Analysis of the Possibility of Transport Mode Switch: A Case Study for Joinville Students

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Highlights:

-A multinomial logit model was used as a tool for identifying factors influencing the choice and switch of transport mode.

-Car users are interested in switching modes of transport if they find more efficient modes, especially related to cost and time.

-Improvements in public transport can be quite significant in attracting users of other transport modes.

-Revealed and stated preference surveys can provide data for narrowing the data gap in transportation demand.

Abstract: This work mainly aims to identify and understand the factors influencing the switching of transportation modes among higher-education students in Joinville, Brazil when traveling to universities. Furthermore, this study evaluates the possibility of switching from individual vehicles to other modes of transport (i.e., bus, bicycle, and walking) by employing a multinomial logit model. The results indicate that students would be interested in switching from individual motor vehicles to other options. The scenarios for switching to buses presented the highest switching probability. The bus cost was the most important factor for switching. Meanwhile, the parking space reduction does not affect the student's choice, indicating that restricting available spaces should not be an isolated measure for decreasing the car mode attractiveness. Finally, the transport mode switch would occur only if alternative modes to the car or their infrastructure are improved; otherwise, students maintain their usual choices.

Keywords: transport mode; revealed preference; stated preference; multinomial logit model; university students

1. Introduction

Good mobility planning requires knowledge on what users demand to make it possible to invest available resources more effectively with measures that encourage more sustainable modes of transport, such as collective and active transport. The demand for transportation is linked to the user's preference for a certain transport mode. This choice is influenced by several factors, such as user characteristics, social environment in which they are inserted, and transportation aspects.

Understanding the factors influencing this choice is fundamental to identifying the main factors leading to one transport being used more than another. Thus, the use of alternative modes to the automobile, which is one of the transport modes generating the highest congestion in urban centers, is being promoted. The factors discouraging the use of other modes can also be determined by promoting improvements in the transport system, thereby offering better options.

In this context, this study proposes the identification and understanding of the factors influencing the switch of transport mode among higher-education students in their commute to universities, focusing on the choice of alternative means to the car. For this purpose, a revealed preference survey was performed to learn the current commuting form of respondents, while a stated preference survey was conducted to evaluate the possibility of switching transport modes by employing hypothetical scenarios. The data from these surveys were used in a multinomial regression model. The city of Joinville, which is located in the north of the Santa Catarina state, was chosen for this study. Joinville is an industrial center in the southern region of Brazil with an estimated population of more than 583,000 inhabitants, which makes it a medium-sized city [1].

Medium- and large-sized cities already have a considerable road network, and its expansion can be discarded if the existing space is better used. Thus, knowing the characteristics that inhabitants consider relevant in a transport mode is necessary in improving the conditions of less-used modes, creating an initial incentive for the population to change their behavior. The balance of using different transport modes is precisely the key to change, which reduces the use of individual motor vehicles and encourages collective and active transport, including buses, bicycles, and walking.

Students were selected as the target audience of this research because they belong to a class that is generally young and can represent a possible tendency of change in behavior toward their commute mode choices. Moreover, students have varied attributes. They are adults with autonomy to decide how to travel and present information that is easier to access for research. Educational institutions are travel-generating poles and, in their majority, attract significant numbers of users in a given time range, thereby contributing to the increase in traffic in the region. With the analysis of this concentrated commute, the flow can be relieved and distributed in a more organized manner.

2. Literature Review

The literature presents many studies that address the mode choice for understanding the factors influencing the use of a certain transport mode. Most studies focus on binary options [2-6] by analyzing two transport modes (e.g., car and public transport) or motorized or non-motorized mode categories. Other studies investigated the mode choice through multinomial models (i.e., with more than two options for the dependent variable) [7-11]. In a more restricted manner, some studies used students as their target audience, regardless of whether they were university students [12-14] or children [15].

Among the factors found, the commute time was quite significant. Users would be less likely to choose transport modes with longer commute times [16]. The perception of the commute time is more sensitive to the bus mode (i.e., a shorter or longer trip can influence bus use more than the other modes) [17].

For university students, time is also an important factor considering that longer and further routes encourage the use of individual vehicles [18]. Time can be analyzed as the total commute time, just the time of commute within the vehicle, waiting time, or access time to the boarding place. In this context, if the walking time to a boarding point is shorter, and the commute time of the car increases, a significant possibility of switching the car for public transportation can be observed [19]. The waiting and the period inside the vehicle during the commute are more important for decision making than the walking time to access transport and reach the destination [20].

Users' interest in switching to a more efficient public transport mode grows as the commute time and costs for private transport increase [17].

For students, the bicycle choice is influenced both by the commute times using the bicycle and the bus [21].

Users would be encouraged to use public transport if they received a bonus or had reduced fare even if the total commute time was longer [22]. In some cases, public transport users would be willing to pay higher for a more comfortable and frequent service with up to 15 min of waiting [17] or for a shorter travel time [19].

Cost is another very relevant factor for the transport mode choice, on which switching has a direct influence. The increase in fares in transport reduces its utility, which is the measure of the mode attraction [17]. A 10% change in the commute costs would not change the user's choice, but a 20% increase in the commute costs by car could switch the choice to public transport [19]. The bicycle has an advantage in this sense because it presents low acquisition cost and does not consume fuel, thereby exempting this mode from expense [6]. For students, low-cost parking would encourage car use [23].

