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A Characterisation of Commuter Bicycle Trips

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Abstract

This paper presents the results from a set of surveys conducted in the city of Rio de Janeiro with bicycle users travelling to work or to school. From these surveys, we identified the main characteristics of bike trips and could establish a demand model based on the bike user's behaviour. This travel demand model could be used in estimating the number of bicycle trips that may be generated by employees of shopping centres as an example of a demand model for bike trips. Moreover in some locations, a survey was conducted with non-users to identify issues regarding the use of this mode of transport. The surveys were conducted in universities, workplaces and in subway stations. In the subway stations, people who used a bicycle in addition to this system and people who did not use a bicycle to access the subway stations were interviewed. The results of this research not only shed light on bike users, but also develop a tool to aid the estimation of a potential demand of commuter bicycle trips.

Keywords: bicycle trips; demand; commuter trips; cyclist profile.

1. Introduction

The use of the bicycle for transportation is currently regarded as a way of increasing sustainable mobility and population health. Therefore, it is important to encourage bicycle use especially by those who travel daily from home to work or to school. This incentive can be accomplished by conducting campaigns, but also providing bicycle facilities. In order to achieve this, it is important to know the characteristics of bike commuters who travel to work or to school, and how this movement is already happening today. This knowledge provides a preliminary assessment of the potential users of a cycle path and other facilities that could be implemented.

For modal choice, according Larrãnga (2008), users seek to satisfy their needs for travel that often are subject to financial, temporal and technological impedances. The modes of transportation available are analysed

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considering characteristics such as travel time, the hurry to reach their destination, the cost of travel, comfort, accessibility, the availability of automobile, the financial individual conditions and subjective characteristics for each mode (Ortuzar *et al*, 1999). With this information, users choose the transportation mode based on the knowledge they possess and their conditions.

Some models have been used in an attempt to quantify the quality of service or level of service offered to cyclists travelling in urban areas. The criteria commonly used to describe these conditions are: speed or travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety. Until 80's, all of these factors were also used to evaluate the operational quality of a road (Lipari, 2004).

Besides the analysis of the quality of existing systems, an estimated number of trips by bike in a certain area is useful to subsidise investment and policy decisions. However, according to the "Guide to Investment Analysis for Bike" (NCHRP, 2006), there is a model of demand for travel by bicycle, and the review developed in this study did not find a demand model that could be applied using real data surveyed.

In order to support the studies for the implementation of new facilities for cyclists, in section 2 of this paper a survey with users of bicycles in Rio de Janeiro travelling to work or school is presented. From the survey responses, we propose two models to estimate demand based on the attractiveness of places to work and study. Section 3 presents a survey with users who use bicycles to access subway stations. Section 4 presents a conclusion that includes a comparative analysis of the two surveys.

2. Survey on University and work places

From a literature review about factors that influence bicycle use, we designed a survey questionnaire (Franco, 2012). This questionnaire was administered in universities and work places in the city of Rio de Janeiro. In this survey, people using bikes were interviewed when they arrived to these places during the morning. The questionnaire was developed in order to obtain two types of information: personal characteristics of the cyclists and the conditions of their trips.

According to the SMAC (Municipality Environment Governmental Institution), the city of Rio de Janeiro has approximately 235 km of bike lanes (June 2011), which is the largest cycleway in Brazil and the second largest in Latin America, behind only to Bogotá city.

2.1 Sizing the sample

The sample size was calculated based on the estimate of the population proportion (p), when one does not know the size of the population as cited in Richardson (1999), obtained from the following expression:

$$n = \frac{z^2_{\alpha/2} \cdot p.q}{E^2} \tag{1}$$

n = Number of individuals in the sample
$Z\alpha_{/2}$ = critical value that corresponds to the desired degree of confidence.
p = population proportion of individuals belonging to the category to be studied
q = Proportion of population of individuals who do not belong to the category being studied
(q = 1 - p).

E = maximum error of estimate; identifies the maximum difference between the sample and the true proportion of population (p).

According to the Urban Transportation Plan developed in Rio de Janeiro in 2003 (IPP-Rio, 2011), only 3% of the total travel demand in the metropolitan area of Rio de Janeiro is by bike. Therefore, p = 3% (or 0.03), considering a 95% level of confidence ($Z\alpha_{/2}$ =1.96), q = 1-p = 97% (or 0.97) and the maximum error estimate (E) of ± 5% (or 0.05); we have the minimum sample size of 45 interviews. If considering p = 4% (an increase in the percentage of cyclists), the minimum sample would be 59 respondents.

