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# Combining Kano's Model, IPA, and FMEA to Evaluate Service Quality Risk for Bus Service: Case of Bangkok Bus Service

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**Abstract:** Although the past research results have provided many effective tools for evaluating public bus service quality, they still lack the concept of risk. This study assessed the quality risk for city bus service by constructing a quality risk assessment model that integrated Kano's model, IPA, and FMEA. The online questionnaire was distributed to commuters who use BMTA's bus service in Bangkok with 429 samples. This study analyzed the service quality attributes of bus services via Kano's model, an IPA, and an FMEA. For the results of Kano's model, this study identified nine one-dimensional and three attractive attributes. The results of the IPA showed that the safety of boarding and disembarking from the bus, the cleanliness of vehicles, and the punctuality of buses according to the schedule were the top three attributes that had a large gap between importance and satisfaction. According to the results of the FMEA, the safety of boarding and disembarking from the bus, the cleanliness of vehicles, and the punctuality of buses according to the schedule were the top three attributes that had a high service quality risk and considered a priority improvement. These attributes belonged to interaction with passengers, tangible service equipment, and operating management support dimensions. Therefore, the government should take action and improve service quality to make Bangkok commuters consider switching from driving cars to using a bus. Finally, this study provides practical improvement strategies for managers to improve passenger experiences and enhance the quality of bus services.

**Keywords:** bus service; service quality risk; Kano's model; importance–performance analysis; failure mode and effects analysis



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## 1. Introduction

The daily activities of people who live in the Bangkok Metropolitan Region, especially those who do not own personal vehicles, are supported by public transportation as an intermediary to link almost all such activities. As a result, public transit is unavoidably important and connected to their everyday lives. In particular, the bus operated by the Bangkok Mass Transit Authority (BMTA) helps link all public transportation networks and has more than 200 million users each year, which is more than all forms of mass transportation systems provided in the Bangkok Metropolitan Region [1]. However, a survey showed that the number of bus users has continued to decline: the number of bus passengers per day in 2013 was 690,000, but in 2021 it was found that there were only 491,673 people per day [2]. This means that the number of bus passengers dropped an average of 22,036 people per day per year from 2013 to 2021. Furthermore, there are still problems with traffic congestion, traveling time, and travel routes that are not yet covered in all areas, so these issues are considered the main problems that should be urgently addressed.

Traffic problems in Bangkok are likely to worsen as the number of private cars increases. This is a problem that must be thoroughly studied, analyzed, and solved properly and systematically. Both domestic and international organizations have conducted extensive research on the problems associated with mass transit systems. Khemapech and

Kidbunjong [3] identified the issues and challenges confronting Bangkok's mass transit system development, and they showed that the quality of the mass transit system in Bangkok lags behind other major cities in the region. The rail project was developed as a stand-alone project with no connection to the bus system. The network connection between the public transportation system, the activity source, and the community is inefficient. Moreover, Bangkok residents spend a lot of time and travel expenses without being able to predict the time it takes to travel. The traffic area is mainly occupied by private cars.

Bangkok is known for its severe traffic congestion and has a congestion level of 44%. This means that a 30 min trip in Bangkok will take 44% more time than it would under normal, uncongested conditions. Furthermore, a study reported that Bangkok commuters spend an additional 35 min per trip, resulting in an opportunity cost of THB 11 billion annually or THB 66 million daily [4]. This issue also led to a THB 6 billion increase in Thailand's fuel spending per year and forced many Bangkok commuters to reallocate their spending [5]. The government is making efforts to encourage residents to use public transportation instead of personal cars in order to reduce road congestion and address PM2.5 issues, which are primarily caused by cars. However, the coordination in addressing these issues is not as unified as it should be, and there are still flaws in the discipline of road users. All of these things are important factors causing more traffic problems. However, the service attributes are numerous and wide-ranging. Commuters are not only concerned about safety, speed, punctuality, and convenience, but also value the driver's service attitude, information provision, a friendly ride environment, etc. [6].

From a business operation perspective, in a fiercely competitive market, improving service quality to attract customers and make them loyal customers has become an important issue for many companies. However, when faced with limited resources, knowing how to formulate improvement strategies is an important issue. In traditional thinking and research, service quality is often evaluated as either good or bad based on sophisticated indicators for each attribute, and improving bad service quality is believed to increase customer satisfaction and repurchase rates [7]. However, in a complex reality, if you blindly invest in the improvement of unreasonable service attributes, you cannot know the impact on customer satisfaction, which often prompts companies to face the dilemma of increasing sunk costs with no improvement in operating performance [8].

Mass transportation is very important for national development both economically and socially, especially in reducing residents' living costs. In addition, having a good public transportation system, a variety of modes of transportation, and convenient and reasonable prices also helps tourists decide to travel to Thailand as well, resulting in the growth of the Thailand tourist industry. Based on the survey results of the Office of the Permanent Secretary of the Prime Minister's Office on the number of complaints, it was found that the BMTA was the state enterprise with the highest number of complaints on average. The most complaints about the BMTA's bus service regarded the quality of drivers, fare collectors, bus conditions, increasing numbers, expanding routes, services, and travel convenience [9]. People in Bangkok spend a lot of time and expenses traveling without being able to predict the time spent traveling [3]. While Bangkok already has the BTS SkyTrain and MRT subway, these do not cover all the routes available in Bangkok. The bus services in Bangkok are deployed to cater to locales beyond the purview of the BTS SkyTrain and MRT subway. The commuters still need to use the public bus for transport. Despite the interconnectivity of bus and subway stations, the schedules of the two modes of transportation do not always align perfectly. In addition, residents also rely on buses for transferring to other modes of transportation such as water transport and trains. Therefore, bus service still plays a crucial role as a mode of transportation for the residents. However, in some areas of Bangkok, passengers have raised significant concerns about the physical amenities and dependability of the bus services [10,11]. Enhancing the service quality of Bangkok's bus service is a crucial matter.

The quality of bus service is a significant research topic in the field of public transportation. This means if passengers are satisfied with the bus's service quality, they will continue

to use it and it can reduce the traffic problem, which tends to become more severe due to the increasing number of private cars. Susilawati and Nilakusmawati [12] investigated the factors that affect the public bus transportation services quality in Bali Province, Indonesia. They identified six factors that influence the satisfaction of public transportation users in Bali: comfort, responsiveness, capacity, tangibility, safety, and reliability. Furthermore, Farrar et al. [13] conducted a study on customer satisfaction with bus service users in Cape Town, South Africa. The study found that the most important service quality items for customers were the helpfulness of staff, affordability of fares, and reliability of buses not breaking down. The study revealed that there are certain areas in need of improvement, specifically the travel time after boarding the bus and the availability of routes. Therefore, service quality is a critical issue that the public sector should consider to provide commuters with an attractive alternative to private cars.