The greater the distance to work or school, the lower the probability of going by bicycle and the greater the probability of using public transportation in the absence of a car [16, 24]. Students who move to another city to study are already looking for housing close to educational institutions and usually shift to walking or traveling by bicycle. None of the students who moved up to 2 km close to the IHE (Institution of Higher Education) used public transportation because they preferred to walk or cycle, which is an option also influenced by cost [13].

The socioeconomic characteristics of respondents also frequently appear in the literature [24]. In terms of gender, women use public transport more [18] and are less likely to commute by bicycle compared to men [20, 24]. Among students, the conclusions follow the same trend, with women preferring cars to bicycles [23]. Women also prefer buses to cars when compared to men and are less likely to have a driver's license [25].

As regards age, the youngest are more likely to walk to the destination [20], as is compatible with the age group of the students.

Students with incomes close to the middle-class value give less importance to bus fare than people with other income levels [21]. For users in general, the bicycle [24] and public transport [26] modes have lower chances of being used as incomes increase.

Another point is the family structure, in which married users and those from larger families tend to use cars more often [16].

Factors, such as weather [23], provision of parking spots, accessible routes, and showers at the destination for pedestrians and cyclists, encourage the use of the walking and cycling modes [6].

In addition to promoting other transport modes, discouraging the use of individual vehicles can help in the possible change of behavior in the way people choose to commute [27]. Meanwhile, other quality transport modes must be offered when decreasing car usage.

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[23] evaluated the increased cost of parking in educational institutions as a disincentive measure to the car. However, they noted that a coordinated action with the municipal government is needed to avoid overburdening areas surrounding the university with parked cars. Charging for parking inside the university campus would be the most impacting measure to decrease the car mode attractiveness [21]. For [20] the availability and cost of parking are not significant.

The factors influencing the choice of transport mode can be extracted based on the works found in the literature. These factors are presented in Table 1. "Costs" and "time" had the highest occurrence. Studies also brought another interesting point: for the user to choose a certain transport mode, both mode characteristics and structure at the destination, such as parking availability and changing rooms, are sufficient.

Table 1. Factors influencing the switch of the transport mode choice

Factors	
Costs (travel, parking)	Frequency (time)
Distance	The time within the transport mode (time)
Comfort	Seat availability (capacity)
Exclusive lane availability	Access to college (from parking to college)
Structure at destination	Access to the transport mode (time)

3. Characteristics of the study area

The city of Joinville is the study area. Joinville is located in the north of Santa Catarina state (Figure 1). It is the largest city in the state, and its main activities are concentrated in the industry of the metal-mechanical, plastic, and metallurgical sectors [28].

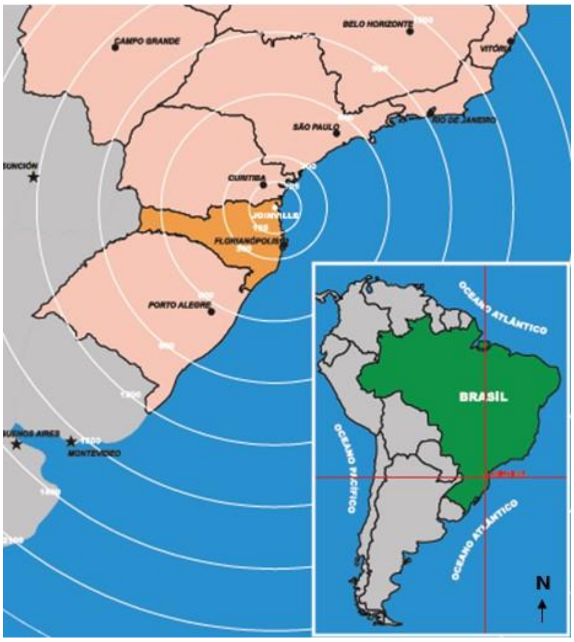

Figure 1. Joinville/SC location [28]

The last origin/destination survey in Joinville that was used as a reference was conducted in 2010 [29]. It presented a modal division of 35% car use, followed by public transport with 24%, walking with 23%, and bicycle with 11%. In 2017, the population index per vehicle was 1.47 (i.e., 3.14 in 2000). The vehicle fleet almost tripled in 17 years.

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For public transportation, the city has an integrated bus system with 10 terminals and a single ticket payment. Bus transportation has reduced the number of users since 2000. The indicator of passengers transported per day in terms of the population fell from 32% in 2000 to 17% in 2017 [29].

4. Materials and Methods

The data were obtained through the application of a questionnaire consisting of sample characterization and information about its daily commute in a revealed and stated preference survey format. The face and content of the questionnaire were validated and approved by the university's ethics committee (project identification code: 96026418.8.0000.0118, approval date: 01 November 2018, by Research Ethics Committee Involving Humans of Santa Catarina State University - CEP/UDESC).

Table 2 presents the main questions asked to students in each section of the questionnaire, which was divided into three parts: parts A and B of the questionnaire were related to the characterization and aspects of the user's current commute, respectively, and part C, which presented the proposed scenarios to evaluate the possible switch in the transport mode choice for users available only for those who use cars as their current transport mode.

