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Obtaining Primary Behavioral Data for Transportation Demand Estimates and Social Variables by means of ExperimentalScenarios as an Empirical Tool for the Application of Transportation Planning and Public Policies in the Basin

Cristian Eduardo Zamora Matute[1] , Dario Alberto Ordoñez Aray[2], Edwin Paúl Feijoo Criollo[3]

Abstract

The article highlights the growing issue of congestion and traffic caused by the increasing number of cars in cities. It emphasizes the need for public institutions to develop strategies for sustainable mobility and address daily traffic problems. Despite efforts to discourage motor vehicle use, data from the Municipal Traffic Department of Cuenca shows a significant rise in the number of vehicles, with 2021 marking a historical peak. The study identifies preferences and choices of transportation modes, as well as the reasons for their use, with private vehicles satisfying the mobility needs of only 30% of the population. The findings indicate that traffic issues are particularly associated with private vehicles. The article concludes by presenting a demand estimate involving variousmodes of transport and their associated attributes. It emphasizes the value of travel time savings, waiting time, and blocks walked as significant factors in transportation projects. The research also explores the impact of weather variations on people's valuations of these factors. Furthermore, the study calculates the elasticities of transport modes in response to various policy scenarios, highlighting the sensitivity of these modes to fare changes, waiting times, travel costs, and parking costs. The research confirms that price increases generally lead to decreased demand, while service improvements or reduced travel times increase the likelihood of using a particular mode of transport. The article provides valuable insights for transportation planning and policy development.

Keywords: *Transportation Demand, Traffic Congestion, Sustainability and Elasticity of Demand.*

INTRODUCTION

Currently, the proliferation of cars in cities has exacerbated issues of congestion and traffic. The uncontrolled expansion of the vehicle fleet, driven partly by populationdesires and convenience, has strained cities ill-equipped to handle the current vehicular load. Public institutions must take responsibility for devising effective strategies to promote sustainable mobility and tackle the daily traffic problems, as recommended by ECLAC (2013). Despite concerted efforts to discourage motor vehicle use, cities across the country, including Cuenca, have witnessed a surge in vehicles. For instance, data fromthe Municipal Traffic Department (DMT) of the Municipality of Cuenca reveals that the vehicle count doubled from 52,674 in 2006 to 105,178 in 2015, reaching approximately 145,000 vehicles in 2021. This rapid increase in vehicles does not align with population growth, indicating an unsustainable trajectory. It's possible that strategies employed bythe automotive sector, like reduced entry fees and favorable financing terms, have bolstered vehicle sales, intensifying traffic not only during peak hours but throughout the day, even with the pandemic's temporary impact.

[1] Mayor of the city of Cuenca-Ecuador, cristianzamora@hotmail.com, 0009-0008-0797-0129

[2] General Manager of Empresa Pública de Movilidad, Tránsito y Transporte of Cuenca-Ecuador, dordonez@emov.gob.ec, 0009-0009-8170-3763

[3] Mobility Technical Manager. Public Company of Mobility, Transit and Transportation of Cuenca-Ecuador, efeijoo@emov.gob.ec, 0000-0002-8436-0075

Figure 1 shows the data of vehicles registered in the last 9 years, according to historical data from EMOV EP[3] (El Mercurio, 2021). Where an ascending behavior can be appreciated in some years, however, the years 2015, 2018 and 2021 are the peaks in this process. Especially 2021, has become the historical figure, despite still maintaining certain restrictions due to the COVID-19 pandemic.

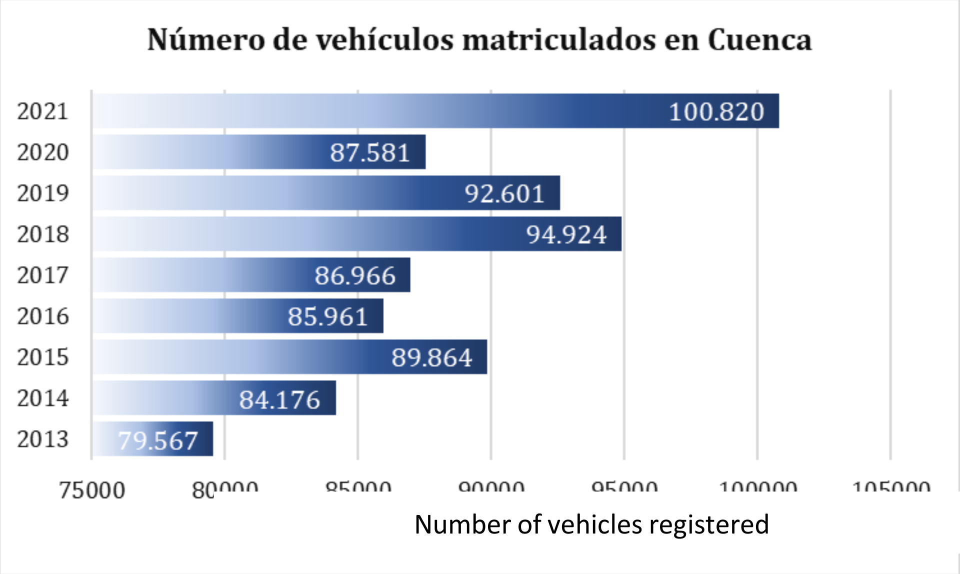

Figure 1 Number of vehicles registered in Cuenca-Ecuador

Source: Own elaboration, based on EMOV EP data (Mercurio, 2021)

The growth that can be seen between 2013 and 2021 is 21% in the number of registered vehicles, however, there is a lot of volatility in the records from year to year, the highest growth is between 2020 and 2021, where only in that period there is an increase of 15.11%. This situation also shows that the increase in the vehicle fleet is not simply a public perception at times of high mobility, but is a reality expressed through official statistics.

Although some data can be found in academic works, there are no formal studies in Cuenca to determine preferences and choices of means of transport, nor reasons for their use. A first approximation can be found in a study conducted by the Mayor's Office of Cuenca, which landed in the Mobility and Public Spaces Plan (PMEP), a document built for a 10-year horizon, 2015 - 2025. The PMEP (2015) identifies four modes of transportation or mobility: On foot (walking), Bicycle, Public Transportation, and Private Vehicle, and the reasons for mobilization are labor, educational, commercial and leisureor recreational.

