Perceived reality: *Understanding the relationship between customer perceptions and operational characteristics*

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ABSTRACT

Ensuring that customers are satisfied with public transit is important, as satisfied customers are likely to demonstrate loyalty by continuing to use the service over time. Traditionally, transit agencies have assessed customer satisfaction using questionnaires designed to collect information about users' personal characteristics and perceptions of service. However, these questionnaires only assess individuals' perceptions of transit services, without accounting for the service that users actually experienced. With this in mind, the purpose of this paper is to analyze the drivers of public transit satisfaction among users based on an analysis of customer satisfaction questionnaires, as well as operations data obtained from automatic vehicle location (AVL) and automatic passenger counter (APC) systems for an express bus route in Vancouver, Canada. We seek to understand what are the main factors influencing customer satisfaction in this context, and question whether using operations data in parallel with passengers' perception data is useful to understand customer satisfaction. Using a series of logit models we find that both actual crowding and users' reported satisfaction with crowding influence 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, on-board safety, and cleanliness also influence 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 in order to effectively increase riders' overall satisfaction.

KEY WORDS: Customer satisfaction; crowding; AVL/APC; public transit; bus; service attributes

INTRODUCTION

As cities around the world plan for sustainable transport options, public transit agencies are becoming increasingly customer-oriented in order to retain current users and attract new ones. Accordingly, many transit agencies are currently focusing on understanding the policies that are needed to increase customer satisfaction among users (*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 by recommending 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 only assess 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 to 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 this in mind, the purpose of this paper is to analyze the drivers of public transit satisfaction among users of an express bus route in Vancouver, Canada based on an analysis of data derived from both customer satisfaction questionnaires, and operations data obtained from automatic vehicle location (AVL) and automatic passenger counter (APC) systems. We seek to answer two research questions: the first asks whether users' perceptions of customer satisfaction along a high-frequency express route in Vancouver, Canada match the reality that is reported on the ground; and, the second questions whether using both data coming from customer satisfaction surveys and operations data can be useful to better understand overall customer satisfaction. To our knowledge, no previous research has combined perception and personal characteristic variables obtained from customer satisfaction questionnaires together with operations data to evaluate users' overall satisfaction with a transit service.

We start this paper with a review of the literature focusing on the service factors which influence customer satisfaction. Second, we discuss the data sources and methods used in the analyses. Third, we present our results of logistic regressions, where we develop three models to better understand the influence of various elements on overall customer satisfaction; the first two models include information derived from operations data, whereas the third includes variables that account for users' levels of satisfaction with specific service attributes. This is followed by a discussion of whether it is beneficial to use both AVL/APC and customer satisfaction data in statistical analyses that aim to better understand overall customer satisfaction. Finally, we discuss the findings of the analysis and potential policy implications.

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 a customers' level of satisfaction with a service influences their behavioral intentions (*7; 8*). Understanding what will make a customer satisfied in transit is complex and depends on many different factors (*9-11*). Previous research has suggested that perceptions of service quality are positively related 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 socio-demographic 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 both directly and indirectly influenced overall satisfaction (*24*). In another study, Weinstein *(11)* analysed customer satisfaction in the San Francisco Bay Area and found that on-time performance and service information were particularly important factors explaining service quality. In addition, Tyrinopoulos and Antoniou *(23)* 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. In a separate study, dell'Olio, Ibeas and Cecín (*2)* 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. In another Spanish study, de Oña et al. (*1)* used Structural Equation Modelling to assess the drivers of overall satisfaction amongst bus users in Granada and highlighted the importance of satisfaction with service quality, comfort, and safety. More recently, Mouwen (*25)* found that public transit users in the Netherlands particularly value on-time performance, travel speed, and service frequency. All of these studies have demonstrated that users' perceptions (satisfaction) of specific service attributes influence how individuals perceive their overall transit experience.

Satisfaction with on-board experience

While the discussion above has made clear that there are many factors influencing users' overall satisfaction with transit services, on-board experiences specifically, are considered to be important for affecting overall satisfaction. On-board experiences are influenced by many aspects and range from the 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, they can include users' perceptions of the comfort of the seats inside the vehicles (*31*), and cleanliness (*11*). Other factors that influence passengers' on-board 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*).