Service failure refers to any breakdown, flaw, or issue that occurs during the delivery of a service that leads to an unsuccessful service outcome or customer dissatisfaction. This affects the quality and reliability of the service; businesses are unable to deliver services that meet customer expectations, and issues are still not being resolved effectively until it may have a negative impact on the relationship with the customer. Services failure can be remedied through effective restoration, helping to keep customers loyal to the service. The service-restoration process can lead to positive word of mouth or help reduce negative rejection of erroneous services. Few studies have examined the quality risk concerning bus service. Wijaya [14] explored service failure of public bus transportation in Jakarta, Indonesia. Commuters expect public bus services to be efficient, high quality, convenient, and affordable, but unfortunately, these expectations are often not met due to the buses being unreliable, uncomfortable, and even dangerous. Therefore, despite being a key solution to reducing the number of cars on the road, commuters often avoid using public buses due to their unreliability, lack of comfort, and safety issues. Hu and Hsiao [15] developed a model of service quality risk assessment that combined Kano's model, an importance–performance analysis (IPA), and a failure mode and effects analysis (FMEA). The service quality was assessed through a quantitative evaluation of quality risks, which allowed for the identification of improvement priorities for various attributes to enhance the overall quality of service. A useful tool for prioritizing improvements to bus service quality attributes is the quality risk evaluation developed by Hu and Hsiao [15].

The purpose of this study was to assess the quality risk related to city bus service and to provide quality-improvement strategies by integrating Kano's model, IPA, and FMEA. The study identified and analyzed the factors that have an impact on the perceived quality of the services provided by BMTA's Bangkok bus that affect customers' satisfaction levels by applying Kano's model and using IPA to analyze the improvement priority ranking of the Bangkok bus service. Furthermore, we used FMEA to discover potential failures during the Bangkok bus service's quality improvement.

## 2. Literature Review

### *2.1. Bus Service Quality*

In the context of education, according to researchers, service quality is defined as the gap between a customer's initial expectations and their actual experience with a particular service provider, [16]. For the evaluation of service quality, the SERVQUAL model is one of the most commonly used models [17]. The widely used SERVQUAL model, developed by Parasuraman et al. [18], is an effective tool for evaluating service quality that analyzes the gap between customer expectations and perceptions of an organization's service quality performance. Service quality is determined by two factors: perceived quality and expected quality. Perceived quality is the customer's evaluation of the overall status and excellence of the service provided, while expected quality refers to the customer's anticipated level of service [19]. The SERVQUAL scale, also known as gap analysis, measures the extent to which the service quality meets customer expectations [20]. According to Parasuraman et al. [18], service quality can be defined as the sum of positive and negative service

features that occur during the interaction process between the service provider and the customer. To assess service quality, Parasuraman et al. [18] proposed a SERVQUAL scale that includes five crucial aspects of quality (tangibility, reliability, responsiveness, assurance, and empathy) to assess service quality. These five aspects serve as the evaluation criteria and provide a practical measure for assessing service quality.

The satisfaction and perception of the quality of the public transport system are crucial to its success. Grujičić et al. [21] demonstrated that improving the cleanliness and ventilation of vehicles can have a dual effect on increasing user satisfaction and improving the overall impression of public transport quality. This in turn may attract more private car users to switch to public transportation. Therefore, an improvement in these elements should be a starting point in the process of enhancing the quality of public transport services with a focus on meeting the needs of both users and non-users.

Mahmoud and Hine [22] conducted a study to examine the impact of perceived service quality on the perception of both current and potential users of bus services in Belfast City, UK. Their research revealed 11 key factors that influence passengers' perceptions of the service. These factors include the frequency and reliability of the service, waiting and transfer times, security at stops/stations, bus comfort, availability of discounted tickets, information at stops/stations, bus fares, needs for transfers, bus stop locations, and availability of park and ride services. Chaikittiphorn and Pavakanun [23] conducted a study on the bus service of the Bangkok Mass Transit Authority (BMTA) and identified areas where improvements were needed. The most pressing issue was the timeliness of the buses followed by the frequency or continuity of the buses, the poor condition of the buses, the coverage/thoroughness of the bus routes, the safety of the service, and the quality of the buses. By improving and developing the quality of the bus services, the majority of users were likely to switch to using more BMTA bus services. In a separate study, Pokwanvit [6] investigated the factors that influence Bangkok commuters to switch from driving cars to using buses. The results showed that the top three factors were bus punctuality, sense of safety, and routing information, while payment methods and bus fare were the least important factors. The researcher recommended several improvements to the Bangkok Mass Transit Authority (BMTA) based on the study results. These included increasing the number of buses to reduce waiting times, providing clear and accurate information about bus routes and arrival times at each bus stop, and enhancing the mobile application to estimate the correct arrival time of the bus for which commuters are waiting.

Deb and Ali Ahmed [24] conducted a study to investigate the service quality of the city bus service by examining users' perceptions and expectations. The study findings indicated that passenger perceptions and expectations are both crucial factors in assessing service quality. Through the analysis, four underlying factors were identified: safety, comfort, accessibility, and timely performance. These factors were extracted based on the perceived and expected values of the passengers. Sonita et al. [25] conducted an evaluation of the city bus service quality in Cambodia and identified five main factors that contribute to public transit service quality: the quality of the bus services, the condition of the vehicles, the attitude of the drivers, the facilities at the bus stops, and the bus capacity. Moslem [26] utilized the AHP-BWM method to assess public transport quality based on four criteria: service quality, transport quality, tractability, and fare.

### 2.2. Kano's Model

Kano's model is one of the techniques used to study consumer demand and is based on the principle that consumer satisfaction with the product is strongly related to the ability to meet consumers' needs. The consumer must achieve the highest satisfaction with the defect that causes the consumer's least dissatisfaction. Customer satisfaction has often been seen as one-dimensional, which means that when the quality elements are sufficient, people feel satisfied (and vice versa); however, in reality, not all quality factors are the same [27,28].

Kano et al. [29] proposed a two-dimensional quality model that pointed out that the customer's "satisfaction" and "quality attributes" are not completely linearly related. When

the quality factors are sufficient, it may not make people feel satisfied, and sometimes it will cause dissatisfaction or unsatisfactory results; or when a certain aspect of the service does not meet the customers' expectations, it can result in dissatisfaction. However, after improving these quality factors, there is no significant improvement in the satisfaction of consumers. It can be inferred that the quality attributes that affect consumer satisfaction or dissatisfaction are different. Chen and Lee [30] also pointed out that quality factors may cause customers to be dissatisfied or indifferent.

Kano's model classifies quality into five attributes [29,31], which are attractive quality attributes (A), one-dimensional quality attributes (O), must-be quality attributes (M), indifferent quality attributes (I), and reverse quality attributes (R). A Kano questionnaire allows for determining individual features/requirements of customers and referring to the significance of quality-perception features [32]. Kano's questionnaire is designed to ask questions about customer needs, and each question on customer needs is answered in a functional and dysfunctional format [29,33]. The classification of attributes can be obtained by cross-checking the results of the positive and negative responses of the interviewees. Participants can choose from five response options when answering each item: "I like it that way", "I expect it to be that way", "I am neutral", "I can accept it that way", and "I dislike it that way". Table 1 provides a questionnaire matrix that categorizes a quality attribute as either functional or dysfunctional. Matzler et al. [34] found that the customer's most important quality element was must-be quality followed by one-dimensional quality. Therefore, when some quality attributes cannot be classified into a certain category, the classification rule is M > O > A > I [35].