It can be seen that private vehicles satisfy the mobility needs of only 30% of the population, while approximately 35% use urban transport, and the rest of the population uses other modes of transport, as can be seen in Figure 2. Urban mobility in Cuenca involves about 600,000 trips to and from the city, of which 69% are motorized trips, and 31% are non-motorized, that is, pedestrians and bicyclists. Also, it has been observed that the bus and the car are the first and second priority modes of transportation, the third

[3] Empresa Pública Municipal de Movilidad, Tránsito y Transporte de Cuenca (Municipal Public Company of Mobility, Transit and Transportation of Cuenca)

option corresponds to walking, the cab is the fourth, and finally the use of bicycles and motorcycles. Figure 2 shows the 3 main forms of transportation, however, one of the biggest problems that are generated by one of them in general, is the private vehicle.

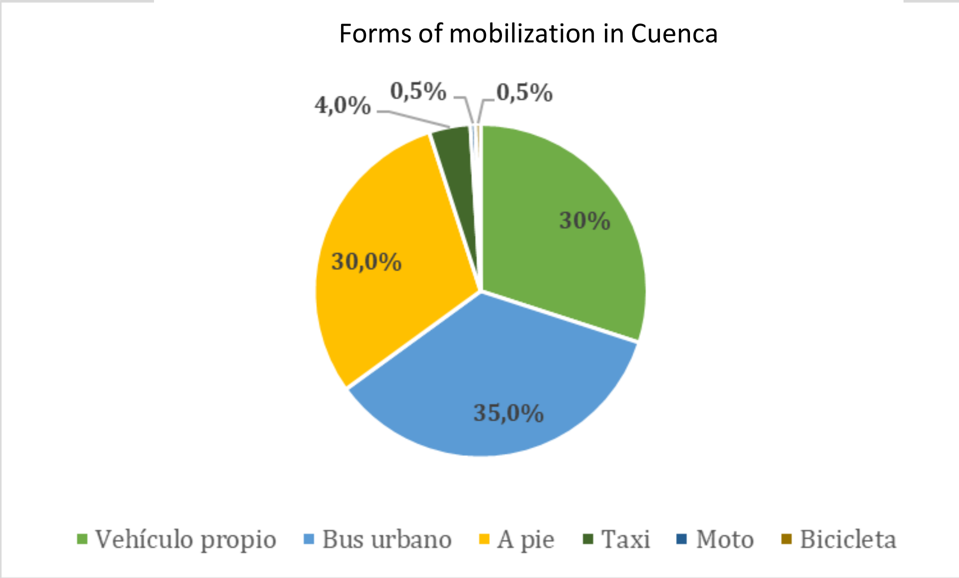

Figure No 2 Forms of mobilization, Cuenca-Ecuador

Source: Own elaboration (DMT, 2021)

According to the PMEP (2015), among the main reasons why people would substitute the use of public vehicles are: Health (28%), avoiding traffic (26%), avoiding the problem of lack of parking (8%) and environmental awareness (6%). People who intend to change their mode of transportation, leaving aside the private vehicle, would opt for bicycles (33%), public buses (30%) and walking or walking (23%).

Table 1 presents the public and private transportation options.

Type of transport	Type of mobility	Transportation option	Tariff
Public Transportation	Traditional mobility	Urban Bus	$0,30
		4 Rios Tramway	1.00 (tourists) 0,50 (ticket) 0.35 (card) 0.30 (multi-trip)
	Sustainable mobility	Public bicycle	0.25 (travel) $10.00 (cost per day) $ 15.00 (cost for 3 months) 30.00 (cost per year)
Private Transportation	Traditional mobility	Cab	$1.39 (Daytime Minimum) $1.67 (Night Minimum)

Table 1 Types of transportation and tariffs

Source: Own elaboration (PMEP, 2015)

The PMEP (2015) does not consider transportation demand planning, nor transit through advanced statistical and econometric modeling, so the studies conducted do not have the versatility to adjust to variations in some variables so that the reaction of demand to certain characteristics cannot be determined so that even the effect of some relatedpolicies cannot be properly measured or evaluated.

CONCEPTUAL FRAMEWORK

In order to fulfill the objective of analyzing demand and forecasting its behavior, based on the variation of some attributes or service factors, the following conceptual framework is presented, based initially on the economic theory of demand and the theory of consumer choice. In the case of consumer choice theory for public transportation services. Figure 3 shows the process that a person follows for decision-making. It can be seen that the decision starts with the clear and precise identification of the needs to be solved. Subsequently, information is sought about the products and all the related characteristics and variables (attributes). A decision rule is formed, where the parameterization in the function of which the individual makes a certain decision is established. Order of preference for the use or selection of the product is formed, where the budgetary restrictions are included, and finally, the selected alternative is chosen.

