User satisfaction and service quality improvement priority of bus rapid transit in Belo Horizonte, Brazil

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ABSTRACT

The implementation of Bus Rapid Transit (BRT) is intended to provide higher-quality services and significantly improve rider satisfaction. Previous studies have investigated rider satisfaction and its determinants to improve BRT services as well as the comparison between BRT and conventional bus/rail transit regarding the rider satisfaction. However, many of previous studies have assumed that service attributes have linear and symmetric influences on rider satisfaction, and among the very few studies that capture the non-linear or asymmetric relationship, there is no combination of different methods to achieve the advantages of both. Besides, to our knowledge, no previous studies have examined changes in the performance and importance of different service attributes after BRT implementation. This paper analyzes the QualiÔnibus rider satisfaction survey data in Belo Horizonte, Brazil, and compares rider satisfaction and the importance of service attributes to overall satisfaction across three cases: two years prior to the BRT implementation, one year after the BRT was implemented, and four years after the BRT implementation. A combination of the ordinal logit regression (OLR) approach and random forest (RF) approach is adopted, which enables a nonlinear relationship between service attributes and rider satisfaction, considers the impact effect size in determining the importance of service attributes, and captures the attitudinal randomness of different riders when rating their satisfaction. Our results show that "expenses with public transport" (i.e. fares) should be addressed first among all the attributes, and the improvement priorities of "speed", "reliability" and "customer service" increased after the BRT opening. These findings can help policymakers fine-tune improvement strategies targeted at different types of services.

Keywords: Bus Rapid Transit, User Satisfaction, Service Attributes Importance, Improvement Priority, QualiÔnibus Survey

1 INTRODUCTION

Bus Rapid Transit (BRT) is a bus-based public transport system that aims to combine the capacity and speed of rail with the flexibility and lower cost of a bus system (Levinson et al., 2003; Canadian Urban Transit Association, 2004). As of June 2020, BRT has been implemented in 173 cities around the world, totaling 5,196 kilometers and carrying more than 30 million passengers per day[1]. Among all countries, Brazil has the greatest number of BRT passengers (10,852,339 per day) and the greatest total BRT length (778 kilometers).

As a low-cost 'rail-like' rapid transit, BRT can provide a higher quality of service than conventional bus routes. The higher quality of service is achieved with bus-only lanes, fare prepayment systems, information for customers, limited stops, and high-capacity vehicles, among other improvements (Blonn et al., 2006). As a result, BRT is usually advantageous over conventional buses in speed, comfort, service frequency, and schedule reliability (Cain et al., 2009).

Rider satisfaction is an essential criterion to evaluate the performance of BRT. Specifically, transit agencies would like to know the rider-facing performance of current BRT services as well as the relative importance of each service attribute. Based on this, policymakers and planners can decide which aspects of service improvement should be prioritized.

Previous studies have focused on rider satisfaction and its determinants to improve BRT services (Baltes, 2003; Adebambo and Adebayo, 2009; Mahmoudi et al., 2010; Deng and Nelson, 2012; Wu et al., 2020) and comparisons of the quality of service and rider satisfaction between BRT and conventional bus/rail transit (Cain et al., 2009; Cao et al., 2016). However, many previous studies are based on assumptions that service attributes have linear and symmetric influences on rider satisfaction. Among the very few studies that capture the non-linear or asymmetric relationship, methods like importance grid, regression of dummy variables, or gradient boosting decision tree have been adopted, but there is no combination of different methods to achieve the advantages of both. Therefore, this paper adopts a combination of the OLR and RF approaches to investigate the relationship between service attributes and riders' overall satisfaction. Besides, to our knowledge, none of the previous studies have examined changes in the performance and importance of different service attributes following BRT implementation. To address this gap, this paper presents the comparison of rider satisfactions at three important milestones regarding the BRT implementation: two years prior to the BRT implementation, one year after the BRT implementation, and four years after the BRT implementation.

Through a case study that analyzes the QualiÔnibus rider satisfaction survey data in Belo Horizonte, Brazil, three research questions are answered in this study: 1) How did influences on overall rider satisfaction vary across different service attributes? 2) How did rider satisfaction and service quality importance change one year after the BRT implementation and four years after the BRT was implemented? 3) The improvement of which services should be prioritized to enhance user satisfactions towards BRT?

In Section 2, we review previous research on riders' satisfactions with BRT, and the methods to assess the attribute performance and the importance of each attribute to riders' overall satisfaction. Section 3 introduces the study area, data, and methodology. In Section 4, we discuss the empirical results. And lastly, Section 5 summarizes the key findings and contributions of this study.

2 LITERATURE REVIEW

2.1 BRT Rider Satisfaction

Rider satisfaction is an important measure of public transit service quality from the customer point of view (Aniley and Negi, 2010; Ojo, 2019), as satisfaction forms the foundation of customer loyalty (Zhao et al., 2014; Diab et al., 2017). Rider satisfaction surveys are often adopted to collect riders' satisfaction towards a specific service attribute and towards the overall transit system.

[1] Global BRT Data: https://brtdata.org/. Accessed on June 21, 2020.

Previous studies have focused on evaluating riders' satisfaction with the quality of various services and their overall satisfaction with the BRT system. For example, Wan et al. (2016a) investigated the relationship between riders' overall satisfaction and underlying driving factors of the BRT service in New York City, and found that frequency, on-time performance, and speed are the most important factors. By conducting a questionnaire survey, Deng and Nelson (2012) revealed that the Beijing Southern Axis BRT system is popular among passengers and has a positive impact on the attractiveness of residential property, while the captive users are more satisfied than the choice users with the BRT system and some service attributes such as the reliability, comfort and cleanliness.

Previous research also identified the service attributes that are more associated with the overall satisfaction, or determined the priority of service quality improvements to improve riders' satisfaction. Baltes (2003) concluded from two on-board surveys on the BRT in Miami and Orlando, Florida, that frequency of service, comfort, travel time, and reliability of services are of greater importance to passengers' overall satisfaction. Mahmoudi et al. (2010) found that BRT service, BRT speed, driver's behavior, and ergonomics all significantly correlated with riders' satisfaction of BRT in Tehran City. Cao et al. (2016) found that ease of use, safety while riding, and comfort while waiting are the three most influential attributes for overall satisfaction with BRT in Guangzhou, China. Wan et al. (2016b) studied the BRT in New York City and concluded that reliability and travel time are the common concerns of all BRT riders, while information provision, convenience and comfort are relatively more important for riders on routes in areas with less commercial land use. Wu et al. (2020) studied the BRT in Twin Cities, Minnesota, and recommended that transit agency give priorities to improving hours of operation, personal safety while riding, reliability, and total travel time to advance the overall riders' satisfaction.