**Table 1.** Kano Category Table.

| **Question Type** | | **Dysfunctional** | | | | |
|---|---|---|---|---|---|---|
| | **Response Options** | **I Like It That Way** | **It Must Be That Way** | **I Am Neutral** | **I Can Live with It That Way** | **I Dislike It That Way** |
| Functional | I like it that way | Questionable | Attractive | Attractive | Attractive | One-dimensional |
| | It must be that way | Reverse | Indifferent | Indifferent | Indifferent | Must-be |
| | I am neutral | Reverse | Indifferent | Indifferent | Indifferent | Must-be |
| | I can live with it that way | Reverse | Indifferent | Indifferent | Indifferent | Must-be |
| | I dislike it that way | Reverse | Reverse | Reverse | Reverse | Questionable |

Source: Reproduced from Kermanshachi et al. [36].

In addition, Berger et al. [33] developed two customer satisfaction indices based on Kano's model to analyze the impact of meeting certain attributes on customer satisfaction. The satisfaction increment index (SII) is used to measure the increase in customer satisfaction after a certain attribute is met, while the dissatisfaction decrement index (DDI) is used to measure the decrease in customer dissatisfaction after meeting their demand [33,34]. SII and DDI are calculated using the percentage numbers of the A, O, M, and I from Kano's model. The formulas used to calculate customer satisfaction coefficients are shown below [33].

$$\text{Satisfaction increment index (SII)} = \frac{(A+O)}{(A+O+M+I)} \quad (1)$$

$$\text{Dissatisfaction decrement index (DDI)} = \frac{(O+M)}{(A+O+M+I)\times(-1)} \quad (2)$$

Kano's model has been applied in many other industries. Materla et al. [37] conducted a systematic search of databases to explore the application of Kano's model in service quality improvement, business growth, and sustainability in the healthcare industry. Moreover, Chiang et al. [38] employed the Kano methodology in the hotel industry and obtained valuable insights that can guide hotel operators who intend to incorporate technology in their establishments. Currently, many industries face higher competition to fulfill customers' demands and product design requirements. Backar [39] utilized Kano's model to enhance the development of a light bulb changer and to ensure customer satisfaction and

requirement tracking in future product development. In addition, Pai et al. [40] utilized Kano's model to categorize restaurant service quality attributes and examine how each attribute may affect customer satisfaction differently. Kano's model was also used in the airline industry. Wong and Ho [41] applied Kano's model to low-cost carrier airlines to identify the service area that needed to improve and pay attention to increasing customer satisfaction in the future.

### 2.3. Importance–Performance Analysis (IPA)

Martilla and James [42] introduced the importance performance analysis (IPA). An IPA is typically presented as an importance–performance matrix, which shows the relationship between the level of importance that customers place on various aspects of an institution's services and their level of satisfaction with those aspects. In other words, this concept is used to measure or assess consumers' acceptance of a product for a variety of characteristics. It is an easy-to-use analytical method for evaluating or measuring the performance and importance of a product that can lead to a breakthrough in effective marketing. By analyzing customer perceptions of importance, the most dominant variable can be identified and associated with the reality of the customer experience. For instance, if price is deemed a crucial factor by customers but they perceive the price to be high, then reducing the price could improve the company's performance. This can be represented in an importance–performance matrix that combines customer satisfaction levels with an institution's services [43].

An IPA has been widely used in many other industries. Disastra et al. [44] applied an IPA in the tourist industry to investigate the tourists' satisfaction levels with tourism destination attributes in Ciamis Regency, Indonesia. By using IPA, they knew which attributes needed to be a priority to improve and which attributes should be maintained to ensure tourist satisfaction. Moreover, Simpson and Parker [45] utilized an IPA to evaluate the importance and satisfaction levels of public green infrastructure and urban nature spaces in Perth, Western Australia. By applying the IPA technique, the researchers were able to collect valuable data that could be used to inform evidence-based approaches for managing and allocating resources to PGI and UN spaces. Das and Basu [46] utilized an IPA to evaluate the satisfaction of local communities with ecosystem services in Chatra Wetland, India. An IPA has also been used by colleges for measuring student satisfaction levels to increase competitive advantages. Zulfahri et al. [7] implemented an IPA to evaluate services provided to students so the college could improve the quality of service based on students' perspectives to increase student satisfaction in the future.

An IPA has the advantage of assessing consumer acceptance in marketing programs. It is a low-cost assessment, has easy-to-understand assessment techniques, and provides important in-depth information in terms of the marketing mix. It is very important in defining the marketing mix of an organization because it allows management to analyze what factors are important to improve and develop and to effectively manage the company's resources or budgets.

### 2.4. Failure Mode and Effect Analysis

A failure mode and effects analysis (FMEA) focuses on identifying the nature of the damage or the cause that could lead to the failure (potential failure mode) due to the design, manufacture, or service. After that, the impact of the expected damage (effects analysis) will be analyzed, and finally, a way is found to prevent the expected damage (problems prevention) [47]. Using FMEA principles to analyze and solve the root of real problems in the process (design, manufacture, or service) will give manufacturers a more comprehensive perspective on problem solving, which will reduce repetitive problems and thus result in reduced variations in the manufacturing process [48]. Therefore, every product is of consistent quality and meets the required standards. During an FMEA, risks are prioritized based on predefined criteria, and actions are then taken to address the higher-priority failure modes first [49].

The FMEA technique was developed for aerospace, vehicle, and military applications in the 1950s and was initially known as the failure mode effects and criticality analysis (FMECA); later in the 1960s it was applied to reliability engineering [50]. The FMEA technique is a widely used method for engineering risk analysis aimed at identifying possible defects and predicting their consequences. It was developed and applied to assess the risk of defect characteristics in design, process, and quality management, and it is a popular tool in these areas [51]. A risk analysis using the FMEA technique prioritizes the risk of the critical failure characteristics (potential failure mode) under the risk priority number (RPN) obtained from the three criteria assessments: severity: S, occurrence: O, and detectability: D; this is calculated as PRN = S × O × D [52]. To evaluate the severity, occurrence, and detectability of each failure mode, a 10-point scale is used. Failure modes with higher RPN values are considered more critical and given higher priority than those with lower RPN values [52,53]. While FMEA techniques are widely used across various industries to assess the risks of failure modes, multiple expert opinions can result in vague and imprecise risk evaluations, leading to conflicting evidence that can be challenging to manage. As business situations become more complex with uncertainties and service process characteristics, FMEA applications are continuously evolving and becoming more advanced [54].

FMEA has been applied in many other industries and is widely used by many companies worldwide to develop new designs and technologies and analyze and plan the quality of production processes and products. An FMEA has been used in previous studies to assess service quality and enhance the quality of services provided in the airline industry [15,55,56]. Anjalee et al. [57] applied an FMEA in the healthcare industry to improve medication safety in the medication use process. The authors used an FMEA to analyze both existing systems and new policies to identify potential errors in the system. Borkovskaya and Passmore [58] applied an FMEA in the construction industry in the Russian Federation and demonstrated its potential application to ecological issues. Applying the FMEA methodology in ecology enables developers to evaluate the risks and potential damages resulting from inconsistencies in design and technological processes at the early stages of product development. Tang et al. [59] proposed a method for enhancing the service quality of logistics centers by integrating an FMEA with Kano's model. The approach allows for the identification of potential failures and their consequences as well as the evaluation of customers' satisfaction and dissatisfaction with logistics center services.