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

METHODOLOGY

Context

This study analyzes customer satisfaction among users of TransLink's 99 B-Line, which is an express bus service that runs east-west in Vancouver, Canada. 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 (UBC) in the west, Vancouver General Hospital at Willow and Cambie Streets, as well as several elementary schools and high schools.

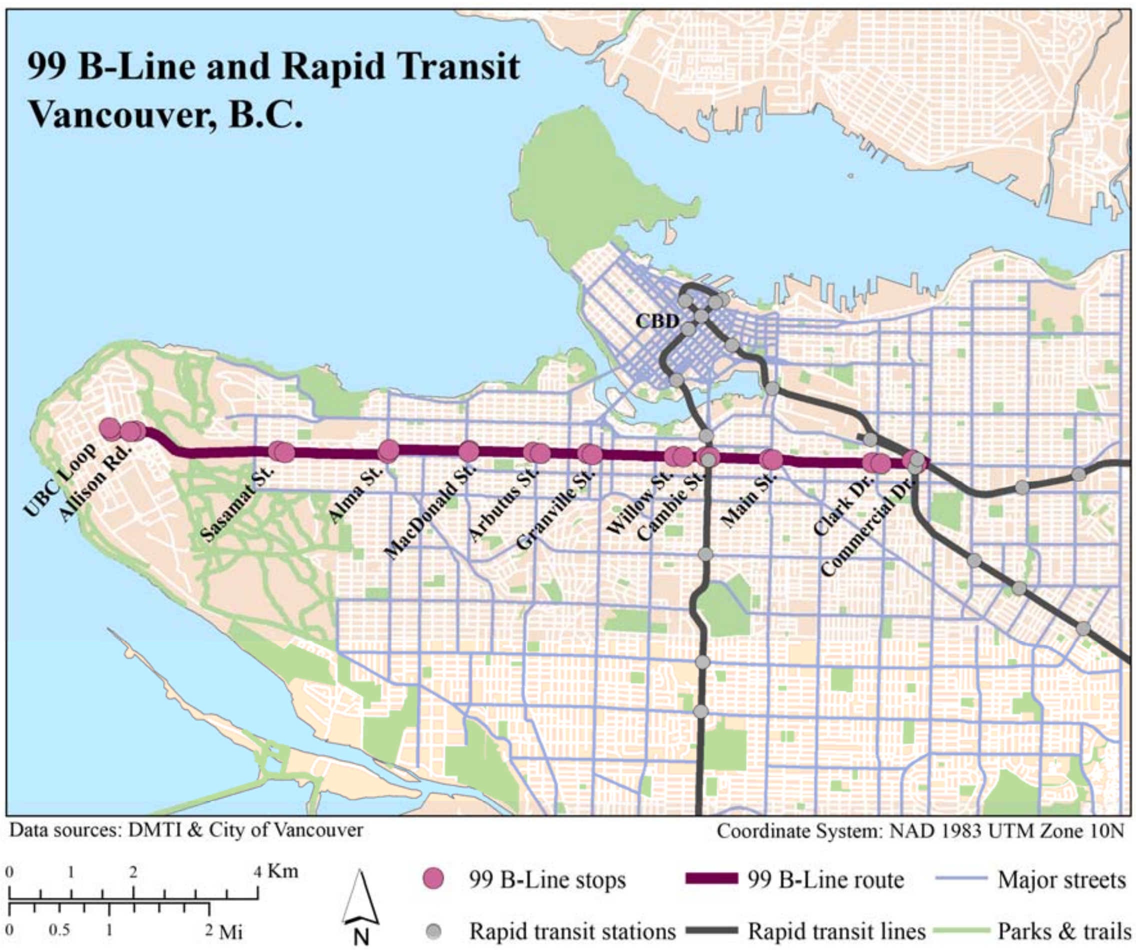

Fig. 1: Context map for 99 B-Line in Vancouver, B.C.

Since it 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 meter 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 minutes, and buses run every three minutes during the AM and PM peaks, and every four-five minutes during the day-time off-peak period.

Data

The data used for this study was obtained from TransLink under a data sharing agreement to be used in academic research. In 2011, the population of the Vancouver census metropolitan area (CMA) was 2,313,328 with 19.7 percent of the commuters using transit for work trips (*41*).

