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Understanding captive user behavior in the competition between BRT and motorcycle taxis

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ABSTRACT

Transit-dependent users, far from being captives, may have other transportation alternatives. In some developing countries, depending on the characteristics of the city, instead of cycling or walking, captive users opt for informal services to commute. Although they are less safe and possibly less comfortable than regulated BRT services, demand for informal services such as motorcycle taxis has grown in recent years, affecting the self-sustainability of some BRT systems. This research aims to provide a richer explanation of the choice process between the BRT feeder service and motorcycle taxis in the context of the City of Bucaramanga, Colombia. Initially, we analyzed a set of effect indicators by diverging stacked bar charts, and then we used a hybrid discrete choice model to incorporate comfort and safety perceptions, in addition to the tangible attributes traditionally used. We found that safety perception, which varies by gender, age and income, is a key variable in modeling the choice process. Based on an empirical chart analysis and the modeling results, we proposed some policies aimed at changing user choices to stimulate the demand for BRT feeder system.

1. Introduction

Traditional knowledge often divides transit users into two categories: choice and captive users. Choice users, which are also described as discretionary users (Giuliano, 2005), are people with cars; meanwhile, captive users, transit dependent (Polzin et al., 2000) or disadvantaged users (Litman, 2015), are lower-income people who must use transit because they do not own cars. However, far from being captives, people without cars are susceptible to the quality of service (Jacques et al., 2013), which makes some users opt for other alternatives. In some developing countries, especially in those cases in which quality of service offered to captive users is not always a priority for the service providers, some bus rapid transit (BRT) systems have lost ground to informal transportation services (Hidalgo and Díaz, 2014). In other cases, informal transportation systems may be more attractive to users because they offer low costs, high speed and, in many cases, door-to-door services.

Improving informal services (Rahman et al., 2016), integrating them with the BRT (Salazar et al., 2013), or rationalizing them (Chavis and Daganzo, 2013) may be valid options depending on the context of analysis. However, it is becoming increasingly difficult to ignore that the demand for informal transportation services has grown in recent years, and today it is not just a transportation issue, but it has become a social problem (Cervero and Golub, 2007). There is increasing concern that many cities in developing countries have to deal with problems of financial self-sustainability of their BRT systems. One of the causes is competition from informal transportation services such as motorcycle taxis, which are relevant options in some developing African, Latin American, and Asian countries, such as the Philippines (Guillen et al., 2013). For instance, motorcycle taxis, which typically carry only one passenger, has become an essential part of the transportation sector in an increasing number of Sub-Saharan African cities (Díaz et al., 2015). It is also the case in some major Colombian cities (Jiménez et al., 2015), where this informal service is illegal.

In comparison with BRT, informal services are certainly less safe, as appears from the high prevalence of traffic accidents involving motorcycle-taxi drivers (Barbosa et al., 2014; Sumner et al., 2014), and possibly, less comfortable. The BRT systems have resulted in positive impacts due to reductions in operational costs, travel time and traffic fatalities (Wirasinghe et al., 2013; Nikitas and Karlsson, 2015), as well as reductions in air pollutant emissions, particularly for the introduction of cleaner technologies (Galván et al., 2016). Nevertheless, some captive users avail themselves of informal services as can be seen in the

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metropolitan area of Bucaramanga, Colombia, where the motorcycle taxi service carries about 15% of total demand (Metrolínea, 2017), which amounts to 40,000 captive users.

Informal transportation services are problematic to rationalize from a public policy standpoint because they provide significant benefits, particularly for poor people in terms of mobility, being that the reason why authorities simply give up doing anything about them (Cervero and Golub, 2007). However, it is important for authorities to address this issue, because informal transportation services contribute to congestion, and can produce disproportionate competition between public transit providers, especially in cities with high unemployment. Informal transportation may also contribute to elevated accident rates. For instance, in Bucaramanga, Colombia, the accident rates are correspondingly 1.17 and 3.68 times higher than the national rates of death and injury (Vargas, 2015). Therefore, it is necessary to address the problem.

Some authors point to as a need to analyze how transit service factors relate to mode captivity and mode choice (Beimborn et al., 2003; Krizek and El-Geneidy. 2007). These works highlight the importance of accessibility and connectivity on captivity and describe how specific transit service characteristics may play out in influencing demand, which is the first step toward ensuring more targeted and equitable policy responses (Jacques et al., 2013). However, far too little attention has been paid to the competition between BRT and motorcycle taxis in developing countries, where captive users should be the focus of consideration.

Several authors have studied the use of motorcycle taxis. In Akure, Nigeria, for example, Fasakin (2001) showed that motorcycle taxis are very popular among users because of non-availability of mass transit vehicles. In the same vein, de Vasconcellos (2005, 2013) suggested that quality problems of public transportation lead to an increase in the use of motorcycle taxis in Brazilian cities, while traffic deaths associated with motorcycles increased exponentially. Cervero and Golub (2007) showed how despite their illegality, motorcycle taxis are also popular in many Asian cities, including Jakarta and Bangkok. Kumar (2011) suggested that the collapse of contracted bus services led to the growth in motorcycle taxis in the in the capital cities of Douala (Cameroon), Lagos (Nigeria), and Kampala (Uganda). Likewise, Guézéré (2015) showed how motorcycle taxis came to dominate three secondary towns in Togo since appearing in the early 1990s. Finally, from the perspective of policies to address the phenomena, Diaz Olvera et al. (2012) concluded that public authorities must increase regulation of all transport modes.