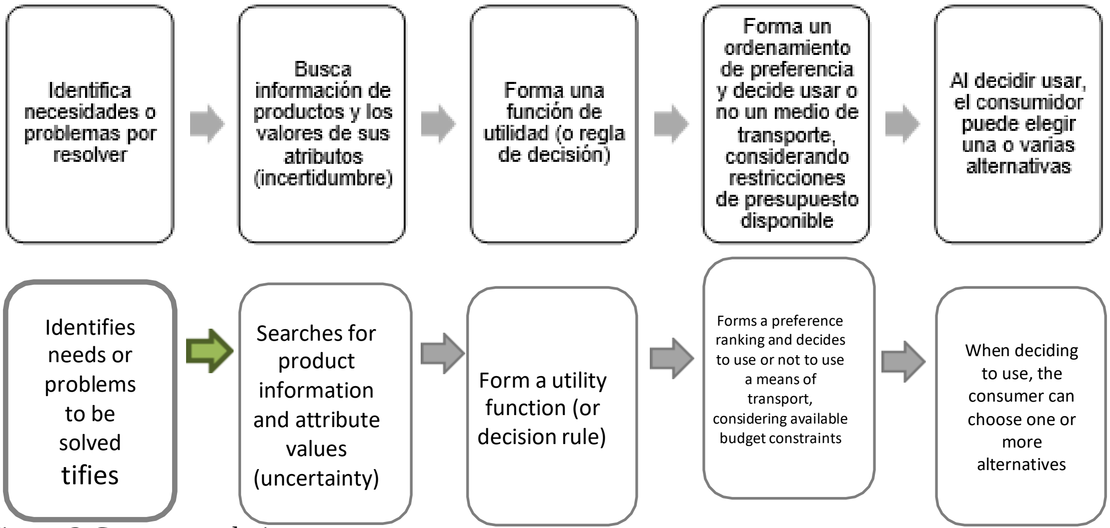

Figure 3 Consumer choice process

Source: Sartori (2013)

The consumer choice process, described in Figure 3, is perfectly applicable to the case of public transportation. People identify the need to move, according to the PMEP, for 4 reasons: work, education, business and leisure or recreation, then determine the alternatives of mobilization and evaluate which is more useful to them. When talking about utility, it is necessary to anchor it to the microeconomic theory that analyzes consumer behavior, where it is stated that the good itself does not generate utility for the consumer, but rather the characteristics or attributes that it has are those that will providea greater or lesser level of utility. In this sense, each good has characteristics that will be common to several goods, in the same way, the characteristics or attributes for the set of goods may be different from the characteristics obtained by each of the goods individually. Once the utility of each of the goods and/or services has been identified, andthe decision rule has been identified, the goods are ordered according to the fulfillment and level of the factors so that the utility of the good can be optimized, in addition to the utility function is bounded with a budget constraint issue. Finally, the decision is made. Depending on the type of user's decision, whether individual or collective, two models can be initially established to determine the demand for transportation, it should be noted that both follow the process shown in Figure 3.

Figure 4 shows some characteristics of both the surveyed and stated preference models.

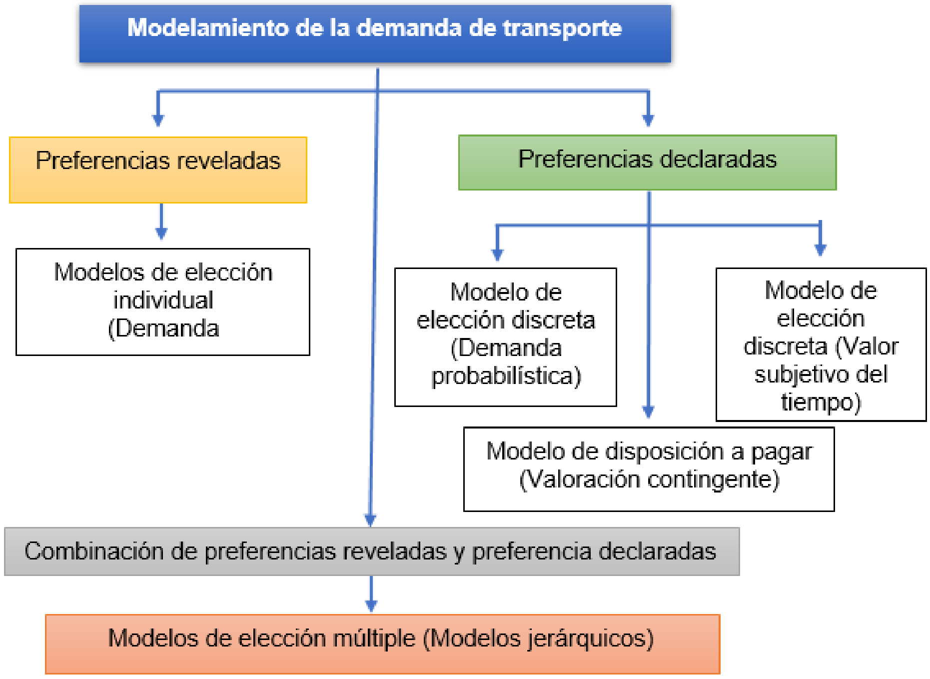

Figure 4 Transportation demand models

Source: Feijó (2021)

Revealed preferences models, which examine real-life individual choices, and stated preferences methods, which analyze different scenarios to assess individual behavior towards a good, play a vital role in estimating transportation demand. While revealed preferences rely on observing real-world behavior, the method's access to data can be challenging. In contrast, stated preferences involve individuals expressing their willingness to choose specific transport modes under certain conditions or scenarios, often employing probabilistic models to determine demand. This method is advantageous for analyzing potential scenarios, such as the introduction of new transportation optionsor improved services. Logit Multinomial Models (LNM) are frequently used to apply stated preference methods, offering several advantages, including expanded choice variation, error correction, and the ability to assess future user behavior. Given the lack of comprehensive trip and time data in Cuenca, revealed preferences may not be suitable, while stated preferences offer a more practical approach to estimate demand and sensitivity to various factors through discrete choice methods and random utility theory. This approach allows the calculation of probabilities for choosing different options without identifying individual choices. (Mogas, 2004).