The first data source is derived from TransLink's customer satisfaction surveys. These surveys include information about users' reported levels of satisfaction with various service attributes as well as overall customer satisfaction, and also contain information about users' personal characteristics. TransLink provided the results of five 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 occurred in February 2010 are included in this study. The second data source is operations data which is derived through AVL/APC systems and includes information about the performance of the bus and the number of passengers boarding and alighting at every stop for the same study period. It is important to note that traditionally customer satisfaction and operations data are collected and analyzed separately, with customer satisfaction surveys being the responsibility of the marketing department and operations data that of the operations or planning department. The goal of our study is to combine operations data with customer satisfaction surveys to develop a better understanding of system performance and overall customer satisfaction.

Customer satisfaction surveys

The customer satisfaction surveys were conducted by telephone, and because participation was voluntary, non-response bias may be present. The questionnaire is intended to evaluate how residents 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 and/or improvements to service attributes 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 their experience of their last or second to last trip. The data is a representative random sample of transit users only, and, according to TransLink it is 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, but not limited to, socioeconomic status, personal preferences related to transit use, satisfaction with service attributes and travel habits.

AVL/APC data

TransLink also provided us with access to the AVL/APC operations data for the 99 B-Line for the same period of analysis. Since one of the goals of the paper is to merge the AVL/APC data with results from the customer satisfaction surveys, it was necessary to aggregate the stop-level operations data so that it could be matched. The data from the customer satisfaction surveys includes information about whether a user's reported trip was conducted from Monday to Friday during the AM peak from 5:00-9:30AM, during the off-peak from 9:30AM-3:00PM, the PM peak from 3:00-6:30PM, the evening or night after 6:30PM, or during the weekend or on a holiday. Operations data was therefore aggregated to match these broad timeframes, and for the purposes of this study, we analyzed only trips taken Monday to Friday on non-holidays between 5:00AM and 6:30PM. We chose to analyze only weekday AM peak, day-time off-peak, and PM 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 regarding where passengers board or alight, or in which direction trips occur, so the operations data was aggregated for both directions.

To clarify the process of generating operations variables to be matched with the customer satisfaction questionnaires, we use crowding as an example. First, to generate a crowding variable based on the AVL/APC data, we calculated the percentage of trips that had a passenger load larger than 85, which 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, we calculated the average percentage of extremely crowded buses over the past 30 days, for the specific time period. For example, for a 99 B-Line user who was surveyed on June 15th 2013 and reported that he or she had used the service within the last thirty days and that their trip had occurred during the morning, the associated crowding variable was based on the level of crowding along the entire route during the AM peak from May 15th to June 15th 2013. In other words, the customer satisfaction surveys and the aggregated and rolling 30-day average AVL/APC data were matched based on (1) the reported trip time slot, and (2) 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 the 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 the average level of crowding over thirty days prior to participating in the survey at a specific time of day. While the date the survey was administered was recorded, the date on which survey participants took their last trip was not, although all survey participants were required to have used transit within thirty days of participating in the survey. Using this method we generated variables measuring travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and usage of the bicycle rack and ramp.

After generating the various variables, we joined them to the data derived from the customer satisfaction surveys in order to better understand the context within which the surveyed users had experienced the transit system with regard to bus operations. This yielded a total sample size of 737, with 208 users travelling at the AM peak, 292 at during the day-time off-peak, and 237 during the PM peak.

As mentioned before, a limitation that we 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 usage during the study period was higher during the PM, and westbound was higher during the AM, this bus service connects many employment hubs and schools and is heavily used to access both directions at all times of the days. Therefore, because the route is heavily used throughout the day in both directions, we calculated an average crowding score for all buses operating at a particular time of day. 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.

