MODELLING INDIVIDUAL PERCEPTION OF BARRIERS TO BIKE USE

Angélica Caicedo
Research Institute for Sustainability Science and Technology (IS.UPC); Universitat Politècnica de Catalunya-Barcelona
Miguel Mayorga
Civil Engineering School of Barcelona. Universitat Politècnica de Catalunya-Barcelona
Miquel Estrada
Civil Engineering School of Barcelona. Universitat Politècnica de Catalunya-Barcelona

ABSTRACT

People face different barriers when choosing to commute by bike. The predominance of these barriers in users' perception could explain the low cyclability rates present in many cities. An investigation of cyclists' perceptions is developed using the data set obtained through a survey made to individuals from Quito, Ecuador. This study is aimed to evaluate the perception of a group of individuals about barriers to bike use, in particular, assesses how perception varies according to the available information and the different profiles. Using ordered probit models, the study compares the overall evaluation of bike acceptance before and after making individuals reflect on the importance of certain variables (e. g. lack of bike infrastructure, city temperatures, etc.). The main results show that to improve bike use acceptance, enhancing multimodality or providing facilities like electric bikes must be considered. The results also demonstrated a high heterogeneity of individuals' perceptions caused by their socio-demographic characteristics and the environmental context.

1. INTRODUCTION

Nowadays cities face major environmental, socio-economic, and transport challenges, whereby, the importance of promoting non-motorized modes of transport such as the bicycle, is recognized. Bike transportation offers many important benefits at environmental, health, social interaction, and urban mobility levels. However, despite its wide advantages, regular bike use is still not broadly accepted in many cities, especially in Latin America (Gutiérrez, Hurtubia, & Ortúzar, 2020; Keeling, 2013). The unconcern in integrating the bicycle in urban mobility has caused several challenges including identifying the most effective ways to spend the resources, usually limited, allocated to its promotion. Commonly, bike mobility planning is focused primarily on solving the service from a technical perspective (e.g. proposing the fastest routes or with lower agency costs). However, several authors conclude that to achieve a positive bike assessment and its acceptance among users, the system must also comply with other subjective aspects that respond to individuals' needs (Cepeda

Zorrilla, Hodgson, & Jopson, 2018; Heinen, Maat, & van Wee, 2011; Jakovcevic, Franco, Visona Dalla Pozza, & Ledesma, 2016).

From this perspective, in contexts with low rates of bike use, it seems reasonable to focus on identifying the weakest points of the system to work and invest in them, reducing the risk of investing in solving other aspects that will not necessarily motivate people to commute by bike (Dell'Olio, Ibeas, & Cecín, 2010).

This study aims is to identify the barriers that influence individuals around bike use, as well as obtaining the comparative weights of each of these variables. Previous studies have proven that *Ordered Probit Models* are satisfactory for the analysis of categorized or non-quantitative ordered choices and replies (Dell'Olio, Ibeas, De Oña, & De Oña, 2018c). The contribution is a model that identifies and ranks the perceived barriers of bike use, therefore, this research pretends to better understand citizens' needs to facilitate better bike mobility planning.

This work is divided into several parts. First, a brief contextualization of the problem is presented. Afterward, the methodology, the collected data, and some results are discussed. And to finish, the main conclusions are presented.

2. LITERATURE REVIEW

2.1 Choice to commute or not by bicycle

Studies conclude that bike commute decision is highly complex since it can be influenced by both objective and subjective factors (Konstantinidou & Spyropoulou, 2017; Muñoz, Monzon, & Lois, 2013). This section describes the role of psychological factors, such as attitudes and perception towards bike use in its acceptance among individuals. These factors are related to travel motivations, socio-economic, journey, and environmental characteristics, among others (Cepeda Zorrilla et al., 2018; Majumdar & Mitra, 2013).

Likewise, other authors conclude that these aspects are not necessarily equally perceived by all individuals or have the same weight in the overall perception of the service (Dell'Olio et al., 2010; Weinstein, 2000). Therefore, the importance of understanding the relationship between individuals' perception towards bike use and their different profiles is recognized (Dell'Olio et al., 2010; Dell'Olio, Ibeas, De Oña, & De Oña, 2018b; Garrido, De Oña, & De Oña, 2014).

The literature suggests that aspects such as the *weather conditions* incluiding the *temperature, rain or wind* (Fernández-Heredia, Monzón, & Jara-Díaz, 2014; Freitas & Maciel, 2017; Heinen, Maat, & van Wee, 2011; Helbich, Böcker, & Dijst, 2014), *long-distance travels* (Corcoran, Li, Rohde, Charles-Edwards, & Mateo-Babiano, 2014; Fernández-Heredia et al., 2014; Heinen, Maat, & Van Wee, 2011; Konstantinidou &

Spyropoulou, 2017), *lack of well-connected and high-quality cycle-path networks* (Buehler & Pucher, 2012; De Sousa, Sanches, & Ferreira, 2014a; Fernández-Heredia et al., 2014; Gutiérrez et al., 2020; Konstantinidou & Spyropoulou, 2017), the *perception of risk* (Fernández-Heredia et al., 2014; Gutiérrez et al., 2020), *traffic insecurity* (Branion-Calles, Nelson, Fuller, Gauvin, & Winters, 2019; Muñoz et al., 2013), *topography* (De Sousa, Sanches, & Ferreira, 2014b; Fernández-Heredia et al., 2014; Majumdar & Mitra, 2013), *physical abilities* (Branion-Calles et al., 2019; Freitas & Maciel, 2017; Majumdar & Mitra, 2013), *insecurity against crime and vandalism* (Eren & Uz, 2019), and the *personal appearance* (Iwińska, Blicharska, Pierotti, Tainio, & de Nazelle, 2018) affect bike commutes and reduce the frequency of trips.

Wide studies have investigated barriers to cycling, however, this number is limited when identifying the weight of each variable in individuals' perception (Handy, van Wee, & Kroesen, 2014; Porter, Suhrbier, & Schwartz, 1999). Dell'Olio, 2010 among others authors (Dell'Olio et al., 2010; Garrido et al., 2014; Weinstein, 2000) have estimated the different influence that each attribute's perception exerts on users' global assessment, focusing mainly on public transport (PT) services, however, the implemented methods are found suitable to the present study.