The last category of previous studies compared riders' satisfaction of BRT systems with the other transit systems such as bus and rail. Cain et al. (2009) examined different types of transit services in Los Angeles, California, and concluded that BRT performed well in terms of overall rating achieved per dollar of investment and thus can compete with rail-based transit. Cao et al. (2016) concluded that transit riders are most satisfied with metro, followed by BRT and conventional bus. Regarding service attributes, the ease of use, comfort while riding, convenience of service, travel time, and comfort while waiting are the five attributes that contribute most to the difference in the overall satisfaction between BRT and metro. Cao and Cao (2017) used Importance-performance analysis (IPA) to determine the priority of service attributes improvement to enhance riders' satisfaction, and concluded divergent improvement priorities for bus, BRT, and metro transit. Zhang et al. (2019) conducted surveys on bus, BRT, and Van riders in Indore, India, and found that different transit services tend to have different important service attributes, whereas safety while riding and while waiting and comfort while riding are the critical attributes for all three transit services.

2.2 Importance of Service Attributes

Previous studies have applied various methods to examine the performance of service attributes and the association between the service attributes and overall rider satisfaction towards the transit system. Mean score is normally calculated to evaluate the performance of service attributes, based on riders' ratings on their satisfaction towards various aspects of service qualities. Assessing the relative importance of different service qualities to riders' overall satisfaction, however, is more complicated.

Correlation analysis and regression are adopted by some studies to assess which service attributes contribute more to the overall rider satisfaction. Weinstein (2000), Cain et al. (2009) and Mahmoudi et al. (2010) calculated the correlation between riders' perceived service qualities and the overall satisfaction. Baltes (2003) conducted surveys on the BRT riders about their satisfactions with various service attributes and overall satisfaction with the system, and applied STEPWISE regression to identify important service attributes. Wan et al. (2016b) used the OLS regression to examine the importance of various service attributes. Both methods assumed a linear relationship between the service attributes and the overall satisfaction. Mouwen's research on Dutch public transit also assumed a linear relationship between service attributes the overall satisfaction, but contributed to the literature by incorporating the interaction terms between the attribute satisfaction of person and his/her characteristics (Mouwen, 2015). Eboli and Mazzulla (2015), Ingvardson and Nielsen (2019) and Shen et al. (2016) examined the factors that influence the overall satisfaction via structural equation models (SEMs). Cao et al. (2016) examined the importance of different service attributes to the overall satisfaction of Guangzhou BRT riders, using a multivariate ordered probit regression. This study made significant progress in the methodology, as the ordered probit regression is more appropriate for the ordinal measures, and the method enables comparing the relative importance of different attributes. The approaches based on regression or correlations, however, have notable limitations, as they assume the linear relationship between perceived service qualities and overall satisfaction, which is often not true due to the ordinal nature of people's satisfaction level towards different attributes. Besides, the traditional methods also ignore the size of influencing effect of service attributes.

To capture the non-linear relationship between service attributes and overall satisfaction, the three-factor theory (TFT) has been adopted increasingly in rider satisfaction studies (Sun et al., 2020; Zhang et al., 2019). Based on the Kano Model (Kano et al., 1984), the TFT classifies service attributes into three factors: Basic factors, Performance factors, and Exciting factors (Matzler et al., 2004): Basic factors significantly impact overall satisfaction when they perform poorly, Exciting factors significantly impact overall satisfaction when they perform well, and Performance factors significantly impact overall satisfaction when they perform both well and poorly. Factors that fall outside any of these three categories are considered to be unimportant as they do not have impacts on overall satisfaction.

Previous studies have implemented TFT through two approaches: importance grid and regression with dummy variables. Cao and Cao (2017) compared these two methods using the survey data of BRT, bus, and metro in Guangzhou, and found that the importance grid reaches more plausible results. By contrast, some studies concluded that the regression with dummy variables had a better theoretical foundation than the importance grid (Matzler and Sauerwein, 2002). Zhang et al. (2019) applied the TFT importance grid approach to examine the relative importance of service attributes in BRT, bus, and van services of Indore, India. Wu et al. (2018) applied the regression with dummy variables to study the relative importance of service attributes on rider satisfaction of public transit systems in Twin Cities, Minnesota.

Although the importance grid and regression with dummy variables are able to capture the non-linear relationship between service attributes and riders' overall satisfaction, they are parametric methods that rely on pre-defined relationship between the dependent and independent variables, and they only capture the significance level without considering the effect size of the influence. To capture the effect size of different factors, Wu et al. (2020) applied the impact-asymmetry analysis framework and gradient boosting decision trees to capture both the non-linear relationship and the effect size of the influence of service attributes.

In this study, we adopt regressions with dummy variables combined with RF to implement TFT. To the best of our knowledge, no existing studies have accounted for both statistical significance and effect size when determining the importance of the attributes. OLR with dummy variables is able to capture the non-linear relationship between service attributes and overall satisfaction. However, it only determines the importance of service attributes based on the significance of the influence (i.e. p-value), without considering the effect size of the influence. Therefore, we further implemented TFT via RF. Compared to traditional regression, RF has several advantages. Firstly, it improves prediction accuracy by accounting for variability in the data. Secondly, unlike traditional regression that assumes people base their general satisfaction on all service attributes, RF assumes that different riders may rate their overall satisfaction depending on different (subsets of) conditions and can capture this attitudinal randomness by using an ensemble of simple decision trees, each dependent on a set of conditions (Rasouli and Timmermans, 2014). Lastly, RF is able to capture the effect size of the influence.

3 DATA

3.1 Study Area

Belo Horizonte of Brazil is selected as the study area of this paper. As the capital of the state of Minas Gerais, Belo Horizonte is the 6th most populous city in Brazil, is 4th-highest in GDP, and sits at the core of the 3rd most populous metropolitan area in the country (IBGE, 2020). It was initially designed for a population of 200,000 inhabitants (GIZ, 2014). However, after a century of tremendous growth, it now has 2.51 million inhabitants as of 2020 (IBGE, 2020).

In 2008, the Belo Horizonte transit agency (BHTRANS) began developing its urban mobility plan (PlanMob-BH) (Brasil, 2012). PlanMob-BH covers several actions to reverse the increasing trend of trips in private automobiles and to stimulate a transit-oriented development approach (Belo Horizonte, 2013). PlanMob-BH is now considered a national reference; and it is currently being reviewed, extending its planning horizon to 2030 and updating its targets.

One of PlanMob-BH's main projects was the construction of a BRT system that was concluded in March 2014 for the FIFA World Cup. MOVE, as the Belo Horizonte BRT system is branded, is 23 km long and carries almost 280,000 passengers per day (BRT+ Centre of Excellence, 2020). It delivers full BRT services along segregated lanes, with pre-payment and overtaking at stations and terminals, level boarding, and real time information to passengers. MOVE consists of three corridors: (i) Antonio Carlos, the main connection between downtown and Pampulha (northwest of the city); (ii) Cristiano Machado, an alternative connection towards the north of city; and (iii) Área Central, the shortest in extension as it functions as a downtown circulator in distributing services between the other two corridors (Lindau et al., 2015). In this paper, we focus our analysis on the Cristiano Machado (CM) BRT corridor.