## 3. Methods

### *3.1. Service Quality Risk Evaluation*

Based on the methods described above, this study developed a complete conceptual framework incorporating Kano's model, an IPA, and an FMEA quality risk assessment model to measure the bus service quality risk. The following three steps were designed to develop a quality risk assessment model. Step 1 was to classify service quality characteristics based on Kano's model. Step 2 combined Kano's model and an IPA into a contributory improvement index (CII). Step 3 was to calculate Cr by combining the CII and the FMEA.

- Step 1: Development of Composite Satisfaction Index (CSI)

Based on the literature review above, Berger et al. (1993) proposed two useful customer satisfaction coefficient indices: the satisfaction increment index (SII) and the dissatisfaction increment index (DDI) according to the results of Kano's model. This indicates that product or service features may affect customer satisfaction. In other words, the attribute has both the SII and DDI effects, although these two effects have no sub-relationship with compliance or non-compliance. Hu and Lee [60] pointed out that the SII shows an increase in satisfaction, while the DDI shows a decrease in satisfaction. Therefore, the combined effect of these two indicators can be regarded as the overall change in satisfaction to understand the influence of specific attributes on satisfaction. According to the customer

satisfaction coefficient matrix proposed by Berger et al. [33], the vector concept is used to combine the SII and DDI. The equation for the CSI by Hu and Lee [60] is as follows:

$$CSI = \sqrt{SII^2 + DDI^2}/\sqrt{2} \quad (3)$$

To compare the degree of satisfaction between different quality attributes, Hu and Lee [60] suggested that the distance between the attribute and the origin can be used as the comparison value. In the above, the coordinates of the two axes of SII and DDI are regarded as two different vectors, and the two vertical vectors are added together to reflect the design concept of the CSI system to understand the degree of comprehensive improvement of satisfaction with attributes.

- Step 2: Contributory Improvement Index (CII)

Considering the importance of research on satisfaction levels and the characteristics of improvement to meet customer satisfaction, this study's objective was to measure the quality of service performed using an IPA and the CSI. The results will show how satisfied customers were with the services and can be used as assessments to improve service quality. This concept was useful in calculating the standard weights, which contained the satisfaction and importance results and could indicate the priority of improvement from the IPA. The importance and satisfaction of each attribute were measured via a questionnaire with a five-point Likert scale. The processes to calculate the standardized weight were as follows.

a. Calculate the difference index, which equals importance minus satisfaction.
b. Rank the difference index from maximum to minimum. If there are some attributes with the same difference index, the attribute with better satisfaction has a higher ranking. This ranking number is called the priority weight ($w_i$) which represents the attribute with a larger value of difference index ranking priors to be improved.
c. Calculate the standardized weight ($a_i$) via normalizing the priority weight. The equation is:

$$a_i = w_i/\max(w_i) \quad (4)$$

To obtain a more comprehensive understanding of the relative importance of both standard weights and the customer satisfaction index (CSI), this study proposed a synthetic index called the contributory improvement index (CII). The following equation can represent this:

$$CII = a_i \times CSI \quad (5)$$

The contributory improvement index (CII) is a synthetic index that combines both the standardized weight and customer satisfaction index (CSI) to provide a comprehensive understanding of their relative importance. The CII was calculated by multiplying the standardized weight derived from Kano's model by the CSI quality attribute rating. The attributes with a higher CII were more aligned with customer requirements and contributed to greater satisfaction. The CII ranged from 0 to 1 (both the standardized weight and CSI were normalized).

- Step 3: Combination of the CII and the FMEA

The risk priority order of failure modes can be determined by utilizing the RPN in an FMEA. According to Hu and Hsiao [15], this study defined "risk priority number of service quality risk management ($RPN^{SQR}$)" as the product of "worth improving the level of an attribute, occurrence of quality failure and detection of quality failure". Therefore, CII could be used to replace the severity (S) in the original RPN equation ($RPN = S \times O \times D$), and we amended the equation as $RPN^{SQR} = CII \times Oc \times D$. Then, we put it into the "correction

ratio (Cr)" proposed by Shahin [61]. The modified Cr can be expressed by the following equation:

$$Cr = 1 - \frac{RPN_{Tg}^{SQR}}{RPN_{0}^{SQR}} = 1 - \frac{CII_{Tg} \times Oc_{Tg} \times D_{Tg}}{CII_{0} \times Oc_{0} \times D_{0}} \quad (6)$$

where:

$RPN_0^{SQR}$: current risk priority number of service quality risk management;
$RPN_{Tg}^{SQR}$: goal risk priority number of service quality risk management;
$CII_0$: current contributory improvement;
$CII_{Tg}$: goal contributory improvement;
$Oc_0$: current failure occurrence;
$Oc_{Tg}$: goal failure occurrence;
$D_0$: current failure detection;
$D_{Tg}$: goal failure detection.

Assuming that the detection (D) was constant, this meant $D_{Tg} = D_0$, then the equation of Cr value could be simplified as the following equation:

$$Cr = 1 - \frac{CII_{Tg} \times Oc_{Tg}}{CII_{0} \times Oc_{0}} \quad (7)$$

An attribute with a higher CII was more in line with customer needs and contributed to greater satisfaction. In other words, attributes with a low CII represent a lower quality of service risk and are not worth improving. Hu and Hsiao [15] took the lowest current contributory improvement $(CII_0)$ as the goal contributory improvement $(CII_{Tg})$; that is, $CII_{Tg} = \min\{CII_i\}, i = 1, \ldots, N$. In addition, the lowest current failure occurrence $(Oc_0)$ was taken as the goal failure occurrence $(Oc_{Tg})$; that is, $Oc_{Tg} = \min\{Oc_0\}, i = 1, \ldots, N$ (N represents the number of service attributes).

### *3.2. Measurements*

This study refined and adapted the quality attributes of the Bangkok bus service by building upon Hu [62], Wu et al. [63], Mohamed and Hine [22], Hu and Cai [64], and Fachrurrozy et al. [65]. Hu [62] proposed four dimensions to identify the 12 quality attributes related to bus service: interaction with passengers, tangible service equipment, convenience of service, and operating management support. Table 2 shows these dimensions and their corresponding quality attributes.