2.2 Service Quality and User Satisfaction

Service Quality (SQ) has been widely studied since Parasuraman, Zeithaml, & Berry (1985) first introduced it, defining SQ as the difference between both, the expected and the perceived quality of service. User perceived quality has been shown to have a positive effect on user satisfaction with transport services (Braun et al., 2016; J. De Oña, De Oña, Diez-Mesa, Eboli, & Mazzulla, 2016; Rocío De Oña, 2013). However, evidence suggests that although users perceive a good quality of service, taking this indicator as a criterion of success could be precarious, hence, it cannot be used as the only reference when planning policies aimed at retaining customers and attracting new ones (J. De Oña et al., 2016; Dell'Olio, Ibeas, De Oña, & De Oña, 2018a; Fernández-Heredia et al., 2014).

Parasuraman et al. (1988) suggested that for the study of the SQ of transport services, their defining variables or attributes should be established, proposing a generic list of 22 attributes and dimensions applicable to any type of service. However, many authors criticized this generic list stating that the attributes must respond to each specific case (Babakus & Boller, 1992). Likewise, other evidence demonstrates that the predictive value of the model developed by Parasuraman et al. 1988 increased when the items were adapted to the study context (Carrillat, Jaramillo, & Mulki, 2007). The key then is to enlist the generic attributes but adding other aspects own of each specific context and service.

Diversity of methodologies and tools have been developed to evaluate SQ variation according to users' preferences. For example, *satisfaction surveys* allow researchers to associate quality perception to a type of user classifying them accordingly to their socio-economic and journey characteristics (Alonso, Barreda, dell'Olio, & Ibeas, 2018; Bordagaray, Ibeas, & Olio, 2012; Branion-Calles et al., 2019). Others studies establish this relationship by developing methodologies based on *structural equations* (J. De Oña, De Oña, Eboli, & Mazzulla, 2013; Rocio De Oña & De Oña, 2015; Dell'Olio, Ibeas, De Oña, & De Oña, 2018d) or the application of *decision trees*, the latter permits to generate models able to differentiate between different kinds of users (Rocío De Oña, 2013). Likewise, other not model-based methods have provided interesting results, such as *descriptive statistics* (Eboli & Mazzulla, 2011) or *neural networks* (Garrido et al., 2014).

Ordered probit models have proven to be a highly efficient and useful tool for modeling perceived quality (Alonso et al., 2018; Bordagaray et al., 2012; Dell'Olio et al., 2010, 2018c). This particular methodology allows ordered qualitative responses to be modeled, meaning that the *non-linearity* existing between the different replies can be considered (Dell'Olio et al., 2010, 2018c). Another key feature of the model is its ability to use interactions to incorporate systematic variations resulting from the socio-economic characteristics of the different users (Bordagaray et al., 2012), assuming that these factors follow a *statistical distribution*.

However, evidence on the combination between systematic and random variations in the same model, as well as the inclusion of attributes' importance within the modeling of bike use perception is limited (Porter et al., 1999). Therefore, using *ordered probit models,* the present research aims to fill this gap and complete the knowledge about bike use perception, by studying the *relative importance* of barriers to bike use in the general individuals' perception (Dell'Olio et al., 2018b).

3. METHODOLOGY

3.1 Description of the study area

The city of Quito has an area of 372 square kilometers and approximately 1.7 million people (INEC, 2017). Its particular allocation close to the equatorial line, its altitude, and its closeness to the Andes mountain range gives the city special climate conditions (spring relatively constant throughout the year), and a mostly irregular landscape with steep slopes (IGM, 1992). In 2011, inhabitants' global mobility rate was 2 trips per day, which is equivalent to almost 3.4 million daily trips. From these, the majority were made by public transport (62%), 20 % by private car, 15% by foot, and only 0.3% by bicycle (Metro de Quito, 2012). Since 2012, Quito has a Public Shared Bicycle Service (BiciQuito) and a 173 km long cycle path network of which only 32% are exclusively for bikes, the rest are shared spaces with pedestrians or motorized vehicles.

3.2 Data Collection

Data collection was conducted in the city of Quito, Ecuador. After a deep literature review aimed to identify psychological, socio-economic, environmental, and travel-related factors that could affect bike use, in particular, the barriers, a first draft of the survey was developed and presented to specific groups of individuals from the study area.

Afterward, considering this first stage's feedback, a second draft was designed and applied in a pilot survey tested to verify the clarity of the questionnaire and to ensure the proper capture of the information necessary for the model estimation. The final survey was applied via the web in the last week of January of 2021 and collected 422 completed forms. Figure 1 presents a flow chart of the process.

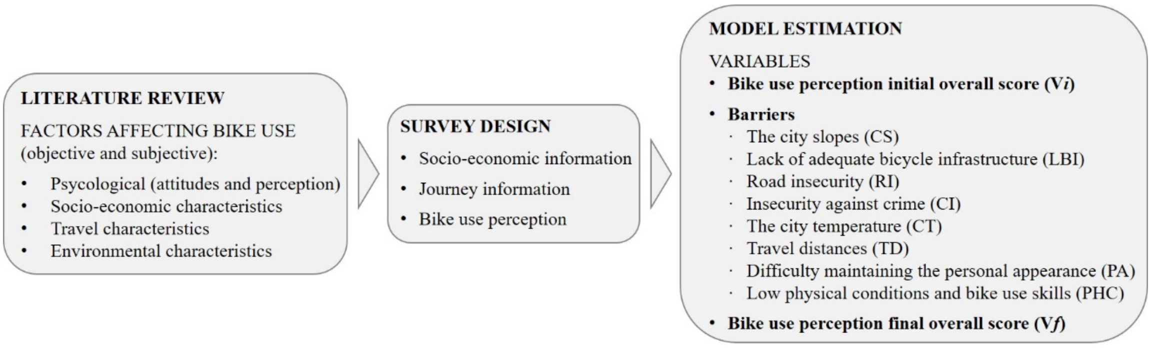

Figure 1 – Methodology flow chart

Survey design

The questionnaire consisted of two main segments. The first part collected information about the person's *socio-demographic* and *journey characteristics* (see Table 2). This information will permit respondents' stratification into different profiles. The second part enclosed bike use perception and consisted in asking an individual to give an opinion about a subjective aspect related to bike use, in this case, a barrier. This segment consisted of three questions.