METHODOLOGY

Most discrete choice models mention that there is an individual q, who associates with each alternative (i) a stochastic utility $(Uiiq)$, choosing the alternative that maximizes his utility. Two drawbacks lead to consider utility as the sum of two distinct components, on the one hand, the impossibility of appreciating all the attributes and the variations in the tastes and preferences of individuals for the attributes that determine the behavior of individuals, as well as any measurement error. Thus, it is essential to consider utility through formula 1:

$$W_{iq} = V_{iq}(Q_{iq}, S_q) + \varepsilon(Q_{iq}, S_q) = U_{iq} + r_{iq} \quad (1)$$

Where:

- V_{iq}: is the deterministic component of random utility that is a function of measurable attributes,
- η_{iq}: is the idiosyncratic error representing individual tastes
- r_{iq}: is the measurement error in the dependent variable, which may represent respondent fatigue or idleness. Assuming that r_{iq} is homoscedastic the resulting equation is:

$$U_{iq} = V_{iq} + (\eta_{iq} - r_{iq}) \quad \rightarrow \quad U_{iq} = V_{iq} + \varepsilon_{iq} \quad (2)$$

It is necessary to indicate that the utility function used in traditional models for estimating transportation demand includes independent or explanatory variables: the individual's income, travel time and minimum travel cost. On the other hand, for the composition to be adequate, all citizens surveyed must face the same set of alternatives, so that the choice or decision is made among a homogeneous set of alternatives, always considering the principle of economic theory that expresses that the individual q will choose the alternative i as long as the utility of this alternative is greater than the utility of any of the remaining alternatives j, belonging to the set of alternatives available to the individual q ($A(q)$):

$$U_{iq} \geq U_{jq}\ , \forall\ j \in A(q), \quad i \neq j \quad (3)$$

In other words:

$$V_{iq} + \varepsilon_{iq} \geq V_{jq} + \varepsilon_{jq} \rightarrow V_{iq} - V_{jq} \geq \varepsilon_{jq} - \varepsilon_{iq} \quad (4)$$

Since it is unknown (ε_{jq}- ε_{iq}), only the probability of the occurrence mentioned in equation 4 is possible, so the probability of opting for the best alternative, that is,alternative i is given by:

$$P_{iq} = Prob\{\varepsilon_{jq} \leq \varepsilon_{iq} + (V_{iq} - V_{jq}), \forall\ j \in A(q)\} \quad (5)$$

The residuals ε are random variables with zero mean, which will give rise to different probabilistic models depending on the statistical distribution considered. Generally, the expression adopted for the deterministic component of utility is a linear function in the attributes and the parameters, that is:

$$\mathrm{V_{iq}} = \mathrm{CEA_{iq}} + \sum_{\mathrm{k=1}}^{\mathrm{K}} \beta_{\mathrm{ki}} \mathrm{x_{kiq}} \quad (6)$$

Where,

- x_{kiq}: corresponds to the value that the k-th attribute takes for the individual q
- β_{ki}: corresponds to the parameter linked to this attribute, which is considered constant for all individuals. It is necessary to consider that the assumption of fixed coefficients has been taken, since traditionally, in the literature it has been used in this way to derive the subjective values of individuals' time.

Initially, in the estimated utility function it would be expected that as some transport service attributes increase, such as travel time, travel cost, waiting time and/or blocks walked to the nearest station of the transport service considered, the individual's utility decreases, causing a decrease in the probability of choosing the alternative whose cost or the time has increased since it makes it less attractive (Sartori J. P., 2006). However, stated preference methods include certain biases that should be considered and minimized, since there could be differences between what individuals state about their possible actions in the hypothetical situation and what they would do if such a situation arises, this is known as random errors, one of the first problems of the model.

Design of experiment of choice

In conducting the stated preference experiment, a few steps were followed:

- The specifications of the models to be used were determined with all the parameters to be estimated. From these specifications, a type of experimental design was selected and then the design was generated. Finally, a questionnaire was created in Kobbo Collect based on the underlying experimental design and data were collected. We chose to use an efficient design, whose main virtue is to obtain a smaller number of choice situations since efficient attribute levels would be selected over all choice situations for each attribute, thus obtaining good results with a smaller number of scenarios (6 in the present case) than the full and fractional factorial designs.
- The design of the mode choice experiment considered nine choices: car, motorcycle, cab, bus, bus, streetcar, public bicycle, private bicycle, car sharing, and walking.
- The attributes considered were travel time, travel cost, waiting time for public transportation alternatives (cab, bus and streetcar), parking costs (for cars andmotorcycles) and walking distance at origin and destination (bus and streetcar). All attributes were incorporated as specific to each of the alternatives. This research sets up the experimental design matrix so that each column represents a different attribute of eachtransport mode (transport service variables) within the experiment and each row represents a different choice situation (between the different transport modes). The combination of the different attributes and their variations in time and cost was performedconsidering the concept of balanced or balanced utility and the control of relevant activities (ChoiceMetrics, 2018).
- Efficient designs were obtained using the Ngene software, given the feasible attribute levels for all modes of transport, the number of choice situations and the previous values of the parameters (or their probability distributions), seeking to determinea balanced design in attribute levels that minimizes the efficiency error (D-error), using a column-based algorithm (RSC) that generates a design by selecting attribute levels over all choice situations for each attribute and performing attribute level relabeling operations (relabeling), swapping places between attribute levels (swapping) and/or cyclic attribute level exchanges (cycling).

Sampling method

For the empirical estimation of demand, a sample size of 648 declared preference surveys was determined; a total of 400 surveys were applied in urban parishes and 248 surveys in rural parishes, which were stratified according to the population weight of each of the parishes. The variable of interest for the study was the proportion of trips to work or to the place of study by bus, which according to the 2014 Household Origin-Destination Matrix Survey, amounted to 47% PMEP (2015), being this the mode of transportation that has had the highest percentage of use for these reasons of transportation and that will determine the highest value for the minimum sample size to be implemented considering the existing alternatives of choice. The minimum sample size for a stated preference survey of 6 scenarios (6 responses for each individual), is determined as follows:

$$n = \frac{N * z^2 * p * q}{e^2 * (N - 1) + z^2 * p * q} \quad (7)$$

Where:

- z: is the inverse of the cumulative normal distribution function for a given confidence level.
- p: success share of the population (users opting for a given mode of transport).