Table 2. Sections of the questionnaire

Part	Description	
Part A	Characterization of respondents	IHE, course, period, age, gender, income, marital status, if they work, if they have children, if they know how to ride a bike, etc.
Part B	Revealed preference: description of current commute	Transport mode currently used, commute time, commute routine, travel time, etc.
Part C	Stated-preference: analysis of switch in transport mode choice	Eight scenarios with different infrastructure or current transportation system situations, with four options each (walking, by bicycle, bus, and car).

In Part C, eight attributes of the transport modes with two levels each were chosen to generate scenarios that could be evaluated by the respondent. An orthogonal arrangement experiment was performed, resulting in eight scenarios.

The respondent was presented with a chart explaining all the factors and their levels (Figure 2) to facilitate the understanding of questions. As an example, for the walking mode, the existence of accessible pavement was evaluated, being described as a good pavement that allows the locomotion of people with reduced mobility.

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Figure 2. Factors

Appendix A shows the summary of the eight scenarios.

The data collected were estimated to be at a minimum of 400 responses considering 95% confidence level, 5% margin of error, and a population of 10,000 students. Six institutions were selected from a total of 13 (i.e., A, B, C, and Others (D)). For analysis purposes, University C composed of two poles had the pole with fewer students included in group D because it had similar characteristics to others and was located far away from the northern region.

All participating educational institutions offer presence-based courses with both free and paid tuition. Among the free institutions are a state university (A) and a federal university (B), which both focused on technology and exact sciences fields. In private colleges (C and D), the courses are of diverse fields, and classes are in all periods (i.e., mainly night and morning). Institutions that offered online-based learning courses at the time of the research were excluded.

The questionnaire was applied in online format between November 2018 and January 2019. A total of 511 responses were received. Most of the responses were from students in the northern part of the city (i.e., from universities A to C), with a response rate of 83.2%.

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4.1. Logit Model

Discrete choice models are a recurrent method for the analysis of the revealed and stated survey data. This type of model is useful for reproducing, describing, or evaluating situations where individuals must select an option from a finite set of alternatives [30]. One of the applications for the discrete choice models is in understanding the preference of transport modes by users.

Logit models "represent complex aspects of user displacement decisions, incorporating important demographic and policy-sensitive explanatory variables." [18] (p. 1415).

Binary logit model comprises the choice between two dependent variables (e.g., choosing to use a car or a public transport). The individual chooses between yes or no (0 or 1). The multinomial logit model has more than two categories for the dependent variable [31].

The choice of an individual can be predicted by the random utility model: "The main assumption is that each person associates a quantity, called utility, to each alternative, selecting the alternative with the greatest utility."[32] (p. 02). Logit model is mathematically based on the theory of maximizing this utility. The utilities come from the attribute characteristics and of the individuals themselves and are related to the attractiveness of choice and the individual [30].

This study proposed the identification of influential variables both in the current transport mode choice and in an eventual shift of the students' commute mode through hypothetical scenarios alternative to the current one. Two distinct multinomial logit models were adjusted and presented in the subsections that follow. The first one refers to the revealed preference survey (n = 411). The second one refers to the stated preference (i.e., only for those who use cars; n = 150). To specify the revealed preference model, the answers of students who did not live in Joinville (29) and those referring to the "Other transport mode" (14) and carpooling (56) were removed.

The dependent variable is the transport mode with four options: by car (reference), walking, by bicycle, and bus. The independent variables are educational institution, age, gender, income, who they live with, whether they work, and commute time. The scenario variables were also included for the stated preference models.

The model evaluation was done using the pseudo r^2 (McFadden, adjusted McFadden, Nagelkerke and Cox, and Snell). The likelihood ratio test was performed. The results of the confusion matrix, general accuracy values, sensitivity, specificity, and Kappa index were also analyzed. The confusion matrix was elaborated only for the stated preference survey considering the number of answers. The odds ratio values were used to analyze the significant parameters.

All analyses were performed in R *software* [33] using the *mlogit* [34], *nnet* [35], and DoE.Base [36] packages. For modeling, the sample was divided into two parts: 70% for model calibration and 30% for validation with a 5% significance level. The QGIS software [37] was used to visualize the spatial distribution of the place of origin of the students' travels and analyze the transport mode chosen in terms of distance to the universities.

5. Results and Discussion

The sample characterization indicated that of the 511 respondents, 302 were women, and 209 were men. Most were between 18 and 25 years old. The mean age of the respondents between 18 and 44 years old was 22 years old. Income comprised the average family income (if the respondent lives with them) or only theirs (if they live alone or with friends). The average income of three to five minimum wages was more frequent (44%), followed by the income of up to two minimum wages (27%). Most of the respondents were

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single, live with their families or partners, know how to ride a bicycle, know how the city's public transportation system works, have no children, and live in Joinville.

The most used mode of travel between the origin (home or work) and the IHE is the bus (184 students: 36%), followed by the car (150 students: 29%), and carpooling (11%). Carpooling obtained an impressive number because University B is located in a region with little transport supply and transport infrastructure. Thus, carpooling has become an easier way to commute.

Half of the students who said they use “Other transport modes” do not live in Joinville and use a private bus or van/mini-bus (16 students) and motorcycles (12 students).

