Perceived Reality

Understanding the Relationship Between Customer Perceptions and Operational Characteristics

Dea van Lierop and Ahmed El-Geneidy

Ensuring that customers are satisfied with public transit is important, and traditionally transit agencies have assessed customer satisfaction by using questionnaires designed to collect information about users' personal characteristics and perceptions of service. However, these questionnaires assess only individuals' perceptions of transit services, without accounting for the service that users actually experienced. With that in mind, the purpose of this paper is to analyze the drivers of public transit satisfaction for users on the basis of an analysis of customer satisfaction questionnaires, as well as operations data obtained from automatic vehicle location and automatic passenger counter systems for an express bus route in Vancouver, British Columbia, Canada. The goal of the paper is to understand what the main factors influencing customer satisfaction in this context are. The paper questions whether using operations data in parallel with passengers' perception data is useful in understanding customer satisfaction. With a series of logit models, it is found that actual crowding and users' reported satisfaction with crowding are associated with how transit users perceive overall satisfaction with the bus service. Furthermore, the models reveal that car access, age, past use, and users' perceptions of frequency, onboard safety, and cleanliness are also positively associated with overall satisfaction. This study could be useful for public transit planners as it provides new insight into how data derived from customer satisfaction surveys and bus operations can be used to identify which modifiable components of the service can be prioritized to effectively increase riders' overall satisfaction.

As cities around the world plan for sustainable transport options, public transit agencies are becoming increasingly customer oriented to retain current users and attract new ones. Accordingly, many transit agencies are currently focusing on understanding the policies that are needed to increase users' customer satisfaction (*1, 2*). Ensuring that customers are satisfied with public transit is important, as satisfied customers are more likely to demonstrate loyalty by continuing to use the service over time (*3*) and recommend it to others (*4*). Traditionally, transit agencies have assessed customer satisfaction and priorities using questionnaires designed to collect information about users' personal characteristics and perceptions of service. However, these questionnaires assess only individuals' perceptions of transit services, without accounting for the service users actually received. Previous research has revealed that there is a disconnect between the level of satisfaction that users experience in comparison with the improvements in service quality that are introduced by a transit agency (*5, 6*). Therefore, while findings from customer satisfaction questionnaires are useful to assess how transit users experience different aspects of a transit service, customer satisfaction studies alone tend to provide an incomplete picture of actual service performance. With that in mind, the purpose of this study is to analyze the drivers of public transit satisfaction for users of an express bus route in Vancouver, British Columbia, Canada, according to an analysis of data derived from customer satisfaction questionnaires and operations data obtained from automatic vehicle location (AVL) and automatic passenger counter (APC) systems. The goal of the paper is to answer two research questions: the first question asks whether users' perceptions of customer satisfaction along a high-frequency express route in Vancouver match the reality that is reported on the ground. The second question asks whether using data coming from customer satisfaction surveys and operations data can be useful to better understand overall customer satisfaction. To the authors' knowledge, no previous research has combined perception and personal characteristic variables obtained from customer satisfaction questionnaires with operations data to evaluate users' overall satisfaction with a transit service.

This study begins with a review of the literature, focusing on the service factors that are associated with customer satisfaction. The data sources and methods used in the analyses are then discussed and the results of the logistic regressions are presented. Three models are developed to better understand how various elements of travel and personal characteristics are associated with overall customer satisfaction. The first two models include information derived from operations data, whereas the third model includes variables that account for users' levels of satisfaction with specific service attributes. A discussion follows on whether it is beneficial to use AVL and APC and customer satisfaction data in statistical analyses that aim to better understand overall customer satisfaction. Finally, the findings of the analysis and potential policy implications are discussed.

LITERATURE REVIEW

Overall Customer Satisfaction

Research on perceived rider satisfaction is important for the economic well-being of transit agencies, and many studies have shown that customers' level of satisfaction with a service influences their behavioral intentions (*7, 8,* p. 7). Understanding what will make a

School of Urban Planning, McGill University, Suite 400, 815 Sherbrooke Street West, Montréal, Québec H3A 2K6, Canada. Corresponding author: A. El-Geneidy, ahmed.elgeneidy@mcgill.ca.

Transportation Research Record: Journal of the Transportation Research Board, No. 2652, 2017, pp. 87–97.
http://dx.doi.org/10.3141/2652-10

customer satisfied in transit is complex and depends on many factors (*9–11*). Previous research has suggested that perceptions of service quality are related positively to satisfaction (*12–14*) and that satisfaction influences customer loyalty, which includes continuous usage and recommending transit to others (*15, 16*). Furthermore, while satisfaction with specific trip attributes is important for assessing overall trip satisfaction, passengers' individual experiences with transit and sociodemographic characteristics are also important to better understand users' perceptions of service quality (*17*).

Researchers have made attempts to understand overall satisfaction with transit service quality by evaluating passengers' satisfaction with different service attributes (*18–23*). For example, an early study of customer satisfaction of users of the New York City subway found that station cleanliness and reliability directly and indirectly influenced overall satisfaction (*24*). In another study, Weinstein analyzed customer satisfaction in the San Francisco Bay Area and found that on-time performance and service information were particularly important factors explaining service quality (*11*). In addition, Tyrinopoulos and Antoniou used factor analysis and ordered logit modeling to assess customer satisfaction in Athens and Thessaloniki, Greece, and found that satisfaction with transit service coordination, service frequency, accessibility, waiting time, and vehicle cleanliness were especially important aspects in explaining overall satisfaction (*23*). In a separate study, dell'Olio et al. used focus groups and stated preference surveys to assess the quality of service desired by bus users in Santander, Spain, and found that waiting time, cleanliness, and comfort were the most important service factors (*2*). In another Spanish study, de Oña et al. used structural equation modeling to assess the drivers of overall satisfaction of bus users in Granada and highlighted the importance of satisfaction with service quality, comfort, and safety (*1*). Recently, Mouwen found that public transit users in the Netherlands particularly value on-time performance, travel speed, and service frequency (*25*). All of these studies have demonstrated that users' perceptions of, and satisfaction with, specific service attributes are associated with how individuals perceive their overall transit experiences.

