Comparing passengers' satisfaction with fixed-route and demand-responsive transport services: Empirical evidence from public light bus services in Hong Kong

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Abstract

Conventional public transport services are usually highly regulated with fixed-route and fixed-schedule, which are considered less flexible and efficient to serve low-density and dispersed settled areas. Demand-responsive transport is possibly a more economically and operationally viable solution, which offers dynamically allocated routes and schedules and serve the widespread passenger demand. There have been numerous simulation studies comparing the effectiveness of these two types of transport services in different settings, but which type is more favorable to passengers and what service aspects play the key role in shaping the overall satisfaction with the service quality from the passengers' point of view are largely unknown. Using fixed-route and demand-responsive public light buses in Hong Kong as a case study, this research conducted an on-street questionnaire survey with 547 samples regarding the passengers' perception of the performance of ten service aspects and the overall performance. An ordered logit model was accordingly developed to identify the relative importance and contribution of these service aspects to the overall service quality. An importance-performance analysis was further carried out to visualize the ratings of importance and performance of the service aspects, and to prioritize the improvement areas. The findings reveal that the passengers were less satisfied with the demand-responsive public light bus services in general. Among all the service aspects, we find that the in-vehicle environment, waiting time, driver's attitude, and safety hold a higher improvement priority. Policy implications for improving and regulating both fixed-route and demand-responsive public light bus services are suggested.

Keywords: fixed-route transport service; demand-responsive transport service; ordered logit model; service quality; importance-performance analysis

1. Introduction

In areas of low population density and during the period of low passenger demand, fixed-route transport services are considered less flexible and efficient (Chandra et al., 2013). They sometimes travel with few passengers or even no passengers onboard, which causes profit loss to the service operators. Demand-responsive transport is hence proposed to serve low-population areas or during the low-demand period, which is possibly more economically and operationally viable (Diana et al., 2009; Li and Quadrifoglio, 2010; Potts et al., 2010; Chandra et al., 2013; Calabrò et al., 2022).

To serve diverse passenger demand, both fixed-route and demand-responsive public light buses (PLBs, also known as mini-buses) are operating by medium-sized vehicles (either 16- or 19-seaters) in Hong Kong. PLBs provide specialized services to satisfy specific travel needs, serve the areas left unserved by the two dominating mass transit modes (i.e., railways and buses), and mainly feed key stations of the railway (which is recognized as the backbone of the urban transportation system by the government) and housing clusters (Cervero and Golub, 2007; Loo, 2007). The PLBs are made up of green mini-buses and red mini-buses. The former services have fixed routes, fixed schedules, and fixed fares, and are highly regulated by the government, while the latter services are demand-responsive, and they can operate almost anywhere (except along expressways and in some restricted zones) with no fixed-scheduled (commonly wait for a full load of passengers at the terminals) and usually with semi-fixed routes, pick up and discharge passengers along streets without fixed stops, and alter service routes during operation (change the trip origin and destination or take a by-pass to skip some pick up/drop off points) depending on the variation in passenger demand (based on operator's historical knowledge of passenger demand and telephone booking for seat reservation from passengers).

The PLBs play an important role in the transportation system. They are the third most popular form of transportation in Hong Kong, contributing about 13% of all mechanized trips made in a day (Transport Department, 2014). As they are lighter and smaller than double-decked buses, which makes them easier for maneuvering, especially along hilly roads and traveling at a higher speed (Szeto et al., 2015), and makes them unique in the public transportation system. As of 2021, the number of PLBs permitted to operate in Hong Kong was 4228, of which 3251 (76.9%) were green mini-buses (with fixed routes, schedules, and fares), and the remaining 977 (23.1%) were red mini-buses (demand-responsive). The daily associated patronages of these services were around 1.33 million and 0.22 million, respectively. It is noted that the number of green mini-buses was triple of red mini-buses, but the daily served passengers were over six times of red mini-buses. It is probably because of the difference in their operational characteristics, the red mini-bus drivers have flexibility in altering fares and routes, and have no timetable restrictions. Therefore, the drivers commonly aim to maximize their profit by increasing the fare when there is an excessive passenger demand, and by waiting for a full load of passengers at the terminals. Although the drivers can earn more through these strategies, the service frequency is adversely reduced and hence fewer passengers are served. The unstable service frequency may lead to a negative passengers' perception of the service quality.

The number of complaints towards PLB services should be noted since it is a way that passengers raise their concerns about the service aspects they are dissatisfied with. According to the annual report of the Transport Complaints Unit (2020), there were 8.02 complaints per million passenger journeys on the green mini-bus services, and about 60% of them were related to the regularity of service and the conduct and performance of staff (including drivers). As the schedule of services is fixed and regulated by the government, the passengers have a higher expectation of punctual services. Any non-compliance with the timetable and routing would affect the overall satisfaction with the service quality. On the other hand, for the red mini-buses, 4.25 complaints per million passenger journeys were recorded, and over half of the complaints were about improper driving behavior. It is noted that red mini-bus drivers' incomes are highly dictated by the revenue of the fare they charged while the green mini-bus drivers are paid a fixed salary per shift. The red mini-bus drivers, therefore, have more aggressive driving attitudes and risky driving behavior. Such behavior causes excessive speed, arbitrary lane changing, and red light jumping, which is considered detrimental to the safety of passengers and drivers (Wong et al., 2008).

