *et al*., (2009); Yang *et al*., (2013)
12.	Easy procedure for entry	Enterprises may enter the FTPZ with a simple application procedure	Interview
13.	Marketing to foreign investors	To attract more foreign investors	Interview
14.	Excellent financial services	Sufficient financial services and consultants to support the FTPZ	Yang *et al*., (2009)
15.	Easy online system	Excellent web-based interfaces to improve efficiency	Brooks *et al*., (2013)
16.	Quick response ability	FTPZ operator can quickly respond to the user's needs	Lu *et al*., (2013)

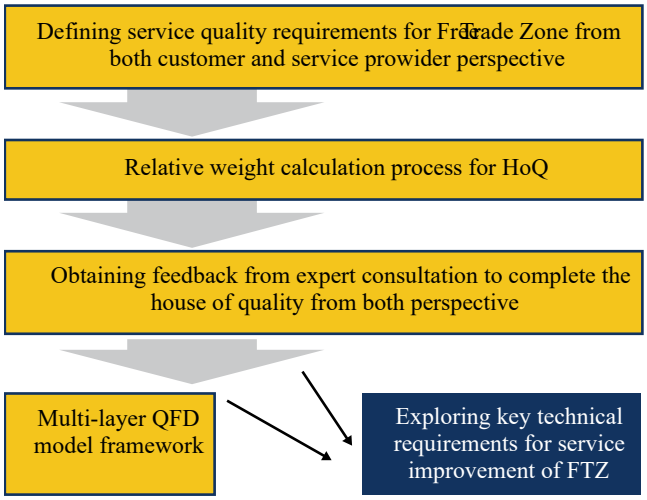
the requirements is based on the calculation of both HoQs. In the QFD process, the relative weight of the technical requirements, $\varnothing_t$ (Eq. (6)), is obtained by

$$\phi_t = \frac{\sum_{j=1}^{l} \omega_j^c r_{jt}^c}{\sum_{t=1}^{n}\sum_{j=1}^{l} \omega_j^c r_{jt}^c} \qquad \text{(Eq.6)}$$

for the HoQ of the service provider, and $\varnothing_t^{'}$ is calculated by (Eq. (7)):

$$\phi_t' = \frac{\sum_{j=1}^{l} \omega_j^c r_{jt}^c}{\sum_{t=1}^{n}\sum_{j=1}^{l} \omega_j^c r_{jt}^c} \qquad \text{(Eq.7)}$$

for the HoQ of the customer. t ($t = 1, 2, \ldots, n$) is the number of technical requirements, and c and s are the relationship values for the HoQ of the customer and service provider, respectively (Bulut et al., 2018). The multilayer QFD process is shown in Fig. 3.



Source: Huang *et al.,* (2016).

Fig. 3. Multilayer QFD model process.

IV. EMPIRICAL STUDY IN TAIWAN'S FTPZ AND DISCUSSION

To construct the house of quality, the customer requirements, service provider requirements, and technical requirements are selected from academic papers that focus on FTPZs. These attributes have been further revised by business practitioners and official experts on FTPZs to ensure they are consistent with practical operations, as shown in Table 2 and Table 3. In 2015, an empirical study was carried out on the major Taiwan FTPZs. These include the Port of Keelung, Port of Taipei, Port of Taichung, Port of Kaohsiung, Port of Anping, Port of Suao, and Farglory FTZ. The participants include senior executives and employees of TIPC, MPB, enterprises,

Table 3. Service provider requirement.

Row No.	Service provider's requirement	Description	Source
1.	Frequent density of shipping services	Increased shipping services may attract customers to the FTPZ.	Interview
2.	Lower operating cost	Lower operating costs may attract more enterprises.	Lu and Yang (2007)
3.	Access to highway and port	The FTPZ's convenience for connecting with other transportation modes	Yang *et al.,* (2009)
4.	Hinterland scale	Hinterland size is directly related to FTPZ operations.	Chiu *et al*., (2011)
5.	One-stop shop functions	One-stop window to handle user's requirements within the FTPZ	Chiu *et al*., (2011)
6.	Simple custom clearance procedure	A simple and fast customs process in the FTPZ is important.	Chiu *et al*., (2011)
7.	Automation process	FTPZ automation process may reduce labor requirements and costs.	Interview
8.	Information technology quality	Investment in IT may increase overall FTPZ efficiency.	Chiu *et al*., (2011)
9.	Flexible labor regulations	Hire enough employees under FTPZ regulations	Interview
10.	Tax exemption	Users may enjoy lower taxes or exemptions.	Chiu *et al*., (2011)
11.	Good communication process	Service providers need good mechanisms to communicate with users.	Interview
12.	Process re-engineering	Eliminate unnecessary processes and bureaucratic procedures in the FTPZ	Interview
13.	Administrative support	Policy makers may implement supportive measures to facilitate operations.	Lu and Yang (2007)
14.	Value-added serviceability	The FTPZ provides users with excellent value-added service.	Chiu *et al*., (2011)
15.	Logistics capabilities	Provide strong logistics functions to satisfy customers	Lu and Yang (2007)
16.	Good human resources	Educate professional staff to handle FTPZ operations	Interview