Satisfaction with Onboard Experience

While the discussion above has made clear that there are many factors influencing users' overall satisfaction with transit services, onboard experiences specifically are considered to be important for affecting overall satisfaction. Onboard experiences are related to many aspects and range from physical aspects such as vehicle quality (*11, 23, 26, 27*) to interpersonal interactions, such as those with drivers and other personnel (*27–30*). For example, users' perceptions of the comfort of the seats inside the vehicles (*31*) and cleanliness can be included (*11*). Other factors that influence passengers' onboard experiences include in-vehicle temperature (*1, 32*), the quality and physical accessibility of a vehicle (*2, 26, 27, 33*), safety from traffic and crime (*34, 35*), and service information (*11*).

In addition, in-vehicle crowding is repeatedly cited as being one of the most important factors influencing onboard experience in transit (*2, 3, 26*). Crowded vehicles can be perceived as an encroachment on personal space and even a personal safety concern (*36*). A measure similar to crowding is the seating capacity of the vehicle, which has been found to be strongly associated with satisfaction, as users tend to be more satisfied when they are able to sit down (*37, 38*).

METHOD

Context

This study analyzes the customer satisfaction of users of TransLink's 99 B-Line, which is an express bus service that runs east–west in Vancouver. TransLink is the transit authority responsible for Metro Vancouver's regional transportation network, and Figure 1 shows the 99 B-Line, which connects to all of Vancouver's SkyTrain lines (automated rapid transit rail service). This bus service is used as a connection to and from several of Vancouver's busiest employment hubs, including the city's central business district, the University of British Columbia in the west, Vancouver General Hospital at Willow and Cambie Streets, as well as several elementary schools and high schools.

Since the service opened in 1996, the number of users has increased annually, and in 2013 it ran an average of 16 buses per hour and was ranked the most crowded bus in the Greater Vancouver Regional District, with a daily ridership of 55,000 on weekdays (*39*). This route is serviced exclusively by 18-m, low-floor articulated vehicles that have 54 seats and a maximum capacity of 85 passengers (*40*). The travel time of this route is scheduled to be approximately 42 min, and buses run every 3 min during the a.m. and p.m. peaks, and every 4 to 5 min during the daytime off-peak period.

Data

The data used for this study were obtained from TransLink under a data-sharing agreement to be used in academic research. In 2011, the population of the Vancouver census metropolitan area was 2.3 million with 19.7% of commuters using transit for work trips (*41*).

The first data source is derived from TransLink's customer satisfaction surveys, and users of the 99 B-Line were extracted for the purposes of this study. These surveys include information about users' reported levels of satisfaction with various service attributes as well as overall customer satisfaction; they also contain information about users' personal characteristics. TransLink provided the results of 5 years of customer satisfaction questionnaires that were conducted throughout the year from spring 2010 to spring 2015. Only trips operating after the Vancouver Winter Olympic Games, which took place in February 2010, are included in this study. The second data source is operations data that are derived through AVL and APC systems; information about the performance of the bus and the number of passengers boarding and alighting at every stop for the same study period is included. Each data source that is bounded in a box has been collected and analyzed separately in the past, with the customer satisfaction surveys being the responsibility of the marketing department and the operations data that of the operations or planning department. The goal of this study is to break the boundary between these two boxes and combine operations data with customer satisfaction surveys to develop a better understanding of system performance and customer satisfaction.

Customer Satisfaction Surveys

The customer satisfaction surveys were conducted by telephone, and because participation was voluntary, nonresponse bias may be present. The questionnaire is intended to evaluate how residents