3.2 Data and Variables

QualiÔnibus Satisfaction Survey measures the perceptions of bus transit system users. It was conceived by WRI Brasil Ross Center for Sustainable Cities based on an extensive literature review of existing practices (e.g. reports from TCRP, European Standard 13816, among others) and on surveys applied in different cities and systems worldwide (Barcelos and Albuquerque, 2018).

QualiÔnibus Satisfaction Survey provides a quantitative assessment of the users' perception. The Survey, in its basic module, consists of four sections: (i) customer profile; (ii) usage profile; (iii) satisfaction; (iv) general perception. The satisfaction section uses a 5-point Likert Scale to measure the subjective evaluations by respondents to one question about general satisfaction and 16 questions that are specific to each quality factor as described below (Barcelos and Albuquerque, 2018):

i. access to transport: ease of getting to points of access and circulating in stations and terminals;
ii. availability: time interval between buses at the required period and location;
iii. speed;
iv. reliability: arrival on time;
v. easiness to transfer: between bus lines and other means of transport to get to destination;
vi. comfort at bus stops: lighting, protection, cleanliness, loading;
vii. comfort at stations: lighting, protection, cleanliness, loading;
viii. comfort at integration terminals: lighting, protection, cleanliness, loading;
ix. comfort inside buses: lighting, cleanliness, loading, availability of seats;
x. customer service: respectfulness, friendliness, qualification of drivers, ticket collectors, staff and call center;
xi. customer information: including timetables, routes, lines and general information;
xii. security: against theft, robberies and assault on the way to bus stops, stations and terminals as well as inside the bus;
xiii. road safety;
xiv. exposure to noise and pollution: produced by the buses;
xv. easiness to pay fares: including the recharging of travel cards;
xvi. expenses: with bus transit (i.e. fares).

An example survey block that collects respondent's perceptions towards various service attributes and their overall satisfaction is presented in **Figure 1**. The survey questions regarding respondents' socio-demographic information are shown in **Table 1**.

Considering the public bus system in XXXXXX, how would you rate your satisfaction level with each of the following aspects?

Very dissatisfied - 1 -	Dissatisfied - 2 -	Neither satisfied nor dissatisfied - 3 -	Satisfied - 4 -	Very satisfied - 5 -	

S1. Access to transport: ease of getting to points of access and circulating in stations and terminals	[1]	[2]	[3]	[4]	[5]	[CGO]
S2. Availability: time interval between buses at the time and places I need	[1]	[2]	[3]	[4]	[5]	[CGO]
S3. Speed	[1]	[2]	[3]	[4]	[5]	[CGO]
S4. Reliability: arrival on time	[1]	[2]	[3]	[4]	[5]	[CGO]
S5. Easiness to transfer between bus lines and other means of transport to get to destination	[1]	[2]	[3]	[4]	[5]	[CGO]
S6. Comfort at bus stops: lighting, protection, cleanliness, number of people	[1]	[2]	[3]	[4]	[5]	[CGO]
S7. Comfort at stations: lighting, protection, cleanliness, number of people	[1]	[2]	[3]	[4]	[5]	[CGO]
S8. Comfort at integration terminals: lighting, protection, cleanliness, number of people	[1]	[2]	[3]	[4]	[5]	[CGO]
S9. Comfort inside buses: lighting, cleanliness, number of people, seats	[1]	[2]	[3]	[4]	[5]	[CGO]
S10. Customer service: respectfulness, friendliness, qualification of drivers, ticket collectors, staff and call center	[1]	[2]	[3]	[4]	[5]	[CGO]
S11. Customer information: about timetables, routes, lines, and other information	[1]	[2]	[3]	[4]	[5]	[CGO]
S12. Security against thefts, robberies and assaults on the way to bus stops and on the bus	[1]	[2]	[3]	[4]	[5]	[CGO]
S13. Road safety	[1]	[2]	[3]	[4]	[5]	[CGO]
S14. Exposure to noise and pollution produced by buses	[1]	[2]	[3]	[4]	[5]	[CGO]
S15. Easiness to pay fares and reload travel card	[1]	[2]	[3]	[4]	[5]	[CGO]
S16. Expenses with public bus transport	[1]	[2]	[3]	[4]	[5]	[CGO]
S17. General satisfaction with the public transport bus system	[1]	[2]	[3]	[4]	[5]	[CGO]

Note: "CGO" stands for "cannot give an opinion"

Figure 1 Example Survey Block with Questions about Service Attributes

Table 1 Socio-Demographic Characteristics of Survey Sample

Socio-demographic characteristics	Question	Data Type	Bin

Gender	What is your gender?	Categorical	0: Female 1: Male
Age	How old are you?	Numeric	
Car Ownership	Do you have any cars at home?	Categorical	0: No 1: Yes
Education Level	What is your education level?	Ordinal	1: Illiterate 2: Incomplete Primary Education 3: Complete Primary Education 4: Incomplete Secondary Education 5: Complete Secondary Education 6: Incomplete College/University Degree 7: Complete College/University Degree 8: Graduate Degree (PhD, Masters)
Monthly Household Income	What is the monthly average of your total household gross income, considering all sources (such as salaries, overtime wages, rental income, etc.)?	Ordinal	1: Less than 1 minimum wage 2: Between 1 and 1,5 minimum wages 3: Between 1,5 and 2 minimum wages 4: Between 2 and 3 minimum wages 5: Between 3 and 5 minimum wages 6: Between 5 and 10 minimum wages 7: More than 10 minimum wages

To assure the representativeness of the samples, the methodology considers a minimum confidence level of 95% and maximum sampling error of 5% (Barcelos and Albuquerque, 2018). As it is a standardized Survey, the benchmarking analysis and solutions were allowed to be exchanged among cities (Lindau et al., 2017). The QualiÔnibus Satisfaction Survey has been used to verify the impact of interventions in the public transport system and to support decision making at the local level in more than 15 cities thus far (WRI Brasil, 2020). For the work reported in this study, we use data obtained from the application of QualiÔnibus Satisfaction Survey in Belo Horizonte as follows:

- 2013: sampling of the Cristiano Machado corridor before BRT implementation (conventional routes operating in a segregated bus corridor), 400 respondents.
- 2015: sampling of the Cristiano Machado corridor after BRT implementation, 2,593 respondents.
- 2018: sampling of the Cristiano Machado corridor after BRT implementation, 1,683 respondents.

The descriptive statistics of the transit service attributes and the social demographic information for the three years of surveys are reported in Table 2. As it is impossible to apply the questionnaire to all bus users, the survey is applied to a sample that represents the population to be known. For the sample to be representative of the population (bus users), a minimum sample size is established following certain criteria (by time frame and by bus route), and a correction factor is applied to the data before further analysis to guarantee the system stratification.