The above service aspects are potentially in need of improvement, which should be confirmed and identified by an importance-performance analysis, in which a service aspect with a high-importance rating and a low-performance rating holds a priority for improvement. As a result, a questionnaire survey for passengers' perceptions of the service quality of the fixed-route and demand-responsive PLBs is hence essential and necessary.

To address the aforementioned research gap, this study conducted an on-street questionnaire survey in Hong Kong with 547 passengers interviewed. They were invited to report their level of satisfaction with each of the ten service aspects, and the overall service quality of either the fixed-route or demand-responsive PLB based on their latest travel experience. Using the data collected, an ordered logit model is developed to identify the relative importance and contribution of the ten service aspects to the overall service quality. An importance-performance analysis is further conducted to determine and prioritize the service aspects in need of improvement in the view of passengers. Policy implications are discussed based on the results. We believe that the findings of this study can serve as a valuable reference for improving and regulating both fixed-route and demand-responsive PLB services in Hong Kong, and provide policy insights to some other cities with a similar public transportation system.

This paper makes several contributions: (1) To the best of our knowledge, we are pioneers to evaluate and compare the service quality of the fixed-route and demand-responsive PLB services; (2) it develops an ordered logit model to identify the relative importance and contribution of various service aspects to the overall service quality; (3) it proposes a new methodology to rank the significantly underperforming areas that should be improved; and (4) it discusses novel and valuable policy implications for improving and regulating both fixed-route and demand-responsive transport services PLB services.

The remainder of this paper is structured as follows. Section 2 provides a literature review regarding the studies on the fixed and demand-responsive transport services and the measures of transport service quality. Section 3 describes the details of data collection for this study. This section also provides the socio-demographic characteristics, and the satisfaction with the fixed-route and demand-responsive PLB services of the respondents. Section 4 introduces the methodologies of the ordered logit model and importance-performance analysis to prioritize the improvement areas. Section 5 shows the model results, and discusses the policy implications. At last, Section 6 concludes the paper and suggests a future research direction.

2. Literature Review

2.1 Fixed-route and demand-responsive transport services

Conventional public transport services are usually highly regulated with fixed-route and fixed-schedule, which are considered less flexible and efficient to serve low-density and dispersed settled areas. Demand-responsive transport is possibly a more economically and operationally viable solution, which offers dynamically allocated routes and schedules and serves the widespread passenger demand. Demand-responsive transport is defined as an intermediate form of transport somewhere between a bus with a regular service route and a taxi offering a personalized transport service. The associated service routes can be altered based on the operator's historical knowledge of passenger demand and seat reservation from passengers, and the vehicles only stop where passengers request for picking up and dropping off. The demand-responsive services can be free-standing or integrated with other mass transit modes as feeder services (i.e., railways and buses) (Mageean and Nelson, 2003; Brake et al., 2004).

To empirically compare the fixed-route and demand-responsive transport services, Coutinho et al. (2020) studied the impacts of a 12-month pilot program implemented in Amsterdam (Netherlands), Mokumflex, to replace a fixed-route bus service with a demand-responsive transport service. They investigated the changes in travel distances, ridership, cost, and greenhouse gas emissions, and found that all of these aspects were dropped drastically. The provision of public transport service was successfully maintained in a low-demand area at a lower cost. Perera et al. (2020) provided some insights into the operations of demand-responsive transport based on the experience of Bridj, a new demand-responsive transport service in Sydney (Australia). They concluded that it has three major functions including feeding the mass transit services, connecting local areas during inter-peak periods, and covering large areas with less passenger demand. Although there is a great potential to improve public transport service provisions in less connected areas, the services should be affordable (e.g., offering mode transfer discounts) and well-regulated.

Some other simulation studies have also been conducted for assessment to compare fixed-route and demand-responsive transport services in different settings. For instance, Chandra et al. (2013) simulated the feeder transit systems in Denver (United States) to identify the optimum number of stops for fixed-route transit and the optimum number of passengers in a given cycle for demand-responsive transit to maximize the potential accessibility. Edwards and Watkins (2013) used Atlanta (United States) as a case study, and demonstrated that a demand-responsive feeder transit system has lower total users' and operators' costs than a fixed-route transportation system. Navidi et al. (2018) conducted a simulation study using a real-world network in Victoria (Australia), and the results show that replacing conventional public transport with demand-responsive transport will improve passengers' mobility. Dytckov et al. (2022) explored the potential effects of replacing the current bus lines with demand-responsive services in Lolland (Denmark), and indicated that the demand-responsive services are more cost-efficient and environmentally friendly in the scenarios with low passenger demand. Most of these studies focused on the effectiveness of two types of transport services and indicated that a demand-responsive service usually outperforms a fixed-route service, in particular when passenger demand is low.