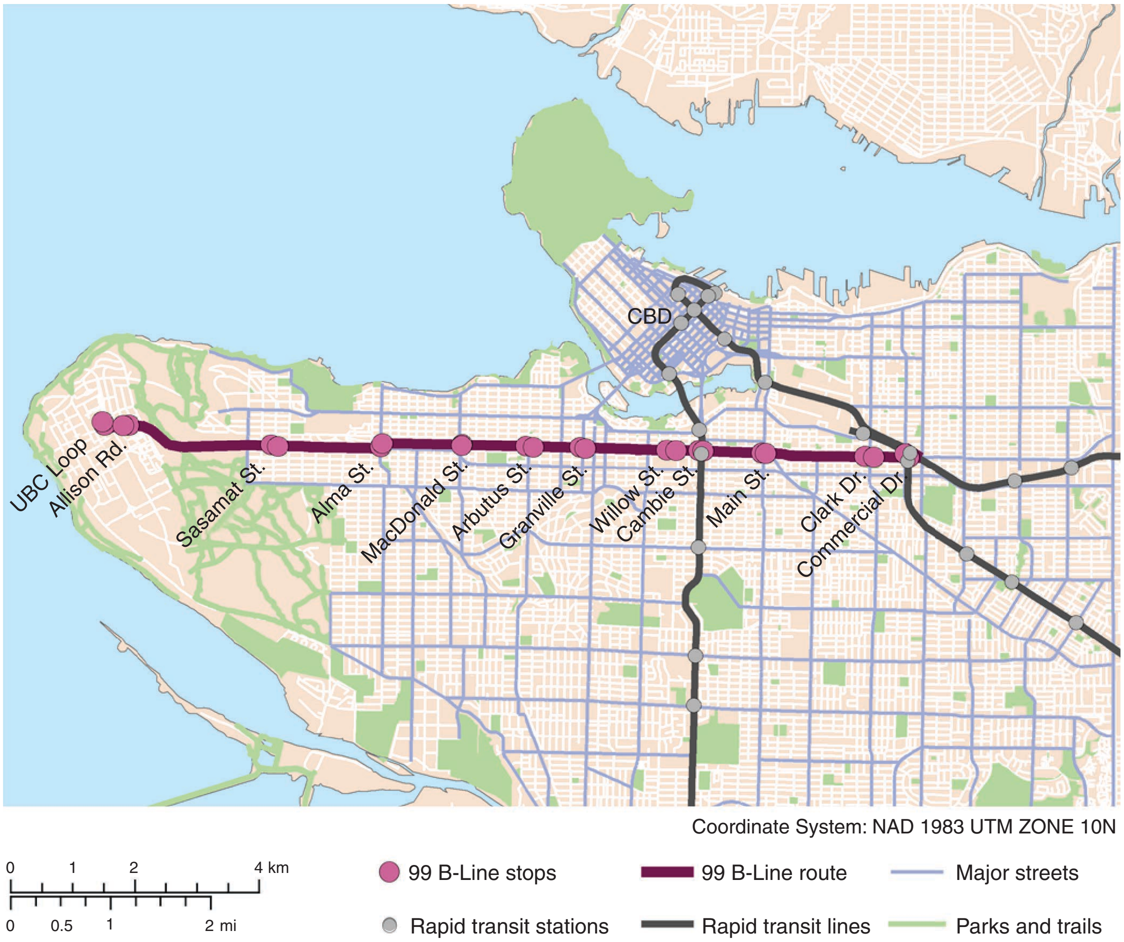


FIGURE 1 Context map for 99 B-Line in Vancouver. (Source: DMTI and City of Vancouver.)

perceive the quality of the transit service provided by the transit agency. It is used by TransLink to better understand users' perceptions of service quality and also as insight into where changes or improvements to service attributes or both can be accomplished to increase customer satisfaction and accordingly increase ridership. To assess customer satisfaction with the transit service, TransLink asks participants to specifically report on the experience of their last or second-to-last trip. The data are a representative random sample of transit users only and, according to TransLink, the data are representative of the greater population (*42*).

Responses from users of the 99 B-Line were extracted from the larger customer satisfaction survey, and data cleaning was required to remove entries that were missing relevant information as well as apparent mistakes in the data, such as entries that were too high for the scale provided (e.g., satisfaction 11/10). The surveys were designed to collect information including socioeconomic status, personal preferences related to transit use, satisfaction with service attributes, and travel habits.

AVL and APC Data

TransLink also provided access to the AVL and APC operations data for the 99 B-Line for the same period of analysis. Since one of the goals of this study is to merge the AVL and APC data with results from the customer satisfaction surveys, it was necessary to aggregate the stop-level operations data so that they could be matched. The data from the customer satisfaction surveys include information about whether a user's reported trip was conducted from Monday to Friday during the a.m. peak from 5:00 to 9:30 a.m., the off-peak from 9:30 a.m. to 3:00 p.m., the p.m. peak from 3:00 to 6:30 p.m., the evening or night after 6:30 p.m., or during the weekend or on a holiday. Operations data were therefore aggregated to match these broad time frames, and for the purposes of this study, only trips taken Monday to Friday on nonholidays between 5:00 a.m. and 6:30 p.m. were analyzed. It was decided to analyze only weekday a.m. peak, daytime off-peak, and p.m. peak, as the sample sizes of customer satisfaction surveys completed during other times were not large enough to be representative. In addition, TransLink's customer satisfaction surveys do not collect information on where passengers board or alight or in which direction trips occur, so the operations data were aggregated for both directions.

To clarify the process of generating operations variables to be matched with the customer satisfaction questionnaires, crowding was used as an example. First, to generate a crowding variable based on the AVL and APC data, the percentage of trips that had a passenger load larger than 85 was calculated; 85 is the maximum capacity of a bus serving the route (*40*). This variable is used to represent extreme crowding. Next, for every time period on every day that a customer satisfaction survey was completed, the average percentage of extremely crowded buses during the past 30 days, for the specific time period, was calculated. For example, for a 99 B-Line user who was surveyed on June 15, 2013, and reported that he or she had used the service within the past 30 days and that the trip had occurred during the morning, the associated crowding variable was based on the level of crowding along the entire route during the a.m. peak from May 15 to June 15, 2013. In other words, the customer satisfaction surveys and the aggregated and rolling 30-day average AVL and APC data were matched on the basis of (*a*) the reported trip time slot and (*b*) the day the customer satisfaction survey was administered. This method makes the assumption that for a given time of day, the single trips described by respondents of the customer satisfaction survey provide a representation of the service characteristics on the route for the past 30 days. By doing so, the method ensures that in this example, every customer satisfaction survey could be linked to a unique crowding variable based not only on a specific day, but also on the average level of crowding during the 30 days before participation in the survey at a specific time of day. The date the survey was administered was recorded, but the date on which survey participants took their last trip was not, although all survey participants were required to have used transit within 30 days of participating in the survey. With this method, variables measuring travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and use of the bicycle rack and ramp were generated.

After the various variables were generated, they were joined to the data derived from the customer satisfaction surveys to better understand the context in which the surveyed users had experienced the transit system with regard to bus operations. The total sample size was 737, with 208 users traveling at the a.m. peak, 292 during the daytime off-peak, and 237 during the p.m. peak.