**Table 2.** City bus service quality attributes.

| Dimensions | | Attributes |
|---|---|---|
| Interaction with passengers | 1. | Drivers prioritize the safety of passengers during boarding and alighting. |
| | 2. | Drivers provide good service by displaying friendly, polite, and caring behavior toward passengers. |
| | 3. | Drivers exhibit proficient driving skills and operate the buses smoothly. |
| | 4. | Bus attendants can quickly respond to passengers' complaints or opinions. |
| Tangible service equipment | 5. | Vehicles are clean inside. |
| | 6. | The bus companies offer contemporary and secure buses. |
| | 7. | The bus service ensures security against criminal activities on buses and at bus stops. |

**Table 2.** *Cont.*

| Dimensions | | Attributes |
|---|---|---|
| Convenience of service | 8. | Provided with schedule and route information on the bus and at the bus stop. |
| | 9. | Availability of online bus schedules on the internet or a mobile application. |
| | 10. | Convenience of a fare payment system. |
| Operating management support | 11. | Buses operated punctually according to the schedule. |
| | 12. | The bus company informs customers of changes in the timetable and prices in advance. |

Source: this study.

The questionnaire contained four parts. Part one was "bus usage information", which asked about the main purpose of taking a bus, the frequency of taking a bus within a week, and the time of taking a bus. Part two was "passengers' attributes preferences of bus service quality based on Kano's model". According to Kano's model, each item had two questions. This part of the questionnaire presented each service item in two narrative forms: when the quality performance was good and when the quality performance was poor. The respondent was asked to note their feelings based on the narration of the question; the answer options included: "I dislike it that way", "acceptable", "I am neutral", "It must be that way", and "I like it that way". Part three was "passengers' perception of importance and satisfaction of bus service quality". This part mainly sought to determine the importance of the bus's service quality items and passengers' satisfaction by using a five-point Likert scale ("very unimportant", "unimportant", "neutral", "important", and "very important") to determine the degree of importance. The level of passengers' satisfaction was also measured by using a five-point Likert scale ("very dissatisfied", "dissatisfied", "neutral", "satisfied", and "very satisfied"). Part four was "respondents' basic information", which included questions regarding gender, age, and occupation.

### *3.3. Data*

This research utilized snowball sampling, a technique in which participants initially selected are asked to refer other potential participants from their network for inclusion in the study. The questionnaire was distributed to commuters who used BMTA's bus service in Bangkok via an online questionnaire. This questionnaire was distributed by researchers to their friends and relatives residing in Bangkok with a request for them to share it with acquaintances. Moreover, the survey was distributed through social media platforms such as Facebook and Instagram to encourage Bangkok residents to participate and complete the online questionnaire. To ensure the randomness and representativeness of the sampling process, at the very beginning, respondents were asked if they had ever taken a bus in Bangkok. If they had not, they were asked to discontinue the survey. Furthermore, the questionnaire also inquired about the frequency of the respondents' bus usage in order to ensure their suitability as survey participants for this study. Since the population size was 438,414 according to the BMTA in 2019, the sample size was calculated to be 399.635381 based on the formula of Yamane [66] with a 95% confidence level.

A total of 429 commuters participated in this study, and all of the questionnaires were completed and usable. A total of 61.5% were female; most were 26–35 years old (42.2%), and some were 36–45 years old (34.7%); 23.3% were office workers in private enterprises, and 19.6% were office workers in state-owned enterprises; 41.3% were taking a bus with the purpose of going to work, and 15.9% were sending children to school; 54.5% were taking a bus 4–6 days per week, and 28.2% were taking one 2–3 days per week. The sample structure of this study was similar to that of previous studies on Bangkok buses (e.g., Wethyavivorn and Sukwattanakorn [10] and Ueasangkomsate [11]), which demonstrated that the sample of this study had a certain level of representativeness.

Cronbach's α was employed to assess the reliability of satisfaction in this study. The Cronbach's α of "interaction with passenger" (with 4 items) was 0.94, "tangible service equipment" was 0.89 (with 3 items), "convenience of service" (with 3 items) was 0.88, and "operating management support" (with 2 items) was 0.86. The results showed that the data in this research had a high level of reliability because the α of satisfaction was greater than 0.7 in the above four dimensions of service quality.

## 4. Results

### 4.1. Results of Kano's Model

Kano's model is a model that describes the satisfaction or desire of a customer regarding the attributes of the product or service. In this study, the questionnaire was designed to present each service item in two narrative forms: when the quality performance was good and when the quality performance was poor. The results of Kano's model are shown in Tables 3 and 4. There were nine attributes classified as one-dimensional quality (O). These attributes mostly came from the interaction with passengers and tangible service equipment dimensions. If the bus company could not fulfill these nine attributes for the commuters sufficiently, it would decrease the commuters' satisfaction; on the other hand, it would increase commuters' satisfaction if these attributes were provided sufficiently—the higher the quality, the higher the satisfaction.

**Table 3.** Results of Kano's model.

| Attributes | Kano Quality Attribute Classification Percentages (%) | | | | | | Result | SII | DDI | CSI |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | O | M | I | R | Q | | | | |
| Item 1 | 9.79% | 56.18% | 24.01% | 10.02% | 0.00% | 0.00% | O | 0.66 | −0.80 | 0.73 |
| Item 2 | 24.48% | 45.45% | 13.52% | 16.08% | 0.23% | 0.23% | O | 0.70 | −0.59 | 0.65 |
| Item 3 | 8.16% | 40.79% | 26.57% | 24.01% | 0.47% | 0.00% | O | 0.49 | −0.68 | 0.59 |
| Item 4 | 11.42% | 47.79% | 22.84% | 17.25% | 0.23% | 0.47% | O | 0.60 | −0.71 | 0.66 |
| Item 5 | 18.41% | 47.09% | 19.35% | 15.15% | 0.00% | 0.00% | O | 0.66 | −0.66 | 0.66 |
| Item 6 | 20.28% | 39.86% | 17.48% | 21.91% | 0.23% | 0.23% | O | 0.60 | −0.58 | 0.59 |
| Item 7 | 11.42% | 48.95% | 22.84% | 16.08% | 0.47% | 0.23% | O | 0.61 | −0.72 | 0.67 |
| Item 8 | 12.59% | 41.49% | 21.68% | 23.78% | 0.23% | 0.23% | O | 0.54 | −0.63 | 0.59 |
| Item 9 | 16.08% | 31.47% | 18.18% | 32.17% | 1.40% | 0.70% | A | 0.49 | −0.51 | 0.50 |
| Item 10 | 14.45% | 44.76% | 19.11% | 21.21% | 0.23% | 0.23% | A | 0.59 | −0.64 | 0.62 |
| Item 11 | 15.62% | 34.03% | 16.08% | 33.80% | 0.23% | 0.23% | A | 0.63 | −0.65 | 0.64 |
| Item 12 | 15.62% | 34.03% | 16.08% | 33.80% | 0.23% | 0.23% | O | 0.50 | −0.50 | 0.50 |

Notes: A: attractive, O: one-dimensional, M: must-be, I: indifferent, R: reverse, Q: questionable.