In general, students usually spend an average of 36 min to make the commute to the IHE. Specifically, 34% (174 students) take 11 to 20 min, and 28% (144) take more than 41 min on their way. Appendix B presents a table with the sample characteristics.

Table 3 shows the sample characteristics separated by the respondent's current transport mode. Students who use cars had the highest mean age (24.73 years old), while the lowest mean was from those who use buses (21.21 years old). However, the values can be considered very close considering that the mean of the total sample was 22.53 years old.

Table 3. Sample characteristics by transport mode

Levels	Transport mode (%)						
	Car	**Bus**	**Bicycle**	**Walking**	**Carpool**	**Other**	**Total**
	150	184	45	45	58	29	511
Gender							
Female	29,8	39,1	5,0	9,6	11,9	4,6	302
Male	28,7	31,6	14,4	7,7	10,5	7,2	209
Income							
Up to 2 m.w.	18,7	42,4	10,8	13,7	11,5	2,9	139
3 to 5 m.w.	28,1	37,9	7,6	6,3	12,0	8,0	224
6 to 9 m.w.	36,8	30,5	9,5	7,4	11,6	4,2	95
Over ten m.w.	49,1	20,8	7,5	9,4	7,5	5,7	53
Marital status							
Single	26,8	36,8	8,6	9,8	12,4	5,5	451
Married	48,3	30,0	10,0	1,7	3,3	6,7	60
Lives with							
family/partner	29,5	41,1	8,3	5,4	8,8	7,0	387
With friends	31,4	9,8	15,7	9,8	31,4	2,0	51
Alone	27,4	27,4	6,8	26	10,9	1,4	73
Work							
Yes	27,2	39,2	9,6	6,8	7,2	10,0	250
No	31,4	33,0	8,0	10,7	15,3	1,5	261
Has children							
Yes	43,3	33,3	3,3	10,0	10,0	0	30
No	28,5	36,2	9,1	8,7	11,4	6,0	481
Can ride a bike							
Yes	29,9	35,2	9,5	8,4	11,6	5,5	475
No	22,2	47,2	0	13,9	8,3	8,3	36
Has a bike							
Yes	25,6	33,1	17,7	8,7	8,7	6,3	254
No	33,1	38,9	0	8,9	14,0	5,1	257
Knows how to use buses							
Yes	26,2	40,7	8,7	8,7	11,1	4,7	450
No	52,5	1,6	9,8	9,8	13,1	13,1	61
City							

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Joinville	29,4	37,5	9,1	9,3	11,6	3,0	482
Other	28,0	10	3,0	0	7,0	52,0	29
IHE							
IHE_A	26,6	33,0	13,8	19,3	4,6	2,8	109
IHE_B	35,8	33,3	7,3	0	22,0	1,6	123
IHE_C	24,4	42,5	7,3	7,3	8,8	9,8	193
IHE_D	34,9	29,1	8,1	11,6	10,5	5,8	86
Type of IHE							
Private	27,6	38,4	7,5	8,6	9,3	8,6	279
Public	31,5	33,2	10,3	9,1	13,8	2,2	232
Course phase							
Start	17,6	47,1	8,4	7,6	13,4	5,9	119
Half	32,4	33,8	7,9	10,7	11,4	3,8	290
Graduating	34,3	29,4	11,8	4,9	8,8	10,8	102
Travel time (min)							511
Mean	24,2 (24,4)	55,1 (28,1)	23,9 (11,1)	16,6 (11,9)	22,2 (8,15)	55,5 (38,6)	
Age							
Mean	24,73 (5,68)	21,21 (3,62)	23,56 (4,72)	21,87 (3,68)	21,28 (2,83)	21,52 (2,78)	

Standard deviation is in brackets.

Men use cars and bicycles more, while women use buses, walk, and catch rides more. As regards income, students who use cars have a higher income, while those who use buses have an income of up to five minimum wages.

Most married students use cars (29 students), followed by those who use buses (18 students) and bicycles (6 students). A total of 166 single students commute by bus. Those who share a house with friends usually go by car or catch rides to college. The “living alone” option does not affect the mode choice. For students who live with their families or classmates, the most chosen option is the bus (160 students), followed by the car (114).

Students who work use the bus more, followed by the car.

Even if most of them know how to ride a bicycle, only half of them have one. Even the latter group uses other transport modes aside from the bicycle. Some indications showed that owning a bicycle does not change the transport mode choice.

Among the educational institutions, institution C had more students who use buses (42.5%) and less cars compared to others. Universities B and D had more students who use cars (35.8% and 34.9%, respectively).

Students use public transport more at the beginning of their education and as they move to the middle and end of their education. The opposite happens with the car transport mode, thereby increasing usage as students advance to the end of their education.

The mean bus time was 55.1 min, which is close to the mean time of the “Other transport modes” (i.e., you can compare the time that you spend riding buses within the city with that spent by those who have come from other cities to study). The shortest mean time was obtained for walking because this mode is associated with short distances.

A cyclist can travel 3.2 km in 10 min considering an average speed of 20 km/h [38]. The mean time of the responding students (23.9 min for cycling) may represent a longer distance traveled than the reference distance of 3 km. In turn, the average time for the car is less than half the time for the bus (24.2 min).