As mentioned previously, a limitation that was encountered during this process was that the customer satisfaction questionnaires did not ask participants about the travel direction or location of stops that passengers boarded and alighted from, so trip direction could not be distinguished. However, although the operations data revealed that eastbound use during the study period was higher during the p.m. period, and westbound was higher during the a.m. period, this bus service connects many employment hubs and schools and is heavily used to access both directions at all times of the day. Therefore, because the route is heavily used throughout the day in both directions, an average crowding score for all buses operating at a particular time of day was calculated. Figure 2 demonstrates the average load after each stop and reveals that the route consistently has a higher load in the east part of the route than it does in the west, regardless of the direction.

Methods

The way different factors affect the odds that a 99 B-Line bus user will be satisfied or not was determined with the use of a binary logistic modeling technique. The dependent variable of interest was derived from the question on overall satisfaction with the bus trip:

> Thinking about the trip you made on the 99 B-Line bus, on a scale of one to ten, where "ten" means "excellent" and "one" means "very poor," how would you rate it for service overall?

To convert these ratings into discrete binary variables, ratings of seven and below were classified as dissatisfied and eight and above were classified as satisfied. This cutoff was chosen as TransLink considers ratings of 8 to 10 as good to excellent and focuses specifically on analyzing this group (*42*). Other satisfaction ratings of the various service components were kept as continuous variables, but the variables related to personal information were coded as dummy variables for inclusion in the model. Table 1 provides the summary statistics for individuals' socioeconomic information and personal characteristics, which were derived from the customer satisfaction questionnaires.

In addition, Table 2 provides summary statistics of the satisfaction questions included in the customer satisfaction surveys as well as the route information derived from the AVL and APC data. The

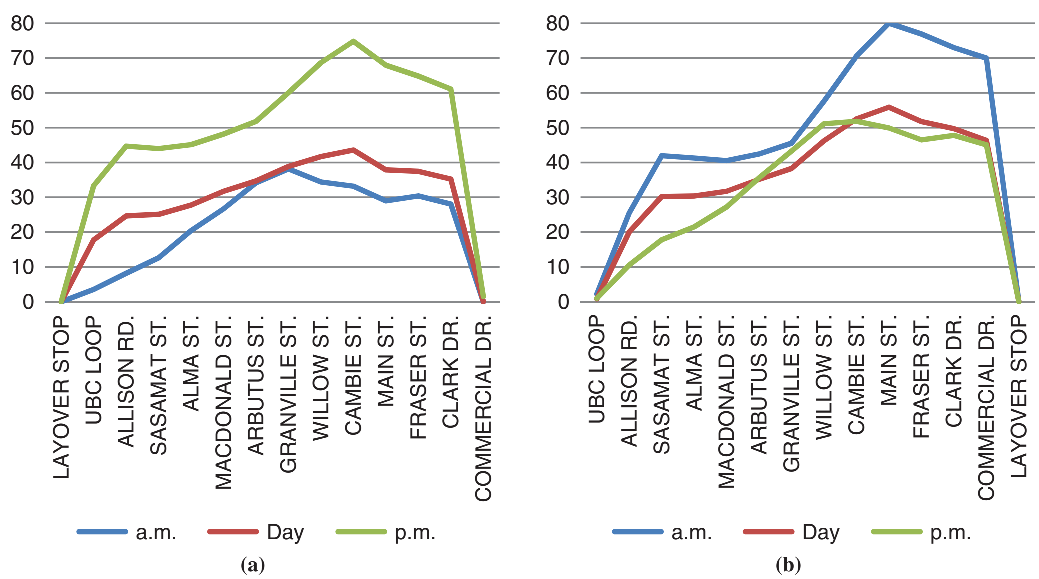
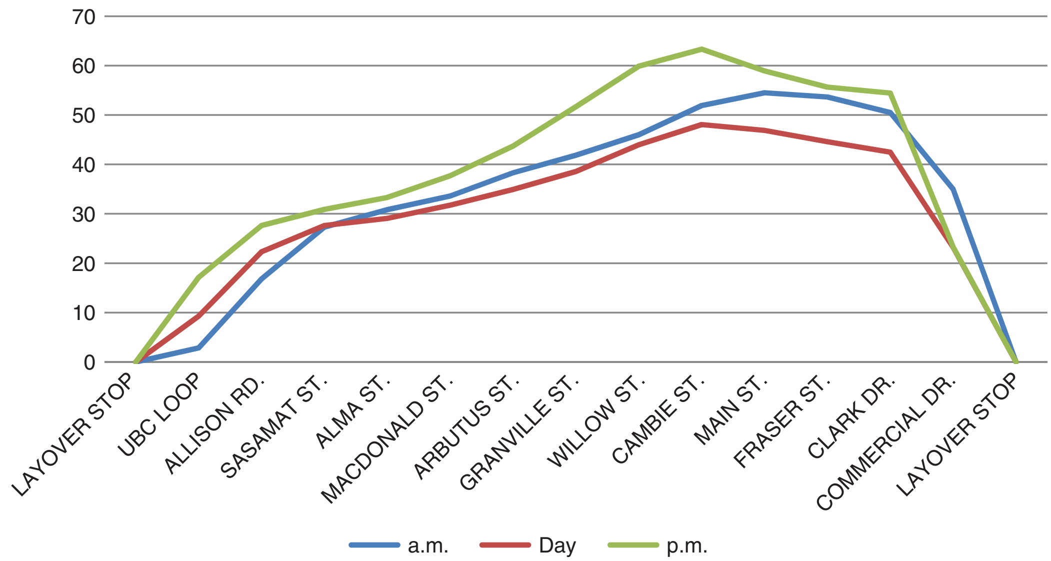


FIGURE 2 Average leave load per stop for (*a*) eastbound trip and (*b*) westbound trip.

(continued)



(c)

FIGURE 2 *(continued)* Average leave load per stop for (*c*) both eastbound and westbound trips.