- q: Failure portion of the population (users opting for another means of transport).
- *e*: admissible sampling error, in absolute value, of the variable of interest.
- Considering a sampling error of 0.05 in the absolute value of the proportion and a 0.95 confidence level, and with 6 election scenarios. The sampling, as indicated, is defined as stratified, to have greater representativeness of the total population of the urban and rural areas of Cuenca.
- The sample was stratified according to the weight of households in each of the parishes, considering the information maintained by INEC on its platform. The stratification of these was generated as follows:

Table 2 Distribution of Urban Sector Surveys

Source: Own elaboration

Distribution Urban Sector		
STRATUM	Size	Percentage
El Sagrario	10	2,5%
Gil Ramírez Davalos	10	2,5%
San Blas	13	3,2%
Cañaribamba	15	3,7%
Hermano Miguel	20	5,0%
Huayna-Cápac	21	5,2%
Sucre	22	5,5%
Machángara	25	6,2%
Monay	25	6,2%
El Batan	29	7,2%
Totoracocha	31	7,7%
Bellavista	32	8,0%
El Vecino	37	9,2%
San Sebastián	49	12,2%
Yanuncay	62	15,5%

Table 3 Distribution of Rural Sector Surveys

Source: Own elaboration

Rural Distribution		
STRATUM	Size	Percentage
Baños	24	9,7%
Chaucha	2	0,8%
Checa	4	1,6%
Chiquintad	7	2,8%
Cumbe	8	3,2%

Llacao	8	3,2%
Molleturo	10	4,0%
Nulti	6	2,4%
Octavio Cordero Palacios	4	1,6%
Paccha	9	3,6%
Quingeo	10	4,0%
Ricaurte	28	11,3%
San Joaquín	10	4,0%
Santa Ana	8	3,2%
Sayausi	12	4,8%
Sidcay	7	2,8%
Sinincay	23	9,3%
Tarqui	14	5,6%
Turi	12	4,8%
Valle	35	14,1%
Victoria Del Portete	7	2,8%

Regarding the field survey, the strategy for the random selection of the case studies was carried out according to the zoning of the maps managed by INEC, that is, the samplewas distributed according to Zone, Sector and Block within each of the parishes. The selection of these was made by simple random jump with the help of the Excel program, thus obtaining the starting point for the beginning of the sample, for the following sample elements, a jump of k values is made for the previous one until the pre-established sample is fulfilled.

The jump k is the quotient between the population size of each parish for the total number of surveys in the urban or rural area as the case may be, which is why a different value of k is obtained for each of the parishes, thus guaranteeing randomness and geographic coverage of the entire parish and therefore of the canton.

The survey was conducted in two stages. In the first stage, a pilot survey of households was conducted to reveal information on the mode of travel to work, complemented with sociodemographic variables. In the second stage, a personal survey of stated preferences was conducted, following the indicated, i.e. based on Zone, Sector and Block. It should be noted that the information provided by the respondents was only used to collect behavioral data for the choice of modes of transportation for this research, and the possibility of not participating in the survey was always allowed if the respondent did not wish to do so, guaranteeing, in any case, the anonymity of the respondent.

Econometric Model

In order to estimate the probability of choice of each of the alternatives faced by the consumer, it is necessary to apply appropriate econometric methods, so some methods that have been considered in this analysis are presented.

Multinomial Logit Model

The multinomial logit model for choice among k alternatives expresses the probability that an individual chooses some alternative j as a function of the utilities of the available k alternatives of transportation means:

$$P_i = \frac{\exp(V_j)}{\sum k\exp(V_k)} \quad (8)$$

Frequently, the expression adopted for the deterministic component of utility is a linear function in the attributes and the parameters, that is:

$$V_{iq} = CEA_{iq} + \sum_{k=1}^{K} \beta_{ki} x_{kiq} \quad (9)$$

Where x_{kiq} is the value taken by the k-th attribute for the individual q and β_{ki} is the parameter linked to that attribute, which is considered constant for all individuals. When a linear utility function such as the one given by (9) is specified, the value of time is the quotient between the time parameter and the cost parameter, which represents the marginal rate of substitution between travel time (x_{ki}) and travel cost (c_{ki}), and the willingness to pay of individuals for saving travel time, for waiting time and for blocks walked is measured:

$$VS_{ki} = \frac{\sigma v_i / \sigma x_{ki}}{\sigma v_i / \sigma c_{ki}} \quad (10)$$

It will also be possible to obtain subjective evaluations of the savings in waiting time and blocks walked at origin and destination, either to the top of a means of transport or directly to the place of work or studies.

RESULTS

Table 4 presents a summary of the descriptive data from the surveys conducted.

Table 4 Descriptive statistics

Source: Own elaboration

	Variable	Urban	Rural
Genre	Female	56,36%	61,29%
	Male	43,63%	38,71%
Age	16 - 20 years	6,98%	10,48%
	21 - 30 years	29,18%	28,23%
	31 - 40 years old	24,94%	30,24%
	41 - 50 years	21,20%	17,34%
	More than 50 years	17,71%	13,71%
Education level	PhD	0,25%	0,00%
	Postgraduate	0,75%	0,00%
	Superior	23,44%	15,32%
	_Secondary	53,37%	56,05%

	Primary	21,20%	27,82%
	None	1,00%	0,81%
Income level	Less than $425 per month	29,43%	45,16%
	426 - $800 per month	50,62%	39,92%
	801 - $1,000 per month	13,47%	12,50%
	1001 - $ 2000 per month	5,24%	2,42%
	$ 2001 - $ 3000 per month	0,75%	0,00%
	More than $ 3000 per month	0,50%	0,00%
Means of transportation owned	Automobile	41,14%	33,97%
	Motorcycle	8,64%	8,40%
	Bicycle	10,00%	4,96%
	Electric Motorcycle / Scooter	0,68%	1,15%
	None	39,55%	51,53%

The sample consisted of 649 persons surveyed on stated preferences, whose demographic composition is detailed in Table 4. In the rural area, women represented 56.36% of women, while in the rural area they reached 61.29%. Most of the people surveyed were between 21 and 30 years of age in the urban zone and between 31 and 40 in the ruralzone. People between 41 and 50 years of age also form an important part of the people surveyed.

Most of the people who responded to the survey have attained secondary education, both in urban and rural areas, representing more than 50%. In the rural area, no person was surveyed with the fourth level of education, nor at the postgraduate or doctorate level. For income level, most of the population in the urban zone is located in a range between $426 and $800, while in the rural zone most of the people surveyed indicate that their income is located in a range below $425. Finally, in the urban zone there is a simple majority that indicates having a car, while in the rural zone, most of the people surveyed mention not having any means of transportation of their own.