The first obtained a first valuation of the bicycle as an option to commute, representing individuals' initial opinion based on the information they have, ergo, their understanding of the service through the personal experience. The second gets separate values for each of the previously defined variables (barriers). The third and final question was asked right after individuals valued each barrier and consisted in a second score of the overall perception of bike use. This second score is required to analyze any changes on the bicycle's global score once individuals have had the opportunity to analyze every aspect that makes up the system.

Namely, to check the degree by which they changed their opinion after the reflection made on each barrier that may be affecting bike use (Dell'Olio et al., 2010, 2018b).

The set of selected barriers was: city slopes (CS), lack of adequate bike infrastructure (LBI), road insecurity (RI), crime insecurity (CI), city temperature (CT), long travel distances (TD), difficulty in maintaining the personal appearance (PA), and insufficient physical conditions and cycling skills (PHC).

Using a 5-point Likert scale, participants were asked to rate the variables (see Table 1).

Question 1	***Do you agree that the bike, in your city, is a good option to commute?***								
			Strongly disagree	1	2	3	4	5	Totally agree
Question 2	***The following aspects could DEMOTIVATE bike use, how much do you think they influence?***								
	Variable		Very influential	1		→		5	Not influential
	CS	The city slopes							
	LBI	Lack of adequate bicycle lanes and parking slots							
	RI	Fear of having a traffic accident							
	CI	Insecurity against crime							
	CT	The temperature of the city (too cold, too hot)							
	TD	Travel distances							
	PA	Difficulty maintaining the personal appearance							
	PHC	Low physical conditions and abilities to bike use							
Question 3	***Do you consider the bicycle as a good option to commute in your city?***								
			Strongly disagree	1	2	3	4	5	Totally agree

Table 1 – Survey segment 2: Perception on bike use

3.3 Statistical Approach

The type of model was selected after collecting and analyzing the data. Since that, the dependent variables (initial and final overall bike use perception) are ordinal by nature, ordered probit models seemed to be suitable. Following the belief that latent and continuous variables cannot be measured discretely, thus the variable (bike use perception) is intended to be segmented into several options associating each one of them with a range value of the latent variable (in this case from 1 to 5). The key idea of this method first proposed McKelvey & Zavoina, (1975) is that allows to transform a continuous latent variable into an ordered, observed, and discrete reply, so when individuals select an option, are in fact selecting not a discrete value but rather the closest answer to their true perception, of bike use in this case (Alonso et al., 2018; Dell'Olio et al., 2010, 2018a, 2018c; Echaniz, Ho, Rodriguez, & dell'Olio, 2019).

Segement 2 of the survey regarding bike use perception was performed as follows:

1st. *Initial overall valuation* of bike use (V_i).

2nd. Scoring the eight variables previously identified as possible *barriers* to bike use.

3rd. A *second overall valuation* of bike use (V_f).

Two types of models were estimated for the different profiles of respondents. Both V_i and V_f were related separately to the variables identified as possible barriers to bike commute. The first model aims to identify which variables are unconsciously relevant when an

individual decides not to commute by bike, and the second, which variables would individuals consider as important after having more information about the service.
According to the literature a *probit ordered model* consists of a direct relationship between the dependent variable, in this case, bike use perception -initial (V_i) and final (V_f) scores-, and the independent variables (barriers) V_{ik}. A constant β_0 and an estimation error $\mathcal{E}_i$ associated with individuals' heterogeneity complements the model (Dell'Olio et al., 2018c).

The models are based on the following mathematical expression:

$$Q_i^* = \beta_0 + \sum_{k=1}^{N} \beta_k \cdot V_{ik} + \varepsilon_i \qquad \text{with } k \in [1, 2, \dots, N] \tag{1}$$

$\mathbf{Q}_i$ represents the general evaluation of the person i; $\boldsymbol{\beta_0}$ the model constant; N the number of evaluated bike use aspects (barriers); β_k the coefficient of the variable *k (barrier)*; V_{ik} is the valuation made by each individual *i* of each variable *k*.

To fit the models Log Likelihood function was used:

$$\log L = \sum_{i=0}^{n} \quad \sum_{j=0}^{J} m_{ij}\, log\left[F\left(\mu_j - \beta'_{V_i}\right) - F\left(\mu_{j-1} - \beta'_{V_i}\right)\right] \tag{2}$$

Once the corresponding models were estimated for each individuals' categories, possible relationships between them were identified.

4. RESULTS AND DISCUSSION

4.1 Initial data analysis

First, the data set composed of 422 observations were analyzed to characterize individuals' profiles as shown in Table 2.

Variable	Category	Frequency	Percen
Sample		**422**	
Gender	Female	186	44%
	Male	236	56%
Age (years)	< 24	121	29%
	25 to 44	142	34%
	45 to 64	132	31%
	> 65	27	6%
Main occupation	Student	104	25%
	Dependent worker	87	21%
	Self-employed or independent worker	57	14%
	Home care	62	15%
	Unemployed	91	22%
	Retired/pensioner/other	21	5%
Household income	< 400 USD	75	18%
	400 - 800 USD	166	39%
	800 - 1.200 USD	135	32%
	> 1.200 USD	46	11%
Mode of transport	Walking	43	10%
	Bicycle	23	5%
	Public Transport (bus, BRT)	186	44%
	Private car	31	7%
	Motorcycle	14	3%
	Taxi / Service on demand (Uber, Cabify)	27	6%
	Teleworking / No commute	98	23%

Table 2 – Profile of respondents

As explained in subsection 3.3, the overall valuation of bike use was asked twice, the first (V_i) immediately before and the second (V_f) immediately after scoring each variable (barriers) separately (see Table 1). So, the difference between V_f and V_i will show if there were any changes in people's opinion concerning the first valuation. The results showed that around 60% of individuals changed their score, either positively or negatively (see Tables 3 and 4). When categorizing the surveyed according to the previously defined characteristics (22 categories), some differences could be identified (see Tables 3 and 4).