logistics companies, and manufacturers in FTPZs. To complete the house of quality and expert consultation, 177 interviews have been conducted in FTPZs. The interviewees include experiential executives, managers, and employees. Respondent profiles include 60 available interviews with MPA and TIPC workers and 117 available interviews with FTPZ workers, to reflect the voice of the service provider and the voice of the customer, respectively. Interview data was collected through email, personal visits, and company visits. Through the consultation process, the house of quality was completed under the multilayer QFD framework. Cross synthesis of priority is performed in Table 4 to consider both expectations. This includes conflict resolution for the correlation among requirements, their current weight, and their weight after the cross-synthesis process. Based on the weights after the cross-synthesis process, the relative weight is used to calculate the house of quality of the customers' and service providers' perspectives.

Tables 5 and 6 illustrate the HoQ from both customer and service provider perspectives for Taiwan's FTPZ. In Table 5, important technical requirements from the customer's perspective are "Strengthening information and technology systems" (0.156) and "Constructing automated road and regulation systems" (0.112). In Table 6, the important technical requirements are revealed to be "Coordination and unified regulations" (0.119) and "Strengthening cargo transit functions" (0.097). It is obvious that key technical solutions are quite different when explored from customer and service provider standpoints. Table 7 combines customer and service provider perspectives regarding service quality solutions. Finally, the mean relative weight and final priorities are obtained to illustrate the useful technical solutions and their implications for Taiwan's FTPZ.

Based on the numerical calculation results in Table 7, the most important technical requirement is "Strengthening information and technology systems" (0.115). Thus, building a complete information and technology system is important for effective operation. Efficient, real-time, seamless information transit is indispensable for maintaining the high efficiency and speedy operation of Taiwan's FTPZ. More investment in building an IT system may significantly improve overall service quality and operational performance. The second important technical requirement is "Coordination and unified regulations" (0.113). Taiwan's FTPZ should create a unified regulation center to coordinate operations and facilitate a smooth operational process. For technical requirements, the policymaker should define a good supervising system, since poor governing structure may delay free trade port zone operation and make it lose its competitiveness. The third important technical requirement is "Constructing automated road and operation systems" (0.103). Automation is the world trend in the port and logistics business. Automation may require a large investment; however, labor costs and requirements may significantly decrease. The benefit of automation is to reduce both the total labor cost and human error. It will also improve overall productivity. Investment on automation may be a good solution for improving overall productivity, which the policymaker and practitioner may consider an effective strategy.

Table 4. Conflict Resolution Matrix.

		Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
		Relative weight	0.088	0.081	0.029	0.037	0.096	0.110	0.051	0.022	0.066	0.118	0.015	0.074	0.103	0.059	0.007	0.004			
Row No.	Relative weight		Frequent density of shipping services	Lower operating cost	Access to highway and port	Hinterland scale	One-stop shop functions	Simple custom clearance procedure	Automation process	Information technologty quality	Flexible labor regulation	Tax exemption	Good communication process	Process re-engineering	Administrative support	Value added service ability	Logistics capabilities	Good human resource	Sum product	Relative weight	Weight after Cross-Synthesis
1	0.081	Access to highway and port			■	▲								▲			■		0.822	0.031	0.056
2	0.037	Local market capabilities	■		●	■										▲			1.678	0.063	0.050
3	0.096	Infrastructure completeness		■	■				■	●						■	■		1.769	0.067	0.081
4	0.029	Stevedoring efficiency	▲	●	▲		■	■	■	▲						■	■	▲	3.240	0.122	0.076
5	0.051	Management flexibility						●	■	■			■		■				1.781	0.067	0.059
6	0.015	Smooth cargo planning			●			■	■				■		■				2.310	0.087	0.051
7	0.059	Simple custom clearance procedure					■	■	▲	▲		●	■	▲	■				3.425	0.129	0.094
8	0.103	One-stop shop functions					■			●			■	■					1.652	0.062	0.083
9	0.044	Tax exemption						●				■		●					1.224	0.046	0.045
10	0.110	Lower rent cost		■								●		▲		■			1.401	0.053	0.081
11	0.066	Flexible labor regulation		■							■			▲		■	●	●	1.997	0.075	0.071
12	0.074	Easy procedure for entry											■		▲	■	■		1.108	0.042	0.058
13	0.022	Marketing to foreign investors												●	■			■	1.067	0.040	0.031
14	0.007	Excellent financial services								■				■			▲	●	0.787	0.030	0.018
15	0.088	Easy online system					●	■	■	■									1.446	0.055	0.071
16	0.118	Quick response ability								▲			■	■					0.815	0.031	0.074
		Sum product	0.378	2.115	1.655	0.633	1.693	1.479	2.527	2.319	0.594	0.447	3.221	3.663	1.634	2.910	2.316	0.359			
		Relative weight	0.014	0.076	0.059	0.023	0.061	0.053	0.090	0.083	0.021	0.016	0.115	0.131	0.058	0.104	0.083	0.013			
		priorities	0.051	0.048	0.044	0.030	0.078	0.081	0.071	0.052	0.044	0.067	0.065	0.103	0.081	0.082	0.045	0.028			