To complement the descriptive analysis, Figure 3 illustrates the mapping of the student responses to the transport mode chosen for daily use. The point indicated by the car design, for example, is the location of the residence or a junction near the home of the student who

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uses a car to commute to the IHE. Buffers (limiting regions by a certain radius) were inserted to evaluate the distances covered by the different means of locomotion.

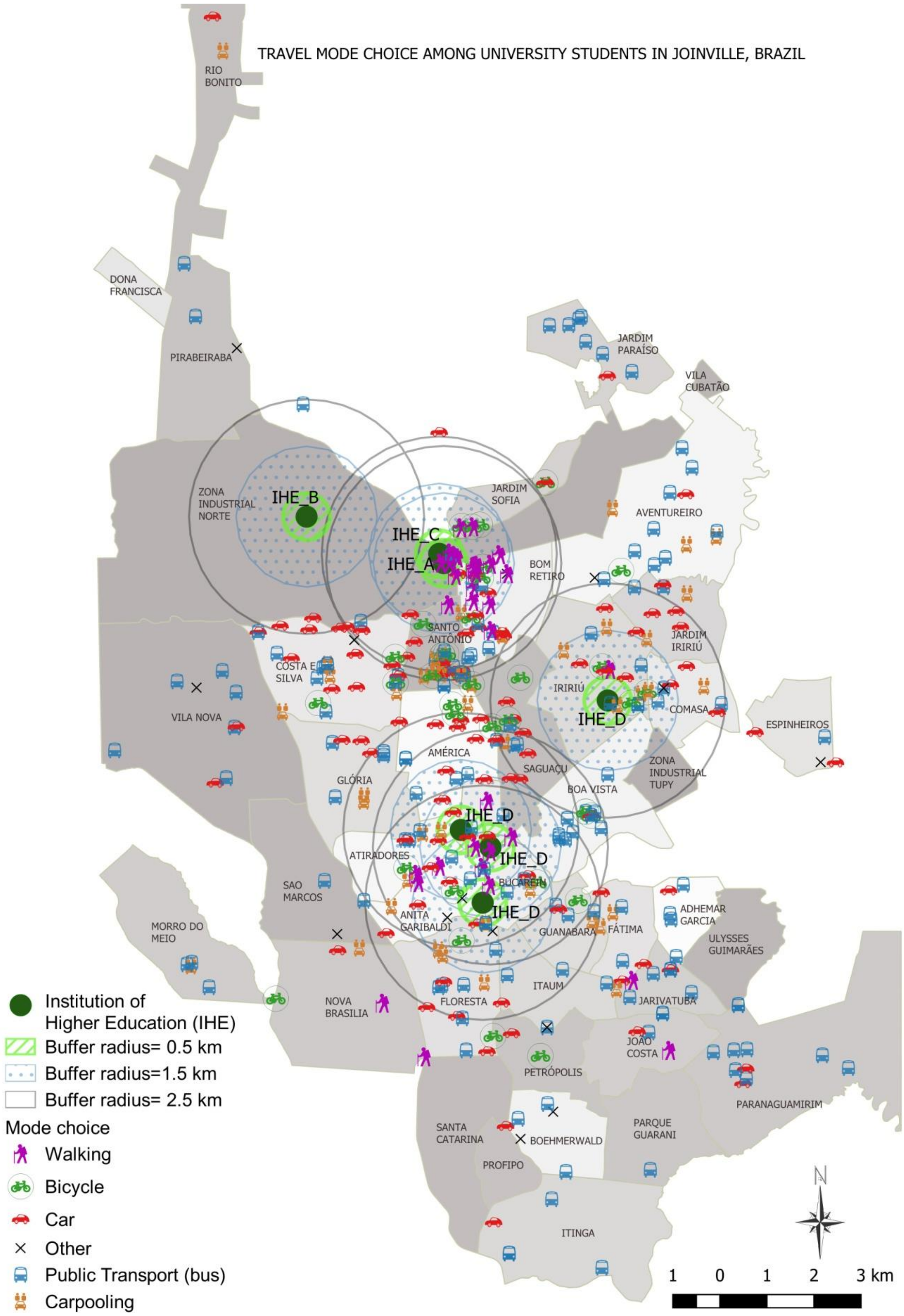

Figure 3. Joinville and respondent choices

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The 0.5- and 1.5-kilometer buffers covered most non-motorized displacements, as stated by [11]. The region with the highest incidence of this occurrence was around universities A and C. This is a fact justified by the presence of two very close universities. Another reason is the existence of many student housings in that region considering that many respondents come from other cities to live in Joinville to study. The central region also favors walking as a form of commute. However, in the southern region, some students choose to walk even if the distance is more than 2.5 km.

Some bicycle movements outside the limited regions were noted, indicating that some students cycle more than 2.5 km to go to college.

The 2.5 km buffer is the region in which students mostly used cars and buses; however, many motorized commutes are made beyond these distances. This shows that students come from quite diverse backgrounds in the city, but are at the bottlenecks near the destination.