In all categories, the second valuation had a higher score than the first, generally double, except for two: *bike users* and private car users, from now on *car users* (see Tables 4 and 5). These results show that people tend to be more critical than they would be if they had more knowledge about the service, that is, ignorance or misinformation prevents them from evaluating it impartially. Seem to be that, in the initial valuation(V_i), individuals tend to perceive more negatively the barriers. In this case, these results can be explained by the lack of familiarity with bike use present in the majority of the inhabitants of the city of study (see Table 1). However, in other contexts where bike use for commuting is more positioned, the results would be different. Since previous findings suggest that an individual is more positive towards modes that are included in the daily mobility patterns compared to the modes that are not (Ton et al., 2020).

Regarding the ‘working' category, this second higher evaluation could be because respondents possibly realized those bike use barriers would not actually be as influential for cycling. Since evidence suggests that bike use is more prevalent in young people, for reasons such as the smaller technological gap compared to other ages, resulting in more openness to route planners or bike-sharing systems (Goodman, Sahlqvist, & Ogilvie, 2013). About the positive variation of PT users, this is not necessarily unexpected. It is in accordance with previous studies that conclude the clear tendency to change from PT to cycling. This could be because users may find PT to be a relatively inflexible (and sometimes unreliable) mode, therefore they would choose more flexible options such as the bicycle (Thorhauge, Kassahun, Cherchi, & Haustein, 2020). Furthermore, in many cities, PT service quality is poorly perceived (Cepeda Zorrilla et al., 2018; Mark & Heinrichs, 2019), so the bike can be seen as a better choice. A fact that, within the bad, could be seen as an opportunity to position it in the urban transport offer.

This knowledge is important, since policies aimed at improving certain factors may have little effect on people's opinion if aspects with an apparently greater weight than they actually do are prioritized. Therefore, any strategy seeking to increase bike use acceptance must first focus on knowing what are the aspects that really influence people's perception.

The difference between V_f and V_i is denoted below by δ_{value}.

$$\delta_{value} = V_f - V_i \quad (3)$$

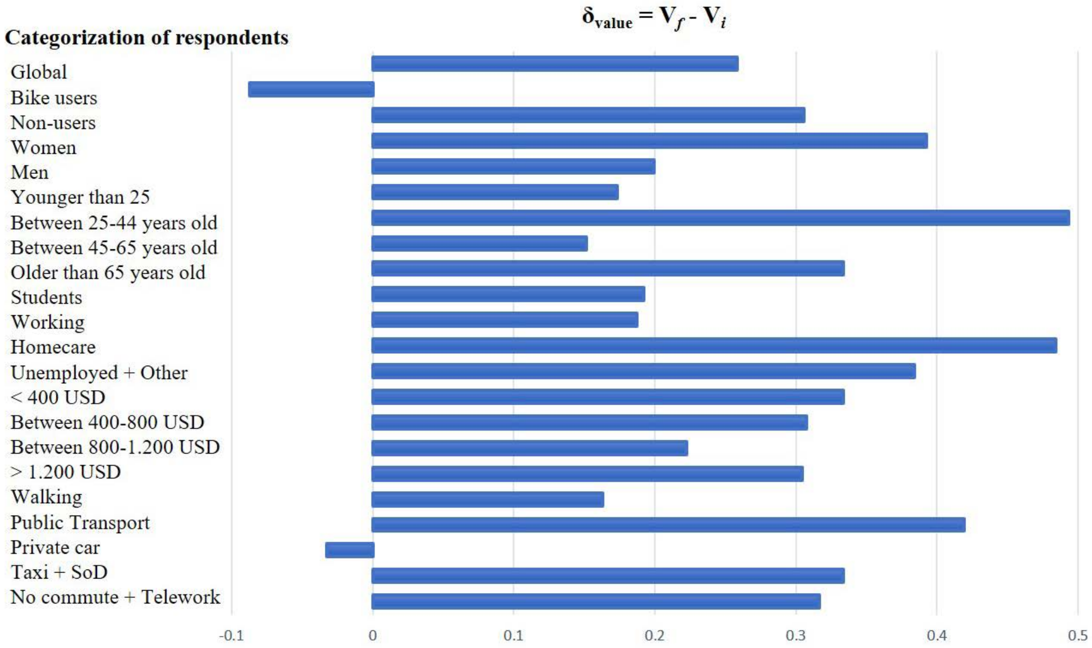

Table 3 – Variations on δ_{value} according to respondents' categorization

Given that bike use V_f trending was to change positively, this paper presents the *models* estimated for the two categories which did so negatively: *Bike users* and *car users*.

The negative change in bike users can be explained because in contexts with poor cycling facilities and lack of incentives, in short, non-friendly cycling mobility contexts, people who decide to commute by bike do so out of beliefs and not out of any kind of incentives (Iwińska et al., 2018; Jakovcevic et al., 2016). In other words, they are bike commuters 'no matter what', with which the reflection process may have made them focus on the weakest aspects of the system and therefore have been more critical. This agrees with previous studies concluding that bike use incentives work in the first stage, as a hitch for new users. However, if the aspects that users identified as barriers from the beginning are not improved, they will not find benefits in using it once the incentives are removed, and therefore, they will stop doing it (Jakovcevic et al., 2016). Therefore, it is important to prioritize the improvement of the weaknesses of the system if what is sought is the retention of users and the creation of habits.