2.2 Measures of transport service quality

Improving the service quality of public transport is an essential way toward the goal of stimulating usage and patronage (Diana, 2012; Eboli and Mazzulla, 2009; 2011). Therefore, a line of research focuses on the service quality of public transport systems. The service quality involves a wide variety of issues, such as seat availability, reliability, comfort, and waiting conditions. Various studies have been devoted to determining which service aspects of conventional mass transit with fixed routes (e.g., railways and buses) should be given priority for improvement from the users' perspective. Hensher (1990) conducted a stated response survey of thousands of public bus users in Sydney and Newcastle (Australia) and determined the most important service aspects influencing bus service satisfaction (i.e., on-time at stops and seat availability). Foote and Stuart (1998) used a quadrant analysis to visualize priorities to enhance the bus service in Chicago (United States), and consequently proposed that on-time performance and bus frequency hold a top priority for improvement. Mazzulla and Eboli (2006) used the survey data from Cosenza (Italy) to examine the influences of individual service quality attributes on global customer satisfaction, in which service frequency and seats on the bus were identified as having a major weight. Wall and McDonald (2007) studied the service quality of selected bus routes in Winchester (United Kingdom) and confirmed the effectiveness of introducing new buses, increases in service frequencies, and provisions of new bus infrastructure and park-and-ride car parks on improving bus patronage and satisfaction of bus passengers. Tyrinopoulos and Antoniou (2008) assessed the transit service quality and analyzed transit satisfaction in Athens and Thessaloniki (Greece). Their study illustrated that the service aspects in need of improvement were service frequency, vehicle cleanliness, waiting conditions, transfer distance, and network coverage. dell'Olio et al. (2010) identified key service aspects affecting transit satisfaction in Santander (Spain) and indicated that service reliability and waiting time were the two most important areas. de Oña et al. (2018) conducted an online customer satisfaction survey of the users of the metro system in Seville (Spain), and identified eight key service aspects, including the availability of the service, and accessibility. Recently, there have been some other studies further investigating the differences in desired transit service quality and/or satisfaction with transport services between users and potential users (Bellizzi et al., 2020), between male and female users (Zheng et al., 2022), and between clusters with different user profiles (de Oña et al., 2016), and suggesting demographic segment-specific strategies for attracting new users and enhancing ridership of current users of public transport systems (Deepa et al., 2022).

In addition to evaluating the service quality of conventional mass transit, some studies concentrated on that of demand-responsive transport modes (e.g., demand-responsive mini-buses and taxis). Joewono and Kubota (2007) focused on the services of Angkutan Kota (with a capacity of 12–14 seats) in Bandung (Indonesia), which has a semi-fixed route and no service schedule. They concluded that customer service, comfort, and safety and security hold a high priority for improvement. Govender (2014) conducted a survey in Johannesburg (South Africa) and found the reliability, affordability, and extent of the service highly influenced passengers' perception of the quality of mini-bus taxi service, a kind of shared taxi service. Rahman et al. (2016) used the structural equation modeling approach to examine the service quality of Tempo in Dhaka (Bangladesh). Tempo can carry 12 people, runs along a more or less defined route, and then stops to pick up or discharge passengers on request. They concluded that punctuality and reliability, vehicle fitness, and travel cost greatly contribute to service quality. Similarly, Shaaban and Kim (2016) calibrated a structural equation model for evaluating the taxi service quality in Doha (Qatar), and provided suggestions to enhance the accessibility of taxi ranks. Wong and Szeto (2018) examined the service quality of urban taxis in Hong Kong (China) and conducted an importance-satisfaction analysis to find out that driver's attitudes and professionalism, waiting time, and the difficulty of hailing taxis on streets should be improved.

Although the above studies suggested some key aspects that potentially influence the overall service quality of fixed-route transport and demand-responsive transport services, none of them compared their service quality. Therefore, which type is more favorable to passengers and what service aspects play the key role in shaping overall satisfaction remain unknown. A comprehensive study investigating and comparing passengers' satisfaction with fixed-route and demand-responsive transport services is hence essential and important.

3. Data

3.1 Data collection

This study adopted fixed-route and demand-responsive PLBs in Hong Kong as a case study. An on-street questionnaire survey was conducted in December 2018 in Hong Kong for data collection. Our surveyors approached potential respondents randomly on streets to explain that the data would be exclusively used for research purposes, and then asked whether they were willing to participate in the survey. The respondents who traveled by either the fixed-route or demand-responsive PLB or both in the past month were suitable to participate in the survey. Once a respondent was confirmed to be eligible and accepted to participate in the survey, the surveyor read the questions aloud and asked for the respondents' answers. The times and venues of the survey were carefully designed to cover a broad spectrum of respondents. A total of 547 respondents were sampled, of which 362 were fixed-route PLB passengers and the other 185 were demand-responsive PLB passengers. As introduced in Section 1, the daily patronage of the fixed-route PLBs was higher than that of the demand-responsive PLBs, more samples from the fixed-route PLB passengers are considered reasonable.

The questionnaire consisted of three parts: (1) socio-demographic characteristics of the respondents; (2) details of the latest PLB trip of the respondents; and (3) satisfaction with individual service aspects and the overall service quality of PLBs.

3.2 Socio-demographic characteristics

Table 1 summarizes the socio-demographic characteristics of the respondents. The sample covers a broad spectrum of passengers. The sets of data for the fixed-route and demand-responsive PLB passengers have similar socio-demographic characteristics. Overall, male respondents (56.7%) were slightly more than their female counterparts (43.3%). It is noted that 61.1% of all respondents were younger than 35 years old, while old adults aged 65 or over constituted only 7.2%. As for the education level, only 4.8% of the respondents were at the primary level or below, and 52.8% of them received tertiary education or above. Most of the respondents (44.8%) had either a full-time or a part-time job. About 60% of the respondents earned less than $10000 a month, which was primarily contributed by those respondents reported as students, retired, and others (homemakers and unemployed).