This paper aims to investigate the attributes influencing the choice process between BRT feeder system and motorcycle taxis, popularly called *mototaxis* in some Latin-American countries, including Colombia, to recommend appropriate policies aimed at changing captive user options. In addition to the traditional observable attributes such as access time, travel time and fare, this research studies comfort and safety perceptions of riding a motorcycle taxi and a BRT feeder service. Specifically, this research studies the city of Bucaramanga, Colombia. The model only considers captive users, which can provide a better representation of transit choice, since it only applies to those who have a choice rather than to the entire population. To the best of our knowledge, this is the first study to incorporate alternative-specific latent attributes to investigate the choice process between BRT feeder service and motorcycle taxis.

The organization of the paper is as follows: After the present introduction, section 2 describes the context of the study, section 3 explains the methods and data, and section 4 shows the model specification. Section 5 summarizes the results and section 6 provides a discussion of them. Section 7 reveals policy implications, and, finally, section 8 summarizes the significant findings from the study and concludes the paper.

2. Context

Bucaramanga is the capital city of the department (province) of Santander, Colombia. The metropolitan area of Bucaramanga has the fifth largest economy by gross domestic product in Colombia and has the fifth largest population in the country with about 1.3 million inhabitants. The city is located on a plateau in the Cordillera Oriental of the Colombian Andes, and many inhabitants occupy unstable lands descending steeply from it. Bucaramanga features a tropical monsoon climate and, on average, the temperatures are always high. In contrast with Bogotá, which is a predominantly flat and bike-friendly city, Bucaramanga is a city where cycling seldom used, because of its topographic characteristics, as well as its hot weather. Nevertheless, there are government and civil society efforts to increase levels of cycling in the city (Traffic Direction of Bucaramanga, 2016). Table 1 shows the main characteristics of Bogota vis-à-vis the metropolitan area of Bucaramanga.

The BRT system of the city, called *Metrolínea* locally, started operation in 2009. Its first phase, which consisted of six lines, opened with only a few stations (Jiménez et al., 2015). Along the BRT feeder system, there are several stops without access control (Fig. 1). At such stops, users can choose between feeder buses and motorcycle taxis, especially when the feeder service is slow to arrive. Besides, the feeder lines to a main BRT trunk network circulate on infrastructures where the congestion produces a greater effect on buses than on motorcycles. More information about *Metrolínea* may be obtained from its official website, www.metrolinea.gov.co.

According to the local transportation authorities, the main problems facing the BRT system have to do with low-quality service and, consequently, demand reduction. In fact, the current situation indicates that the system serves less than 50% of the expected transportation demand (Administration of Bucaramanga Metropolitan Area, 2011). During 2016, the BRT system carried 34 million and a half passengers (Metrolínea, 2017), which represented an average of 191,282 passengers per day, that is to say, 23% of the daily demand. Although this service is illegal in the whole country, motorcycle taxis mobilize 15% of total demand (Metrolínea, 2017), almost 125,000 trips a day, which is about 40,000 captive users.

In 2014, the BRT service fare was 1750 COP (about 0.875 dollars) while the motorcycle taxi fare was 2000 COP on average (approximately 1 dollar). In contrast to the BRT service fare that is flat and paid by card, the motorcycle taxi fare is negotiable and paid in cash. In the same year, Bucaramanga exhibited a rate of 10.05 deaths in traffic accidents per 100,000 inhabitants meanwhile the injury rate was 315.10 (Vargas, 2015). When classifying accidents by mode of transportation, motorcycle riders were in first place with 44.28% of deaths and 50.62% of injuries. Transit users were located well below with 11.38% of deaths and 2.43% of injuries (Vargas, 2015); clearly, the real risk of accidents for motorcycle users was considerably higher.

3. Methods and data

With the aim of studying the main factors affecting the choice process between BRT feeder service and motorcycle taxis, we reviewed relevant documentation (Administration of Bucaramanga Metropolitan Area, 2011) and interviewed public transportation users, including motorcycle taxis users, in eight stops without access control near local universities.

Table 1
Features of Bucaramanga vis-à-vis Bogota.

Feature	Bogota	Bucaramanga
Region	Andean Region	Andean Region
Department	Capital District	Santander
Population	8′080,734	1′322,950
GDP per capita (USD)	17,500	14,292
Elevation (m)	2.640	959
Average temperature (°C)	14.5	23
Average slope (%)	2	2 to 7
BRT system	*Transmilenio*	*Metrolínea*
Length of trunk network (km)	113	50
Length of feeder bus network (km)	663	70
Number of stations	147	139
Average headway (min)	7	8

Fig. 1. Bus stop without access control and motorcycle taxis stop.

From interviews to public transportation users, we learned that, usually, the travel time of the BRT feeder service was greater than the travel time of motorcycle taxis. We also noted that the access time, i.e., the sum of walking time plus waiting time, was a key attribute in the choice process because users were not willing to wait long for the arrival of the BRT feeder service, preferring in some cases to travel by motorcycle taxis.

We conducted a focus group discussion with 12 captive users with the aim of selecting two sets of effect indicators (Bollen, 2002) to form two *a priori* latent variables for each alternative, namely comfort and safety perception. Table 2 summarizes the indicators emerged in the focus group and their corresponding scales. All the statements were written in Spanish, taking into consideration the main rules regarding indicators design (Johns, 2010).

After the focus group, we designed an initial version of the survey involving three alternatives: BRT service, motorcycle taxis, and taxis. In the same line of Beimborn et al. (2003), the basic definition of captive users referred to those individuals who do not have a driver's license or do not own a car. For this reason, we did not consider this alternative. As it was evident in the pilot survey, the set of alternatives comprised the two options that users have for commuting: BRT and motorcycle taxis. The pilot also showed that it was better to use two designs: one for short trips and one for longer trips.