		Negatively				No variation	Positively						
Respondents categories		**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**Variated**	**Positively**	**Negatively**
Global	**Freq.**	8	5	28	54	166	88	42	19	12	256.0	161	95
	%	1.9	1.2	6.6	12.8	39.3	20.9	10.0	4.5	2.8	**60.7**	**38.2**	**22.5**
Bike users	**Freq.**	1	0	3	4	8	4	1	2	0	15.0	7	8
	%	4.3	0.0	13.0	17.4	34.8	17.4	4.3	8.7	0.0	**65.2**	**30.4**	**34.8**
Non-users	**Freq.**	7	5	25	50	158	84	41	17	12	241.0	154	87
	%	1.8	1.3	6.3	12.5	39.6	21.1	10.3	4.3	3.0	**60.4**	**38.6**	**21.8**
Women	**Freq.**	3	2	10	27	71	34	21	10	8	115.0	73	42
	%	1.6	1.1	5.4	14.5	38.2	18.3	11.3	5.4	4.3	**61.8**	**39.2**	**22.6**
Men	**Freq.**	5	3	18	27	95	54	21	9	4	141.0	88	53
	%	2.1	1.3	7.6	11.4	40.3	22.9	8.9	3.8	1.7	**59.7**	**37.3**	**22.5**
Younger than 25	**Freq.**	5	2	6	18	48	21	11	6	4	73.0	42	31
	%	4.1	1.7	5.0	14.9	39.7	17.4	9.1	5.0	3.3	**60.3**	**34.7**	**25.6**
Between 25-44 years old	**Freq.**	2	1	8	12	56	33	20	4	6	86.0	63	23
	%	1.4	0.7	5.6	8.5	39.4	23.2	14.1	2.8	4.2	**60.6**	**44.4**	**16.2**
Between 45-65 years old	**Freq.**	1	2	13	18	54	26	8	8	2	78.0	44	34
	%	0.8	1.5	9.8	13.6	40.9	19.7	6.1	6.1	1.5	**59.1**	**33.3**	**25.8**
Older than 65 years old	**Freq.**	0	0	1	6	8	8	3	1	0	19.0	12	7
	%	0.0	0.0	3.7	22.2	29.6	29.6	11.1	3.7	0.0	**70.4**	**44.4**	**25.9**
Students	**Freq.**	5	1	4	16	40	19	11	6	2	64.0	38	26
	%	4.8	1.0	3.8	15.4	38.5	18.3	10.6	5.8	1.9	**61.5**	**36.5**	**25.0**
Working	**Freq.**	2	1	17	15	55	32	14	5	3	89.0	54	35
	%	1.4	0.7	11.8	10.4	38.2	22.2	9.7	3.5	2.1	**61.8**	**37.5**	**24.3**
Homecare	**Freq.**	0	0	3	9	24	15	5	4	2	38.0	26	12
	%	0.0	0.0	4.8	14.5	38.7	24.2	8.1	6.5	3.2	**61.3**	**41.9**	**19.4**
Unemployed + Other	**Freq.**	1	3	4	14	47	22	12	4	5	65.0	43	22
	%	0.9	2.7	3.6	12.5	42.0	19.6	10.7	3.6	4.5	**58.0**	**38.4**	**19.6**
< 400 USD	**Freq.**	0	1	6	7	32	16	9	3	1	43.0	29	14
	%	0.0	1.3	8.0	9.3	42.7	21.3	12.0	4.0	1.3	**57.3**	**38.7**	**18.7**
Between 400 - 800 USD	**Freq.**	6	1	12	19	61	35	18	6	8	105.0	67	38
	%	3.6	0.6	7.2	11.4	36.7	21.1	10.8	3.6	4.8	**63.3**	**40.4**	**22.9**
Between 800 - 1.200 USD	**Freq.**	2	1	8	22	57	24	11	7	3	78.0	45	33
	%	1.5	0.7	5.9	16.3	42.2	17.8	8.1	5.2	2.2	**57.8**	**33.3**	**24.4**
> 1.200 USD	**Freq.**	0	2	2	6	16	13	4	3	0	30.0	20	10
	%	0.0	4.3	4.3	13.0	34.8	28.3	8.7	6.5	0.0	**65.2**	**43.5**	**21.7**
Walking	**Freq.**	2	0	2	9	15	7	4	3	1	28.0	15	13
	%	4.7	0.0	4.7	20.9	34.9	16.3	9.3	7.0	2.3	**65.1**	**34.9**	**30.2**
Public Transport	**Freq.**	2	3	8	21	75	42	20	10	5	111.0	77	34
	%	1.1	1.6	4.3	11.3	40.3	22.6	10.8	5.4	2.7	**59.7**	**41.4**	**18.3**
Private car	**Freq.**	0	0	4	6	11	7	3	0	0	20.0	10	10
	%	0.0	0.0	12.9	19.4	35.5	22.6	9.7	0.0	0.0	**64.5**	**32.3**	**32.3**
Taxi + SoD	**Freq.**	1	1	0	3	11	8	0	1	2	16.0	11	5
	%	3.7	3.7	0.0	11.1	40.7	29.6	0.0	3.7	7.4	**59.3**	**40.7**	**18.5**
No commute + Telework	**Freq.**	2	1	9	8	41	17	13	3	4	57.0	37	20
	%	2.0	1.0	9.2	8.2	41.8	17.3	13.3	3.1	4.1	**58.2**	**37.8**	**20.4**

Table 4 – Variations on V_f according to respondents' categorization

Figure 2 shows the frequency diagrams of the δ_{value} according to the categorization of respondents. The distribution seems to be mainly asymmetrical in most of the cases

Figure 2 – δ_{value} frequency diagram according to respondents' categorization

4.2 Estimated models

Special statistical software STATA was used for its capability to estimate *ordered probit models* (Simons, 2018; StataCorp, 2017). These models were developed to work with the ordinal-natured dependent variables, in this case, V_i and V_f. Two models were developed: one for *bike users* and one for *car users*. The final data set enclosed 54 observations (23 bike users and 31 car users). Each respondent evaluated 10 variables. First, to track any data error, descriptive statics was performed. Said *data cleaning* examined mean, minimum, and maximum values of the variables (see Table 6).

Bike users						Private car users				
Variable	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs
Bike_V*i*	4.3043	1.1455	1	5	23	3.4194	1.1482	1	5	31
CS	3.3043	1.5502	1	5	23	4.1290	1.2039	1	5	31
LBI	3.9565	1.2239	1	5	23	4.0323	1.1397	2	5	31
RI	4.1739	1.3702	1	5	23	4.5161	1.0286	1	5	31
CI	3.5652	1.3425	1	5	23	3.4839	1.1796	1	5	31
CT	4.0435	1.1862	1	5	23	4.2581	0.9650	1	5	31
TD	3.1304	1.4555	1	5	23	4.0645	0.8920	2	5	31
PA	2.8261	1.3702	1	5	23	2.7419	1.3655	1	5	31
PHC	3.3478	1.5843	1	5	23	3.1935	1.4473	1	5	31
Bike_V*f*	4.2174	1.0853	1	5	23	3.3871	1.1159	1	5	31

Table 5 – Descriptive statistics of the variables

Comparing the models, conclusions can be drawn about how the mode of transport affects the variables' evaluation (see Table 7). The most representative changes in barriers’ perception are described as follows.