Table 1
Socio-demographic characteristics of the respondents

Personal particulars	Frequency (percentage)		
	Fixed-route PLB service	Demand-responsive PLB service	Total
Gender			
Male	196 (54.4%)	113 (61.1%)	309 (56.7%)
Female	164 (45.6%)	72 (38.9%)	236 (43.3%)
Age			
21 or below	139 (38.7%)	70 (38.0%)	209 (38.5%)
22 – 34	68 (18.9%)	55 (29.9%)	123 (22.7%)
35 – 44	47 (13.1%)	19 (10.3%)	66 (12.2%)
45 – 54	33 (9.2%)	19 (10.3%)	52 (9.6%)
55 – 64	37 (10.3%)	17 (9.2%)	54 (9.9%)
65 or above	35 (9.7%)	4 (2.2%)	39 (7.2%)
Education			
Primary or below	21 (5.8%)	5 (2.7%)	26 (4.8%)
Secondary	161 (44.5%)	71 (38.4%)	232 (42.4%)
Tertiary or above	180 (49.7%)	109 (58.9%)	289 (52.8%)
Occupation			
Full-time/part-time job	158 (43.7%)	87 (47.0%)	245 (44.8%)
Student	140 (38.7%)	77 (41.6%)	217 (39.7%)
Retired	37 (10.2%)	13 (7.0%)	50 (9.1%)
Others (homemaker and unemployed)	27 (7.5%)	8 (4.3%)	35 (6.5%)
Monthly income			
$10000 or below	214 (59.9%)	105 (58.0%)	319 (59.3%)
$10001 – 20000	60 (16.8%)	27 (14.9%)	87 (16.2%)
$20001 – 30000	38 (10.6%)	28 (15.5%)	66 (12.3%)
$30001 – 40000	18 (5.0%)	10 (5.5%)	28 (5.2%)
More than $40000	27 (7.6%)	11 (6.1%)	38 (7.1%)

3.3 *Trip characteristics*

Table 2 tabulates the PLB trip characteristics of the respondents based on their latest travel experience. It is noted that the trip durations of PLBs were generally short, and most of the trips were less than 15 minutes. Comparatively, the fixed-route trips had a shorter duration than the demand-responsive trips on average. After 11 pm, the demand-responsive PLB services were much more frequently used. It is because most of the fixed-route PLB lines were not in service after 11 pm, when the services of conventional mass transit were suspended. The demand-responsive PLB services were one of the limited transport options for passengers at a late night. For transfers, the respondents were asked whether or not to have another trip preceded or followed by the PLB trip. If another trip was involved, the transport mode was recorded. Different transfer patterns for the fixed-route and demand-responsive PLB passengers can be observed from the data. More than 50% of the demand-responsive PLB passengers took a direct trip (involving no transfer), but less than 40% of the passengers traveled directly by the fixed-route PLB services. Moreover, a higher proportion of the fixed-route PLB passengers were involved in a railway-minibus transfer than the demand-responsive PLB passengers. Two possible reasons for this are: (1) a travel fare discount for railway-green minibus transfer attracts the passengers to use both services together; (2) the fixed-route PLB services are designed to provide connections between railway stations (major transport hubs) and the local community.

Table 2

Trip characteristics of the fixed-route and demand-responsive public light bus services

Trip characteristic	Frequency (percentage)		
	Fixed-route PLB service	Demand-responsive PLB service	Total
Journey time			
5 min or below	92 (25.5%)	22 (12.0%)	114 (20.9%)
6 – 10 min	129 (35.7%)	40 (21.7%)	169 (31.0%)
11 – 15 min	76 (21.1%)	54 (29.3%)	130 (23.9%)
16 – 20 min	36 (10.0%)	33 (17.9%)	69 (12.7%)
More than 20 min	28 (7.8%)	35 (19.0%)	63 (11.6%)
Trip period			
6 am – 10 am (morning peak)	113 (31.5%)	55 (29.9%)	168 (30.9%)
10 am – 1 pm	39 (10.9%)	20 (10.9%)	59 (10.9%)
1 pm – 4 pm	79 (22.0%)	33 (17.9%)	112 (20.6%)
4 pm – 8 pm (evening peak)	83 (23.1%)	34 (18.5%)	117 (21.5%)
8 pm – 11 pm	42 (11.7%)	23 (12.5%)	65 (12.0%)
11 pm – 6 am	3 (0.8%)	19 (10.3%)	22 (4.1%)
Transfer to/from another transport mode			
None	140 (38.7%)	99 (53.5%)	239 (43.7%)
Railway	167 (46.1%)	63 (34.1%)	230 (42.0%)
Franchised bus	40 (11.0%)	17 (9.2%)	57 (10.4%)
Others	15 (4.1%)	6 (3.2%)	21 (3.8%)

3.4 Satisfaction with the PLB services

The selection of service aspects was primarily informed by existing literature, while considering the unique characteristics of the fixed-route and demand-responsive PLB services in Hong Kong. As such, a total of ten individual service aspects were finally chosen:

(1) Service hours (times of the first and last services). The demand-responsive PLB services do not have a fixed schedule, and allow the operators to provide services with longer service hours than buses and metro in a day without restrictions. It can better serve the passenger demand during a late night when most of the other public transport services are suspended, which may lead to a positive influence on the overall service quality.

(2) Route details (consistent route and clear stops). The downside of flexible or semi-fixed route services is that the passengers may not fully comprehend the route details, leading to passengers' confusion about the stop location and potential arguments between passengers and the PLB drivers. Unclear routes and stops may adversely affect the service patronage and level of satisfaction of the passengers.

(3) Waiting facilities (sheltered waiting area and seats). Waiting conditions at terminals and stops concerning the provision of various facilities (e.g., shelters and seats) were found to play a significant role in service performance and the satisfaction of passengers (Tyrinopoulos and Antoniou, 2008). It was also identified as the most influential factor affecting the overall satisfaction level of the elderly with public transport services (Wong et al., 2017).