The survey was conducted between June and September 2011 with a sample of 180 bike users in Rio de Janeiro. The sample consisted of students and workers at universities PUC-Rio UNI, IME and Downtown Mall, and workers in bike parking at Cinelandia, Petrobras, Norte Shopping, Rio Sul Shopping, Botafogo Praia Shopping and many stores in Lapa, Copacabana, Ipanema and Urca.

Most of the places surveyed had bike lanes, except the Norte Shopping, IME and UNI-RJ (for the date of the survey in 2011, the Urca had no bike lane yet). Figure 1 shows the bike lanes implemented (red line in map) and projected (blue line in map) in the city of Rio de Janeiro as well as the location of the bike parking where the surveys were conducted.

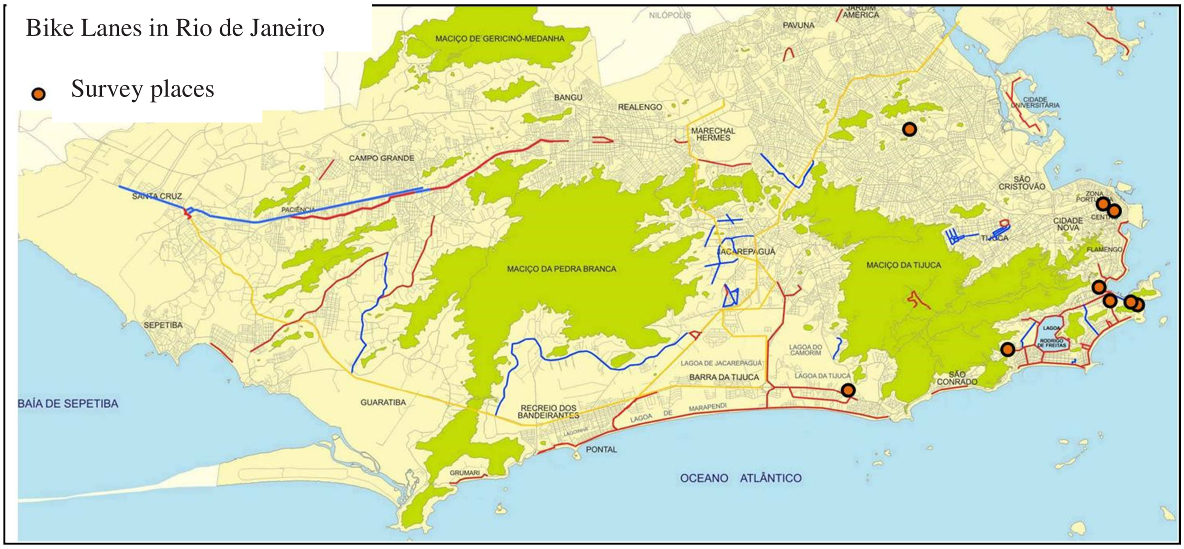

Fig. 1. Map of Bike paths, lanes or shared.
Source: SMAC-Rio, 2012.

2.2 Analysis of Data

The interviewed sample consisted of 62 students and 118 workers. Men were the majority of respondents (students and workers). The age of respondents ranged from 18 to 59 years; the maximum age of students was 37 years old while the average was 24 years old. For the group of workers, the maximum age was 59 years and the average was 33 years old.

Over 60% of respondents had at least a high school diploma; this percentage is large due to the fact that the survey was conducted in universities, offices and stores.

Household income was questioned using the five range income groups or social classes (E to A), defined by the IBGE (Census Brazilian Institute) for the year 2011 (minimum wage of R$ 545.00). The majority of respondents (45% of users) are, according to the IBGE, in the E class gaining up to 2 minimum wages. The majority of respondents, 68%, did not have a car.

The majority of students (94%) have bike parking at the university and 68% of workers reported the availability of bike parking at their work place. Most respondents spent between 5 to 20 minutes on their trip. Since the mentioned maximum travel time was 45 minutes, the average was 19 minutes. The average distance travelled is about 6 km with a maximum of 22 km.

Over 50% of respondents declared that they use the bike daily with the students using more frequently than the workers.

When asked about the influence of weather conditions on the choice of transport mode, the majority of respondents (64%) stated that when it rains, they do not use the bike, and a small part (4.5%) cited the intense heat as a difficulty, and 31.5% of respondents admitted that no factors affect the use of bicycles for travelling to school or to work. When they cannot use the bike for some reason, they travel, mostly, by bus. The availability of public transport was also questioned and 92.2% of respondents said they have this transportation mode option.

Half of the interviewed workers have suffered some kind of accident using a bicycle in their daily trips and 34% of student also responded affirmatively to this question.