As can be seen in Table 3, we used only the most relevant attributes, namely access time, travel time, and fare. With the purpose of presenting a credible experiment to respondents, the survey provided two scenarios according to travel time. These scenarios were selected based on the user responses regarding their actual travel time. According to the study context, the choice experiment assumed that captive users were waiting for public transportation service at bus stops, focusing the study on the three most important observable attributes: access time, travel time and fare.

The average duration of long trips was 40 min on BRT feeder service and 25 min riding motorcycle taxis. In the case of short trips, the design involves average travel times of 20 and 16 min. Besides, while the BRT fare remained flat, the motorcycle taxi fare varied into three levels. Each respondent faced nine choice situations, a number that seems to be optimal regarding the minimization of error variance, thus avoiding an increase of the cognitive burden overload (Caussade et al., 2005). Respondents were expected to make trade-offs between different attributes based on an orthogonal design.

Table 3
Attributes and levels of the choice experiment.

Attribute	BRT feeder service		Motorcycle taxis	
	Long trips	Short trips	Long trips	Short trips
Access time (minutes)	15	6	5	1
	20	12	10	6
	25	18	15	11
Travel time (minutes)	35	15	25	9
	40	25	30	16
	45	20	35	23
Fare (COP)	1750		2000	
			2250	
			2500	

The final instrument consisted of the following parts: socioeconomic characterization of users, a rating of effect indicators, and a discrete choice experiment. Surveys were applied where the respondents started their trips on feeder lines with a greater presence of motorcycle taxis. Taking advantage of the special feature of the stops without access control, we decided that the best method to adopt for this investigation would be to take a sample before arriving at the bus stops of the feeder lines, in educational and commercial areas, on the trip back home, throughout the day. Undergraduate civil engineering students gathered the surveys. On average, each survey took about 7 min.

After answering socio-economic information, respondents rated each indicator on a five-point scale, in which they stated their level of opinion with the given statement. For example, on the indicator “Probability of an accident,” we assumed that respondents had an opinion on how likely it is that an accident occurs when they ride a BRT feeder service or a motorcycle taxi. Hence, each respondent picked a relevant Likert point to state such level of opinion. Each rating scale is a set of five answers designed with the aim of collecting information to form the latent variables.

After rating the indicators, respondents faced a stated preference experiment.

Table 2
Indicators of comfort and safety.

Latent variable	Indicator	Measurement scale				
		1	2	3	4	5
Comfort	I1- Likelihood of reaching the destination within expected travel time	Extremely unlikely	Unlikely	Somewhat likely	Likely	Extremely likely
	I2-Passenger comfort	Very poor	Poor	Fair	Good	Very good
	I3-Driver's kindness	Very poor	Poor	Fair	Good	Very good
Safety	I4-Level of compliance with transit rules	Very low	Low	Average	High	Very high
	I5-Probability of an accident	Extremely likely	Likely	Somewhat likely	Unlikely	Extremely unlikely
	I6-Probability of injury in case of accident	Extremely likely	Likely	Somewhat likely	Unlikely	Extremely unlikely

The research team conducted definitive surveys in Bucaramanga, Colombia, during October 2014. We used a quota sampling to obtain a representative sample of captive users in Bucaramanga by gender, age and income level. The sample consisted of 236 captive users for whom the motorcycle taxi was a part of its transportation alternatives. In addition to not having neither a car nor a driver's license, all respondents in our sample reported having used motorcycle taxis or BRT feeder service at least once during the last year to make the trip back home.

Fig. 2 shows the sample distribution of the main socioeconomic attributes of the respondents. Participants aged between 17 and 64, with an average age of 28. Possibly because young people are more likely to perform a risk-taking behavior, respondents aged 20–30 represented almost a half of the sample. In this regard, it is important to notice that the sample excluded people that did not use motorcycle taxis. With 46% of female respondents and 54% of male, our sample exhibited an acceptably balanced gender distribution.

Regarding the socioeconomic situation of the interviewees, it is appropriate to clarify that in Colombia, a socioeconomic stratification system, on a scale from 1 to 6, classifies urban populations into different strata with similar economic characteristics in order to grant subsidies to the poorest residents. In the sample, income groups were determined as follows: Low-income level included strata 1 and 2, middle-income level included strata 3 and 4, and high-income level included strata 5 and 6. The middle-income group was predominant, which is adequately representative of the studied context, where many poor people are unable to access public transportation services, and the richest people have other transportation alternatives. Finally, regarding the level of education, the majority of respondents had secondary education.

4. Model specification

To provide a richer explanation of the choice process between BRT feeder service and informal services for captive users, we incorporated four alternative-specific latent attributes (Bahamonde-Birke et al., 2015) through structural equations (Ashok et al., 2002):

- Comfort perception of riding a BRT feeder service (η_1)
- Safety perception of riding a BRT feeder service (η_2)
- Comfort perception of riding motorcycle taxis (η_3)
- Safety perception of riding motorcycle taxis (η_4)

The alternative-specific latent attributes were explained by a set of individual characteristics through structural equations that, in turn, account for a set of perceptual indicators (gathered from the individuals) through measurement equations.