(4) Waiting time (frequent and regular service). A recent customer satisfaction survey determined that service characteristics, including the regularity and frequency of services,

possessed the highest positive effect among all the attributes in the evaluation of global customer satisfaction with transit services (Eboli and Mazzulla, 2012).

(5) Ease of boarding (a low platform for boarding). Easy access was identified as an important service aspect for people with reduced mobility (de Oña et al., 2018). Some PLB operators in Hong Kong have been offering low-platform vehicles for specific lines (e.g., traveling towards hospitals) to improve the accessibility of passengers in need.

(6) Driving stability (comfortable ride without sudden breaks). A rough and uncomfortable ride was determined as one of the reasons for the elderly not preferring traveling by the PLBs (Transport Department, 2014; Wong et al., 2017). Hence, driving stability is a potential service aspect significantly influencing the overall satisfaction with transport services of all passengers with different profiles.

(7) Safety (obeying traffic rules without red light jumping and speeding). Safety onboard obtained the third highest average importance rate among the attributes contributing to the overall service quality, which is related to driver behavior (de Oña et al., 2013). It was suggested to improve onboard passenger safety by changing driver behavior through safety training programs (Govender, 2014).

(8) Reliability (arriving at the destination on time). Passengers were found dissatisfied with the reliability of bus services. The highest priority was assigned to a better on-time performance by matching satisfaction against importance scores (Foote and Stuart, 1998). Service reliability was considered a very important variable for all users, which holds the most weight in the overall evaluation of bus services (dell'Olio et al., 2010).

(9) Driver's attitude (friendly response to stopping requests). There have been many complaints received from passengers regarding the driver's attitudes and professionalism in demand-responsive transport (Wong and Szeto, 2018). As most of the demand-responsible PLBs are private-owned and operated independently, their attitude is quite diverse and difficult to control.

(10) In-vehicle environment (comfortable seats and temperature). Comfort onboard was identified as an important positive influence in evaluating bus services, concerning properly functioning interior facilities (e.g., air-conditioners) and comfortable seats (Andaleeb et al., 2007). The introduction of more comfortable buses was suggested to improve passenger ratings on satisfaction (Wall and McDonald, 2007).

The associated performance ratings were measured on a five-point scale, while the verbal representation of "1" is "very dissatisfied", "2" is "dissatisfied", "3" is "neutral", "4" is "satisfied", and "5" is "very satisfied". Other than the performance ratings on the ten service aspects, the respondents were required to report the overall performance rating of their latest PLB trip. The performance ratings of individual service aspects were considered to be highly correlated to that of the overall service quality (Olawole and Aloba, 2014).

Table 3 displays the means of performance ratings of the ten service aspects and the overall performance rating. It is noted that the average ratings of them are all over 3 (neutral), indicating that the passengers were basically satisfied with both types of PLB services, individually and collectively. In general, ease of boarding received the highest performance rating, closely followed by reliability. In contrast, waiting time was the worst performed service aspect in the view of passengers. The only service aspect that demand-responsive PLB services had a higher performance rating was service hours, as they had longer service hours usually covering late nights. The fixed-route PLB services obviously outperformed in various areas, with the greatest differences occurring in the waiting facilities (0.29), followed by driver's attitude (0.22), and driving stability (0.15). From the overall performance scores, it is noted that the passengers were less satisfied with the demand-responsive PLB services in general.

Table 3

Performance ratings of the individual service aspects and the overall performance

Service aspect	Fixed-route PLB service	Demand-responsive PLB service	Average
Service hours (times of the first and last services)	3.50	3.54	3.51
Route details (consistent route and clear stops)	3.70	3.50	3.63
Waiting facilities (sheltered waiting area and seats)	3.74	3.45	3.64
Waiting time (frequent and regular service)	3.31	3.19	3.27
Ease of boarding (a low platform for boarding)	3.82	3.74	3.79
Driving stability (comfortable ride without sudden breaks)	3.50	3.35	3.45
Safety (obeying traffic rules without red light jumping and speeding)	3.68	3.38	3.58
Reliability (arriving at the destination on time)	3.75	3.68	3.73
Driver's attitude (friendly response to stopping requests)	3.54	3.32	3.47
In-vehicle environment (comfortable seats and temperature)	3.57	3.53	3.55
Overall performance	3.68	3.59	3.65

4. Methodology

4.1 Ordered logit model

This study adopts the ordered logit modeling approach to investigate the level of contribution of each service aspect individually towards the overall satisfaction level. It is an extended logistic regression and is suitable for the ordered dependent variable *z* (overall satisfaction measured by the five-point scale in this study). The model suggests that the ordered dependent variable *z* is determined by a latent and continuous variable *z**. The unobservable variable *z** is linearly correlated to independent variables (i.e., the performance rating of service aspect *m*, x_m), where *m* = 1, 2, ..., *M*, and their relationship can be expressed as

$$z^* = \sum_m \beta_m x_m \,, \tag{1}$$

where x_m is the performance rating of the *m*-th service aspect, β_m is the coefficient associated with x_m representing the implicitly derived importance rating of service aspect *m*, and *M* is the number of service aspects concerned.