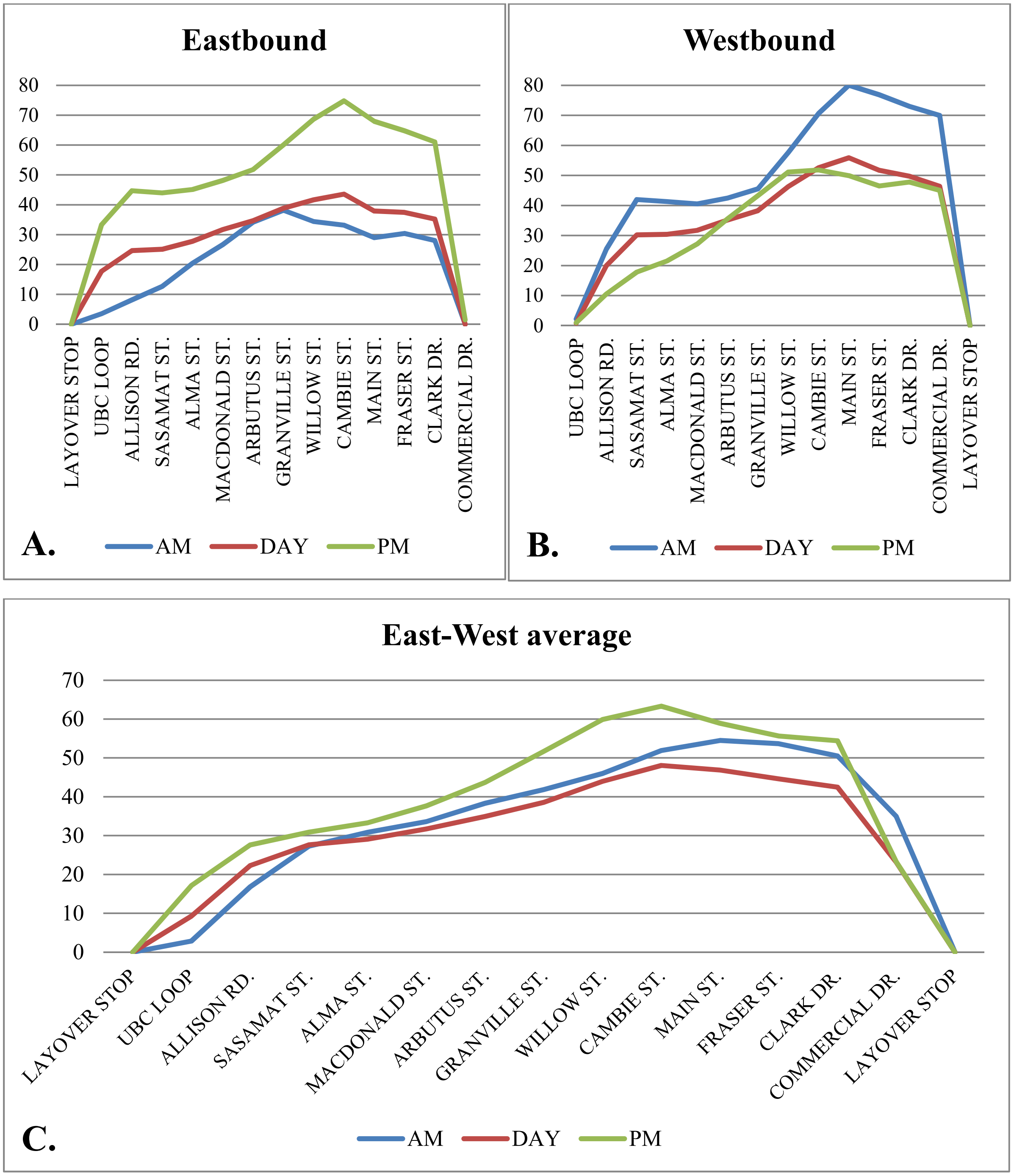

Fig. 2: A. Eastbound average leave load per stop, B. Westbound average leave load per stop, and C. Average for both eastbound and westbound trips

Methods

Using a binary logistic modelling technique we determined how different factors impact the odds that a 99 B-Line bus user will be satisfied or not. 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, we classified ratings of seven and below as dissatisfied and eight and above as satisfied. This cut-off was chosen as TransLink considers ratings of eight to ten as good to excellent, and focuses specifically on analyzing this group (*42*). We kept other satisfaction ratings of the various service components as continuous variables, but coded the variables related to personal information as dummy variables for inclusion in the model. Table 1 provides the summary statistics for individuals’ socio-economic information and personal characteristics that was derived from the customer satisfaction questionnaires.