The four latent variables (η_l) were specified as a function of observable individual characteristics (S_q) as seen in (1), where q relates to individual, l to a latent variable, r to an explanatory variable, and α is a set of parameters to be estimated. Error terms υ_{lq} were assumed to follow a Normal distribution with mean zero. In the study case, since only socioeconomic characteristics explained the latent variables, the structural model allowed for capturing population heterogeneity but no objective changes in the transportation system that might affect perceptions. For identification issues (Diaz et al., 2015), the variance of the structural equation was set at one.

$$\eta_{lq} = \sum_r \alpha_{rl} S_{rlq} + \upsilon_{lq} \tag{1}$$

The measurement equations were specified as ordered logit models in attention to nature of the observed indicators. The underlying assumption is that each discrete response k observed within each indicator p is obtained from the latent variables plus an error term, through a censoring mechanism that defines different categories of response, according to (2) and (3), where each categorical response in the indicator C_{pq} was defined by a set of threshold parameters (τ) to be estimated.

$$C_{pq} = \begin{cases} 1 & if\ (-\infty) < C^*_{pq} \le \tau_{p1} \\ 2 & if\ \tau_{p1} < C^*_{pq} \le \tau_{p2} \\ \dots & \\ K & if\ \tau_{p(K-1)} < C^*_{pq} \le \infty \end{cases} \tag{2}$$

$$C^*_{pq} = \sum_l \gamma_{pl} \cdot \eta_{lq} + \zeta_{pq} \tag{3}$$

Error terms (ζ) were assumed to follow a logistic distribution and to be independent from the set of parameters γ. Therefore, if F is the cumulative distribution function, the probability of observing C_{pq} within a discrete indicator or category k can be written as (4) and (5), where $\tau_{p0} = (-\infty)$ and $\tau_{pK} = \infty$.

$$P\{C_{pq} \in k | \eta_{lq}\} = F\left(\tau_{pk} - \sum_i \gamma_{pl} \cdot \eta_{lq}\right) - F\left(\tau_{p(k-1)} - \sum_i \gamma_{pl} \cdot \eta_{lq}\right) \tag{4}$$

$$P\{C_{pq} \in k | \eta_{lq}\} = \frac{1}{1 + e^{-\left(\tau_{pk} - \sum_l \gamma_{pl} \cdot \eta_{lq}\right)}} - \frac{1}{1 + e^{-\left(\tau_{p(k-1)} - \sum_l \gamma_{pl} \cdot \eta_{lq}\right)}} \tag{5}$$

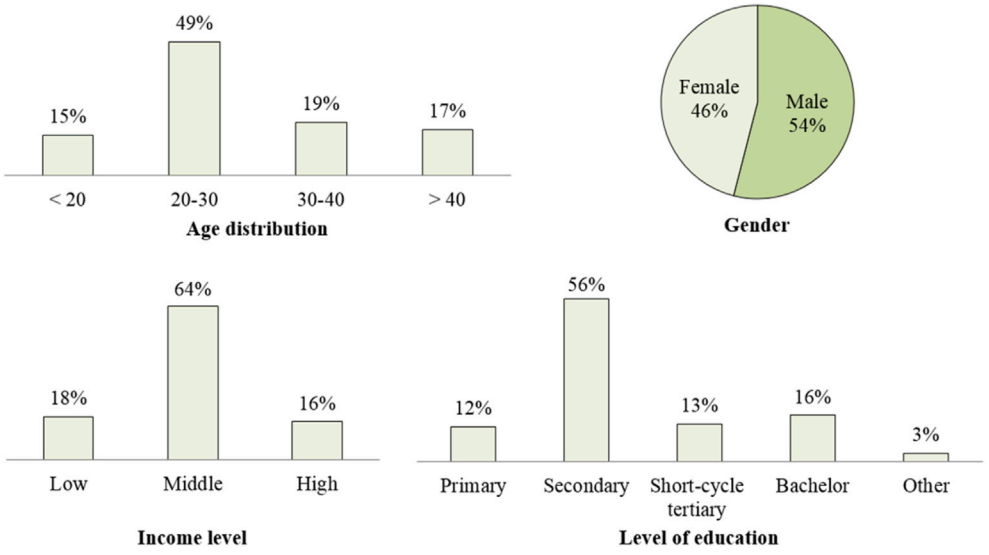

Fig. 2. Profile of the captive users.

The hybrid choice model allowed the inclusion of latent variables in the utility function for each alternative i as shown in (6), where θ and β are parameters to be estimated and associated with the modal attributes X_q and the latent variables η_q. Although generic estimators may also be considered (Bahamonde-Birke et al., 2015), this specification considered a specific estimator for each of the latent variables.

$$U_{iqt} = \sum_k \theta_{ki} X_{kiqt} + \sum_l \beta_{li} \eta_{liq} + \varepsilon_{iqt} \quad (6)$$

Under the assumption that the error terms (ε_{iqt}) are independent and identically distributed extreme value, the differences between the utilities of the alternatives follow a Logistic distribution, leading to the logit kernel model. The individual choices, given the choice set A_q, were expressed as a function of the utilities according to (7).

$$y_{iqt} = \begin{cases} 1 & if\ U_{iqt} \geq U_{jqt},\ \forall j \in A_q \\ 0 & otherwise \end{cases} \quad (7)$$

Finally, the joint probability of observing choice and latent variable indicators was built as seen in (8), where $P(.)$ is the choice probability of selecting alternative i, $f(.)$ is the density function of the indicators, and $g(.)$ is the density function of the latent variables.

$$\overline{P}\left(y_{iqt},\ C_{iq} \middle| X_{iqt}, S_q, \theta, \beta, \tau, \gamma, \alpha, \Sigma_\varepsilon, \Sigma_\zeta, \Sigma_\upsilon\right) = \int_\eta P\left(y_{iqt} \middle| X_{iqt}, \eta_{iq}, \theta, \beta, \Sigma_\varepsilon\right) f\left(C_{iq} \middle| \eta_{iq}, \gamma, \tau, \Sigma_\zeta\right) g\left(\eta_{iq} \middle| S_q, \alpha, \Sigma_\upsilon\right) d_{\eta_q} \quad (8)$$

5. Results

Results are based on an empirical chart analysis by diverging stacked bar charts and the modeling results via hybrid discrete choice modeling approach. The empirical chart analysis not only provided interesting insights but also helped recognize the main socioeconomic characteristics specified in the structural models.