TABLE 1 Summary Statistics for Users' Socioeconomic Information and Personal Characteristics

Income		Car Access	
Under $15,000	7%	Yes	63%
$15,000–$25,000	7%	No	37%
$25,000–$35,000	8%	Previous Use	
$35,000–$45,000	7%	Less than a year	6%
$45,000–$55,000	7%	2–5 years	26%
$55,000–$65,000	12%	6–10 years	20%
$65,000–$75,000	7%	More than 12 years	49%
$75,000–$85,000	7%	Future Use	
$85,000–$95,000	6%	Definitely not continue as often	1%
$95,000+	32%	Probably not continue as often	2%
Age		Might or might not continue as often	3%
16–24 years old	11%	Probably continue as often as I do now	26%
25–34 years old	12%	Definitely continue as often	67%
35–44 years old	19%	Intention to Use	
45–54 years old	20%	More regularly	15%
55–64 years old	19%	Less regularly	8%
65+ years old	19%	The same	76%
Employment		Trip Time	
Full time	48%	a.m. peak	28%
Part time	15%	Daytime	40%
Student	11%	p.m. peak	32%
No job	25%		
Education			
Some high school	4%		
Graduated from high school	10%		
College	16%		
Some university	13%		
Graduated from university	57%		

percentage of users who are very satisfied with a particular service factor indicates ratings of 8 to 10 on a 10-point scale.

RESULTS

Model Selection

Table 3 demonstrates the results of the logistic models used to uncover important qualities that are associated with overall satisfaction. The dependent variable determines whether a user is satisfied with the 99 B-Line or not, and the results in the table are presented with the odds ratios and 95% confidence intervals for all models and include only the significant variables.

To generate these models, the R statistical program was used and exhaustive model selection processes were run to understand which variables should be used to best understand the causes of satisfaction. Models were compared and selected according to the Akaike information criterion (AIC) and Bayesian information criterion (BIC) scores. In addition, to assess the predictive ability of the models, the error rate was calculated in accordance with maximizing sensitivity and specificity on the receiver operating characteristics curve for each model as a goodness-of-fit statistic.

Surprisingly, the only variable derived from the AVL and APC data that showed statistical significance in these models measuring overall satisfaction was crowding. Although variables measuring travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and use of the bicycle rack and ramp were tested, none of these variables showed statistical significance. The lack of significance in AVL and APC variables other than crowding is likely the result of the high-frequency nature of Route 99 B-Line; this subject will be further discussed in a later section of this paper. In addition, the lack of significance may be because of the absence of directional information of the data, which was explained earlier in the study. Accordingly, only variables that showed a statistically significant relationship with overall satisfaction are reported.

TABLE 2 Summary Statistics for Customer Satisfaction Questions and Route Information

Overall Satisfaction	
Average overall satisfaction	7.5
% of users very satisfied with overall service	60
Satisfaction with the 99 B-Line	
Average satisfaction with the previous trip on the 99 B-Line	7.6
% of users very satisfied with the previous trip on the 99 B-Line	61
Satisfaction with Onboard Safety	
Average satisfaction with onboard safety	8.4
% of users very satisfied with onboard safety	79
Satisfaction with Safety at Stop	
Average satisfaction with safety at the stop	8.4
% of users very satisfied with safety at the stop	78
Satisfaction with Crowding	
Average satisfaction with crowding	5.2
% of users very satisfied with crowding	25
Satisfaction with Reliability	
Average satisfaction with reliability	7.9
% of users very satisfied with reliability	70
Satisfaction with Cleanliness	
Average satisfaction with cleanliness	7.9
% of users very satisfied with cleanliness	64
Satisfaction with Directness	
Average satisfaction with trip directness	8.9
% of users very satisfied with trip directness	88
Satisfaction with Duration	
Average satisfaction with trip duration	8.4
% of users very satisfied with trip duration	80
Satisfaction with Frequency	
Average satisfaction with trip frequency	8.2
% of users very satisfied with trip frequency	76
AVL/APC Data	
Average trip time	35.2 min
Average delay	−1.7 min
Average arrive load	37.2

Another important finding that was revealed during the model selection process was that including data based on users' reported levels of satisfaction with service attributes in the same statistical model with operations data was not useful for gaining a better understanding of what influences overall satisfaction. The reason is that, as expected, satisfaction with various service attributes closely predicted overall satisfaction with the route, and the influence of personal characteristics and the crowding variable was weakened, meaning that the effects of these variables on overall satisfaction could not be observed.

With that in mind, the first model presented in Table 3 assesses only the effect that actual crowding has on satisfaction with the route. The second model builds on the first by adding variables that control for users' personal characteristics. Last, Model 3 describes how personal perceptions of specific service attributes affect trip satisfaction while controlling for bus users' personal characteristics.

Perception and Reality

The purpose of Model 1 is to assess whether the crowding variable has an effect on bus users' trip satisfaction. As expected, it was found that as users experience more crowding, their satisfaction decreases. Next, in Model 2, users' personal characteristics are included and the same relationship between actual crowding and overall satisfaction was observed. Once vehicle access, age, and past usage were controlled for, it was found that for every unit increase in crowding, the odds of being satisfied decreased by 76% (odds ratio (OR) = 0.236, 1 − OR = 0.764, which represents a decrease of 76% for ease of interpretation). The results of Model 2 also demonstrate that the odds of being satisfied for users who do not have access to a car is 40% higher than for those that do have a car, when other variables are controlled for. This result is in line with previous research that suggested that captive users who do not have access to a car and have a low income tend to be more satisfied with bus services compared with choice users (*16*). Also, age is shown to have a significant effect on users' satisfaction. The odds of being satisfied for users 35 to 54 years old is 44% lower than for older users (55+). This finding is unsurprising, as this age group tends to be employed full time and often has many life responsibilities that include travel, such as taking care of both younger and older family members. Furthermore, users' previous behavior is especially important for describing satisfaction, as those who use the service more regularly or the same amount compared with 6 months ago tend to be more satisfied than those who use it less. Income was not included in the model as it is confounded with age. Being a student was also not included because the category "student" was not representative of employment status. The number of months that a user had been taking the bus is strongly related to age and therefore was not included. In addition, users' level of education and future usage did not show statistical significance in the model and therefore were also not included. As was mentioned earlier, several operational variables were also tested, including travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and use of the bicycle rack and ramp, but none showed statistical significance.