Table 2 Descriptive Statistics for 2013, 2015, 2018 Surveys

Name	2013				2015				2018			
	Mean	**Std.dev**	**Min**	**Max**	**Mean**	**Std.dev**	**Min**	**Max**	**Mean**	**Std.dev**	**Min**	**Max**
Service attributes (evaluated on a 5-point Likert scale):												
Access to transport	2.89	1.09	1	5	3.25	1.01	1	5	3.29	1.06	1	5
Availability	2.56	1.01	1	5	2.93	1.12	1	5	2.63	1.08	1	5
Speed	-	-	-	-	3.44	0.85	1	5	2.85	1.07	1	5
Reliability	2.47	0.96	1	5	3.24	0.87	1	5	2.99	1.09	1	5
Easiness to transfer	2.88	0.99	1	5	3.28	0.89	1	5	3.00	1.04	1	5
Comfort at bus stops	2.14	0.92	1	5	2.66	1.17	1	5	2.54	1.19	1	5
Comfort at stations	-	-	-	-	3.50	0.85	1	5	3.01	1.12	1	5
Comfort at integration terminals	2.52	1.02	1	5	3.43	0.90	1	5	3.00	1.12	1	5
Comfort inside buses	2.45	0.99	1	5	3.55	0.85	1	5	2.91	1.08	1	5
Customer Service	3.23	1.05	1	5	3.45	0.91	1	5	3.51	1.02	1	5
Customer Information	2.67	1.03	1	5	3.28	0.93	1	5	3.33	1.01	1	5
Security	2.37	0.94	1	5	2.58	1.14	1	4	2.19	1.12	1	5
Road safety	2.60	0.96	1	5	3.04	0.94	1	5	2.77	1.12	1	5
Exposure to noise and pollution	2.05	0.80	1	5	3.10	0.94	1	5	2.48	0.97	1	5
Easiness to pay fares	3.10	1.10	1	5	3.41	0.92	1	5	3.38	1.20	1	5
Expenses	2.21	0.96	1	5	2.27	1.08	1	5	2.12	1.13	1	5
Overall Satisfaction	2.27	0.89	1	5	3.27	0.90	1	5	2.86	0.98	1	5
Socio-demographic variables:												
Male (male=1, female=0)	0.41	0.50	0	1	0.36	0.48	0	1	0.39	0.49	0	1
Age	35.53	11.62	18	67	40.19	14.47	15	78	38.92	13.99	14	73
Education level (1-8, lowest to highest)	4.47	1.45	2	8	4.41	1.38	1	8	4.52	1.47	1	8
Car ownership (0%-100%)	-	-	-	-	0.38	0.49	0	1	0.54	0.50	0	1
Income (1-7, lowest to highest)	3.32	1.20	1	7	3.17	1.25	1	7	3.44	1.43	1	7

4 METHODS

In this research, the ultimate goal is to determine the quality improvement priorities for the service attributes in order to inform local transit planning. The improvement priorities are determined based on the performance and importance of the service attributes. The performance score is calculated as the average score rated by all the respondents for that attribute, which ranges from 1 (the lowest) to 5 (the highest). If the performance score is higher than the reference score, the performance level is “good” for that attribute. Otherwise, the performance level is “poor”.

The methods used to determine the importance type of service attributes are described below.

4.1 Importance Types of Service Attributes

We deploy two methods, namely the OLR with dummy variables and RF, to provide a comprehensive study on the importance of each service attribute. We then adopt the TFT to determine the importance types of service attributes.

4.1.1 Coding methodology of independent variables

First, built off of the approach offered by Wu et al. (2018), the performance of each service attribute was recoded into two mutually exclusive dummy variables — namely “high-performance” and “low-performance”. Specifically, “satisfied” and “very satisfied” are recoded as 1 for the high-performance indicators and 0 for low-performance indicators; whereas “dissatisfied” and “very dissatisfied” are recoded as 1 for the low-performance indicators and 0 for high-performance indicators. “Neither satisfied nor dissatisfied” is set as the reference category, so the values of the corresponding high-performance indicators and low-performance indicators are both 0. The recoding strategy is summarized in **Table** .

Table 3 Recoding Strategy

Original rating in the survey	**Recoding**	
	Value for the high-performance dummy variable	**Value for the low-performance dummy variable**
Very dissatisfied (1)	0	1
Dissatisfied (2)	0	1
Neither satisfied nor dissatisfied (3)	0	0
Satisfied (4)	1	0
Very satisfied (5)	1	0

4.1.2 Ordinal logit regression (OLR)

Adapted from previous studies on transit rider satisfaction (Cao and Cao, 2017; Wu et al., 2018), a regression with dummy variables is chosen to determine the statistical importance of each attribute. Based on the ordinal nature of the dependent variable, OLR is deployed to estimate the effect of each service attribute on one’s overall satisfaction, and for each attribute, two performance-related dummy variables (“high-performance” and “low-performance”) are included as the independent variables in the regression model. For each dummy variable, if the estimation coefficient is significant, this means the associated attribute is important in that specific dimension (low-performance dimension or high-performance dimension). We use a p-value of 0.05 as the critical significant level.

4.1.3 Random forest (RF)

To identify the importance of different transit service attributes, a sizable amount of literature applies one model and uses the estimated parameters to determine the effects of the attributes on people's general satisfaction (Wu et al., 2018). However, developing only one model may not be the best approach given the uncertainty in forecasting owing to the inherent variability in people's perceptions (Rasouli and Timmermans, 2014). Therefore, we apply RF as the second method to generate the comprehensive estimation results.

RF assembles K decision trees which are built on random samples from the dataset (Breiman, 2001). Each tree recursively partitions the randomly drawn sample using a subset of randomly selected condition variables for each split. To illustrate, let $h(X, \theta_k)$ denote the tree-structured classifier for tree k; where θ_k represents the parameters in tree k, which characterizes the split variables, cutpoints at each node and terminal node values (Ogutu et al., 2011). Let $P(X)$ represent the output of the RF and X denote the vector of the independent variables, then the predicted outcome is specified as:

$$P(X) = argmax_j \left[\frac{\sum_{k=1}^{K} I(h(X, \theta_k) = j)}{K} \right]$$

In the above equation, $I(h(X, \theta_k) = j)$ is equal to 1 if the prediction given by the classifier $h(X, \theta_k)$ is equal to j, and otherwise $I(h(X, \theta_k) = j)$ is equal to 0 (Ghasri et al., 2017). The RF modeling is carried out in R using the "caret" package.