Following symbols stand for different levels of relationship:
●: low relationship, ▲: moderate relationship, ■:strong relationship

Table 5. House of quality matrix for customers' requirements.

Row No.	Relative weight		Constructing automated road and regulation systems	Building more public warehouses	Human resource management	Lower land utilization charges for enterprises	Strengthening cargo transit functions	Unbinding commerce restrictions	Coordination and unified regulations	Adopt flexible policy to facilitate cargo flow	Unbinding labor employment re-strictions	Tax weaiver or exemption policy	Build complete multimodal transport network	Partnership with adjacent science and industrial area	Periodic meetings with key stake-holders	Strengthening information and technology system
1	0.056	Access to highway and port					■						■	▲		
2	0.050	Local market capabilities					■	▲		●			▲	■		
3	0.081	Infrastructure completeness	■	■									■			■
4	0.076	Stevedoring efficiency	■	■			▲						■			■
5	0.059	Management flexibility	■					▲		▲					■	■
6	0.051	Smooth cargo planning	▲				●			■			●			
7	0.094	Simple custom clearance procedure	▲						■	■						■
8	0.083	One-stop shop functions			●				■						▲	●
9	0.045	Tax exemption				▲						■				
10	0.081	Lower rent cost		●		■		●								
11	0.071	Flexible labor regulation						●			■					
12	0.058	Easy procedure for entry		●		■		■							▲	
13	0.031	Marketing to foreign investors						■			●					
14	0.018	Excellent financial services						■	▲						▲	■
15	0.071	Easy online system							■						■	■
16	0.074	Quick response ability			■				■						■	▲
		Sum product	2.498	1.495	0.694	1.420	1.168	1.622	2.369	1.637	0.658	0.406	2.080	0.580	2.121	3.459
		Relative weight	0.112	0.067	0.031	0.064	0.053	0.076	0.107	0.074	0.030	0.018	0.094	0.026	0.096	0.156
		priorities	2	8	11	9	10	7	3	6	12	14	5	13	4	1

Following symbols stand for different levels of relationship:
●: low relationship, ▲: moderate relationship, ■:strong relationship

Table 6. House of quality for service providers' requirements.

Row No.	Relative weight		Constructing automated road and regulation systems	Building more public warehouses	Human resource management	Lower land utilization charges for enterprises	Strengthening cargo transit functions	Unbinding commerce restrictions	Coordination and unified regulations	Adopt flexible policy to facilitate cargo flow	Unbinding labor employment restrictions	Tax weaiver or exemption policy	Build complete multimodal transport network	Partnership with adjacent science and industrial area	Periodic meetings with key stakeholders	Strengthening information and technology system
1	0.051	Frequent density of shipping services					■	▲			●	▲		▲		
2	0.078	Lower operating cost	■	■		■					■	■				●
3	0.044	Access to highway and port					■						■	▲		
4	0.030	Hinterland scale					■	▲		●			▲	■		
5	0.078	One-stop shop functions		●	●				■						▲	
6	0.081	Simple custom clearance procedure			■	●			■	■					■	
7	0.071	Automation process	■	●												■
8	0.052	Information technology quality	■			●										■
9	0.044	Flexible labor regulation						▲			■				▲	
10	0.067	Tax exemption				■			■	■	■	■				
11	0.065	Good communication process			●				▲						■	■
12	0.103	Process re-engineering					■		■		▲		■	■		
13	0.081	Administrative support	▲					■		■						▲
14	0.082	Value added service ability					▲			■	▲			▲		
15	0.045	Logistics capabilities	■	■	▲		▲						■			●
16	0.028	Good human resource			■			■			●					
		Sum product	2.433	1.110	1.138	0.916	2.520	1.231	3.069	2.405	2.405	1.425	1.740	1.955	1.607	1.931
		Relative weight	0.094	0.043	0.044	0.035	0.097	0.048	0.119	0.093	0..093	0.055	0.067	0.076	0.062	0.075
		priorities	3	13	12	14	2	11	1	4	4	10	8	6	9	7