Table 1: Summary statistics for users’ socio-economic 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%		
$35,000-$45,000	7%		
$45,000-$55,000	7%	**PREVIOUS USAGE**	
$55,000-$65,000	12%	Less than a year	6%
$65,000-$75,000	7%	2-5 years	26%
$75,000-$85,000	7%	6-10 years	20%
$85,000-$95,000	6%	More than 12 years	49%
$95,000 +	32%		
AGE		**FUTURE USE**	
16-24 years old	11%	Definitely not continue as often	1%
25-34 years old	12%	Probably not continue as often	2%
35-44 years old	19%	Might or might now continue as often	3%
45-54 years old	20%	Probably continue as often as I do now	26%
55-64 years old	19%	Definitely continue as often	67%
65+ years old	19%		
EMPLOYMENT		**INTENTION TO USE**	
Full time	48%	More regularly	15%
Part time	15%	Less regularly	8%
Student	11%	The same	76%
Non job	25%		
EDUCATION		**TRIP TIME**	
Some high school	4%	AM peak	28%
Graduated high school	10%	Day time	40%
College	16%	PM peak	32%
Some university	13%		
Graduated university	57%		

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/APC data.

Table 2 Summary statistics for customer satisfaction questions and route information

OVERALL SATISFACTION		SATISFACTION WITH RELIABILITY	
Average overall satisfaction	75%	Average satisfaction with reliability	79%
% of users very satisfied with overall service	60%	% of users very satisfied with reliability	70%
SATISFACTION WITH THE 99 B-LINE		**SATISFACTION WITH CLEANLINESS**	
Average satisfaction with the previous trip on the 99 B-Line	76%	Average satisfaction with cleanliness	79%
% of users very satisfied with previous trip on the 99 B-Line	61%	% of users very satisfied with cleanliness	64%
SATISFACTION WITH ON BOARD SAFETY		**SATISFACTION WITH DIRECTNESS**	
Average satisfaction with on board safety	84%	Average satisfaction with trip directness	89%
% of users very satisfied with on board safety	79%	% of users very satisfied trip directness	88%
SATISFACTION WITH SAFETY AT STOP		**SATISFACTION WITH DURATION**	
Average satisfaction with safety at the stop	84%	Average satisfaction with trip duration	84%
% of users very satisfied with safety at the stop	78%	% of users very satisfied trip duration	80%
SATISFACTION WITH CROWDING		**SATISFACTION WITH FREQUENCY**	
Average satisfaction with crowding	52%	Average satisfaction with trip frequency	82%
% of users very satisfied with crowding	25%	% of users very satisfied trip frequency	76%
AVL/APC DATA			
Average trip time	35.2mins		
Average delay	-1.7mins		
Average arrive load	37.2		

RESULTS

Model selection

Table 3 demonstrates the results of the logistic models used to uncover important qualities that impact 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, we used R statistical program and ran an exhaustive model selection processes to understand which variables should be used to best understand the causes of satisfaction. Models were compared and selected based on AIC and BIC scores. In addition, in order to assess the predictive ability of our models, we calculated the error rate based on maximizing sensitivity and specificity on the receiver operating characteristics (ROC) curve for each model as a Goodness-of-Fit statistic.

Surprisingly, the only variable derived from the AVL/APC data that showed statistical significance in these models measuring overall satisfaction was crowding. Although we tested variables measuring travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and usage of the bicycle rack and ramp, none of these variables showed statistical significance. The lack of significance in AVL/APC variables other than crowding is likely due to the high frequency nature of route 99 B-Line, which will be further discussed in the discussion section of the paper. In addition, lack of significance may also be due to the absence of directional information the data, which was explained earlier in the paper. Accordingly, we report only variables that showed a statistically significant impact on overall satisfaction.

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 together in the same statistical model with operations data was not useful for better understanding what influences overall satisfaction. This is because, as expected, satisfaction with various service attributes closely predicted overall satisfaction with the route, and the influence of personal characteristics and the crowding variable were weakened, meaning that these variables' effects on overall satisfaction could not be observed.

With this 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 model by adding variables that control for users' personal characteristics. Lastly, model 3 describes how personal perceptions of specific service attributes affect trip satisfaction while controlling for bus users' personal characteristics.