Model 3 shows users' overall satisfaction as a function of satisfaction with specific service attributes and personal characteristics. Specific service attributes were included in Model 3 to better understand which service attributes most strongly describe overall satisfaction. Results demonstrate that the likelihood of being satisfied with the 99 B-Line increases as users' satisfaction with frequency, crowding, onboard safety, and cleanliness increases. Satisfaction with the frequency of the trip is strongly related to overall satisfaction, and for every unit increase in satisfaction with frequency (scale of 1 to 10) that a user experiences, the odds that a user is satisfied with the route increases by 68%. This finding is similar for other service attributes in which a one-unit increase in satisfaction with crowding, onboard safety, and cleanliness is associated with, respectively, 40%, 28%, and 20% increases in the odds of being satisfied overall. Although crowding and frequency were not highly correlated (0.4), on the supply side these service attributes are very much theoretically related as increases in frequency decrease passenger load per bus. Yet, on the demand side, these two attributes may have a different meaning for passengers as, conceptually, frequency may be more significantly linked to passengers' perceptions of waiting time. Reported satisfaction with safety and crowding is also not statistically correlated, but previous studies suggest that crowding may influence users to feel unsafe (*36*).

TABLE 3 Logistic Modeling Results

	Satisfaction with Bus Service								
	Model 1 Operations			Model 2 Operations + Personal			Model 3 Perception + Personal		
	OR	2.5%	97.5%	OR	2.5%	97.5%	OR	2.5%	97.5%
Dependent Variable Overall satisfaction: 1–7 = not satisfied; 8–10 = satisfied									
(Intercept)	2.348***	1.711	3.246	1.218	0.658	2.242	0.00007***	0.00001	0.0004
Reality Variables									
Crowding									
Extreme crowding	.166***	.046	.594	.236**	.062	.895	—	—	—
Personal Characteristics									
Vehicle access									
No car access	—	—	—	1.395**	1.014	1.926	1.512**	1.011	2.275
Age									
16–34 years old	—	—	—	0.765	0.507	1.158	1.035	0.623	1.726
35–54 years old	—	—	—	0.559***	0.391	0.797	0.859	0.549	1.346
55+ years old	—	—	—	rc	rc	rc	rc	rc	rc
Past use									
More regularly	—	—	—	2.408***	1.273	4.615	1.944	0.860	4.455
Same	—	—	—	2.270***	1.320	3.923	1.873*	0.940	3.785
Perception Variables									
Satisfaction									
Crowded	—	—	—	—	—	—	1.403***	1.294	1.526
Frequency	—	—	—	—	—	—	1.682***	1.445	1.975
Onboard safety	—	—	—	—	—	—	1.280***	1.097	1.502
Cleanliness	—	—	—	—	—	—	1.199**	1.034	1.393
Goodness-of-fit measures	$N = 737$ AIC: 979.9 BIC: 989.1 Error rate: .13[a]			$N = 737$ AIC: 964.2 BIC: 996.4 Error rate: .13[a]			$N = 737$ AIC: 666.6 BIC: 712.6 Error rate: .14[a]		

NOTE: — = not in model, rc = reference category.
[a]Thresholds for error rates are based on maximizing sensitivity and specificity as indicated by ROC curves.
* = .05; ** = .01; *** = .001.

Furthermore, safety, comfort, and cleanliness have repeatedly been found in the literature to be strongly associated with user satisfaction (*9, 23, 27*).

As discussed earlier in the section on summary statistics and shown in Table 2, the customer satisfaction survey also collected information about users' satisfaction with bus reliability, trip duration, directness of the route, and off-board safety. The variable measuring reliability was not included in the model as it was highly correlated with frequency (0.75). In addition, while frequency is a somewhat simple term for users to understand and assess, evaluating reliability is a comparatively more complex issue as it involves knowledge of the full public transport schedule over time (*43*). Furthermore, off-board safety was correlated with onboard safety (0.67), and since onboard trip satisfaction was being assessed, this variable was chosen accordingly. In addition, satisfaction with the duration and directness of the route was not found to be significant and was, therefore, not included in the model. The results of Model 3, hence, demonstrate the service attributes that are most important for increasing users' overall satisfaction with the 99 B-Line: frequency of service, crowding, onboard safety, and cleanliness.

In addition, the personal characteristics in Model 3 revealed that the odds of users who do not have access to a car being satisfied are 51% greater compared with those of users who do have access to a car. The actual crowding variable is not used in Model 3 as it is strongly related to users' satisfaction with crowding. However, while most of the users' personal characteristics are not significant in Model 3, these variables are essential to include as control variables. Overall, Models 1 and 2 have revealed that actual crowding is associated with overall satisfaction, and Model 3 has confirmed that users' satisfaction with crowding is also important for predicting their perceptions of overall satisfaction with the route.

The results of Models 1 through 3 demonstrate how various factors are associated with users' overall satisfaction with the route. The goodness-of-fit measures revealed that statistically Model 3 is better at predicting satisfaction compared with Models 1 and 2. The reason is that the service quality variables included in Model 3 are derived from the same data source as the dependent variable—the customer satisfaction survey. As expected, a strong association between the components of satisfaction (frequency of service, crowding, onboard safety, and cleanliness) and overall satisfaction is revealed. Therefore, because Models 1 and 2 do not model the effects of the components of satisfaction on overall satisfaction, the relationship between the operations variable and overall customer satisfaction can be observed. This finding is important as it demonstrates the benefit of combining data derived from operations and customer satisfaction questionnaires.