Following symbols stand for different levels of relationship:
●: low relationship, ▲: moderate relationship, ■:strong relationship

Table 7. Selection objectives.

		Constructing automated road and regulation systems	Building more public warehouses	Human resource management	Lower land utilization charges for enterprises	Strengthening cargo transit functions	Unbinding commerce restrictions	Coordination and unified regulations	Adopt flexible policy to facilitate cargo flow	Unbinding labor employment restrictions	Tax weaiver or exemption policy	Build complete multimodal transport network	Partnership with adjacent science and industrial area	Periodic meetings with key stakeholders	Strengthening information and technology system
Customer	Sum product	2.498	1.495	0.694	1.420	1.168	1.622	2.369	1.637	0.658	0.406	2.080	0.580	2.121	3.459
	Relative weight	0.112	0.067	0.031	0.064	0.053	0.076	0.107	0.074	0.030	0.018	0.094	0.026	0.096	0.156
Service provider	Sum product	2.433	1.110	1.138	0.916	2.520	1.231	3.069	2.405	2.405	1.425	1.740	1.955	1.607	1.931
	Relative weight	0.094	0.043	0.044	0.035	0.097	0.048	0.119	0.093	0.093	0.055	0.067	0.076	0.062	0.075
Synthesis	Mean relative weight	0.103	0.055	0.038	0.050	0.075	0.060	0.113	0.083	0.061	0.037	0.080	0.051	0.079	0.115
	Final priority rank	**3**	**10**	**13**	**12**	**7**	**9**	**2**	**4**	**8**	**14**	**5**	**11**	**6**	**1**

Based on the results of this study, the important task is to enhance the service quality of Taiwan's FTPZ, thereby strengthening administrative efficiency and infrastructure investment. When defining a supportive policy to improve the service quality of the FTPZ, policymakers should consider coordinating all functions and activities to provide customers with timely and efficient services and facilitate the freedom of cargo flow within the area. As for infrastructure investment, it is important to provide state-of-the-art equipment, automated warehouses, and logistics facilities to attract shipping, logistics, manufacturers, and foreign businesses to invest in Taiwan's FTPZ. Though IT investment, automation may require large capital and a huge financial investment; however, this is a long-term investment, of which policymakers should consider the value from a long-term perspective. Furthermore, the result reveals that IT and automation setup have a direct influence on

service quality, which may improve customer satisfaction.

V. CONCLUSION

This study applies multilayer perspectives to evaluate the service quality of Taiwan's FTPZ using customers' and service providers' perspectives. Technical requirements as solutions are also discussed. This study completes the house of quality through an expert consultation with employees and enterprises in the FTPZ. The implications are as follows: 1. For FTPZ policy makers, technology application is the key technical issue. More budget to establish sophisticated automated, unmanned, and efficient systems is the primary concern for improving overall service quality. Furthermore, a better administrative process is urgently needed to ensure the quality of FTPZ will not be spoiled by bureaucratic inefficiency. 2. For academic studies, this paper combines the voices of the service provider and customer of an FTPZ to explore technical solutions. The service provider's voice is taken into account, and this is the key difference from previous studies.

This paper still has the following limitations. First, multilayer QFD can combine the voice of the customer and service provider; however, the weight is determined by the average mean value of provider and customer. A better technique to determine the weights of the customer and provider may be a good future study topic. Second, the use of interviews and personal consultation to collect the data is another research limit. Personal opinions and respondents' standpoints may unavoidably have bias. Future studies could use secondary data to evaluate the service quality of the FTPZ.

In summary, future studies may consider using secondary data published by the FTPZ to analyze service quality. This paper focuses on seven major FTPZs in Taiwan. A case study on each FTPZ is recommended, since each FTPZ has its specific features in terms of location and resources.

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