Among the reasons for choosing to travel by bicycle, 50.8% of students justified that choice because it is cheap, quick and healthy to travel by bicycle, 9.5% are motivated by it being a healthy mode, 4.8% for being fast and 3.2% because it is cheap. Among the reasons cited, cycling is a pleasurable, fun and eco-efficient mode; in addition, it is difficult to find car parking and also, cycling is a way to escape the traffic congestion. In the group of workers, 40.0% said that they use a bike because it is cheap, quick and healthy, 12.6% are motivated by it being healthy, 17.2% because it is fast and cheap, 2.3% because of a lack of public transport and for being a pleasurable transportation mode relieving stress and being an environmentally friendly mode.

Regarding the difficulties of cycling, the respondents had multiple options in this question. The lack of bike lanes was considered a point that hinders the use of bicycles by 56.9% of students; lack of traffic education (for drivers or pedestrians) was cited by 40%, followed by civil insecurity for 27.7% students and a lack of bike parking for 18.5%. 12.3% said that nothing hinders the use of bicycles. For workers, the lack of bike lanes was cited by over half of respondents (63.2%) as the most perceived difficulty, 59.8% complained about the lack of traffic education (drivers or pedestrians), 35.6% about a lack of civil security (protection, policing, assaults); the lack of bike parking was cited by 13.8%. Also cited were the difficulties in riding with formal clothes, a lack of a bathroom to bathe and change clothes at work, poor lighting and pollution by automobiles. Table 1 presents a summary of the survey data.

Table 1. Summary of the survey with students and workers

		Students	Workers
Gender of respondents	Female	22.6%	17.8%
	Male	77.4%	82.2%
	18 to 25 years	62.9%	22.0%

User age	26 to 30 years	27.4%	33.1%
	31 to 40 years	9.7%	26.3%
	41 to 50 years	0.0%	13.6%
	50 years or more	0.0%	5.1%
Education level	Elementary school	62.9%	2.5%
	Junior High	27.4%	13.6%
	High school	9.7%	31.4%
	Incomplete undergraduate	0.0%	16.9%
	Undergraduate	0.0%	35.6%
Household income	less than 2 minimum wages	25.8%	41.5%
	>2 to 4 minimum wages	14.5%	17.8%
	>4 to 10 minimum wages	24.2%	20.3%
	>10 to 20 minimum wages	27.4%	10.2%
	>20 minimum wages or more	8.1%	10.2%
Travel time	5 to 10 min	29.2%	24.7%
	11 to 20 min	44.6%	36.0%
	21 to 30 min	16.9%	19.1%
	More than 30 min	9.2%	20.2%
Average travel distance	1 to 5 km	69.4%	56.8%
	5 to 10 km	19.4%	28.0%
	10 to 20 km	11.3%	13.1%
	More than 20 km	9.2%	1.7%
Frequency of cycling	1 to 2 times per week	12.9%	16.4%
	3 to 4 times per week	24.2%	31.0%
	Every day	62.9%	52.6%
Alternative means of transportation	By bus	57.6%	46.7%
	On foot	19.7%	15.2%
	By car	13.9%	24.7%
	On foot, By bus	3.0%	3.8%
	By bus, By car	3.0%	1.9%
	Subway	1.5%	4.8%
	Motorcycle	1.5%	2.9%

2.3 Estimation of demand

Based on the survey data, a model to estimate the demand for travel by bicycle was formulated. This demand model has the objective of estimating the bike travel demand (workers travelling by bicycle) attracted to shopping malls in the morning. For the formulation of this model, two independent variables were considered: the number of workers and the number of parking spaces for bicycles at shopping centres.

For the model formulation, the survey data of four shopping centres was considered. In these shopping centres, there was a similar rate, approximately 0.32%, of employees travelling to work by bicycle. The first model is a linear equation that represents the demand function related to the number of employees (workers) as shown in Figure 2, where ***y*** represents the amount of bicycle trips arriving at the shops in the morning peak hour and ***x*** represents the number of employees at the shopping centres. The coefficient of determination, $R^2 = 0.819$, indicates that there is a strong relationship between the number of employees and the number of bicycle trips counted.