After fitting the data with the model, we use the "varImp" function in R to calculate the importance score for each attribute. The function computes permutation importance for each variable. Specifically, to calculate the importance of a variable, the method measures the increase in the prediction error of the model after the values of that variable are permuted (Probst and Janitza, 2020). The importance scores are first calculated for each attribute regarding its influence on each level (5 levels in total) of the dependent variable, and are scaled within a range of 0–100. We then compute the average importance score across all 5 levels for each attribute and use it as the final importance score to determine the importance type of that attribute. Therefore, the final importance score of each attribute reflects the relative importance of that attribute compared with other attributes.

4.1.4 Importance determination

When quantifying the effect of each attribute on the overall satisfaction, OLR emphasizes statistical significance whereas RF emphasizes effect sizes. Therefore, by combining the results of both OLR and RF, we can get a stable and comprehensive importance categorization for each attribute.

A performance-related dummy variable ("high-performance" indicator or "low-performance" indicator) is identified as having a significant impact on people's overall satisfaction if it meets a least one of these two criteria: the coefficient of the variable is significant in the OLR, or the importance score is higher than the average importance score across all the attributes in that dimension (high-performance dimension or low-performance dimension) in RF. **Table** summarizes how the attributes are categorized into four types of importance based on the results of OLR and RF.

Based on the significance of the performance-related dummy variable, we classify the 16 service attributes into the following factors according to the concept of the TFT, as illustrated in **Figure 2** (Matzler et al., 2004; Wu et al., 2018). According to the TFT, the attributes that significantly affect overall satisfaction only when they perform poorly are classified as the Basic factor; those that significantly affect overall satisfaction only when they perform well are the Exciting factor; factors that significantly affect the overall satisfaction both when they perform both poorly and when they perform well are identified as the Performance factor.

Table 4 Determining the Importance Type of the Variables

Type of importance	Definition	Low-performance dummy is significant in regression or has higher-than-average impact in RF analysis	High-performance dummy is significant in regression or has higher-than-average impact in RF analysis
Basic	the attribute significantly affects overall satisfaction only when it performs poorly	Yes	No
Exciting	the attribute significantly affects overall satisfaction only when it performs well	No	Yes
Performance	the attribute significantly affects satisfaction when it performs both poorly and well	Yes	Yes
Unimportant	the attribute does not significantly affect overall satisfaction	No	No

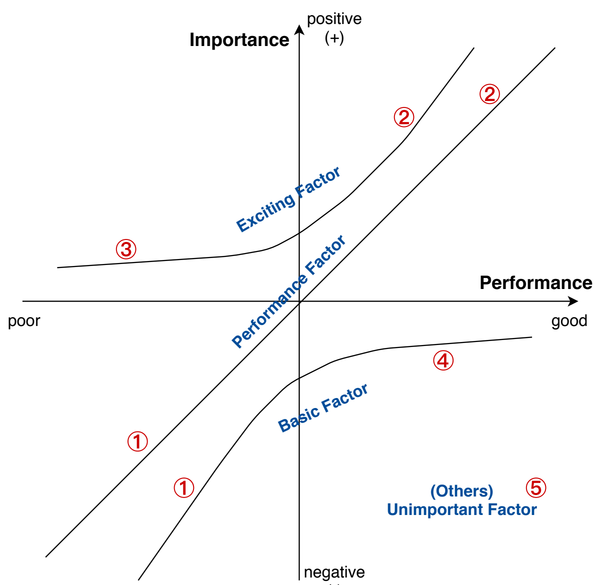

Figure 2 The Illustration of the Three-Factor Theory

4.2 Action Priority Determination

The improvement priority for each attribute is determined based on its performance and importance type. There are five possibilities of the performance scores: 1 (very dissatisfied), 2 (dissatisfied), 3 (neither satisfied nor dissatisfied), 4 (satisfied) and 5 (very satisfied). For each variable, the mean performance score is calculated and compared with the reference performance score (the score which is averaged across all observations and all attributes). The performance of an attribute is "poor" if its performance score is lower than the reference score, and is "good" if its performance score is higher than the reference score.

Then, the improvement priority for each attribute is determined based on the following rule (**Table**): Basic and Performance factors that perform poorly are the first priority, as they have significant and negative impacts on riders' satisfaction. Exciting and Performance factors with good performance also significantly influence riders' satisfaction, but since improving the well-performed factors may not be cost-effective, they are given the second priority. Exciting factors that perform poorly are defined as the third priority, since they will be effective if the performance becomes better than the reference. The fourth priority is given to Basic factors with good performance. Lastly, unimportant factors are least prioritized as they don't have significant impacts on the riders' overall satisfaction.

Table 5 Rule for Determining the Improvement Priority Ranking

Performance Type	Importance Type	Priority Ranking
Poor	Basic	1
Poor	Performance	
Good	Exciting	2
Good	Performance	
Poor	Exciting	3
Good	Basic	4
Poor	Unimportant	5
Good	Unimportant	

4.3 Examining the Change after the BRT Implementation

To examine how the overall satisfaction and service improvement priority changed after the implementation of the BRT system, we apply the methods described in above to model the survey data on 2013, 2015, and 2018 separately, and compare and contrast the results. As is stated in Section 3, the BRT was implemented in Belo Horizonte in 2014, so the year 2013 survey represents the riders' satisfaction before the BRT implementation, while the surveys conducted in 2015 and 2018 represent the riders' satisfaction after the BRT implementation.

5 RESULTS

In order to determine the improvement priority for these different service attributes, we need to first determine their performance level and importance type. The performance, importance and the improvement priority for each service attribute are presented as follows.

5.1 The Performance Level

The performance score and performance levels for all the service attributes across three years are shown in **Table** . The performance score is calculated as the average score rated by all the respondents for that attribute based on their subjective evaluations in the surveys, which ranges from 1 (the lowest) to 5 (the highest). The overall satisfaction increases from 2.27 in 2013 to 3.27 in 2015, showing that the opening of the BRT line in 2015 has greatly improved the transit users' satisfaction, but drops to 2.86 in

2018. **Table** shows that after the opening of BRT line in 2015, the performance level for “comfort inside buses”, “reliability”, “comfort at integration terminals” changed from “poor” to “good”. In addition, the performance scores of “customer service” and “customer information” increased continuously from 2013 to 2018. BRT brought improvements such as differentiated training for operators and staff as well as adding ticketing and station agents — which may explain increasing satisfaction towards customer service and customer information. “Road safety”, however, changed from good performance to poor performance. Another important finding is that the performance for “speed” was good in 2015, but became poor in 2018. In 2015 the average speed of a bus on the Cristiano Machado corridor during the morning peak was 22.7 km/h, but in 2018 the speed decreased to 19.8 km/h. In addition, some BRT routes travel outside the bus corridor and travel in mixed traffic, subjecting them to increasing congestion. The speed decrease may be a reason why the performance score of this attribute had a large drop from 3.44 in 2015 to 2.85 in 2018.