Table 3: Logistic modelling results

Satisfaction with bus service	MODEL 1	MODEL 2	MODEL 3

DEPENDENT VARIABLE Overall satisfaction: where 1-7 = not satisfied, and 8-10 = satisfied									
	OPERATIONS			OPERATIONS +PERSONAL			PERCEPTION + PERSONAL		
	OR	2.5 %	97.5 %	OR	2.5 %	97.5 %	OR	2.5 %	97.5 %
(Intercept)	2.348 ***	1.711	3.246	1.218	0.658	2.242	0.00007***	0.00001	0.0004
REALITY VARIABLES									
Crowding									
Extreme crowding	0.166**	0.046	0.594	0.236*	0.062	0.895			
PERSONAL CHARACTERISTICS									
Vehicle access	---	---	---						
No car access				1.395*	1.014	1.926	1.512*	1.011	2.275
Age	---	---	---						
16-34 yrs old				0.765	0.507	1.158	1.035	0.623	1.726
35-54 yrs old	---	---	---	0.559**	0.391	0.797	0.859	0.549	1.346
55+ yrs old	---	---	---	NA	NA	NA	NA	NA	NA
Past use	---	---	---						
More regularly				2.408**	1.273	4.615	1.944	0.860	4.455
The 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
On-board 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†			*N=737* AIC: 964.2 BIC: 996.4 Error rate: .13†			*N=737* AIC: 666.6 BIC: 712.6 Error rate: .14†		
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·'* *--- = Not in model, NA = Reference Category* *†Thresholds for error rates are based on maximizing sensitivity and specificity as indicated by ROC curves.*									

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, we find that as users experience more crowding, their satisfaction decreases. Next, in model 2, we include users' personal characteristics and we observe the same relationship between actual crowding and overall satisfaction. Once we control for vehicle access, age, and past usage, we find that for every unit increase in crowding, the odds of being satisfied decrease by 76% (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 car is 40% higher than those that do have a car, when other variables are controlled for. This 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 to choice users (*16*). Also, age is shown to have a significant effect on users' satisfaction. The odds of being satisfied for users aged 35-54 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 to six 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 we also tested several operational variables including travel time, variation in travel time, passenger activity, on-time performance, variation in on-time performance, and usage 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. We included specific service attributes in model 3 to better understand which service attributes most strongly describe overall satisfaction. The results demonstrate the likeliness of being satisfied with the 99 B-Line increase as users' satisfaction with frequency, crowding, on board safety, and cleanliness increases. Frequency of the trip has the strongest impact on overall satisfaction and for every unit increase in satisfaction with frequency (Likert-Scale 1-10) 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 where a one unit increase in satisfaction with crowding, on-board safety, and cleanliness is associated with 40%, 28%, 20% increases in the odds of being satisfied overall respectively. Interestingly, 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 are also not statistically correlated, but previous studies have suggested that crowding may influence users to feel unsafe (*36*). Furthermore, safety, comfort, and cleanliness have repeatedly been found in the literature to have a strong influence on user satisfaction (*9; 23; 27*).

As was 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, the 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 on-board safety (0.67), and since we were assessing on-board trip satisfaction, we chose this variable accordingly. In addition, both satisfaction with the duration and directness of the route were not found to be significant, and were therefore not included in the model. The results of model 3 therefore demonstrate the service attributes that are most important for increasing users' overall satisfaction with the 99 B-Line are frequency of service, crowding, on-board safety, and cleanliness.

In addition, the personal characteristics in model 3 revealed that with regard to overall satisfaction, users who do not have access to a car have an increased odds of 51% compared to those who do have access to a car. Note that 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 does influence overall satisfaction, and model 3 has confirmed that users' satisfaction with crowding is also important for predicting users' perceptions of overall satisfaction with the route.

The results of models 1-3 demonstrate how various factors influence users' overall satisfaction with the route. The Goodness-of-Fit measures revealed that statistically model 3 is better at predicting satisfaction compared to models 1 and 2. This is due to the fact that the service quality variables that are 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, on-board 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 is an important finding, as it demonstrates the benefit of combing data derived from both operations and customer satisfaction questionnaires.

DISCUSSION

Overall, the results of models 1-3 help us better understand the determinants of satisfaction for users of the 99 B-Line in Vancouver, and provide additional insight into the research questions that we set out to explore which asked (1) whether users' perceptions match the reality that is reported on the ground, and (2) and how data derived from customer satisfaction surveys and AVL/APC systems can be used to better understand overall customer satisfaction.