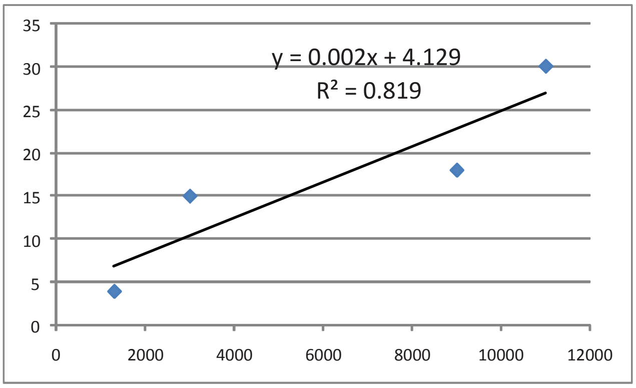

Fig. 2. Travel by bicycle to work at the mall x Workers

In a second analysis, the independent variable was the number of parking spaces for bicycles (x) in each shopping centre, and the demand function is shown in Figure 3. This relation is justified because, as shown in the survey and in some studies (Ehrgott,2012; Monteiro,2012; Landis,1996), the increase of facilities for cyclists encourages the use of bicycles and could increase the demand.

In this case, the equation has a $R^2 = 0.922$ that also indicates a good relationship between the dependent variable travel demand by bicycle and the number of parking spaces.

As the independent variables, number of parking spaces for bicycles and number of employees, had a low correlation with each other (= 0.19), we chose to define a demand function using these two variables. Thus, considering these two independent variables, the demand function was defined as:

$$Y = 2.881 + 0.08\, PS + 0.0019\, Ep \tag{2}$$

Where:
Y - bike trips to work in the morning
PS - number of parking spaces
Ep - number of employees in the shopping centre

For this function, $R^2 = 0.87$ and the confidence level was equal to 95%. However, considering the intercept equal to 0, the following function was obtained:

$$Y = 0.098\, PS + 0.0022\, Ep \tag{3}$$

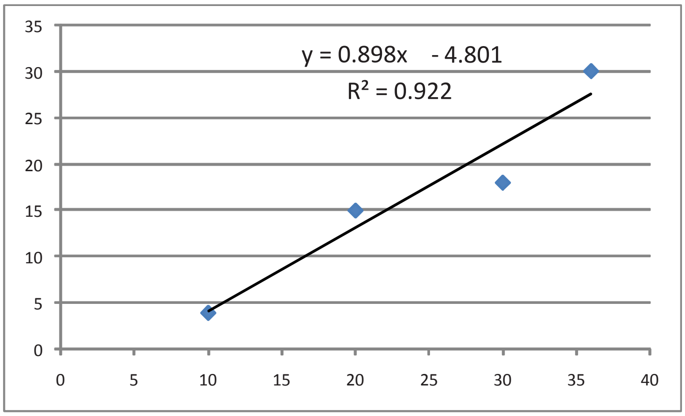

Fig. 3. Travel by bike to work x Space on bicycle rack

Equation 3 has a coefficient of determination $R^2 = 0.6$, the confidence level equal to 95%, and the coefficients t- Stat and p-value (for the significance level 0.95) meaning that Equation 3 is better than Equation 2.

Comparing the bike trips at two universities, IME and PUC-RJ, 135 students were observed arriving by bicycle to PUC-RJ during the morning peak and 18 students to IME. In this case, the percentage of users travelling by bike was greater than was observed in the shopping centres (for workers); in IME the percentage of bike users was 5.23% and in PUC-RIO was 0.75% of total students.

When comparing the number of parking spaces for bicycles with the number of students at the universities, PUC-RJ has 1 bicycle parking space for every 108 students, while IME has one parking space for every 35 students.

A survey was also carried out with non-users of bicycles, both workers and students at one of the universities surveyed. The sample comprised 12% women and 86% men. Most respondents resided within the radius of about 6 km away from the university. Of these, 44% go to the university by bus, 52% by foot and 4% by car with only 36% having a car. When asked about a way to encourage them to use bicycles, 48% interviewed stated the implementation of more bike lanes, 16% stated more bike parking, and others cited having a locker at work, buying bikes and more security.

3. Survey on subway station

A survey was performed at three subway stations in Rio de Janeiro: Ipanema, Pavuna and Colégio stations. These surveys had the objective of getting information from subway users about their mode of transportation to access the subway stations and about using bicycles as a transportation mode. In 2010, a survey developed by the subway system operator showed that an average of 0.2% of subway users arrive at the stations by cycling.

In 2011, at the three subway stations, between 7:30 am and 11:30 am, 390 users were interviewed on the board platforms. The objective of the survey was to identify the largest problem for cycling to the station and the distance travelled. The travel time to the station and which factors she/he considered the most difficult for cycling to the station were asked.

Only 12% of total respondents came to the station using a bike. In Ipanema station during the survey period, no user arrived by bicycle. Most users came to the station on foot (32%) or by bus (34%).