5.1. Empirical analysis of the indicators

Fig. 3, which intentionally omitted the labels for percentages equal to or less than 6%, shows the rating of indicators as diverging stacked bar charts (Heiberger and Robbins, 2014). For each statement, the percentages of negative opinions are found on the left, the percentages of positive views on the right, and split down the middle, in a neutral color, the percentages of neutral opinions.

Concerning the first set of indicators, respondents appeared to have an adverse opinion on the first indicator for the BRT feeder service, but not for the informal service, thus implying a greater likelihood of reaching the destination within expected travel time when they ride motorcycle taxis. Respondents rated the second indicator most favorably toward BRT feeder service, stating that, in general, the BRT feeder service seems more comfortable than the motorcycle taxis. Regarding driver's kindness, it appears that individuals are more satisfied with the manners of the motorcycle taxi drivers. The second set of indicators related to

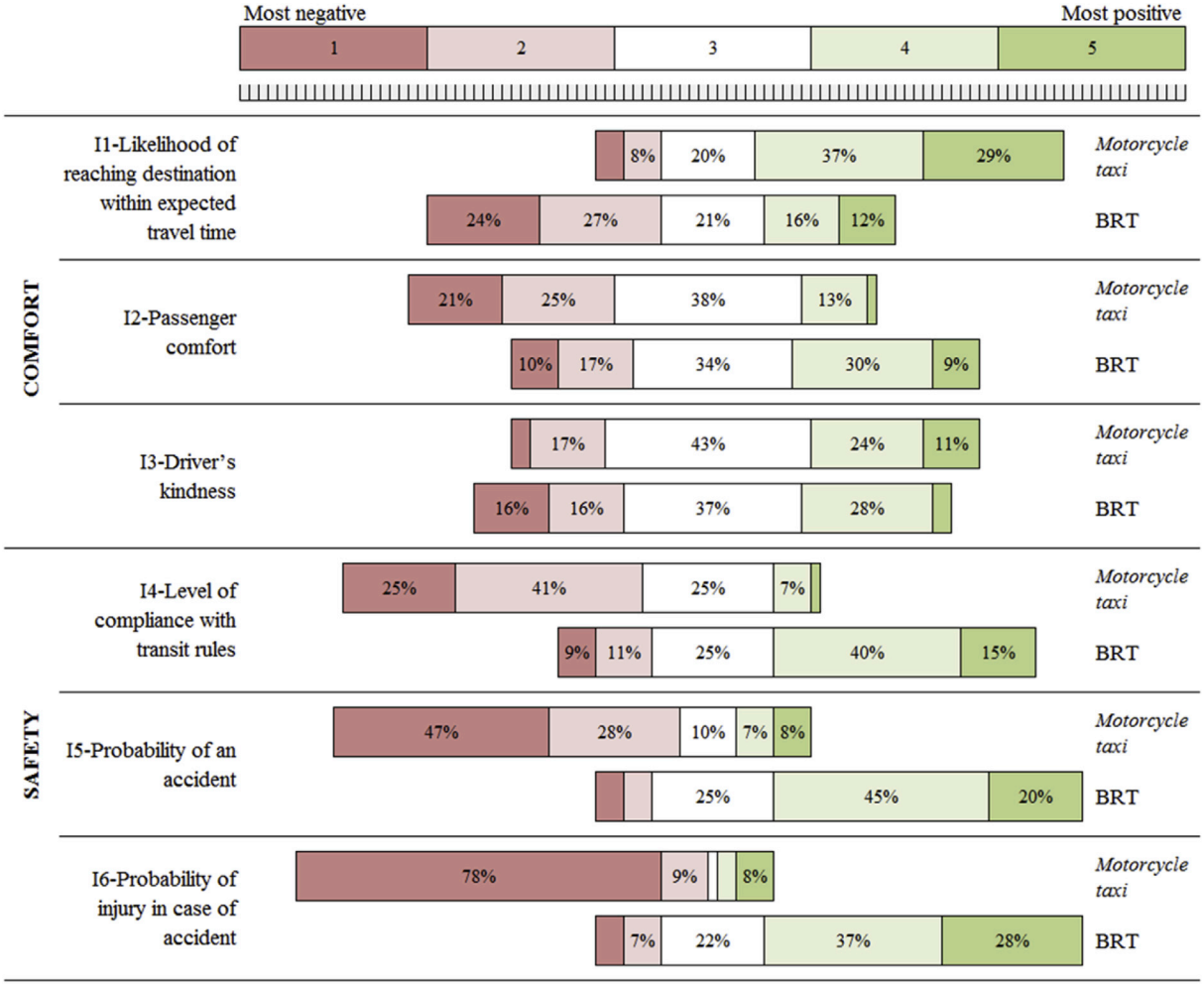

Fig. 3. Rating of indicators.

safety perception showed obvious positive scores for BRT feeder service. This result implies that most people are aware of the greater risks of using the motorcycle taxis compared to the BRT feeder service. It is remarkable how many people considered that motorcycle taxis have a high probability of an accident. Likewise, in the case of an accident riding a motorcycle taxi, most of them stated that the likelihood of being injured was very high.

Fig. 4 summarizes the percentages of choices according to the main socioeconomic characteristics of respondents and shows the 95% confidence interval of these percentages. Despite users perceiving the BRT feeder service to be much safer than motorcycle taxis, they chose the alternatives in a balanced way: 48% of respondents chose the BRT feeder service, and 52% of them chose the motorcycle taxis.

5.2. Model estimations

We carried out all the work on the computer using OxMetrics™, a family of software packages providing an integrated solution for the econometric analysis that has been successfully used in previous studies (Márquez et al., 2014, 2015). Since sequential approach tends to slightly overestimate the weight of the latent variables (Raveau et al., 2010), we estimated the model using all the information simultaneously. To simulate the likelihood, we used 500 drawings for each individual obtained from a modified Latin Hypercube sampling.