The insecurity against crime (CI), barrier perceived by *bike users* as important at the beginning, in the second evaluation does not appear. This may be because, as previously stated, urban cyclists choose bike use by beliefs, therefore, CI may not be such an influential factor in their perception. On the other hand, regarding *car users*, CI went from having null importance to being the most influential barrier. This finding is interesting since it shows that the reflection process to which individuals were subjected indeed had an impact on their perception, since it may be that *car users* perceive CI as the most influential barrier and that is why they decide to commute by car and not tby bike.

Physical conditions and abilities to use the bike (PHC) have the same weight in *car users*' perception in both initial and final evaluations. However, regarding *bike users*, PHC has significantly higher importance on the second valuation (in the first did not appear), this could be explained because maybe in the reflection process individuals comprehended the realities they are exposed to when using the bike (e.g. tiredness).

Travel distances (TD) represents a heavy barrier from *bike users*' perspective since they introduced this aspect after the reflection process (in the initial valuation it did not appear). This may be because individuals could reflect on the times and reasons why they do not use the bike to commute, identifying TD as an influential barrier. TD could be improved by promoting multimodality. Likewise, it is not surprising that *car users* do not take TD into account in either of the two evaluations, this may be because they are not familiar with TD as a commute barrier, as they commute by car.

Dependent variable	Bike users						Private car users					
	Bike_V*i*			Bike_V*f*			Bike_V*i*			Bike_V*f*		
Log likelihood	-19.013			-20.93			-40.47			-36.37		
Pseudo R2	0.17			0.17			0.11			0.20		
LR chi2(8)	8.04			8.51			10.12			18.12		
Prob > chi2	0.09			0.07			0.02			0.00		
Variable	**Coef.**	**z**	**P > | z |**	**Coef.**	**z**	**P > | z |**	**Coef.**	**z**	**P > | z |**	**Coef.**	**z**	**P > | z |**
CS							-0.255	-1.51	0.13			
LBI										-0.489	-2.02	0.043
RI	-0.301	-0.99	0.324	-0.649	-1.92	0.055						
CI	0.349	1.22	0.222							0.729	2.6	0.009
CT							-0.407	-2.33	0.02	-0.769	-3.5	0
TD	-0.701	-2.59	0.010	0.330	1.43	0.154						
PA	0.385	1.44	0.150	-0.672	-1.91	0.057				-0.231	-1.49	0.137
PHC				0.640	1.85	0.065	0.272	1.92	0.055	0.272	1.77	0.076
/cut1	-3.114		-6.383	-3.574		-6.244	-3.391		-5.691	-3.129		-5.750
/cut2	-2.291		-4.929	-2.209		-4.635	-2.494		-4.596	-2.396		-4.899
/cut3	-1.178		-3.683	-1.590		-3.967	-1.765		-3.798	-1.132		-3.526
/cut4							-0.420		-2.466	0.303		-2.148

Table 6 – Ordered probit models of bike users and car users

To perform a complete analysis of the results, table 7 was developed. It shows each variable's contribution (by percentage) in each of the models. The parameters of the model where the dependent variable was V_i are represented by Θ_i, and in the case of V_f, by Θ_f (see Table 8). Θ_f - Θ_i is the difference in the contribution of each variable (Θ) between the models estimated for *bike users* and *car users*.

	Bike users			Private car		
	Θi	Θf	Θf-Θi	Θi	Θf	Θf-Θi
CS	0	0	0	65.4	0	-65.4
LBI	0	0	0	0	100.1	100.1
RI	112.3	184.6	72.3	0	0	0
CI	-130.39	0	130.4	0	-149.2	-149.2
CT	0	0	0	104.4	157.4	53.0
TD	261.6	-93.8	-355.4	0	0	0
PA	-143.6	191.1	334.7	0	47.3	47.3
PHC	0	-181.9	-181.9	-69.8	-55.6	14.1

Table 7 – Percentage and difference in each variable (Θ) contribution to each model

4. CONCLUSIONS

This paper presents the first findings of an ongoing research aimed to identify the aspects of bike use that may be preventing its acceptance among people carried out in the city of Quito, Ecuador. Prior to this study, there was uncertainty about whether if all the elements that make out bike use have the same impact on the overall valuation, whereby the method proposed by Dell'Olio et al. (2010) is useful in identifying the *relative importance* of the barriers to bike use.

Considering their approach, the present study was performed from two points of view: Firstly, know bike use perception from the information held a priori by individuals (V_i). Secondly, to immerse individuals in a process of *problem-analysis* (bike use acceptance as an option to commute) asking them to evaluate specific aspects of bike mobility to measure the relative importance of the variables (barriers) that could be influencing their overall perception. Immediately after this phase of meditation, individuals were asked for the second time to globally assess bike use (V_f).

The two proposed situations arose when seeking to meet two objectives: 1) to identify which variables have an unconscious impact on individuals and, 2) build up valuable information on where to direct the strategies and efforts that seek to improve the overall perception of bike use, focusing on those variables to which individuals seem to be more receptive. This study increases the knowledge about the perception towards bike use according to individuals' characteristics.

The research verifies the different bike use perceptions of a group of individuals before and after having reflected on each of the components of the system. The analysis according to individuals' categorization confirms that bike use perception varies depending in this case, of the mode of transport (*bike users* vs. *car users*). On the one hand, *bike users*' reflection causes a reduction in the weight they placed on aspects such as the importance of *maintaining the personal appearance* and *insecurity against crime*, resulting in increased importance placed on *travel distances*, and the *physical conditions and abilities to use the bike*, this latter being of null importance when the initial valuation was made. Regarding *car users*, aspects such as *city temperatures* fell in the second valuation, while *insecurity against crime*, which in the first evaluation was missed, in the second evaluation was highly influential. Therefore, the greatest impact on bike use perception will be achieved by, regarding *bike users*, enhancing multimodality, and the provision of facilities for bike use such as electric bikes. Whilst for *car users* should be by focusing on *safety*.

The results of this study evidence the importance that people's socio-demographic and journey characteristics have in the perception of a service, therefore, taking into account their needs should be a crucial factor to be considered when developing strategies that seek promoting bike use. Thus, mobility services will be able to meet demand requirements to, firstly, retain existing users and, secondly, attract new ones, especially from motorized modes. Therefore, in the future, bicycle mobility planning should be the product of collaboration between different mobility actors, especially integrating people's knowledge and perception, and not a product developed solely by experts and technicians.