Once the descriptive data have been analyzed, the probabilistic demand for transportation to travel either to the place of work or to the place of study is estimated using different specifications of discrete choice models to compare the results derived from each of them. The choice set consists of the available transportation modes such as car, motorcycle, cab, bus, streetcar, public bicycle, private bicycle, carsharing and walking.All estimations were performed using the freely available BIOGEME software. In all the models estimated in this section, the dependent variable is the choice of transport mode declared by the respondents for each choice scenario, corresponding to the response for a day with and without rain, i.e. considering for each respondent the modes of transport available to travel to work or the place of study. We found 3,894 observations from 649 household surveys with 6 scenarios each, on a day without rain and with rain.

The explanatory variables of the specified utility functions are:

- Transportation service variables:
  - tva: travel time by car;

- cva: cost of travel by car;
- cea: daily parking cost of the car.
- tvm: motorcycle travel time;
- cvm: cost of motorcycle travel;
- cem: daily motorcycle parking fee.
- tvt: cab travel time;
- tet: cab waiting time;
- cvt: cab travel cost.
- tvbus: bus travel time;
- tebus: bus waiting time;
- cvbus: cost of bus trip;
- ccbus: blocks walked (at origin plus destination) when using city bus.
- tvtranv: streetcar travel time;
- tetranv: streetcar waiting time;
- cvtranv: cost per streetcar trip;
- cctranv: blocks walked (at origin plus destination) when using streetcar.
- tvbi: travel time by public bicycle;
- cvbi: cost of travel by public bicycle;
- ccbi: blocks walked (at origin plus destination) when using public bicycles.
- tvcsh: travel time in carsharing
- tecsh: waiting time in carsharing
- cvcsh: cost of travel in carsharing
- ccsh: blocks you walk in carsharing

- Distance dummy variables
  - KMS2-5: 2.5 km trips;
  - KMS5: 5 km trips;
  - KMS7-5: 7.5 km trips;
  - KMS10: 10 km trips.
  - KMS2-5, differential behavior of respondents for trips of 2.5 km.
- Socio-demographic variables:

Dummy variables that assume the value of 1 if respondents meet a certain condition:

- Working; Studying; Gen: for women; D1: if they are between 21 - 30 years old; D2: if they are between 31 -40 years old; D3: if they are between 41 -50 years old; D4: if they are over 50 years old. The base category for age corresponds to respondents who are between 16 -20 years old.
- Educa: dummy variable that assumes a value of 1, 2, 3, 3, 4 and 5 when the respondent has completed primary, secondary, higher, postgraduate and doctoral education.
- $Ing_{1,2,3,4,5}$: for average monthly income level between $ 401 - $800 per month; between $ 801 - $1000; between $ 1001 - $2000; between $ 2001 - $3000; over $3000.

The parameters to be estimated are:

- $CEAauto, moto, taxi, bus, tranvía, bici\ pub, bici\ priv; caminar$, carsharing: 9 constants of the utility function of the transportation alternatives; taking the walking alternative as the referential variable.
- $\beta_{tv,te.cv.ce.cc}$: generic parameters associated with the service variables: travel time; waiting time; travel cost; parking cost; blocks walked at origin plus destination.
- $\beta_{2-5;5;7\_5;10}$: parameters associated with travel distance from home to a place of work or study of 2.5 km; 5 km; 7.5 km and 10 km
- $\beta age1, age2, age3, age4$: parameters of the dummy variable related to the age range of 21 - 30 years; 31 - 40 years; 41 - 50 years and over 50 years; having as a base people younger than 21 years.
- βgen: parameter gender;
- $\beta work$: employment status parameter;

- $\beta stud$: education parameter; $\beta educa$: education level parameter.
- $\beta_{Ing1,Ing2,Ing3,Ing4}$: parameters of the dummy variable related to whether the respondent's household has an average monthly income level between \$401 - \$800; between \$801 - \$1000; between \$1001 - \$2000; between 2001 - \$3000 and greater than \$300.

Thus, nine different models with nine utility functions each are estimated. The deterministic utility functions estimated are as follows:

- $V(Auto) = CEA_{Auto} + \beta_{tv}.TV_{Auto} + \beta_{cv}.CV_{Auto} + \beta_{ce\_A}.CE_{Auto} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (11)

- $V(Moto) = CEA_{Moto} + \beta_{TV}.TV_{Moto} + \beta_{CV}.CV_{Moto} + \beta_{CE\_M}.CE_{Moto} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (12)

- $V(Taxi) = CEA_{Taxi} + \beta_{TV}.TV_{Taxi} + \beta_{TE}.TE_{Taxi} + \beta_{CV}.CV_{Taxi} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (13)

- $V(Bus) = CEA_{Bus} + \beta_{TV}.TV_{Bus} + \beta_{TE}.TE_{Bus} + \beta_{CV}.CV_{Bus} + \beta_{CC}.CC_{Bus} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (14)

- $V(Tranvía) = CEA_{Tranvía} + \beta_{TV}.TV_{Tranvía} + \beta_{TE}.TE_{Tranvía} + \beta_{CV}.CV_{Tranvía} + \beta_{CC}.CC_{Tranvía} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (15)

- $V(Bici\ Púb) = CEA_{bici\ pub} + \beta_{TV}.TV_{Bici} + \beta_{CC}.CR_{Bici} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa + \beta_{Ing1}.Ing_1 + \beta_{Ing2}.Ing_2 + \beta_{Ing3}.Ing_3 + \beta_{Ing4}.Ing_4 + \beta_{Ing5}.Ing_5$ (16)

- $V(\text{Carsharing}) = CEA_{\text{carsharing}} + \beta_{TV}.TV_{\text{Carsharing}} + \beta_{CC}.CR_{\text{Carsharing}} + \beta_5.KMS_5 + \beta_{7-5}.KMS_{7-5} + \beta_{10}.KMS_{10} + \beta_{age1}.D_1 + \beta_{age2}.D_2 + \beta_{age3}.D_3 + \beta_{age4}.D_4 + \beta_{gen}.Gen + \beta_{work}.Trabaja + \beta_{stud}.Estudia + \beta_{educa}.Educa +$