The ordered dependent variable *z* is in category *j*, where *j* = 1, 2, …, *J*, if its observable counterpart *z** falls in the *j*-th interval, and their relationship can be formulated as

$$z = j \text{ if } \alpha_{j-1} < z^* \le \alpha_j \,, \tag{2}$$

where α_j is the *j*-th intercept or threshold value, $\alpha_0 < \alpha_1 < ... < \alpha_J$, $\alpha_0 = 0$, $\alpha_J = \infty$, and *J* is the number of categories of the overall satisfaction.

Based on the above assumptions, the probability of choosing alternative *j*, $P(z = j)$, can be written as

$$P(z = j) = P(\alpha_{j-1} < z^* \le \alpha_j) = F\left(\alpha_j - \sum_m \beta_m x_m\right) - F\left(\alpha_{j-1} - \sum_m \beta_m x_m\right), \tag{3}$$

where $F(.)$ is the cumulative distribution function of the logistic distribution. For model development, α_j and β_m are the model variables and they are jointly estimated by the maximum likelihood estimation method.

4.2 Importance-performance analysis

With the ordered logit model calibrated, the importance rating of each service aspect in shaping the overall satisfaction can be identified; from survey results, the performance rating of each service aspect can be collected. However, it is difficult to decide which service aspect possesses a higher improvement priority. Therefore, an importance-performance analysis is conducted in this study to identify the priority of improvement with the consideration of the combined effects of importance and performance. This approach has been used in some other similar studies for service quality evaluation, and some researchers used different ways to interpret the importance-performance results in accordance with their own judgment. For instance, Guadagnolo (1985) proposed the data-centered quadrant approach, and used the empirical means of importance and performance ratings as a cross-point to divide the performance evaluation matrix into four regions: (I) Concentrate here (in the top-left quadrant, for service aspects with a high importance rating but a low-performance rating, which are in need of improvement); (II) Keep up the good work (in the top-right quadrant); (III) Low priority (in the bottom-left quadrant); and (IV) Possible overkill (in the bottom-right quadrant). Slack (1994) attempted to use a diagonal line to separate regions with different priorities. The region above the line represents a high priority for improvement and the region below the line represents a low priority. Lai and Hitchcock (2015) combined these two concepts and recommended a flexible data-centered diagonal line model using empirical means and a diagonal line. Hence, the region for concentrate here is enlarged and it covers more service aspects. The distance to the diagonal line is served as an indicator for prioritizing the improvement of service aspects.

This study adopts the flexible data-centered diagonal line modeling concept and *proposes* a diagonal line passing through empirical means as a cross-point with a slope of $\frac{\sigma_\beta}{\sigma_x}$, which can be expressed as

$$\left(\sigma_x \beta - \sigma_\beta x\right) - \left(\sigma_x \bar{\beta} - \sigma_\beta \bar{x}\right) = 0\,, \tag{4}$$

where x is the performance rating; β is the importance rating; σ_x and σ_β are the standard deviations of performance and importance ratings, respectively, and $\bar{x}$ and $\bar{\beta}$ are the average values of performance and importance ratings, respectively.

The service aspects located above the diagonal line (within the region of concentrate here) represent areas to improve. The need for improvement increases when the (perpendicular) distance to the diagonal line increases. The distance to the diagonal line (d_m) from service aspect *m* located above the line is calculated as

$$d_m = \frac{\left(\sigma_x \beta_m - \sigma_\beta x_m\right) - \left(\sigma_x \bar{\beta} - \sigma_\beta \bar{x}\right)}{\sqrt{\sigma_x^{\,2} + \sigma_\beta^{\,2}}}\,. \tag{5}$$

5. Results and Discussions

5.1 Results of ordered logit model

An ordered logit model was developed by applying the statistical software package STATA. Table 4 tabulates the model results. It is noted that all variables exhibit positive coefficients. This is in line with our expectations, as the individual service aspect should, in theory, have positive or marginal effects on the overall performance of the PLB services. Moreover, eight out of the ten service aspects, (i.e., all except route details and ease of boarding) are found significant at the 5% level. Among all the variables, the in-vehicle environment has the largest coefficient (1.34), followed by safety (0.87), driver's attitude (0.74), and driving stability (0.51). In addition, all four threshold values are significant at the 1% level. The threshold values define the ranges of satisfaction categories. For instance, if the calculated unobservable variable z^* is larger than 25.10, the estimated overall satisfaction level is 5 (very satisfied).

Table 4

Summary of the ordered logit model results

Service aspect	Coefficient (t-statistics)
Service hours (times of the first and last services)	0.47[a] (2.61)
Route details (consistent route and clear stops)	0.05 (0.29)
Waiting facilities (sheltered waiting area and seats)	0.45[a] (2.58)
Waiting time (frequent and regular service)	0.40[a] (2.58)
Ease of boarding (a low platform for boarding)	0.17 (0.58)
Driving stability (comfortable ride without sudden breaks)	0.51[a] (2.76)
Safety (obeying traffic rules without red light jumping and speeding)	0.87[a] (4.55)
Reliability (arriving at the destination on time)	0.44[b] (2.52)
Driver's attitude (friendly response to stopping requests)	0.74[a] (4.01)
In-vehicle environment (comfortable seats and temperature)	1.34[a] (6.86)
Threshold value between levels 1 and 2	9.05[a] (6.71)
Threshold value between levels 2 and 3	11.94[a] (10.68)
Threshold value between levels 3 and 4	17.98[a] (13.01)
Threshold value between levels 4 and 5	25.10[a] (14.89)

Note: [a] significant at the 1% level. [b] significant at the 5% level.