5.1. Logit model for the revealed preference

Table 4 presents the results of Model 1 for the revealed preference survey. The sensitivity values of Model 1 were good for the car (0.76) and bus (0.86) classes, indicating that the model was correct for the true positives. The sensitivity for the walking mode was 0.55, while that for the cycling mode was 0.18, which proved to be a little less correct. For specificity, all classes had a result above 0.81, which means that the model was correct for the true negatives. The overall accuracy of the model was 0.724 (i.e., Model 1 hits 72.4% of the results).

Table 4. Model 1 estimates

Significant variables	Coefficients	Standard Error	OR	2.5%	97.5%
Age					
Bus	−0.197	0.057***	0.820	0.733	0.917
Walking	−0.152	0.070*	0.858	0.747	0.985
Gender					
Female	Reference				
Male					
Bicycle	1.839	0.535***	6.292	2.204	0.179
Income					
Up to two m.w.	Reference				
Three to five m.w.					
Bus	−0.940	0.515 .	0.390	0.142	1.073
Bicycle	−1.157	0.600 .	0.3142	0.096	1.019
Walking	−1.476	0.676*	0.228	0.060	0.860
Over ten m.w.					
Bus	−1.669	0.019*	0.211	0.051	0.865
Bicycle	−1.742	0.835*	0.175	0.034	0.900
Lives with					
Friend	Reference				
Family/companion					
Bicycle	−1.835	0.920*	0.195	0.026	0.968
Walking	−2.764	1.188*	0.062	0.006	0.647
Alone (a)					
Bicycle	−1.657	0.958 .	0.190	0.029	1.247
Travel time					
Bus	0.113	0.016 ***	1.120	1.084	1.157
Bicycle	0.043	0.020*	1.043	1.003	1.085

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IHE					
IHE_D	Reference				
IHE_A					
Walking	1.531	0.789.	4.623	0.984	2.17
IHE_B					
Bus	−1.876	0.729**	0.153	0.037	0.629
Bicycle	−2.334	0.940*	0.096	0.0153	0.612
Accuracy		0.724			
	95% CI	(0.669, 0.775)			
Kappa index		0.565			
Values of ρ²					
	McFadden	0.377			
	Adjusted McFadden	0.272			
	Nagelkerke	0.6534			
	Cox and Snell	0.593			
Testing the likelihood ratio		258,18			
(p-value ≤ 2.22e−16)					
AIC		498,20			
		Sensitivity	Specificity		
	Car	0.764	0.828		
	Bus	0.861	0.813		
	Walking	0.551	0.968		
	Bicycle	0.187	0.964		

The odds ratio (OR*)* for the significant coefficients of Model 1 show that if the coefficient results are smaller than one, it becomes more likely to choose the reference category (car).

The analysis of the variables showed that students in B have lesser chances of using the bus and bicycle modes. As mentioned, the university location has been changed, and access to the new location is easier by car because the route near the university has no bike lanes and only has a few bus lines. The roadside is also precarious.

The OR evaluation indicated that a student from University A is almost five times more likely to walk than use a car. Young people between the ages of 18 and 35 years are more likely to walk to their destination [20]. Distances of up to 2 km are usually covered by walking or cycling [13]. Students who live on rent worry about finding houses or apartments near the area where they study [13]. Figure 3 shows that many walking distances are close to A within the 1.5 km region, which is a place with many student housings.

Older students are less likely to choose the bus or walk because they usually have enough income to own and maintain cars. Male students are six times more likely to use bicycles than females, which is in agreement with [20, 23, 24].

Meanwhile, the higher the income, the greater the chance of using cars.

Respondents who take a longer commute usually come by bus and bicycle. The result depends on the sample profile.

5.2. Logit model for the stated preference

This multinomial model analyzes the possibility of the transport mode switch. For this step, 150 answers from Part C of the questionnaire were used. In this case, no division needed to be considered between the calibration and validation samples.

The chosen model (i.e., Model 2) presented the following variables: age, gender, income, who the student lives with, whether they work, travel time, and scenario variables.

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By evaluating the coefficients in Table 5, we can identify the factors influencing the mode switch or the continued use of the car. Most variables resulted in a positive sign, indicating the switch from car mode to another mode.

Table 5. Model 2 estimates

Significant variables	Coefficients	Standard error	OR	2.5%	97.5%
Gender:					
Female	Reference				
Male					
Bus	−0.588	0.164***	0.555	0.403	0.765
Bicycle	0.641	0.214***	1.898	1.246	2.889
Income:					
Up to two m.w.	Reference				
Over ten m.w.					
Bus	−0.611	0.273*	0.542	0.317	0.926
Lives with:					
Friend	Reference				
Family/partner					
Bus	0.791	0.286**	2.206	1.258	3.867
Work					
No	Reference				
Yes					
Bus	0.420	0.173*	1.522	1.119	2.965
Bicycle	0.599	0.248*	1.822	1.083	2.139
Walking	1.734	0.510***	5.668	2.083	15.423
IHE: IHE_D	Reference				
IHE_A					
Bus	1.306	0.266***	3.6943	2.190	6.230
IHE_B					
Bus	1.739	0.269***	5.695	3.355	9.668
IHE_C					
Bus	0.971	0.225***	2.642	1.696	4.114
Bicycle	−0.538	0.290 .	0.583	0.330	1.031
Walking	−1.814	0.684**	0.162	0.042	0.623
Travel time					
Bus	0.007	0.037.	1.007	0.999	1.014
Bicycle	0.012	0.004**.	1.013	1.004	1.021
Walking	0.011	0.006 .	1.011	0.998	1.023
Scenario variables					
Accessible _ sidewalk					
No	Reference				
Yes					
Bus	0.362	0.148*	1.436	1.074	1.921
Walking	2.342	0.619***	10.406	3.093e	35.011
Bike_lane					
No	Reference				
Yes					
Bicycle	2.306	0.256***	10.039	6.070	16.602
Infrastructure					
Ideal	Reference				
Minimum					