**Table 4.** Kano quality attributes listed according to classification.

| Classification | CSI |
|---|---|
| One-dimensional | 0.73 |
| 1. Drivers prioritize the safety of passengers during boarding and alighting. | 0.65 |
| 2. Drivers provide good service by displaying friendly, polite, and caring behavior toward passengers. | 0.59 |
| 3. The drivers exhibit proficient driving skills and operate the buses smoothly. | 0.66 |
| 4. Bus attendants can quickly respond to passengers' complaints or opinions. | 0.66 |
| 5. Vehicles are clean inside. | 0.59 |
| 6. The bus companies offer contemporary and secure buses. | 0.67 |
| 7. The bus service ensures security against criminal activities on buses and at bus stops. | 0.59 |
| 8. Provided with schedule and route information on the bus and at the bus stop. | 0.50 |
| 12. The bus company informs customers of changes in the timetable and prices in advance. | 0.73 |
| Attractive | |
| 9. Availability of online bus schedules on the internet or a mobile application. | 0.62 |
| 10. Convenience of a fare payment system. | 0.64 |
| 11. Buses operated punctually according to the schedule. | 0.50 |

There were three attributes classified as attractive quality (A)—availability of online bus schedules on the internet or a mobile application (9), convenience of a fare payment system (10), and punctuality of buses according to schedule (11). These quality attributes not only greatly satisfied the commuters but also created a good impression of the attributes. Most of them originated from convenience of service and operating management support dimensions. This type of quality is something that the commuters did not expect before, but it will made the recipient very satisfied and impressed if it happened. It increased commuters' satisfaction if the bus company provided these three attributes, but if not, it would not decrease their satisfaction. Since the traffic is very congested in Bangkok, the commuters did not expect the bus's punctuality.

In addition, the SII and DDI were calculated using the results of Kano's model. According to the SII, the results showed that the bus company could increase commuters' satisfaction by improving safety in boarding and disembarking from the bus (1), driver attitudes and helpfulness (2), cleanliness of vehicles (5), security against crimes on buses and at stops (7), and punctuality of buses according to the schedule (11). As for the DDI, the bus company could decrease commuters' dissatisfaction by improving safety in boarding and disembarking from the bus (1), the skill/ability of drivers in operating the bus (3), bus attendants' attitudes and helpfulness (4), cleanliness of vehicles (5), and security against crimes on buses and at stops (7).

Furthermore, the CSI integrated the SII and DDI indicators and served as a comprehensive measure of satisfaction by providing insight into specific attributes' contributions to satisfaction. The results of the CSI shown in Table 3 imply that safety in boarding and disembarking from the bus (1) and security against crimes on buses and at stops (7) had the highest and second highest values for the CSI. This implies that these two attributes positively affected the overall satisfaction after quality improvement. It could increase the satisfaction as well as decrease the dissatisfaction of the commuters the most. Hence, implementing a training program for bus drivers can help mitigate service quality risks and enhance customer satisfaction, thereby improving the overall bus service experience. On the other hand, the company can make buses and bus stops safer for passengers and commuters via increasing police patrols, installing surveillance cameras, and providing better lighting and emergency call systems. Bus drivers and staff should also be trained to identify and respond to potential security threats such as suspicious behavior or unattended bags. They should also be trained in first aid and emergency response. On the contrary, availability of online bus schedules on the internet or a mobile application (9) and announcement of changes in the timetable and prices in advance (12) had less of a contribution toward satisfaction.

### *4.2. Results of IPA*

The results for importance and satisfaction could be used to plot the IPA matrix as shown in Table 5 and Figure 1. According to the results of the IPA, safety in boarding and disembarking from the bus (1), cleanliness of vehicles (5), and punctuality of buses according to the schedule (11) were the top three attributes that had a large gap between importance and satisfaction. This can imply that these attributes had a high importance for commuters, but the provider could not provide the service adequately. which made the commuters dissatisfied. Passengers may feel unsafe if the driver is driving recklessly, stopping suddenly or accelerating too quickly, or not paying attention to passengers boarding or exiting the bus. Meanwhile, punctuality is a basic requirement for passengers to accept bus services, but the traffic congestion in Bangkok makes the punctuality of buses very poor. Moreover, there could be two possible reasons for unclean vehicles: the company's neglect in vehicle maintenance or human-caused pollution due to overcrowding by too many passengers. On the contrary, availability of online bus schedules on the internet or a mobile application (9) was the attribute that could satisfy the commuter the most because it has the smallest gap between importance and satisfaction.

**Table 5.** IPA results for Bangkok bus service.

| Attributes | Importance | Satisfaction | Difference Index | Standardized Weight ($a_i$) | IP Matrix |
|---|---|---|---|---|---|
| Item 1 | 4.74 | 1.98 | 2.753 | 1.000 | Concentrated here |
| Item 2 | 4.55 | 2.20 | 2.350 | 0.250 | Keep up the good work |
| Item 3 | 4.54 | 2.14 | 2.403 | 0.333 | Keep up the good work |
| Item 4 | 4.60 | 2.05 | 2.550 | 0.750 | Concentrated here |
| Item 5 | 4.52 | 1.93 | 2.590 | 0.833 | Concentrated here |
| Item 6 | 4.47 | 2.04 | 2.434 | 0.417 | Low priority |
| Item 7 | 4.59 | 2.08 | 2.508 | 0.667 | Keep up the good work |
| Item 8 | 4.58 | 2.12 | 2.459 | 0.500 | Keep up the good work |
| Item 9 | 4.20 | 2.03 | 2.168 | 0.083 | Low priority |
| Item 10 | 4.54 | 2.03 | 2.506 | 0.583 | Concentrated here |
| Item 11 | 4.56 | 1.97 | 2.592 | 0.917 | Concentrated here |
| Item 12 | 4.39 | 2.10 | 2.291 | 0.167 | Possible overkill |

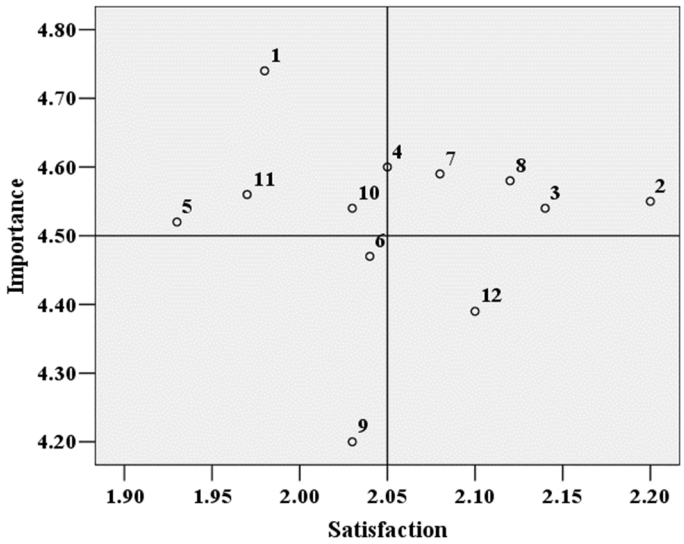


**Figure 1.** IPA matrix for Bangkok bus service. Note: The numbers in the figure represent the identification numbers of the attributes.

In Figure 1, the upper left quadrant is labeled "Concentrated" and contains attributes that were deemed essential by customers. Therefore, attributes falling within this quadrant should be prioritized for improvement. The results showed that there were attributes plotted in this quadrant—safety in boarding and disembarking from the bus (1), bus attendants' attitudes and helpfulness (4), cleanliness of vehicles (5), convenience of a fare payment system (10), and punctuality of buses according to the schedule (11). These attributes originated from the interaction with passengers, tangible service equipment, convenience of service, and operating management support dimensions.