5.2 Results of importance-performance analysis

Figure 1 shows the results of the importance-performance analysis for both the fixed-route and demand-responsive PLB services. The average performance rating of the PLB services is 3.54 (as indicated by the vertical broken line), in which eight out of the ten service aspects of the demand-responsive PLB services and only three service aspects of the fixed-route PLB services are located on the left of the data-centered line. In particular, the driver's attitude, waiting time, and driving stability of the demand-responsible PLB services, and the waiting time of the fixed-route PLB services was obviously worse performed than the others. On the other hand, the mean value of the importance rating is 0.54 (as indicated by the horizontal broken line). It is noted that the in-vehicle environment for both types of PLBs is of paramount importance to the overall satisfaction level, and route details and ease of boarding are the least important areas.

For the four regions divided from the performance evaluation matrix, no service aspect falls within the region (II) Keep up the good work, and service hours and the route details of the demand-responsive PLB services have a low priority for improvement. The bottom-right region (IV) Possible overkill depicts the service aspects with high performance but low importance. The results indicate that the waiting facilities, reliability, route details, and ease of boarding of the fixed-route PLB services, and the reliability and ease of boarding of the demand-responsive PLB services are possible overkill, exceeding the respondents' expectations. It is reasonable that the ease of boarding received a higher performance score and does not have an immediate need for (further) improvement, because some operators have been replacing the aged PLB vehicles with low-platform vehicles to improve the ease of boarding, as introduced in Section 3.4. However, it is rather surprising to note that reliability has a high-performance rating and a low-importance rating. The findings seem to be against that of other previous studies (e.g., dell'Olio et al., 2010; Govender, 2014; Rahman et al., 2016). It is probably because of the unique operational characteristics of the PLB services in Hong Kong. The trip durations were short and generally less than 15 minutes, and resulted in a less unexpected delay in the journey. In contrast, some bus services operated by high-capacity vehicles, with frequent stops for picking up or discharging lots of passengers along long service routes usually encountered bunching and gapping, which led to a severe service reliability problem.

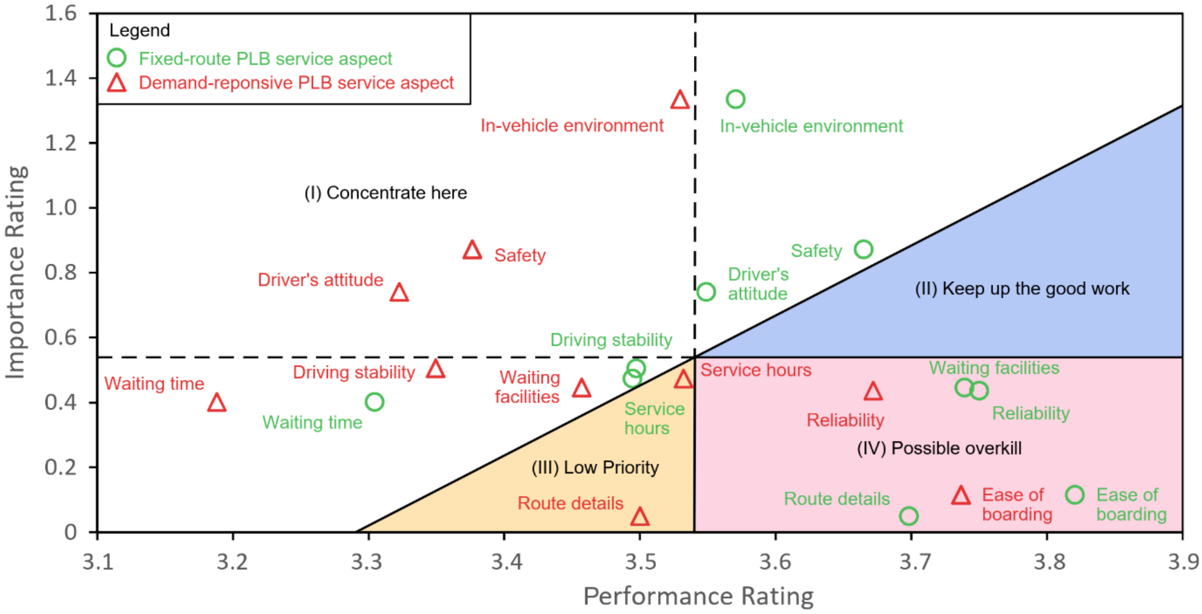

Fig 1. Results of importance-performance analysis

Most importantly, the service aspects located in the region (I) Concentrate here (above the diagonal line) represent areas to improve. Table 5 tabulates the distance to the diagonal line of each service aspect, and suggests a priority for improvement. For the fixed-route PLB services, the in-vehicle environment possesses the top priority for improvement, followed by waiting time (2nd), driver's attitude (3rd), safety (4th), and driving stability (5th). Similarly, for the demand-responsive PLB services, although in a slightly different sequence, these five aspects are also located far away from the diagonal line and they are all in need of improvement. Comparatively, safety has a higher ranking (2nd) for the demand-responsive PLB services than that for the fixed-route PLB services (4th). In addition, the fixed-route PLB services should consider extending the service hours, and the demand-responsive PLB services should provide better waiting facilities for their passengers. The findings generally concur with some previous studies, and show that these service aspects are the priority areas for improvement to enhance the overall service quality (e.g., Andaleeb et al., 2007; Tyrinopoulos and Antoniou, 2008; Eboli and Mazzulla, 2012; de Oña et al., 2013; Wong and Szeto, 2018).