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Bicycle	−0.725	0.205***			
Time					
Same	Reference				
Less					
Bus	0.924	0.161***	2.520	1.836	3.459
Bus _ cost					
Same	Reference				
Smaller					
Bus	1.956	0.163***	7.071	5.130	9.746
Walking	0.865	0.394*	2.376	1.097	5.143
Significance 0'***' 0.001'**' 0.01'*' 0.05 '.' 0.1					

All IHEs had a positive impact on switching from car to bus. However, C students do not switch their cars for walking or cycling even if the university currently provides covered bicycle racks. Considering that 68.4% of the students in this university work, one hypothesis for this result is that the students have many activities to do before or after class, which, according to [39], can impair their choice of modes other than the car. However, the model pointed out that working students would switch the car for any other transport mode. One possible justification would be the perception that working students value their money more and would, therefore, think about the savings made by eliminating car expenses. No other model would have this expense if paid parking at work is considered.

Male students are less likely to switch to the bus and more likely to switch to the bicycle. This result is in agreement with that obtained by [20]. Living with a family or a partner would make the user switch from car to bus. The higher the student's income, the less the likelihood of changing modes (i.e., those who earn more would continue to use cars). In addition to the time and cost of the trip, the increase in the user's income brings resistance to switching from car to bus [26].

According to the “Travel time” variable, the longer the commute time for the car, the greater the tendency to switch to all other means of transport, which supports the idea of creating limits for the use of individual vehicles, thereby reducing its incentive.

All the improvements suggested by the scenarios were positively evaluated, reflecting the transport mode switch. That is, if the road offers accessible sidewalks, the user would switch to walking or taking a bus. Perhaps, the bus was representative because the students related the accessible sidewalk as an incentive to walking to or from the bus stop to the destination. The availability of exclusive lanes encourages the switch from car to bicycle. Exclusive lanes can increase a cyclist's sense of safety and confidence, especially those with little experience, as [40] reported.

The minimum infrastructure for the cyclist decreased the likelihood of switching between car and bicycle (i.e., offering support structures, such as appropriate bicycle racks, and changing rooms can encourage bicycle use). This result is consistent with that obtained by [6, 41].

If the bus offered less travel time than the car, a likelihood of switch to the bus would be observed. If the bus cost was lower than the current cost, the student would switch to going by bus, bicycle, or walking. The perception of the commute time by users is more sensitive to the bus and well evaluated as time is reduced, and its reliability is increased [17]. Increase in the cost and time of the car positively affected the switch to the bus [17].

The “Bus cost” variable is positive for the switch from car to bus, bicycle, and walking if the public transport presents a lower cost than the current cost. This is consistent with the result obtained by [11, 17, 21, 42]. The increased bus cost usually discourages its use [11]. Student responses may indicate dissatisfaction with the current service, opting for its use only if the cost is reduced

The parking restriction did not influence the students at the time of the mode switch, although charging the parking lot would be an important measure for reducing the car mode attractiveness [21]. Meanwhile, [20] showed that the availability and cost of parking are not significant for switching modes.

These differences in the respondents' perceptions can be generated by the wide availability of parking spots in most of the analyzed institutions. In this sense, the student could consider getting to class earlier to secure the few parking spots available or seek to park in the vicinity of the university. Parking restrictions should not be made as the only way to reduce the car mode attractiveness.

Table 3 presents the OR for the significant variables to switch the transport mode, which indicates the trend for this switch.

Male students are approximately twice as likely to switch from car to bicycle. If the student lives with their family or a partner, the likelihood of switching from car to bus is 2 times higher. For working students, the probability of switching from car to bus is 1.5 times higher compared to that of those who are not working. For the bicycle, the probability is almost 2 times higher. A 5.6 times higher likelihood of switching to walking is also obtained.

With relevance to the increase of time for the car mode, the probability of switching exists, albeit small (i.e., less than 2% for all modes). This indicates that although time is an important variable, it may not be the main one. All institutions have a probability of switching to the bus mode in comparison with the reference located in the central area.

The scenario proposals stimulated the switch to all other transport modes. Offering accessible sidewalks would result in a 9 times greater chance of walking compared to low-quality sidewalks. Providing bike lanes would make switching from cars to bicycles 10 times more likely. If the time of commuting by bus is less than that when using a car, the likelihood of switching to the bus would be 2.5 times higher, while that for the lower cost would be 7 times higher.

Nevertheless, a more resistant group of 23 people (15%), who do not switch modes in any of the scenarios, was identified. Furthermore, 56% chose to keep their cars in at least one of the scenarios. In half of the scenarios, the respondents remained with the car option. The bus was chosen in 32% of the scenarios (i.e., a switch from car to public transportation would be observed considering the hypothesis of improvements in buses).