Perceived and actual crowding

Reflecting on our first research question, we have 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. Due to the high frequency nature of the route, the relationship between perception and reality could only be tested for crowding (the variable that greatly varies throughout the day). Accordingly, the results of models 1-3 demonstrate that both actual crowding and users' satisfaction with crowding strongly influence users' overall satisfaction with their experience on-board the 99 B-Line when controlling for personal characteristics.

Because the variables describing actual crowding and perceived satisfaction of crowding could not be included in the same model, we use summary statistics 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. It should be noted that in models 1-3 we did not include a variable describing the time of day, 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 crowing is much higher during the peak periods compared to 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 to only 9% at the off-peak, overall satisfaction only fluctuates 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 the off-peak travel times.

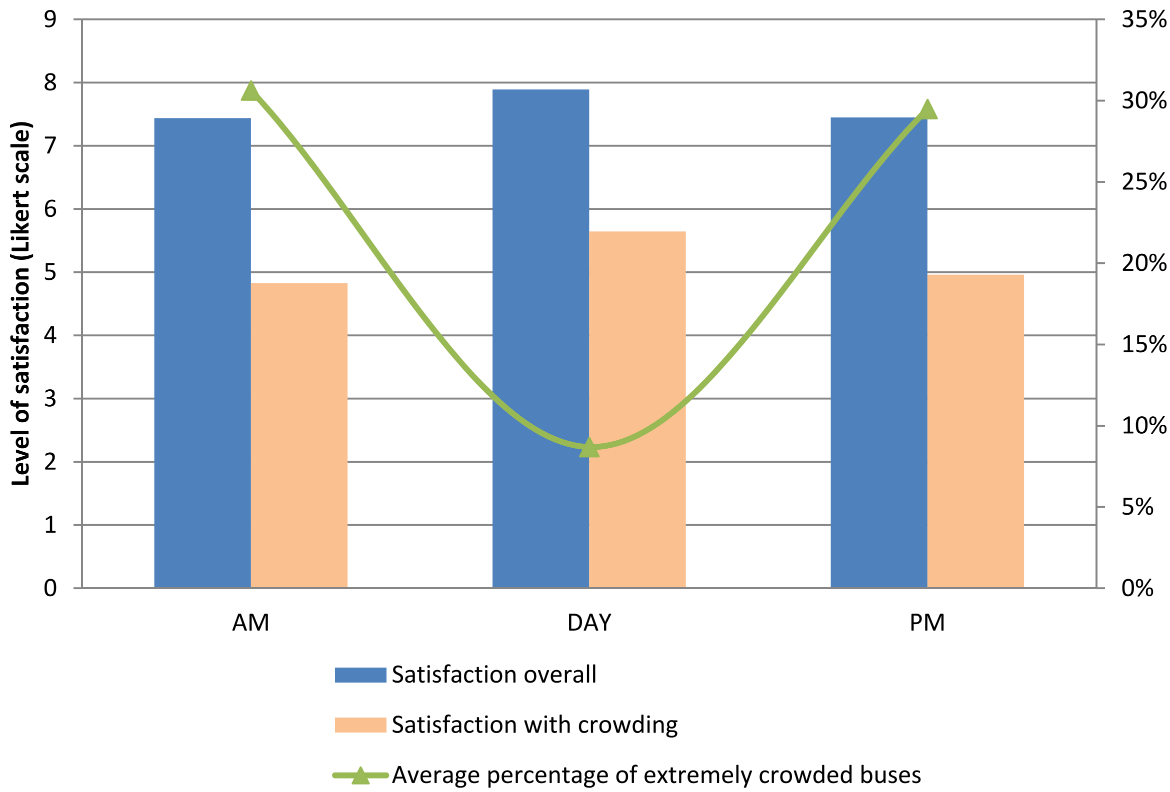

Fig. 3 Variation in satisfaction vs. variation in actual crowdedness

Figure 3 demonstrates that the variation in actual crowding changes much more than that of perceived overall satisfaction and with crowding over 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 over 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, could be because their expectations about crowding change over 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 is individuals' expectations or differences in their personal characteristics that influence how users experience satisfaction over the day, we used a series of t-tests to compare the characteristics of satisfied users (≥8/10) travelling at the AM peak and PM peak compared to all users travelling during the day-time off-peak. While we did observe some differences between specific employment, age, and income categories, overall, few statistically significant differences were observed between time periods. Furthermore, we found that in general, the populations travelling during the three time periods were mostly homogeneous.