$\beta Ing1 \cdot\ Ing_1 + \ \beta Ing2 \cdot\ Ing_2 + \ \beta Ing3 \cdot\ Ing_3 + \ \beta Ing4 \cdot\ Ing_4 + \ \beta Ing5 \cdot\ Ing_5$ (17)

- $V(Bicicleta \quad Privada) = CEA_{bici} \quad priv$ (18)

- $V(Camina) = CEA_{Camina}$ (19)

Table 5 shows the results of the multinomial logit estimation for each of the scenarios, that is, urban and rural areas, and days with and without rain. It should be noted that the most significant parameters have been left in the models. In the case of those parameters that, due to the level of confidence, are not significant due to the level of error, they have also been considered because the sign of their coefficients is correct, a situation that makes them suitable for the proposed estimation.

Table 5 Estimates for each scenario through the Multinomial Logit Model

Source: Own elaboration

Estimación Multinomial Logit												
	Urbano						Rural					
Variable	Sin lluvia			Con lluvia			Sin lluvia			Con lluvia		
	Coef	Std err		Coef	Std err		Coef	Desv est		Coef	Desv est	
ASC_auto	3,900	0.390	***	4,800	0.417	***	1,550	0.637	**	1,570	0.637	**
ASC_bicipr	2,650	0.312	***	2,530	0.346	***	1,230	0.164	***	1,230	0.164	***
ASC_bicipu	3,610	0.323	***	4,230	0.358	***	0,229	0.217		0,266	0.217	
ASC_bus	2,940	0.336	***	3,540	0.370	***	2,050	0.218	***	2,130	0.218	***
ASC_carsh	2,610	0.336	***	3,190	0.363	***	-0,522	0.283	*	-0,463	0.283	*
ASC_moto	3,120	0.325	***	3,870	0.359	***	0,823	0.195	***	0,827	0.195	***
ASC_taxi	3,110	0.328	***	3,500	0.363	***	0,075	0.216		0,032	0.219	
ASC_tranvi	3,220	0.327	***	3,930	0.361	***	0,078	0.216		0,180	0.213	
B10	1,770	0.344	***	1,390	0.348	***	1,200	0.241	***	1,240	0.241	***
B5	0,487	0.144	***	0,116	0.155		0,553	0.190	***	0,568	0.190	***
B7_5	1,260	0.271	***	0,886	0.277	***	1,500	0.302	***	1,530	0.302	***
BIng1	-0,465	0.110	***	-0,408	0.109	***	0,246	0.154		0,248	0.154	
BIng2	-0,569	0.165	***	-0,545	0.165	***	0,727	0.217	***	0,725	0.217	***
BIng3	-1,680	0.323	***	-1,210	0.283	***						
BIng4	-1,870	1.04	*	-1,740	1.04	*						
Bage1	-0,361	0.117	***	-0,193	0.114	*						
Bage4							-0,290	0.206		-0,293	0.207	
Bcc	-0,004	0.00572		-0,020	0.00570	***	-0,014	0.00965		-0,015	0.00957	
Bce	-0,013	0.0187		-0,023	0.0184		-0,054	0.0242	**	-0,054	0.0242	**
Bcv	-0,115	0.0176	***	-0,133	0.0175	***	-0,040	0.0182	**	-0,044	0.0182	**
Beduca	0,275	0.0714	***	0,168	0.0705	**	-0,157	0.123		-0,156	0.123	
Bgen	0,074	0.0993		0,060	0.0981		-0,778	0.131	***	-0,780	0.131	***
Bstud	-0,434	0.153	***	-0,566	0.156	***	-0,518	0.311	*	-0,512	0.312	*
Bte	-0,008	0.00728		-0,011	0.00733		-0,001	0.00632		-0,003	0.00631	
Btv	-0,006	0.00251	**	-0,009	0.00251	***	-0,001	0.00341		-0,003	0.00342	
Bwork							1,150	0.519	**	1,160	0.519	***

*** At a significance level of 1%

** At a significance level of 5%

* At a significance level of 10%

Table 6 shows the results of the parameters that allow calculating the social valuation of the transportation service variables derived from the specifications, Multinomial Logit (LMN) and Nested Logit since the specific parameters of the two models turned out to be significant and evidence is found that the IIA remains within the private transportation nest, this for both a day with and without rain.

Table 6 Social valuation parameters

Source: Own elaboration

Social assessment / Specification of models		Urban Rainless Day	Urban rainy day	Rural rainless day	Rural rainy day
		MNL	MNL	MNL	MNL
Parameters	Btv	-0,0057	-0,0094	-0,0015	-0,0027
	Bte	-0,0079	-0,0114	-0,0010	-0,0032
	Bcc	-0,0043	-0,0195	-0,0140	-0,0153
	Bcv	-0,1150	-0,133	-0,0403	-0,0439
Subjective appraisals	VSATV (S/min)	$ 0,05	$ 0,07	$ 0,04	$0,06
	VSATE ($/min)	$ 0,07	$ 0,09	$ 0,03	$0,07
	VSACC ($/cuadra)	$ 0,04	$ 0,15	$ 0,35	$0,35

Table 6 shows the parameters of the service variables: travel time (Btv), waiting time (Bte), blocks walked (Bcc) and travel cost (Bcv), for four scenarios: a day without rain in the urban area, a day with rain in the urban area, a day without rain in the rural area and day with rain in the rural area. With the data obtained, it was possible to determine subjective valuations.

VSATV represents the subjective valuation of travel time savings and corresponds to the quotient between the estimated travel time parameter over the estimated travel cost parameter. It can be seen that on a rainy day it represents the highest valuation of minute travel time savings, both in the urban and rural areas, with a small difference, thevaluation prevails mainly in the urban area.