Table 6 Performance Levels of Service Attributes (2013-2018)

Name	Year	Performance	Performance Level
Dependent Variable:			
Overall Satisfaction	2013 2015 2018	2.27 3.27 2.86	
Service Attributes:			
Expenses	2013 2015 2018	2.21 2.27 2.12	poor poor poor
Exposure to noise and pollution	2013 2015 2018	2.05 3.10 2.48	poor poor poor
Comfort inside buses	2013 2015 2018	2.45 3.55 2.91	poor good good
Reliability	2013 2015 2018	2.47 3.24 2.99	poor good good
Comfort at integration terminals	2013 2015 2018	2.52 3.43 3.00	poor good good
Easiness to transfer	2013 2015 2018	2.88 3.28 3.00	good good good
Comfort at stations	2015 2018	3.50 3.01	good good
Customer Information	2013 2015 2018	2.67 3.28 3.33	good good good
Customer Service	2013 2015 2018	3.23 3.45 3.51	good good good
Road safety	2013 2015 2018	2.60 3.04 2.77	good poor poor
Easiness to pay fares	2013 2015 2018	3.10 3.41 3.38	good good good
Security	2013 2015 2018	2.37 2.58 2.19	poor poor poor

Comfort at bus stops	2013	2.14	poor
	2015	2.66	poor
	2018	2.54	poor
Availability	2013	2.56	poor
	2015	2.93	poor
	2018	2.63	poor
Speed	2015	3.44	good
	2018	2.85	poor
Access to transport	2013	2.89	good
	2015	3.25	good
	2018	3.29	good
Reference level for service attributes			
Average Score (Reference)	2013	2.56	
	2015	3.16	
	2018	2.87	
Socio-demographic variables:			
Name	**Year**	**Value**	
Male (male=1, female=0)	2013	0.41	
	2015	0.36	
	2018	0.39	
Age	2013	35.53	
	2015	40.19	
	2018	38.92	
Education (1-8, lowest to highest)	2013	4.47	
	2015	4.41	
	2018	4.52	
Income (1-7, lowest to highest)	2013	3.32	
	2015	3.17	
	2018	3.44	
Car Ownership (0%-100%)	2015	0.38	
	2018	0.54	

Note: The performance level of each service attribute is determined based on whether the performance score is higher than the performance score averaged across all the attributes (the reference score). If the performance score is higher than the reference score, the performance level is "good" for that attribute. Otherwise, the performance level is "poor".

5.2 The Importance Type

The importance type of each attribute is determined by applying the OLR and RF. These two modeling techniques are applied to 2013, 2015 and 2018 surveys.

Here we illustrate how the importance type of an attribute is determined based on these two modeling methods using the 2013 survey as an example. The same modeling procedures have been applied to 2015 and 2018 surveys.

First, we regress the dependent variable, the overall satisfaction, on the low-performance and high-performance indicators of 16 transit service attributes using the OLR. As shown in **Table** , the low-performance dummies of three attributes "easiness to pay fares", "comfort inside buses" and "customer information" have significant negative effects on people's overall satisfaction. The high-performance dummies of "security" and "customer information" have significant positive effects on people's overall satisfaction.

Table 7 Ordinal Logistic Regression Result for 2013 Survey

Name	Low-Performance Part			High-Performance Part		
	Coefficient	**P value**	**Significance**	**Coefficient**	**P value**	**Significance**
Easiness to pay fares	-1.05	0.004	**	-0.357	0.285	

Comfort inside buses	-0.832	0.004	**	-0.565	0.105	
Security	0.397	0.210		1.129	0.003	**
Customer Information	-0.650	0.029	*	1.165	0.000	***
Access to transport	-0.068	0.839		0.100	0.768	
Customer Service	-0.019	0.953		0.362	0.191	
Road safety	-0.391	0.159		-0.411	0.217	
Exposure to noise and pollution	-0.088	0.788		0.374	0.493	
Expenses	-0.576	0.066		0.060	0.883	
Availability	-0.406	0.217		0.303	0.389	
Reliability	-0.154	0.617		0.479	0.181	
Easiness to transfer	-0.071	0.812		0.051	0.874	
Comfort at bus stops	0.284	0.431		0.323	0.486	
Comfort at integration terminals	0.137	0.677		0.619	0.095	
Control variables:						
Male	-0.224	0.292				
Age	-0.006	0.481				
Education	-0.150	0.075				
Income	-0.036	0.690				

Note: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Next, we run a RF model using the same independent and dependent variables. The attributes with important low-performance indicators are plotted on the left graph of **Figure 3**, whereas those with an important high-performance indicator are plotted on the right graph of **Figure 3**. The results for 2013 (**Table** and **Figure 3**) show that those influential low-performance variables recognized by OLR (the low-performance indicators of “ease of fare payment”, “comfort inside buses” and “customer information”) are also recognized as important by RF, and the influential high-performance variables (the high-performance indicators of “security” and “customer information”) are also important in RF. In addition, the RF algorithm also captures other important variables, which are “availability”, “security”, “access to transport”, “expenses”, “comfort at integration terminals” and “reliability” in the low-performance dimension, as well as “easiness to pay fares” and “comfort at integration terminals”, “expenses” and “access to transport” in the high-performance dimension. The same modeling strategies are applied for 2015 and 2018, and the full result is shown in **Table** . An attribute with a coefficient that is significant in OLR or has a higher-than average importance score in RF is counted as important in that dimension. Using this rule, the comprehensive importance type for each attribute is determined, which is reported in the last column of **Table** .

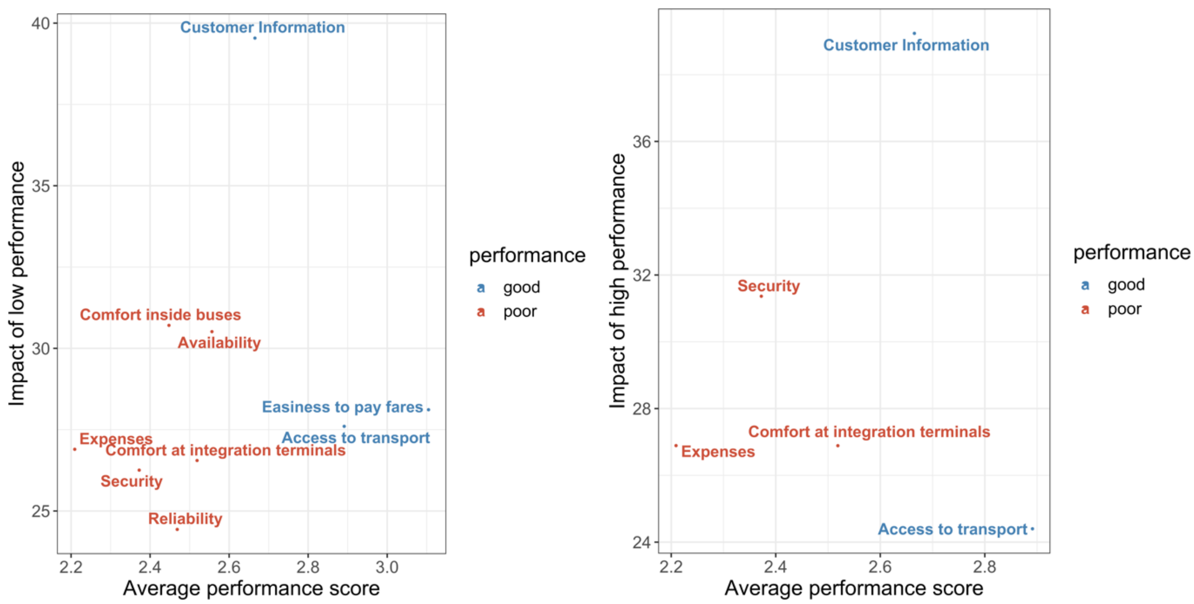

Figure 3 Random Forest Results for 2013 Survey (Left: Influential Low-performance Indicators; Right: Influential High-performance Indicators)