The second quadrant on the upper right Is called "Keep up the good work". Attributes plotted in this quadrant were considered necessary by customers and met their expectations, resulting in a relatively high level of satisfaction. The results showed that there were four attributes plotted in this quadrant—drivers' attitude and helpfulness (2), the skill/ability of the driver in operating the bus (3), security against crimes on buses and at stops (7), and availability of the bus schedule and route information (8). These attributes originated from the interaction with passengers, tangible service equipment, and convenience of service dimensions. The attributes included in this quadrant are crucial to maintain as they contributed significantly to the products/services' superior perception by the users.

The third quadrant on the lower left is called "Low priority". It contains the attributes of service quality that were considered less important by customers. There were two attributes plotted in this quadrant—bus condition (6) and availability of online bus schedules

on the internet or a mobile application (9). These attributes originated from the tangible service equipment and convenience of service dimensions.

The fourth quadrant on the lower right is called "Possible overkill", which contains attributes that were perceived as excessive and considered less important by the customers. The results showed that there was one attribute plotted in this quadrant—announcement of changes in the timetable and prices in advance (12). This attribute originated from the operating management support dimension.

### 4.3. Results of CII and FMEA

The CII results were obtained by multiplying the CSI and standardized weights ($a_i$), which contained the satisfaction and importance results and indicated the priority of improvement. The results of the CII in Table 6 show that the first five attributes that should be considered as priority improvements were safety in boarding and disembarking from the bus (1), bus attendants' attitudes and helpfulness (4), cleanliness of vehicles (5), security against crimes on buses and at stops (7), and punctuality of buses according to the schedule (11). These five attributes have relatively higher values for the CII, which indicated that these attributes contributed significantly to the satisfaction level and are currently rated low but are important to passengers. These attributes originated from the interaction with passengers, tangible service equipment, and operating management support dimensions. They were highly important and could satisfy customers, so this showed those attributes with a higher priority that should be enhanced.

**Table 6.** Service quality risk analysis for Bangkok bus service.

| Attributes | CSI | Standardized Weight ($a_i$) | CII | Oc | Cr | Cr Ranking |
|---|---|---|---|---|---|---|
| Item 1 | 0.73 | 1.000 | 0.73 | 0.46 | 0.97 | 1 |
| Item 2 | 0.65 | 0.250 | 0.16 | 0.26 | 0.76 | 10 |
| Item 3 | 0.59 | 0.333 | 0.20 | 0.34 | 0.84 | 9 |
| Item 4 | 0.66 | 0.750 | 0.49 | 0.37 | 0.94 | 4 |
| Item 5 | 0.66 | 0.833 | 0.55 | 0.42 | 0.96 | 2 |
| Item 6 | 0.59 | 0.417 | 0.25 | 0.28 | 0.85 | 8 |
| Item 7 | 0.67 | 0.667 | 0.45 | 0.37 | 0.94 | 5 |
| Item 8 | 0.59 | 0.500 | 0.30 | 0.31 | 0.89 | 7 |
| Item 9 | 0.50 | 0.083 | 0.04 | 0.30 | 0.16 | 12 |
| Item 10 | 0.62 | 0.583 | 0.36 | 0.37 | 0.92 | 6 |
| Item 11 | 0.64 | 0.917 | 0.59 | 0.40 | 0.96 | 3 |
| Item 12 | 0.50 | 0.167 | 0.08 | 0.25 | 0.51 | 11 |

This study applied an FMEA to evaluate Bangkok bus service risk. The service quality risk analysis of the Bangkok bus service is shown in Table 6. According to the results, safety in boarding and disembarking from the bus (1), bus attendants' attitudes and helpfulness (4), cleanliness of vehicles (5), security against crimes on buses and at stops (7), and punctuality of buses according to the schedule (11) were the top five attributes that had a high value for Cr, which meant that these attributes had a high service quality risk. Among these five attributes, safety in boarding and disembarking from the bus (1) had the highest value for Cr. Additionally, the CII value for this attribute was relatively high, indicating that it had a significant impact on customer satisfaction, and service failures related to this attribute occurred frequently. This result was consistent with the Kano's model classification of this attribute as a one-dimensional quality (O) attribute, meaning that the greater the level of fulfillment of this attribute, the greater the level of customer satisfaction. Buses in Bangkok frequently stop in the middle of the road for passengers to board and alight, posing a potential danger when the road is congested and there are no designated bus stops or waiting areas for passengers. In addition, some bus drivers may not follow safety procedures or regulations such as not coming to a complete stop before opening the doors or not waiting for passengers to safely board or alight from the

bus. Therefore, the bus company should consider this attribute as a priority improvement because it can increase commuters' satisfaction after service quality improvement.

Apart from the safety in boarding and disembarking from the bus (1) on which the bus company should be focusing, cleanliness of vehicles (5) and punctuality of buses according to the schedule (11) were also important attributes that had a large contribution toward commuters' satisfaction, especially punctuality. Cleanliness is often seen as a basic requirement for a transportation service. This result indicated that the respondents were dissatisfied with the level of cleanliness of buses in Bangkok and that the vehicles are frequently found to be insufficiently clean. Moreover, as people value public transport reliability (e.g., frequency, punctuality, and transfer) over convenience, punctuality is an important quality indicator for commuters in choosing a particular mode of transport [67,68]. There are several researchers who found that punctuality is one of the major concerns among the respondents in public transport [68–70]. However, due to the urban traffic congestion in Bangkok, buses are often delayed. Therefore, the attribute of punctuality also has a relatively high risk coefficient.

The attribute with the lowest Cr value was the availability of online bus schedules on the internet or a mobile application (9), which suggested that this attribute poses a low service quality risk. This was supported by the relatively low CII value and the infrequent occurrence of service failures associated with this attribute. The possible explanation for this result might be that the online bus schedules' developer for the mobile application always improves and updates the application according to the commuters' feedback. Therefore, it made the commuters quite satisfied with the service, and fewer service failures occurred.

## 5. Discussion

### *5.1. Managerial Implications*

According to the results of this study, starting from the classification of Kano's model, there were a total of nine attributes classified as one-dimensional quality (O). The attributes classified as this quality would decrease the commuters' satisfaction if the bus company could not fulfill the service for the commuters sufficiently. On the other hand, it would increase commuters' satisfaction if these attributes were adequately provided. Most of them originated from interaction with passengers and tangible service equipment. Regarding interaction with passengers, the management department of the bus company can organize training to improve service quality and continuously monitor and evaluate employees' performance to achieve better working efficiency. Regarding intangible service equipment, the bus company should provide a bus stop with a proper shelter, a bright light, a closed circuit camera, and an emergency button to combat crime. In addition, they should provide buses that are in good condition and clean for the users. Regarding the cleanliness of the vehicle and its interior equipment such as the area on the bus, upholstery, seats, handrails, curtains, windows, etc., there should be a clear standard for the bus's cleanliness and cleaning time, which may be carried out through an organization to take care of cleaning buses in particular.