Given that in cities with low rates of bike commute, the majority of the population is not familiar with the benefits of cycling as a means of transport. Therefore, dissemination strategies could focus on communicating the benefits of cycling as a fast, comfortable and reliable option, presenting it as a mode of transportation and not only as a recreational activity or a healthy lifestyle (Handy et al., 2014; Savan, Cohlmeyer, & Ledsham, 2017). This could be a key factor in changing the mindset towards its adoption as a regular mode of transportation. Short-term targeted campaigns can be an effective policy measure to expose these benefits and potentially engage new users in active mobility.

The application of the proposed methodology may provide planners and policymakers with valuable information for developing strategies aimed at different profiles of people, to improve bike use acceptance and attract new users. Nevertheless, it is important to bring up that this study serves as a first attempt to capture the bike use perception of a group of individuals in a city with a particular size, topography, and climate conditions. Further research should focus on studying the preferences of other sub-groups of people (e. g. males vs. females, students vs. working population, and so on), as well as in other cities with other characteristics where different results could be obtained related to the different contexts.

ACKNOWLEDGMENTS

This research was partially funded by the Universitat Politècnica de Catalunya (UPC).

REFERENCES

ALONSO, B., BARREDA, R., DELL'OLIO, L., & IBEAS, A. (2018). Modelling user perception of taxi service quality. Transport Policy, 63(January 2016), pp. 157–164.

BABAKUS, E., & BOLLER, G. W. (1992). An empirical assessment of the SERVQUAL scale. Journal of Business Research, 24(3), pp. 253–268.

ALONSO, B., BARREDA, R., DELL'OLIO, L., & IBEAS, A. (2018). Modelling user perception of taxi service quality. Transport Policy, 63(January 2016), pp. 157–164.

BABAKUS, E., & BOLLER, G. W. (1992). An empirical assessment of the SERVQUAL scale. Journal of Business Research, 24(3), pp. 253–268.

BORDAGARAY, M., IBEAS, A., & OLIO, L. (2012). Modeling user perception of public bicycle services, Procedia - Social and Behavioral Sciences, 54, pp. 1308–1316.

BRANION-CALLES, M., NELSON, T., FULLER, D., GAUVIN, L., & WINTERS, M. (2019). Associations between individual characteristics, availability of bicycle infrastructure, and city-wide safety perceptions of bicycling: A cross-sectional survey of bicyclists in 6 Canadian and U.S. cities. Transportation Research Part A: Policy and Practice, pp. 123, 229–239.

BRAUN, L., RODRÍGUEZ, D., COLE-HUNTER, T., AMBROS, A., DONAIRE-GONZALEZ, D., JERRETT, M., DE NAZELLE, A. (2016). Short-term planning and policy interventions to promote cycling in urban centers: Findings from a commute mode choice analysis in Barcelona, Spain. Transportation Research Part A: Policy and Practice, 89, pp. 164–183.

BUEHLER, R., & PUCHER, J. (2012). Cycling to work in 90 large American cities: New evidence on the role of bike paths and lanes. Transportation, 39(2), pp. 409–432.

CARRILLAT, F. A., JARAMILLO, F., & MULKI, J. P. (2007). The validity of the SERVQUAL and SERVPERF scales: A meta-analytic view of 17 years of research across five continents. International Journal of Service Industry Management, 18(5), pp. 472–490.

CEPEDA ZORRILLA, M., HODGSON, F., & JOPSON, A. (2018). Exploring the influence of attitudes, social comparison and image and prestige among non-cyclists to predict intention to cycle in Mexico City. Transportation Research Part F: Traffic Psychology and Behaviour, 60, pp. 327–342.

CORCORAN, J., LI, T., ROHDE, D., CHARLES-EDWARDS, E., & MATEO-BABIANO, D. (2014). Spatio-temporal patterns of a Public Bicycle Sharing Program: the effect of weather and calendar events. Journal of Transport Geography, 41, pp. 292–305.

DE OÑA, J., DE OÑA, R., DIEZ-MESA, F., EBOLI, L., & MAZZULLA, G. (2016). A composite index for evaluating transit Service Quality across different user profiles. Journal of Public Transportation, 19, pp. 128.

DE OÑA, J., DE OÑA, R., EBOLI, L., & MAZZULLA, G. (2013). Perceived service quality in bus transit service: A structural equation approach. Transport Policy, 29, 219–226.

DE OÑA, ROCÍO. (2013). Análisis de la calidad del servicio del Transporte Público mediante árboles de decisión. Universidad de Granada.

DE OÑA, ROCIO, & DE OÑA, J. (2015). Analysis of transit quality of service through segmentation and classification tree techniques. Transportmetrica A: Transport Science, 11(5), 365–387

DE SOUSA, A. A., SANCHES, S. P., & FERREIRA, M. A. G. (2014A). Influence of Attitudes with Respect to Cycling on the Perception of Existing Barriers for Using this Mode of Transport for Commuting. Procedia - Social and Behavioral Sciences, 162(Panam), 111–120

DE SOUSA, A. A., SANCHES, S. P., & FERREIRA, M. A. G. (2014B). Perception of Barriers for the Use of Bicycles. Procedia - Social and Behavioral Sciences, 160, 304–313.

DELL'OLIO, L., IBEAS, A., & CECÍN, P. (2010). Modelling user perception of bus transit quality. Transport Policy, 17(6), 388–397.

DELL'OLIO, L., IBEAS, A., DE OÑA, J., & DE OÑA, R. (2018A). Chapter 10: Beyond Perceived Quality: Desired Quality. Public Transportation Quality of Service (pp. 181–194). Elsevier.

DELL'OLIO, L., IBEAS, A., DE OÑA, J., & DE OÑA, R. (2018B). Chapter 2: How to Study Perceived Quality in Public Transport. Public Transportation Quality of Service (pp. 7–32). Elsevier

DELL'OLIO, L., IBEAS, A., DE OÑA, J., & DE OÑA, R. (2018C). Chapter 7: Methods Based on Random Utility Theory. Public Transportation Quality of Service (pp. 101–139). Elsevier.

DELL'OLIO, L., IBEAS, A., DE OÑA, J., & DE OÑA, R. (2018D). Chapter 8: Structural Equation Models. Public Transportation Quality of Service (pp. 141–154). Elsevier.