The lack of differences between the groups travelling during different time periods could suggest that the expectations of users may be changing depending on when they use the service. This is an important hypothesis for transit agencies to consider as it means that developing thresholds of what users consider acceptable levels of crowding may change over the time of the day. Flexible thresholds for service variables may therefore be important for transit agencies to consider when analysing customer satisfaction surveys, and future research is needed to better understand this hypothesis.

Combing data sources

With regard to our 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. On the other hand, non-perception variables include personal characteristics and operations data that measure actual crowding and, for example, on-time performance. These non-perception 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 to analyses that are based primarily on users' perceptions of service quality.

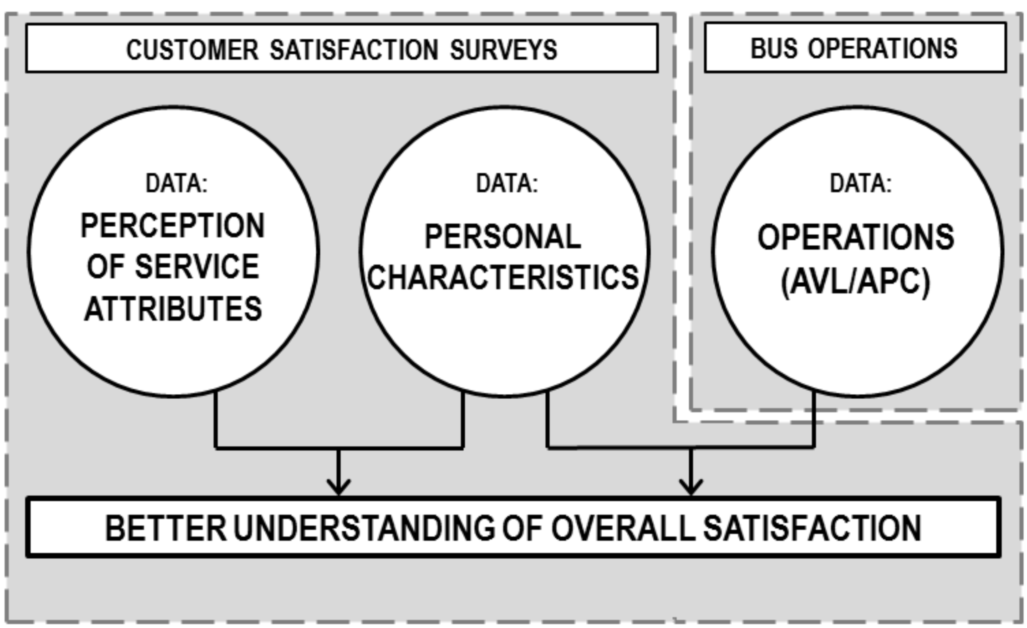

Fig. 4: How to assess customer satisfaction

CONCLUSION

This paper has provided insight on how to use data obtained from customer satisfaction surveys as well as operations data in order 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, on-board safety, and cleanliness are particularly important for increasing overall satisfaction. In addition, actual crowding influences overall satisfaction, as does car access, age, and past use. Finally, based on testing the differences between the populations using transit at different times of the day, the results suggest that users' expectations of crowding may change over the time of the 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 of the findings is that users who are between the ages of 35-54 tend to be less satisfied than other users. This is an 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 usage 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/APC data. For example, if researchers wish to better understand the relationship between users' satisfaction between 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 homogenous, bus routes rather than a single high frequency route. Furthermore, the method used in this study makes the assumption that for a given time of day the single trips described by the respondents of the customer satisfaction survey provide a representation of the service characteristics on the route for the past 30 days. In order 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 our knowledge, this study is a first attempt to combine customer satisfaction data with AVL/APC data, and in order to improve these kinds of analyses in the future, transit agencies should collect information about where and when passengers board and alight in the customer satisfaction questionnaires. 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 with what is actually happening on the ground. These findings suggest that users' expectations of transit may be changing over the day, and results could be used to assist transit agencies to identify which modifiable components of the service should be prioritized in order to effectively increase overall rider satisfaction through service improvements.

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