Table 8 Importance Type for Each Service Attribute

Name	Year	Low-Performance Part		High-Performance Part		Comprehensive Importance Type
		Significance (OLR)	Importance (RF)	Significance (OLR)	Importance (RF)	
Expenses	2013		**26.9**		**26.9**	performance
	2015		**27.5**	**	**29.8**	performance
	2018	**	**57.4**		44.0	basic
Exposure to noise and pollution	2013		21.2		22.8	unimportant
	2015		22.4		18.1	unimportant
	2018		**52.3**		**51.9**	performance
Comfort inside buses	2013	**	**30.7**		22.1	basic
	2015		22.1		22.8	unimportant
	2018	**	**62.2**		**58.4**	performance
Reliability	2013		**24.4**		22.7	basic
	2015		17.0		**25.7**	exciting
	2018	*	48.6		**57.5**	performance
Comfort at integration terminals	2013		**26.6**		**26.9**	performance
	2015		23.5		**26.9**	exciting
	2018		**57.6**		**56.7**	performance
Easiness to transfer	2013		21.7		22.2	unimportant
	2015		22.4		**27.5**	exciting
	2018		47.9		**56.3**	exciting
Comfort at stations	2015		**26.7**	**	**35.3**	performance

	2018		**62.7**		**66.2**	performance
Customer Information	2013	*	**39.5**	***	**39.2**	performance
	2015		25.1		**26.2**	performance
	2018		42.1		**53.7**	exciting
Customer Service	2013		21.0		20.9	unimportant
	2015		23.4		**24.8**	exciting
	2018	*	47.7		**49.6**	performance
Road safety	2013		20.4		21.5	unimportant
	2015		22.3		20.5	unimportant
	2018		48.9		**51.3**	exciting
Easiness to pay fares	2013	**	**28.1**		23.1	basic
	2015		**25.8**		**31.3**	performance
	2018		**51.3**		44.3	basic
Security	2013		**26.3**	**	**31.4**	performance
	2015		21.5		22.9	unimportant
	2018		39.7		46.0	unimportant
Comfort at bus stops	2013		21.5		19.7	unimportant
	2015	**	22.8		20.7	basic
	2018		47.0		49.1	unimportant
Availability	2013		**30.5**		21.2	basic
	2015		20.9		23.4	unimportant
	2018		43.4		43.2	unimportant
Speed	2015		21.6		21.1	unimportant
	2018		46.2		47.5	unimportant
Access to transport	2013		**27.6**		**24.4**	performance
	2015		**28.5**	***	**46.0**	performance
	2018		41.9		48.4	unimportant
Reference level for service attributes						
Average RF Importance Score (Reference)	2013		24.3		24.3	
	2015		24.7		24.7	
	2018		49.5		49.5	
Socio-demographic variables:						
Male (male=1, female=0)	2013		16.8			
	2015		15.4			
	2018		**51.9**			
Age	2013		17.8			
	2015		23.4			
	2018		37.4			
Education (1-8, lowest to highest)	2013		14.9			
	2015		**29.5**			
	2018		40.0			

Income (1-7, lowest to highest)	2013		17.1			
	2015	*	**25.9**			
	2018		47.9			
Car Ownership (0%-100%)	2015		23.1			
	2018		35.2			

Note: The “Significance (OLR)” columns indicate whether the coefficients of the indicators are significant in the OLR: * p<0.05; ** p<0.01; *** p<0.001; the “Importance (RF)” columns report the RF importance scores, and the bold font indicates significance in the RF prediction, which means that the RF score for that attribute is higher than the average RF score.

5.3 The Improvement Priority

Based on the categorized importance and the performance of the attributes, the improvement priority of each of the attributes is determined based on the rule explained in the “methods” section (**Table**), and is reported in **Table** . The smaller the value of improvement priority is, the more urgent it is to improve the corresponding attribute. For example, value ‘1’ means the corresponding attribute should be given the first priority compared to the other attributes, if the service providers are considering improving the service.

Table 9 Improvement Priority for Each Service Attribute

Name	Year	Performance Level	Comprehensive Importance Type	Improvement Priority
Expenses	2013	poor	performance	1
	2015	poor	performance	1
	2018	poor	basic	1
Exposure to noise and pollution	2013	poor	unimportant	5
	2015	poor	unimportant	5
	2018	poor	performance	1
Comfort inside buses	2013	poor	basic	1
	2015	good	unimportant	5
	2018	good	performance	2
Reliability	2013	poor	basic	1
	2015	good	exciting	2
	2018	good	performance	2
Comfort at integration terminals	2013	poor	performance	1
	2015	good	exciting	2
	2018	good	performance	2
Easiness to transfer	2013	good	unimportant	5
	2015	good	exciting	2
	2018	good	exciting	2
Comfort at stations	2015	good	performance	2
	2018	good	performance	2
Customer Information	2013	good	performance	2
	2015	good	performance	2
	2018	good	exciting	2

Customer Service	2013	good	unimportant	5
	2015	good	exciting	2
	2018	good	performance	2
Road safety	2013	good	unimportant	5
	2015	poor	unimportant	5
	2018	poor	exciting	3
Easiness to pay fares	2013	good	basic	4
	2015	good	performance	2
	2018	good	basic	4
Security	2013	poor	performance	1
	2015	poor	unimportant	5
	2018	poor	unimportant	5
Comfort at bus stops	2013	poor	unimportant	5
	2015	poor	basic	1
	2018	poor	unimportant	5
Availability	2013	poor	basic	1
	2015	poor	unimportant	5
	2018	poor	unimportant	5
Speed	2015	good	unimportant	5
	2018	poor	unimportant	5
Access to transport	2013	good	performance	2
	2015	good	performance	2
	2018	good	unimportant	5

Note: "Improvement priority" is determined by "performance level" and "comprehensive importance type" following the rules described in **Table** .