Furthermore, there were three attributes classified as attractive quality (A). The attributes classified as this quality not only greatly satisfied the commuters but also created a good impression of the attributes. Most of them originated from convenience of service and operating management support. For the convenience of service, there should be a definite and clear schedule for the bus, including the frequency of service, and the convenience of payment. The bus company could provide a more convenient payment system such as developing an E-Ticket that can be used for the BTS SkyTrain (Bangkok Mass Transit System) or MRT (Metropolitan Rapid Transit) system simultaneously. In operating management support, punctuality was the most important attribute. Since Bangkok's traffic congestion is quite terrible, a bus might not be able to arrive at the bus stop according to the schedule. The government could allocate their resources to arrange the leftmost lane as the express lane for the buses to run for service only. The first phase may operate only during the peak hours, which are 06:00–09:00 and 16:00–19:00, and may be extended to the whole day in the

next phase. This would be to manage the bus routes of the BMTA to reach the destination within the specified time to provide the bus service continuously according to the schedule and enable the users to plan their trips.

As a result of the IPA assessment, safety in boarding and disembarking from the bus, cleanliness of vehicles, and punctuality of buses according to the schedule were the top three attributes that had a large gap between importance and satisfaction. This can imply that these attributes had a high importance for commuters, but the provider could not provide the service adequately, which made the commuters dissatisfied, which led to the results of the CII assessment. Therefore, the bus company should consider these attributes as a priority improvement.

According to the results of the service quality risk analysis, safety in boarding and disembarking from the bus, cleanliness of vehicles, and punctuality of buses according to the schedule were the top three attributes that have a high value for Cr, which meant that these attributes had a high service quality risk. Among these three attributes, safety in boarding and disembarking from the bus had the highest value for Cr. Additionally, the high CII value and frequent service failure indicated a critical need for the bus company to address this attribute and improve its service quality. To reduce service quality risks, the bus company should consider providing a training program for their drivers.

In conclusion, based on the suggestions mentioned above, there are still several limitations that the Bangkok Mass Transit Authority is still unable to solve effectively, such as the punctuality of the buses caused by traffic congestion. The government has tried to plan and implement various actions to mitigate this problem but has not yet been as successful as it should, and the main reasons are that private cars are used more than public transportation and that there is a lack of adequate service quality of public transport. Therefore, if the public sector could improve the service quality according to the commuters' requirements, it will make Bangkok commuters consider switching from driving cars to using a bus.

### *5.2. Limitations and Suggestions for Future Research*

Due to the limitations of time and budget as well as the COVID-19 pandemic, the researchers could not return to the country on which this research was focused. For the convenience of collecting the sample, the data were collected via an online questionnaire, so the sample might not have been enough to represent an effective result. The generalizability of the analytical results may be limited. However, the participants' responses were reliable with respect to their service perceptions because most reported traveling by bus 4–6 days per week. Thus, we suggest that further research could consider increasing the collected sample to enhance the study's results. Future studies are required to investigate the differences in the service demands and satisfaction levels of different age groups and passenger categories to provide additional practical recommendations for service improvement.

This study referred to and revised the quality attributes of the Bangkok bus service previously identified in other studies. The 12 quality attributes related to bus service were identified in four dimensions proposed by Hu [62]: interaction with passengers, tangible service equipment, convenience of service, and operating management support. Further research related to public transportation can consider the service attributes in this study and modify them to suit the respondents better. In addition, researchers could study and compare bus users' satisfaction with other transportation systems to use that as a guideline for improving the organization's service model to be more diverse. This study aimed to combine an IPA, Kano's model, and an FMEA to evaluate public bus service quality risks in Bangkok. The number of questions might have been excessive since the researcher had to ask the same questions for each model, including those regarding importance and satisfaction in the IPA and functional and dysfunctional questions in Kano's model. This could lead respondents to abandon the survey.

Lastly, this study focused only on bus service in Bangkok. The method proposed by this study can be also applied in other cities. Not only the questionnaire but also the quality

risk model proposed in this study can be used for other cities' bus services. Further research can consider comparing with other countries to make suggestions and recommendations to the Bangkok Mass Transit Authority for improvements and service developments to be more efficient and enhance the results of this study. Conducting similar studies in other major cities can facilitate the comparison of results and identification of various factors that could help in converting car users to bus users. Such studies can provide policymakers with a deeper understanding of how to improve the mass transportation systems in their respective countries.

## 6. Conclusions

This study used service quality risk assessment to seek the attributes that require priority improvement by combining the quality risk and the service quality of the Bangkok bus service. The assessment integrated Kano's model, an IPA, and an FMEA as mentioned above. The conclusions regarding the Bangkok bus service are as follows. The results of the classification of Kano's model showed that there were a total of nine attributes classified as one-dimensional quality (O) and three attributes classified as attractive quality (A). The results of the IPA assessment showed that safety in boarding and disembarking from the bus, cleanliness of vehicles, and punctuality of buses according to the schedule were the top three attributes that had a large gap between importance and satisfaction. On the contrary, availability of online bus schedules on the internet or a mobile application was the attribute that could satisfy the commuters the most because it had the smallest gap between importance and satisfaction. Furthermore, there were five attributes classified as "Concentrated here" in the IPA matrix, four attributes classified as "Keep up the good work", two attributes classified as "Low priority", and one attribute classified as "Possible overkill". The results of the CII assessment showed that the first five attributes that should be considered as priority improvements are safety in boarding and disembarking from the bus, bus attendants' attitudes and helpfulness, cleanliness of vehicles, security against crimes on buses and at stops, and punctuality of buses according to the schedule. The results of the FMEA analysis showed that safety in boarding and disembarking from the bus, bus attendants' attitudes and helpfulness, cleanliness of vehicles, security against crimes on buses and at stops, and punctuality of buses according to the schedule were the top five attributes that had a high value for Cr, which meant that these attributes had a high service quality risk.

This study evaluated the service quality risk of Bangkok bus service effectively from the integration of Kano's Model, an IPA, and an FMEA. The bus company can allocate their resources more effectively according to the improvement priority ranking, which was consistent with the attitudes and needs of the people who used the Bangkok bus service. Evaluating service quality is a crucial method for improving service. Although studies have investigated the quality of bus services in Bangkok, few studies have analyzed the ranking of quality attributes for improvement from the perspective of quality risks. This study contributed to the literature by constructing an integrated evaluation method that combined the service quality risk model and by applying the model to assess the service quality risks of Bangkok bus services. This study analyzed the degree of risk for each quality attribute and established a reference for the ranking of attribute improvements. In Bangkok, commuters are concerned with a host of factors such as the safety of boarding and disembarking from the bus, the amicability and efficacy of the bus attendants, the tidiness of the vehicles, the prevention of crime on the bus and at bus stops, as well as the punctuality of the buses in line with the schedule. The aspect regarding the prevention of crime on the bus and at bus stops was distinct from previous research conducted in other cities; e.g., Belagavi [71], Istanbul [72], and Taipei [62]. By cross-referencing the quality and risk profiles of bus services across various cities, researchers can acquire deep-seated insights into the discrepancies that engender contrasting public perceptions of buses among the populace of different metropolitan areas.

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