Regarding the model's identifiability, necessary and sufficient conditions have not yet been developed (Bahamonde-Birke et al., 2015). Furthermore, it is well known that a model that is theoretically identified may often be empirically unidentified due to insufficient variability in the observed data (Vij and Walker, 2014). For these reasons, to deal empirically with the identifiability issues of our model, we verified that the estimated parameters did not lie outside the range of reasonable values. Also, the model was estimated multiple times, employing different starting values for the parameters for each estimation run, verifying that in all cases we reached the same solution, thus ensuring that the solution obtained was a global maximum (Vij and Walker, 2014).

Table 4 exhibits the estimates and the robust t-values in brackets for the structural model. All the alternative-specific latent attributes considered only socioeconomic characteristics as explanatory variables. All estimated parameters in the structural models are statistically significant at 1%, except for male gender explaining comfort perception of riding a BRT feeder service and high-income explaining safety perception of riding motorcycle taxis. The structural model revealed that gender, age, and income are the main socioeconomic characteristics that explain perceptions. Although different model specifications included the level of education as an explanatory variable, this socioeconomic characteristic was not significant in any of the tested specifications.

Table 5 shows the results of the discrete choice models. Both models consider the panel effect produced by having nine different choices per respondent (Cantillo et al., 2007). Unsurprisingly, the hybrid discrete choice model fitted the data better than the mixed logit with panel effect,

Table 4
Estimated parameters for the structural model.

Latent variable	Socioeconomic Characteristic	Estimate
Safety perception of riding a BRT feeder service	Aged over 40	0.488 (3.50)
	Low income	−0.337 (−2.03)
Comfort perception of riding a BRT feeder service	Male gender	0.367 (1.42)
Safety perception of riding motorcycle taxis	Low-income	0.332 (2.31)
	High-income	−0.202 (−1.13)
Comfort perception of riding motorcycle taxis	High-income	−0.938 (−3.77)

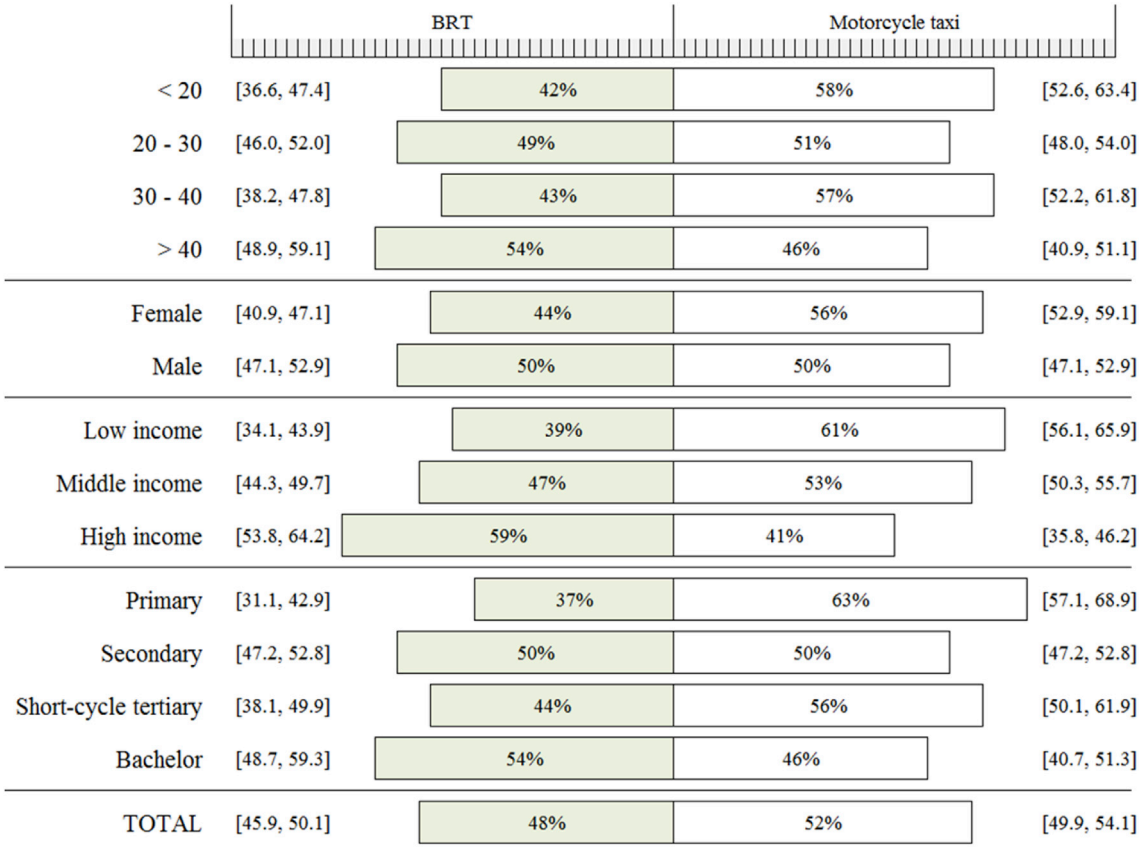

Fig. 4. Choices according to socioeconomic characteristics.

Table 5
Estimated parameters for the discrete choice model.