In Ipanema station, we tried to understand why people did not use the bike to go to the station and it was noticed that the majority of respondents do not use a bike because their residence was located very close to the station, and it was not necessary to use a transport as it was easier to go to the station by foot. But there were also some respondents, coming from a distant neighbourhood by bus integration, who stated the distance is too far (about 30 km) and it was unfeasible to use the bike to go to the station. Another reason for people not biking to the station was no bike lanes connecting directly to the Ipanema station.

In Pavuna station, the distance was the major difficulty in commuting by bike because many subway users come from others distant neighbourhoods. However, some cyclists said that despite the large distance, they prefer to go by bicycle to the station for saving money (one transportation fee). Another relevant factor pointed out by users was the lack of bike lanes in the neighbourhood and especially a bike lane near the station.

In Colégio station, the largest number of respondents said that the most important reason for not using a bike to access the subway was because they do not have a bicycle. This led us to think that a system of bike sharing nearby subway stations could be an incentive to use this mode of transportation.

In general, the travel distance to the station was the most cited problem, but in two different situations, primarily due to proximity of residence to the destination (station), as in the case of Ipanema station, and second by the large distance from residence to the destination, as in the case of Pavuna and Colégio stations.

From the number of cyclists interviewed at stations, only 7 cyclists travelled for school and 40 cyclists travelled for work. Table 2 summarises the characteristics of these commuter cyclists. It was observed that the majority of cyclist students (70%) were between 18 and 30 years old and that workers varied between 18 and 40 years. For workers, 90% have only a high school education. Regarding income, 100% of students and 90% of workers have an average monthly income of up to R$ 2,180.00 (4 minimum wages). We also observed that most students and workers travelled up to 10 km to reach the station.

Table 2. Summary of the survey on subway stations

		Students	Workers
Gender of respondents	Female	0.0%	10.0%
	Male	100.0%	90.0%
Division of users by age	18 to 30 years	71.4%	47.5%
	31 to 40 years	28.6%	30.0%
	41 to 50 years	0.0%	10.0%
	More than 50 years	0.0%	12.5 %
Division of users by education level	Elementary school	14.3%	37.5%
	High school	0.0%	55.0%
	Incomplete undergraduate	71.40%	2.5%
	Complete undergraduate	0.0%	5.0%
	less than 2 minimum wages	85.0%	90.0%
	2 to 4 minimum wages	14.3%	5.0 %

Household income	> 4 to 10 minimum wages	0.0%	5.0 %
	> 10 to 20 minimum wages	0.0%	0.0%
	> 20 minimum wages or more	0.0%	0.0%
Travel time	5 to 10 min	15.2%	15.8%
	11 to 20 min	84.8%	50.8%
	21 to 30 min	0.0%	27.4%
	More than 30 min	0.0%	6.1%
Average travel distance	1 to 5 km	57.6%	45.3%
	5 to 10 km	42.4%	48.6%
	10 to 20 km	0.0%	6.1%
	More than 20 km	0.0%	0.0 %
Frequency of cycling	1 to 2 times per week	12.9%	16.4%
	3 to 4 times per week	24.2%	31.0%
	Every day	62.9%	52.6%

4 Conclusions

Comparatively analysing the two surveys, the cyclist student's education level was different because the first survey was conducted at universities and therefore the students were currently undergraduates, or were already undergraduates and were doing postgraduate education. For workers, most of them have not achieved an undergraduate education level. As for income, in both surveys, students and workers were in the range of monthly income of up to R$ 2,180.00 (4 minimum wages). Also in both surveys, the majority of students and workers travelled up to 10 km. Another interesting point was that most of the cyclists in the survey conducted at universities and workplaces transport on foot or by bus when they are not using the bike.

The acknowledgment of the characteristics of bicycle users and the factors that influence the choice of transport is of fundamental importance to plan and design spaces more suitable for users of these systems. The identification of the behaviour and profile of cyclists could lead to a change in attitude in the sectors of municipality, which, in general, do not know about bicycle users. This acknowledgment can allow them to define policies and guidelines for the promotion of bicycle trips. The actions on the urban space would take into account the particularities of each possible cycle route and, mainly, about the cyclists on their commuter trips (home-school and home-work).

Modelling demand for transport is a complex task that requires a large amount of data which are often not available. And an estimate of the demand for bicycle users is an important tool to implement appropriate cycleway systems and obtain resources to this end. Therefore, this study sought to provide a simplified method for estimating demand based on surveys carried out in Rio de Janeiro. Other surveys are being planned to improve the model presented in this paper.

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