DISCUSSION OF RESULTS

Overall, the results of Models 1 through 3 help one better understand the determinants of satisfaction for users of the 99 B-Line in Vancouver, and they provide additional insight into the research questions that were set out to be explored. These questions asked (*a*) whether users' perceptions match the reality that is reported on the ground and (*b*) how data derived from customer satisfaction surveys and AVL and APC systems can be used to better understand overall customer satisfaction.

Perceived and Actual Crowding

Reflecting on the first research question, it was found that in the case of Vancouver's 99 B-Line, perception does appear to be highly associated with what is happening on the ground. Because of the high-frequency nature of the route, the relationship between perception and reality could be tested only for crowding (the variable that varies greatly throughout the day). Accordingly, the results of Models 1 through 3 demonstrate that when personal characteristics are controlled for, actual crowding and users' satisfaction with crowding are strongly associated with users' overall satisfaction with their experience on board the 99 B-Line.

Because the variables describing actual crowding and perceived satisfaction of crowding could not be included in the same model, summary statistics were used to further investigate this particular relationship. Figure 3 demonstrates the existing variation in satisfaction and the variation in actual crowdedness during different times of the day. In Models 1 through 3, a variable describing the time of day was not included, as crowding is strongly associated with time of day, and therefore only one of these two variables could be included in the models. Yet, a detailed analysis of crowding and time reveals that while actual crowding is much higher during the peak periods compared with the off-peak period, satisfaction does not vary as much. In other words, Figure 3 demonstrates that while 30% of buses are extremely crowded at peak periods, compared with only 9% at the off peak, overall satisfaction fluctuates only between 7.4 and 7.9, and satisfaction with crowding between 4.8 and 5.6 out of 10, respectively. While it is expected that overall satisfaction and satisfaction with crowding would increase as actual crowding decreases, it is unexpected that there is no significant change in the satisfaction variables between the peak and off-peak travel times.

Figure 3 demonstrates that the variation in actual crowding changes much more than that of perceived overall satisfaction and with crowding during different time periods. This observation raises an important question as to why users' levels of perceived satisfaction with crowding and the trip overall do not reflect actual crowding. Although user satisfaction does increase when there is less crowding, the relative changes in satisfaction during the day do not reflect the extreme differences in actual levels of crowding between time periods. One possible explanation for why users on average remain highly satisfied with the trip overall when there is a high level of extreme crowding is that their expectations about crowding change during the day. For example, it might be possible that during the peak periods, it is enough for users to board the bus without waiting in line, whereas during the off-peak, satisfaction depends more on whether or not there is a seat available once they board. Another explanation could be that different populations are using the bus during the peak and off-peak periods. Therefore, to understand whether it was individuals' expectations or differences in their personal characteristics that influenced how users experience satisfaction during the day, a series of *t*-tests was used to compare the characteristics of satisfied users (≥8/10) traveling at the a.m. peak and p.m. peak compared with all users traveling during the daytime off-peak. While some differences between specific employment, age, and income categories were observed, overall, few statistically significant differences were observed between time periods. Furthermore, it was

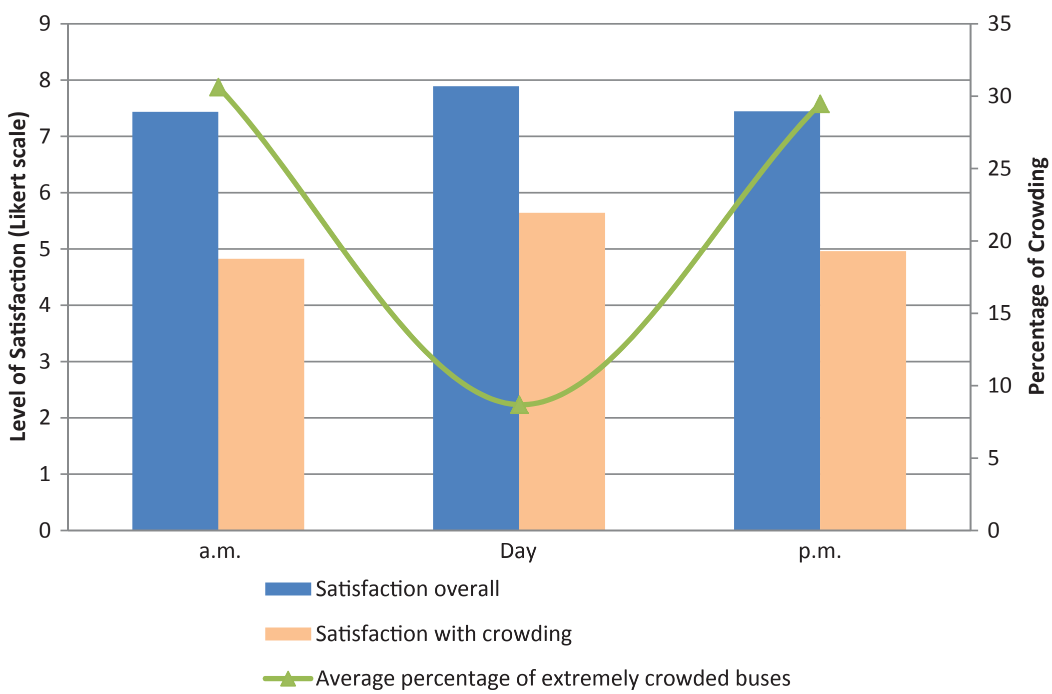


FIGURE 3 Variation in satisfaction versus variation in actual crowdedness.