Table 5

Summary of the distance to the diagonal line and the priority for improvement

Service aspect	Distance to the diagonal line (Priority for improvement)	
	Fixed-route PLB service	Demand-responsive PLB service
Service hours (times of the first and last services)	0.01 (6th)	-0.02
Route details (consistent route and clear stops)	-0.35	-0.17

Waiting facilities (sheltered waiting area and seats)	-0.22	0.04 (6th)
Waiting time (frequent and regular service)	0.16 (2nd)	0.26 (4th)
Ease of boarding (a low platform for boarding)	-0.43	-0.36
Driving stability (comfortable ride without sudden breaks)	0.02 (5th)	0.16 (5th)
Safety (obeying traffic rules without red light jumping and speeding)	0.03 (4th)	0.29 (2nd)
Reliability (arriving at the destination on time)	-0.24	-0.16
Driver's attitude (friendly response to stopping requests)	0.08 (3rd)	0.28 (3rd)
In-vehicle environment (comfortable seats and temperature)	0.31 (1st)	0.34 (1st)

5.3 Policy implications for improving and regulating the public light bus services

According to the findings of importance-performance analysis, the in-vehicle environment is the common service aspect that deserves the top priority for improvement for both types of the PLB services. With no doubt, the drivers and operators have a full responsibility to ensure cleanliness and a comfortable environment inside the vehicles. In addition, this service aspect could further be improved by gradually replacing aged vehicles with more comfortable vehicles (Wall and McDonald, 2007). The government should consider providing subsidies to the PLB service operators to speed up the replacement process.

Driver's attitude and driving stability are other two aspects that need improvement. In the survey, some respondents complained that the door of PLBs closed quickly so that they did not have ample time to board and alight. Rough and uncomfortable rides were also identified as the worst performed service aspect for the elderly in a similar study (Transport Department, 2014). Training courses are hence recommended to the drivers for increasing their awareness of driving behaviors and attitudes. The performance of drivers is also recommended to evaluate periodically to ensure service quality.

For the fixed-route PLB services, the government should keep close monitoring of the performance of operators, in particular on the waiting time and duration of services. Shortening the service waiting time and extending the service hours are recommended to be improved according to the results of this study. Hence, the government should review the service schedule to serve passenger demand and meet their service expectation. Although the demand-responsive PLBs should maintain a certain degree of flexibility on schedule, service waiting time is a key concern of their passengers. The provision of a real-time arrival information system is suggested, which allows passengers to alter their mode choice and minimize their waiting time at stops or on streets.

On the other hand, especially for the demand-responsive PLB services, safety is a major influencing aspect to the overall passengers' satisfaction. Mandatory installations of seat belts, a speed meter, and a speed limiter inside the PLB vehicles are highly recommended. The government should increase the penalties on traffic violations to alleviate risky driving behavior, and organize safe driving campaigns and safety training programs to promote safe driving (Govender, 2014).

At last, shelters and seats are recommended to provide at the demand-responsive PLB terminals, while providing these waiting facilities on roadsides may not be practical because of narrow footways in urban areas and no fixed intermediate stops for the demand-responsive PLB services.

6. Conclusion

Conventional public transport services are usually highly regulated with fixed-route and fixed-schedule, which are considered less flexible and efficient to serve low-density and dispersed settled areas. Demand-responsive transport is possibly a more economically and operationally viable solution, which offers dynamically allocated routes and schedules and serves the widespread passenger demand. Some previous studies have indicated that a demand-responsive transport service usually outperforms a fixed-route transport service, in particular when passenger demand is low. However, there has been a lack of comprehensive studies to investigate which type is more favorable to passengers and what service aspects play the key role in shaping overall satisfaction. To address this gap, PLBs (mini-buses) in Hong Kong are selected as a case study to provide empirical evidence. 547 respondents (with 362 fixed-route PLB passengers and 185 demand-responsive PLB passengers) were interviewed in an on-street questionnaire survey for their satisfaction with ten service aspects and the overall service quality. The performance ratings were measured on a five-point scale, and an ordered logit model and importance-performance analysis were developed and carried out. From the results, the priority areas for improvement of PLB services were identified. The findings of this study can be summarized as follows: (1) the passengers were less satisfied with the demand-responsive PLB services in general; (2) in-vehicle environment, driver's attitude, safety, waiting time, and driving stability hold a higher priority for improvement to both types of the PLB services; and (3) the fixed-route PLB services should also extend service hours, and the demand-responsive PLB services should especially provide waiting facilities for passengers. Some policy implications are suggested for improving and regulating PLB services based on the results, they include but are not limited to: (1) gradually replacing aged vehicles; (2) providing training courses to increase the drivers' awareness of driving behaviors and attitudes; (3) periodically evaluating drivers' performance; (4) reviewing the service schedule of the fixed-route PLB services; (5) providing a real-time arrival information system to passengers; (6) mandatorily installing seat belts, a speed meter, and a speed limiter inside demand-responsive PLBs; (7) increasing the penalties on traffic violation; (8) organizing safe driving campaigns and safety training programs to promote safe driving; and (9) providing shelters and seats at the demand-responsive PLB terminals.

Since the fixed-route and demand-responsive PLB services in Hong Kong are not operated on the same route and they are not in direct competition, this study cannot reveal how the passengers choose between the two types of service. A future study is hence suggested to conduct a stated preference survey considering a public transport route with both fixed-route and demand-responsive services, interviewing the associated passengers, and developing a discrete choice model to determine the contributory factors that influence their travel decision.

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