Variable	Hybrid discrete choice model	Mixed logit with panel effect
BRT specific constant	0.388 (1.45)	0.605 (2.26)
Access time	−0.2683 (−14.39)	−0.2656 (−14.21)
Travel time	−0.2045 (−7.75)	−0.2050 (−7.48)
Fare	−0.003784 (−11.68)	−0.003746 (−11.56)
Panel effect	0.869 (2.21)	1.288 (10.70)
Comfort perception of riding a BRT feeder service	0.0803 (0.34)	
Safety perception of riding a BRT feeder service	0.1182 (2.80)	
Comfort perception of riding motorcycle taxis	0.4642 (2.34)	
Safety perception of riding motorcycle taxis	0.5466 (2.50)	
Log-likelihood	−4881	
Log-likelihood for the choice component	−1,130	−1,148

which is a less complex model (Vij and Walker, 2016). All estimated parameters have the expected signs. Travel time and fare are in the expected direction: delays, additional travel times or fares that are more expensive reduce the utility of alternatives. Furthermore, the signs of the latent variables indicate that these variables affect utility positively.

6. Discussion

It is apparent that income level is one of the socioeconomic characteristics that most influence the choice. Mainly the high-income people exhibited a greater preference for the BRT feeder service. This result is in line with previous researchers which concluded that, in Latin America, the use of the motorcycle is more extended among low-income people (Hagen et al., 2016). We also observed a similar behavior among individuals over 40 years, who also preferred the BRT feeder service to the motorcycle taxis. Surprisingly, women were more willing to choose the motorcycle taxis than men were. A possible explanation for this behavior is that men feel more comfortable than women do when they ride the BRT feeder service, as shown in Table 4 that contains the estimated parameters for the structural model. In general, with the exception of persons with secondary education, the data showed that as the level of education increases, the preference of individuals for the BRT feeder service also increases. Consequently, it is expected that socioeconomic characteristics such as age over 40, male gender, high income or bachelor studies to emerge as significant variables in modeling.

Among observable variables, access time was the most important factor for captive users. They valuated access time at a level of 1.3 times that of in-vehicle time, which was considered valid in the studied context (see for example Márquez, 2013), although it is relatively low when comparing it with the values reviewed by Diab et al. (2015). It is normal that passengers perceive the access time differently from the actual time because of the exposure to adverse weather conditions and the experience of being stressed by access anxiety (Daskalakis and Stathopoulos, 2008).

Estimated parameters provided interesting insights in line with expectations. Compared to other users, those aged over 40 have more positive safety perception of riding a BRT feeder service. Because this service is objectively safer than motorcycle taxis, this behavior coincides with the results of other studies in which older people are usually less willing to take risks (Sullivan et al., 2011; Cantillo et al., 2015). In contrast, low-income people feel the BRT feeder service less safe when compared with other individuals; they also perceive riding motorcycle taxis to be safer than medium and high-income people. As expected, high-income people have a negative safety perception of riding motorcycle taxis. Regarding comfort perception, estimated parameters showed that men are, in average, more comfortable using BRT feeder service than women and high-income people are less comfortable riding motorcycle taxis.

The results of the measurement model revealed that comfort perception was more strongly manifested in the third indicator (Driver's kindness). This finding suggests that, for many captive users, interacting with the driver is important. According to information obtained from a focus group, motorcycle taxi users have some greeting before they board, and occasionally they will strike up a conversation with the driver during the ride, which makes users feel more comfortable. The measurement model also showed that the fourth indicator (Level of compliance with transit rules) and the sixth one (Probability of injury in case of an accident) more strongly manifested the safety perception.

We found that safety perception of riding a BRT feeder service and both comfort and safety perceptions of riding motorcycle taxis were statistically significant in the hybrid discrete choice model. Also, when the latent variables were omitted, the BRT-specific constant became larger, as shown by results of the mixed logit model. In both models, the BRT-specific constant, which captures the average effect on the utility of all factors that are not included in the model, was positive suggesting that, *ceteris paribus*, for captive users, the BRT feeder service is preferable than motorcycle taxis. The BRT-specific constant was statistically significant at 5% in the mixed logit. However, when the latent variables were included to estimate the hybrid model, the constant was not statistically significant at 5%. This finding is consistent with the theory because the mode-specific constants capture the omitted information of alternatives (Bahamonde-Birke et al., 2015). Hence, the inclusion of the latent variables improves the explanatory power of the model and the magnitude of the constants decreases.

7. Policy implications

Transportation planners are increasingly adopting policies aimed at changing travel choices made by citizens. In this regard, some authors have evaluated a set of policies, ranging from the eradication of the informal services and investment in formal options to the complete legalization of such services (Golub et al., 2009). As it frequently occurs in other Latin American cities (Hagen et al., 2016), the vulnerability of motorcyclists to traffic-related injury and death, as well as some cultural aspects of motorcycle use, have forced the authorities to take further measures to make motorcycle taxis safer and improve BRT feeder service. For these reasons, in line with policies adopted in other cities (Qian, 2015), in Colombian cities, motorcycle taxis have become the object of strict state regulation, although in practice the phenomenon is so widespread that its control has become impractical. Within this framework, public transit authorities have considered some measures to reduce the demand for motorcycle taxis and, consequently, decrease the risk of crashes and increasing the demand for BRT.

Unlike other cities throughout the developing world (Sengers and Raven, 2014), in this study context, most persons do not depend on informal transportation services for their mobility needs. As explained before, persons also have formal transportation services available, so that the first package of policies could be aimed at restricting the use of motorcycle taxis. However, aiming to provide significant benefits to users, such as shorter travel times and greater reliability, informal transportation services are challenging to control by enforcement authorities, thus causing serious inconveniences among users that could be transformed into massive social protest and violence.