Among all the attributes, "expenses" (i.e. fares) has the first improvement priority throughout the three years, indicating that this attribute needs improvement most urgently and should be considered first if the providers or planners want to improve their service. The BRT fare in Belo Horizonte increased from R$ 2.85 in December 2014 to R$4.05 in December 2018, which might account for the sustained top priority of the "expenses" attribute. Therefore, the policymakers should consider reducing the transit fare, which implies that the policymakers should consider other economic models to provide a quality bus service without charging users more. Considering transportation is a social right in Brazil (Brazil Constitution, 1988), the service must be affordable to all income levels.

In 2015, there has been a sharp decrease of improvement priority (from the first to the fifth) with respect to "comfort inside buses" "security" and "availability" compared with the result in 2013 when the BRT was not launched. However, it should be noted that the performances of "availability" and "security" are still lower than the average level in 2015 and 2018, only that the effects of their performance-related dummy variables became insignificant in these two years. In contrast, the performance score of "comfort inside buses" has surged from 2.45 in 2013 to 3.55 in 2015. It should be noted that the first fleet of buses with air-conditioning in Belo Horizonte was deployed in 2014 with the launch of the BRT system (assessed in our 2015 survey). Until 2018, only the BRT fleet had air-conditioning, and the rollout of air-conditioning in BRT has potentially contributed to riders' higher comfort inside buses. "Comfort inside buses" has changed from an unimportant factor in 2015 to an Exciting factor in 2018, which shows that by improving riders' experience inside buses, riders' overall satisfaction can be enhanced even more.

The priorities of six attributes have increased after the BRT opening, which are “exposure to noise and pollution” (which increased from fifth in 2013 to first in 2018), “easiness to transfer” (which increased from fifth in 2013 to second in 2015), “customer service” (which increased from fifth in 2013 to second in 2015), “road safety” (which increased from fifth in 2015 to third in 2018), “easiness to pay fares” (which increased from fourth in 2013 to second in 2015) and “comfort at bus stops” (which increased from fifth in 2013 to first in 2015). These findings show that after the BRT opening, the passengers begin to care more about safety, pollution, service and convenience, which provides a useful guideline for future transit quality improvement. For instance, the transit agency can reduce riders’ exposure to noise and pollution by adopting clean fuels on buses such as adopting electric buses. The performance level of “road safety” changed from “good” to “poor” after the BRT was implemented, probably because the introduction of high-speed buses increased people’s concern about road safety, as walking and cycling became more dangerous in the fast-moving traffic. Therefore, measures should be taken to achieve a safer traffic system, which include building dedicated lanes for cyclists and pedestrians, as well as conducting regular and systematic inspection of existing roads to detect safety concerns and road hazards. The performances of “comfort at bus stops” are all “poor” in these three years. As such, measures can be taken to enhance people’s satisfaction at bus stops, such as adding shelters, making enough sitting arrangement in the bus stops, improving lighting at bus stops and their cleanliness. The performance levels for “easiness to transfer”, “customer service” and “easiness to pay fares” are all “good” for these three years. But since they can significantly affect riders’ satisfaction when they perform well after the BRT was implemented (in 2015), the transit agency can further improve riders’ satisfaction by making improvement in these aspects.

6 CONCLUSIONS

Using Belo Horizonte as a case study, this research explores the influences of service attributes of public transit on riders’ overall satisfaction, as well as how the influences change after the implementation of a BRT system. This paper’s contributions include first the innovative adoption of RF to quantify the influence of each service attribute. The RF method has the merits of achieving higher prediction accuracy, picking up the variability in the data, and capturing the attitudinal randomness by using an ensemble of decision trees. Second, this paper demonstrates the application of traditional OLR to the data and the combination of the results of the two methods to determine the importance type of each attribute. Combining the two methods helps reduce the uncertainty in prediction owing to people’s attitude heuristics, since RF evaluates the importance of attributes based on effect size whereas OLR emphasizes statistical significance. Third, our study fills in the gap in research investigating how the influence of service attributes on overall satisfaction changes over time owing to the construction of a BRT system. We do so by exploring the variation of importance and performance of each attribute over 2013 (before the BRT was implemented), 2015 (one year after the BRT was implemented) and 2018 (four years after the BRT was implemented). The improvement priority ranking for each attribute is also proposed to inform local transit planning.

Based on the research results, we specifically identified four types of attributes in terms of improvement priority: the attributes that consistently have very high priorities throughout these three years; the attributes with a sharp decrease of improvement priorities after the opening of the BRT line; the attributes with an increase of improvement priorities after the opening of the BRT line. We then explore potential reasons that account for the variation of priority over time by analyzing the quality indicators of the attributes. These findings can enhance planners’ understanding of how the rider satisfaction impact of each attribute varies with the implementation of the BRT system, and consequently help policymakers come up with a more fine-tuned improvement strategy targeted at different types of services. To be specific, our finding shows that the attribute “expenses” (i.e. fares) should be given the highest priority among all the attributes since it is ranked as the 1st priority throughout these three years. Another group of attributes that should receive significant attention includes “exposure to noise and pollution”, “easiness to transfer”, “customer service”, “road safety”, “easiness to pay fares” and “comfort at bus stops”, since the priorities of these attributes increased after the BRT opening. Based on the fact that the importance of environmental friendliness, service quality, safety and travel convenience has increased after the BRT was implemented, specific policy recommendations for improving the quality of service for these attributes are provided. While the findings of this research are particularly valuable for the transit agency in Belo Horizonte to decide on the aspects of transit services to improve, the new method introduced in this paper can also be adopted for user satisfaction analysis in other cities or developing countries that have no BRT system or are planning to have one, in order to understand transit users' satisfactions which can help inform BRT implementation there.

There are several caveats with our results. First, when determining the importance type of each attribute, we deem a performance-related component ("high-performance" component or "low-performance" component) of an attribute important if it is identified as important by either OLR or RF. This is based on the consideration that we don't want to miss any attribute that contributes to the overall satisfaction in terms of either statistical significance or effect size but not both. However, this criterion can be modified based on how strict we want the threshold for counting an attribute as important to be. Second, while we derive the importance of the attributes from rider satisfaction, we do not take into account the costs and constraints of improving the services. Therefore, to come up with the optimal decisions, the policymakers should consider our recommendations in combination with the real-world conditions and various policy objectives. Third, the performances of the service attributes are elicited from the subjective evaluations by the respondents of the surveys, and although the survey data used in this research was all collected along the Cristiano Machado corridor, the survey respondents were sampled independently in different years. Therefore, the variations of people's perceptions as well as the influence of service attributes may not necessarily stem from the BRT implementation but rather the heterogeneity in the sample itself. Though the respondents were randomly sampled in each year to minimize the selection bias, future research can explore experimental, longitudinal methods to account for respondent heterogeneity when identifying the impact of BRT implementation on people's satisfaction.

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