Appendix C presents the proportion of choices for each transport mode according to the scenario responses.

6. Conclusions

To the best of our knowledge, no similar research has yet identified and analyzed the possible changes in the transportation mode choice among university students in Joinville. Being the IHE travel generator poles, student commutes can affect the performance of the urban transportation system.

This survey mainly aimed to contribute to the identification of the factors considered by the user to be the most relevant when deciding to switch from a transport mode used in their routine to another option.

The multinomial logit model for the revealed preference survey showed that the IHEs, age, gender, income, who the student lives with, and commute time are significant variables for the respondent's choice of transport mode. In addition to the variables already mentioned, the improvements in the scenario also contributed to the choice switch in the stated preference survey model. The results indicate that students would be interested in switching from individual motor vehicles to other options. The mode with the greatest number of positive variables for switching was the bus, but the bicycle and walking modes were also of interest.

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With the increase in car commute time and reduction in bus costs compared to the current values, students would switch to any other mode, as would working students. The results of the scenarios showed that cost and time are relevant variables for Joinville students, influencing the switch in the user's choice for all other modes (i.e., bus, bicycle, and walking). Unlike in the literature, the restriction on the number of parking spaces was not important for the users.

Note that the possibility of quality reduction in car use causes users to switch transport modes. This idea is supported by the literature expressing that reducing the usefulness of cars reduces preference. At the same time, the need to improve other transport services is evident, giving the user the conditions to choose the best option for their routine.

This is the first study to evaluate the mode choices among city students. This exploratory research provides information that can help identify behavior patterns. A difference was observed between the modal split pointed out in 2010, indicating a reversal between public transportation and cars: students in this survey use buses more than the respondents in 2010. This public transportation mode can be used to keep them with this choice and motivate other users, thereby making this mode more attractive.

The city of Joinville proved promising for the development of new incentive measures for alternative modes to individual vehicles because there would be a demand for this transport switch. Aside from the students' answers, the city counts on projects to improve the transportation system, such as the road plan revision. The data used for the transport surveys in Joinville were from 2010, back when the last origin-destination survey was conducted. The results described can serve as a basis for new studies and proposals for interventions according to demand.

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Appendix A

Table A1. Scenarios

Factors	Attributes	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Accessible sidewalk	Yes	x	x	x	x				
	No					x	x	x	x
Exclusive bike lane	Yes	x	x			x	x		
	No			x	x			x	x
Infrastructure at destination	Ideal	x		x		x		x	
	Minimum		x		x		x		x
Bus time	Smaller	x		x			x		x
	Just like the car		x		x	x		x	
Bus cost	50% of currently	x			x		x	x	
	Same as today		x	x		x			x
Car situation	Same as today	x	x					x	x
	With restriction			x	x	x	x		

Appendix B

Table B1. Survey sample characteristics

Variable	Levels	Frequency	Percentage (%)
Age — age group (continuous numerical variable)	Between 18 and 25 years old	432	85%
	Between 26 and 30 years old	52	13%
	Over 31 years old	27	3%
Gender	Female*	302	59%
	Male	209	41%
Income (minimum wage = m.w.)	Up to two m.w.*	139	27%
	Three to five m.w.	224	44%
	Six to nine m.w.	95	19%
	Over ten m.w.	53	10%
Marital status	Single	451	88%
	Married*	60	12%
Lives with	With family/partner	387	76%
	With friends*	51	10%
	Alone	73	14%
Work	Yes	250	49%
	No*	261	51%
Has children	Yes	30	6%
	No*	481	94%
Can ride a bike	Yes	475	93%
	No*	36	7%
Has a bike	Yes	254	50%
	No*	257	50%
You know how to use buses	Yes	450	88%

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	No*	61	12%
City	Joinville*	482	94%
	Other	29	6%
IHE	IHE_A	109	22%
	IHE_B	123	24%
	IHE_C	193	41%
	IHE_D*	86	13%
Type of IHE	Private*	279	55%
	Public	232	45%
Course type	Graduation*	480	94%
	Postgraduate	31	6%
Course phase	Start*	119	23%
	Half	290	57%
	Graduating	102	20%
Travel mode	Car*	150	29%
	Bus	184	36%
	Bicycle	45	9%
	Walking	45	9%
	Carpooling	58	11%
	Other	29	6%
Travel time (continuous numerical variable)	0 to 10 min	55	11%
	11 to 20 min	174	34%
	21 to 30 min	95	19%
	31 to 40 min	43	8%
	More than 41 min	144	28%

*Reference

Appendix C

Table C1 presents the proportion of choices for each transport mode according to the user responses to the eight scenarios in Part C of the questionnaire.

The last column of Table C1 represents the proportion of times the mode was selected considering the sum of all eight scenarios.

Table C1 Proportion of transport mode choice in the scenarios

Modes \ Scenarios	1	2	3	4	5	6	7	8	Sum
Car	27%	66%	61%	41%	59%	29%	56%	77%	52%
Bus	47%	9%	27%	50%	7%	57%	38%	21%	32%
Bicycle	23%	21%	5%	3%	33%	14%	5%	1%	13%
Walking	3%	3%	6%	6%	1%	1%	1%	0	3%