In some cities, like Barranquilla, despite protests from some quarters, transportation authorities have banned people from riding as passengers on motorcycles (The drama of motorcycle taxis, 2011). Depending on the crime levels of cities, this measure is not only aimed at controlling informal transportation services, but in some cases also seeks to control delinquency. In Colombia, there are some capital cities (e.g. Cali, Cartagena, Cúcuta, Ibagué, Medellín, Neiva, Riohacha, and Pasto) where people riding as passengers on motorcycles have been temporarily and partially forbidden (Eight capital cities already banned passengers on

motorcycles to fight crimes, 2016). Nonetheless, because this measure applies to the entire population and not only those who provide informal transportation services, it has a strong negative impact on families using the motorcycle as their main mode of transportation. In Bucaramanga, for example, the percentage of trips made by motorcycle is 19% versus 15% of trips made by motorcycle taxis (Metrolínea, 2017). Furthermore, regulation banning people from riding as passengers on motorcycles would be a useless measurement itself unless authorities implement effective control.

By the empirical chart analysis, it is possible to suggest some measures aiming to improve the rating of the worst-rated indicators of the BRT feeder service. Regarding the first indicator of comfort (Likelihood of reaching the destination within expected travel time), a suggestion would be for the authorities to explore the possibilities of establishing exclusive lanes for feeder services to reduce the travel time and improve reliability. In this context, exclusive feeder-bus lanes could be of great benefit to supply fast and convenient access to captive users and make an effective influence on the priority of public transportation even without improving service frequencies. Although the reduction in access time through improved BRT frequencies is feasible, providing passengers with reliable and updated information in real time using information panels would also be recommended (see for example Tavares et al., 2015).

Regarding the third indicator (Driver's kindness), it is clear that captive users do not perceive BRT drivers to be kind. Therefore, authorities could train not only BRT drivers but also all the staff, to improve communication and customer service, affecting the organizational climate positively for the benefit of users. Besides, authorities should develop and keep effective channels of communication with their users for solving passenger complaints and claims, and improving the level of the service delivered to them.

From the data in Fig. 4, it is noted that a policy aimed at shifting the use of motorcycle taxis should target young people. It is in this segment of the population that authorities should focus the marketing campaigns of the BRT feeder service. For example, authorities could provide transportation allowance for students in public schools and universities by means of the differential reduction of fares through funding from the state, which does not currently occur. Empirical chart analysis suggests that there is also a greater propensity for low-income people to use motorcycle taxis so that this subsidy could also be effectively targeted through the SISBEN Welfare Index (https://www.sisben.gov.co/), which is the Colombian system for the selection of beneficiaries for social programs that classify the people according to their socio-economic level.[1]

Modeling results also showed that fare was also an important objective factor for captive users. Therefore, as suggested, public transit authorities should consider policy alternatives and strategies for targeting subsidies to low-income users; for example, a targeting scheme that discounts fares for users under a certain income threshold. Obviously, the subsidy should be conditioned to verifiable improvements in the level of service offered. As informal services are less safe than BRT feeder services, when evaluating this strategy, authorities should take into account positive impacts, such as reductions in accidents, as well as positive effects on other externalities.

Although fare and travel time are the most significant factors for switching to a motorcycle taxi, subjective factors, i.e., comfort and safety perceptions of riding a motorcycle taxi and a BRT feeder service, are also important in choosing between motorcycle taxis and BRT feeder service for captive users in Bucaramanga. In this regard, policies should consider some socioeconomic characteristics such as age, gender, and income level. With the aim of changing the behavior of captive users, authorities should undertake campaigns that emphasize the risks of using motorcycle taxis and highlight the added safety that the BRT feeder service offers. In this line, authorities could focus their efforts on low-income people to make them see the benefits of the BRT feeder service, highlighting the added safety that this service offers (see for example Litman, 2014). Furthermore, a campaign of awareness of the risk inherent in the use of motorcycle taxis would be more efficient when focusing on low-income people.

[1] The SISBEN Welfare Index is defined by the National Planning Department. Based on this index, each household receives a score from 0 to 100 (from poorest to richest). The score is calculated by a software using 24 variables across four dimensions: health, education, housing, and vulnerability.

8. Conclusions

This paper investigated tangible and latent attributes influencing captive user behavior in the face of choice decision between BRT feeder service and motorcycle taxis in Bucaramanga, Colombia. Together with access time, travel time, and fare, which are the main attributes traditionally studied, our research considered the perceptions of comfort and safety of riding BRT feeder service and motorcycle taxis, which are illegal in the whole country, to provide a better representation of captive user behavior at choosing between these two alternatives.

In this study context, we found that access time and fare were the most important tangible factors for captive users. Regarding latent variables, safety perception of riding a BRT feeder service, and both comfort and safety perceptions of riding motorcycle taxis, were statistically significant in the hybrid discrete choice model. These findings enhance the understanding of captive user behavior, and allow for the formulation of policies focusing on latent variables.

The only alternative-specific latent variable that was not significant in the choice model was the comfort perception of riding a BRT feeder service. Although they emerged in a focus group, the indicators used to form this latent variable may not have been sufficiently relevant for captive users since perceptions of comfort are usually relevant to BRT users. Further investigation is required into the opportunities to improve the design of indicators. On the other hand, the research did not consider the inclusion of tangible attributes linking latent variables, so it was not possible to study how changes in alternatives may affect the perceptions of captive users. For that reason, it is recommended to test the possibility of including tangible factors in the latent variable model. The results provided will be the starting point to carry out further research to study the influence that policies could have on individual perceptions.

Although vaguely treated in this paper, an important issue is that the amount of captive users is decreasing. Mainly because personal income has increased, and the motorcycle and car, as private transportation modes, are becoming more affordable. In Colombia, between 2002 and 2015, the number of new motorcycles registered annually has been multiplied by 12, while the number of new cars registered per year has grown 3.27 times (Ministry of Transportation, 2016). This fact has caused the market share of public transport (including informal services) to reduce. Then, the improvement of the BRT feeder service would be considered the best way to compete and stop the loss of users. We suggest further research on this area, especially in developing countries where the demand for transportation must be dealt with sustainably.

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