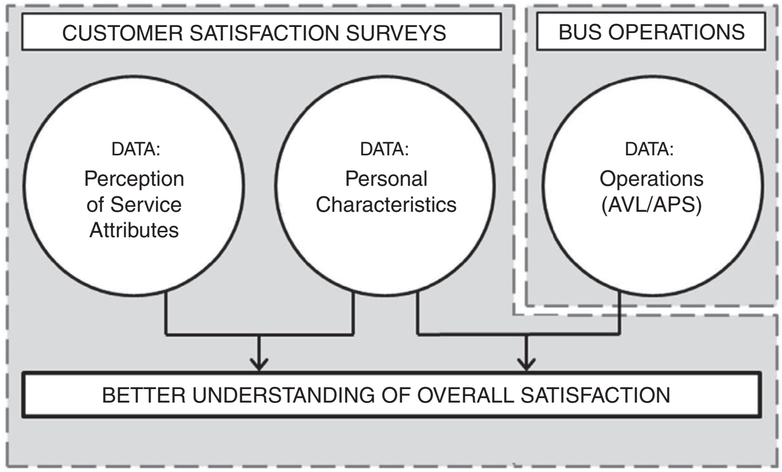


FIGURE 4 How to assess customer satisfaction.

found that, in general, the populations traveling during the three time periods were mostly homogeneous.

The lack of differences between the groups traveling during different time periods could suggest that the expectations of users may be changing depending on when they use the service. This hypothesis is important for transit agencies to consider as it means that developing thresholds of what users consider acceptable levels of crowding may change during the time of day. Moreover, these thresholds can be used to set crowding standards and are useful for indicating when transit agencies must dispatch an additional bus to maintain customers' expectations with regard to crowding. Flexible thresholds for service variables may therefore be important for transit agencies to consider when analyzing customer satisfaction surveys, and future research is needed to better understand this hypothesis.

Combining Data Sources

With regard to the second research question concerning data sources, Figure 4 demonstrates how data derived from customer satisfaction surveys and operations systems can be used together to effectively assess user satisfaction with a bus service. The figure demonstrates that perception variables such as satisfaction with crowding and cleanliness are derived solely from customer satisfaction questionnaires and can be collected and analyzed together with data describing personal characteristics such as age and income. However, nonperception variables include personal characteristics and operations data that measure actual crowding and, for example, on-time performance. These nonperception variables can be analyzed in the same model, and customer satisfaction analyses that use these three types of data are more likely to accurately depict what influences users to be satisfied with a particular route, compared with analyses that are based primarily on users' perceptions of service quality.

CONCLUSION

This study has provided insight into how to use data obtained from customer satisfaction surveys as well as operations data to better understand the drivers of overall customer satisfaction. The findings suggest that variables measuring users' perception about service quality are most useful if they are analyzed separately from variables that are not subjective and not based on users' perceptions. The findings from this study suggest that satisfaction with crowding, service frequency, onboard safety, and cleanliness is particularly important for increasing overall satisfaction. In addition, actual crowding is associated with overall satisfaction, as is car access, age, and past use. Finally, based on testing the differences between the populations using transit at different times of the day, results suggest that users' expectations of crowding may change during the time of day. It is important for transit agencies to understand which service attributes most strongly affect satisfaction on particular routes as increases in satisfaction have been found to increase overall loyalty (*16, 27, 44*). Furthermore, one finding is that users who are between the ages of 35 and 54 tend to be less satisfied than other users. This finding is important for transit agencies to consider, as it suggests that users in this age group are somehow being disappointed by the service, which is a problem because unsatisfied users tend to defect. Thus, increasing the satisfaction of this group could be important to motivate continued ridership as transit use tends to decrease with age and lifestyle changes (*45*).

LIMITATIONS AND FUTURE RESEARCH

In the future, studies should assess multiple routes with more variation to be able to test the variety of data that can be derived from AVL and APC data. For example, if researchers wish to better understand the relationship between users' satisfaction with actual on-time arrival and users' satisfaction with on-time arrival, it would be necessary to match customer satisfaction surveys and operations data from multiple, and less homogeneous, bus routes rather than a single high frequency route. In addition, this study converted the satisfaction variable from a 10-point scale into a binary scale, and in future research it may be interesting to use ordered logit models for similar analyses. However, in this study these ratings were converted into discrete binary variables because the transit agency in this study (TransLink) considers ratings of 8 to 10 as good to excellent and focuses specifically on analyzing that group. Therefore, to increase the policy relevance of this research, the binary approach set by the transit agency was followed. Furthermore, the method used in this study makes the assumption that for a given time of day the single trips described by respondents of the customer satisfaction survey provide a representation of the service characteristics on the route for the past 30 days. To improve data matching, future studies would benefit from using fare card data to better map individuals to specific trips and thereby further assess the relationship between customer satisfaction and operations data. However, when it is not possible to match exact customer satisfaction survey data to operations data for the same trip, then this method has been shown to be useful. Furthermore, to the authors' knowledge, this study is a first attempt to combine customer satisfaction data with AVL and APC data, and to improve these kinds of analyses in the future, transit agencies should collect information in the customer satisfaction questionnaires about where and when passengers board and alight. With the appropriate data, studies could be more accurate and recommendations could be developed to assess specific areas along individual routes.

Overall, the results of this study demonstrate the complex relationship between users' perceptions of transit and what is actually happening on the ground. These findings suggest that users' expectations of transit may be changing during the day, and results could be used to assist transit agencies in identifying which modifiable components of the service should be prioritized to effectively increase overall rider satisfaction through service improvements.

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The Standing Committee on Public Transportation Marketing and Fare Policy peer-reviewed this paper.