EBOLI, L., & MAZZULLA, G. (2011). A methodology for evaluating transit service quality based on subjective and objective measures from the passenger's point of view. Transport Policy, 18(1), 172–181

ECHANIZ, E., HO, C. Q., RODRIGUEZ, A., & DELL'OLIO, L. (2019). Comparing best-worst and ordered logit approaches for user satisfaction in transit services. Transportation Research Part A: Policy and Practice, 130(January), 752–769.

EREN, E., & UZ, V. E. (2019). A review on bike-sharing: The factors affecting bike-sharing demand. Sustainable Cities and Society.

FERNÁNDEZ-HEREDIA, Á., MONZÓN, A., & JARA-DÍAZ, S. (2014). Understanding cyclists' perceptions, keys for a successful bicycle promotion. Transportation Research Part A: Policy and Practice, 63, 1–11

FREITAS, A. L. P., & MACIEL, A. B. L. (2017). Assessing cyclists' perceptions, motivations and behaviors: An exploratory study in Brazil. Procedia Engineering, 198, 26–33

GARRIDO, C., DE OÑA, R., & DE OÑA, J. (2014). Neural networks for analyzing service quality in public transportation. Expert Systems with Applications, 41(15), 6830–6838.

GOODMAN, A., SAHLQVIST, S., & OGILVIE, D. (2013). Who uses new walking and cycling infrastructure and how? Longitudinal results from the UK iConnect study. Preventive Medicine, 57(5), 518–524

GUTIÉRREZ, M., HURTUBIA, R., & ORTÚZAR, J. DE D. (2020). The role of habit and the built environment in the willingness to commute by bicycle. Travel Behaviour and Society, 20, 62–73.

HANDY, S., VAN WEE, B., & KROESEN, M. (2014). Promoting Cycling for Transport: Research Needs and Challenges. Transport Reviews, 34(1), 4–24.

HEINEN, E., MAAT, K., & VAN WEE, B. (2011). Day-to-day choice to commute or not by bicycle. Transportation Research Record:, 2230(1), 9–18

HEINEN, E., MAAT, K., & VAN WEE, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. Transportation Research Part D: Transport and Environment, 16(2), 102–109.

HELBICH, M., BÖCKER, L., & DIJST, M. (2014). Geographic heterogeneity in cycling under various weather conditions: evidence from Greater Rotterdam. Journal of Transport Geography, 38, 38–47.

IGM. (1992). Cap 1 Introducción. In Atlas Infográfico de Quito. Socio-dinámica del espacio y política urbana (p. 29). Quito: Instituto Geográfico Militar.

INEC. (2017). home – Instituto Nacional de Estadística y Censos. Retrieved March 2, 2020, from https://www.ecuadorencifras.gob.ec/institucional/home/

IWIŃSKA, K., BLICHARSKA, M., PIEROTTI, L., TAINIO, M., & DE NAZELLE, A. (2018). Cycling in Warsaw, Poland – Perceived enablers and barriers according to cyclists and non-cyclists. Transportation Research Part A: Policy and Practice, 113, 291–301.

JAKOVCEVIC, A., FRANCO, P., VISONA DALLA POZZA, M., & LEDESMA, R. (2016). Percepción de los beneficios individuales del uso de la bicicleta compartida como modo de transporte. Suma Psicológica, 23(1), 33–41.

KEELING, D. J. (2013). Transport research challenges in Latin America. Journal of Transport Geography, 29, 103–104

KONSTANTINIDOU, M., & SPYROPOULOU, I. (2017). Factors affecting the propensity to cycle - The case of Thessaloniki. In Transportation Research Procedia (Vol. 24, pp. 123–130). Hellenic Open University, Aristotelous street, Patra, 26335, Greece.

MAJUMDAR, B. B., & MITRA, S. (2013). Investigating the Relative Influence of Various Factors in Bicycle Mode Choice. Procedia - Social and Behavioral Sciences, 104, 1120–1129.

MARK, L., & HEINRICHS, D. (2019). More than time and money - Influences on mobility of low-income women in the Villa 20 in Buenos Aires, Argentina. Journal of Transport and Health, 15, 100652.

MCKELVEY, R. D., & ZAVOINA, W. (1975). A statistical model for the analysis of ordinal level dependent variables. The Journal of Mathematical Sociology, 4(1), 103–120.

METRO DE QUITO. (2012). Encuesta domiciliaria de Movilidad (EDM11) del Distrito Metropolitano de Quito. Quito.

MUÑOZ, B., MONZON, A., & LOIS, D. (2013). Cycling habits and other psychological variables affecting commuting by bicycle in Madrid, Spain. Transportation Research Record, (2382), 1–9.

PARASURAMAN, A. P., ZEITHAML, V., & BERRY, L. (1985). A conceptual model of Service Quality and its implications for future research. Journal of Marketing, 49(4), 41.

PORTER, C., SUHRBIER, J., & SCHWARTZ, W. (1999). Forecasting Bicycle and Pedestrian Travel: State of the Practice and Research Needs. Transportation Research Record: Journal of the Transportation Research Board, 1674(1), 94–101.

SAVAN, B., COHLMEYER, E., & LEDSHAM, T. (2017). Integrated strategies to accelerate the adoption of cycling for transportation. Transportation Research Part F: Traffic Psychology and Behaviour, 46, 236–249

SIMONS, K. L. (2018). Useful Stata Commnads. Retrieved from http://www.stata.com/bookstore/books-on-stata/

STATACORP. (2017). Stata User's Guide. https://doi.org/10.1111/j.1600-0447.2011.01711.x

THORHAUGE, M., KASSAHUN, H. T., CHERCHI, E., & HAUSTEIN, S. (2020). Mobility needs, activity patterns and activity flexibility: How subjective and objective constraints influence mode choice. Transportation Research Part A: Policy and Practice, 139, 255–272.

TON, D., ZOMER, L. B., SCHNEIDER, F., HOOGENDOORN-LANSER, S., DUIVES, D., CATS, O., & HOOGENDOORN, S. (2020). Latent classes of daily mobility patterns: the relationship with attitudes towards modes. Transportation, 47(4), 1843–1866.

WEINSTEIN, A. (2000). Customer Satisfaction Among Transit Riders: How Customers Rank the Relative Importance of Various Service Attributes. Transportation Research Record: Journal of the Transportation Research Board, 1735(1), 123–132.