VSATE, which represents the subjective valuation of waiting time savings and is calculated through the quotient of the waiting time parameter over the estimated travel cost parameter. It can be seen that, once again, there is a higher valuation on rainy days inboth the urban and rural sectors. However, it can also be seen that the difference in the valuation of waiting time savings per minute in the rural area is much greater between a day with rain and a day without rain than the same difference in the urban area.

Finally, VSACC represents the subjective valuation of the savings in blocks walked from origin to destination and is calculated as the quotient between the parameter of blocks walked and the estimated travel cost parameter. This subjective valuation has allowed identify once again that in the urban area the savings in blocks walked on a rainy day are more highly valued compared to a day without rain, presenting a highly marked difference. However, in the rural zone, in both cases, on rainy and non-rainy days, the valuation of savings in terms of blocks walked is the same and is much higher than in the urban zone, a situation explained mainly by the long distances that must be traveled in thelatter.

On the other hand, the probabilities of use of the different transports have also been determined, considering exclusively the urban and rural areas and the climatic conditions, the results of which are presented in Table 7.

Table 7 Probability of use of the modes of transport

Source: Own elaboration

Mode of transport	Urban			Rural		
	No rain	In the rain	Difference	No rain	In the rain	Difference
Car	22,15%	27,02%	4,87%	2,78%	23,30%	20,52%
Moto	11,68%	12,64%	0,97%	11,77%	8,98%	-2,80%
Taxi	7,81%	9,05%	1,24%	6,40%	4,55%	-1,84%
Bus	11,11%	8,52%	-2,59%	46,25%	36,28%	-9,97%
Trolley	15,59%	14,93%	-0,66%	6,38%	5,29%	-1,08%
Publ bike	15,06%	17,87%	2,80%	7,27%	5,64%	-1,63%
Carsharing	6,79%	4,91%	-1,88%	3,05%	2,36%	-0,68%
Priv Bike	9,35%	4,91%	-4,44%	12,58%	11,30%	-1,28%
Walking	0,47%	0,16%	-0,31%	3,54%	2,30%	-1,24%

Table 7 shows that in the urban area the weather does not have a highly marked influence on two main behaviors can be seen, on the one hand, the use of the automobile increases by 4.87% on a rainy day, compared to a day without rain, and in the case of the private bicycle, which is reduced by a relatively similar percentage (4.44%), a situation that would suggest that people stop using their private bicycle and change their means of transportation for the vehicle on rainy days.

Once the base probabilities on the use of the different means of transport have been defined, an analysis of scenarios and calculation of elasticities has been generated. Table8 shows the base data based on which the variations according to different scenarios have been calculated. A travel fare has been determined for each of the means of transport, except for the car and the motorcycle, where the travel cost or fare has been replaced by the parking cost. Additionally, the travel time for each of the means of transport has been considered, and in the public ones, mainly the waiting time has also been considered, all this measured in minutes. Finally, the number of blocks walked to access some means of transport has been determined, which has been expressed in the number of blocks.

Table 8 Parameters for estimation

Source: Own elaboration

Parameter	Description	Baseline situation
Travel rate	Bus Fare	0,60
	Car Fare	5,67
	Cab Fare	2,50
	Travel fare Motorcycle	4,00
	Public bicycle travel fare	0,75
	Streetcar Travel Fare	0,60
	Crasharing travel fare	3,33
Parking fees	Car Parking Fare	3,00
	Parking fee Motorcycle	2,00
Travel time	Travel time Bus (minutes)	30
	Travel Time Car (minutes)	15
	Travel Time Taxi (minutes)	15

	Travel Time Motorcycle (minutes)	15
	Travel Time Public Bicycle (minutes)	33
	Travel Time Tram (minutes)	18
	Travel time Carsharing (minutes)	16,67
Waiting time	Waiting time Bus (minutes)	20
	Waiting time Taxi (minutes)	13
	Streetcar waiting time (minutes)	10
	Waiting time carsharing (minutes)	10
Quadrats walked	Walking Blocks Bus	4
	Walking blocks Tram	7
	Walking Blocks public bike	7
	Walking blocks carsharing	7

Finally, a series of policy scenarios have been generated to calculate the probabilities of choice of the different modes of transport, their changes and the elasticities of demand for each of them. Five policy scenarios are presented below:

Increase in bus trip cost by 5%.

Table 9 Elasticities in scenario 1

Source: Own elaboration

Incremento de un 5% en el costo de la tarifa de bus									
Parámetro	Descripción	Urbano				Rural			
		Sin lluvia		Con lluvia		Sin lluvia		Con lluvia	
		Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario
Tarifa de viaje	Tarifa de viaje Bus	0,60	0,63	0,60	0,63	0,60	0,63	0,60	0,63
Probabilidad de uso de un modo de transporte	P(auto)	22,15%	22,16%	27,02%	27,03%	2,78%	2,78%	23,30%	23,31%
	P(moto)	11,68%	11,68%	12,64%	12,65%	11,78%	11,78%	8,98%	8,98%
	P(taxi)	7,81%	7,81%	9,05%	9,05%	6,40%	6,40%	4,55%	4,56%
	P(bus)	11,11%	11,07%	8,52%	8,49%	46,26%	46,23%	36,28%	36,25%
	P(tranvía)	15,59%	15,60%	14,93%	14,93%	6,39%	6,39%	5,29%	5,30%
	P(bicicleta pública)	15,06%	15,07%	17,87%	17,88%	7,27%	7,27%	5,64%	5,64%
	P(carsharing)	6,79%	6,79%	4,91%	4,91%	3,02%	3,02%	2,36%	2,36%
	P(bici privada)	9,35%	9,35%	4,91%	4,91%	12,58%	12,58%	11,30%	11,30%
	P(caminar)	0,47%	0,47%	0,16%	0,16%	3,54%	3,54%	2,30%	2,30%
Variación en la probabilidad de uso de un modo de transporte	Variación % P(auto)		0,0000838		0,0000869		0,0000155		0,0001038
	Variación % P(moto)		0,0000444		0,0000413		0,0000660		0,0000435
	Variación % P(taxi)		0,0000288		0,0000295		0,0000364		0,0000225
	Variación % P(bus)		-0,0003366		-0,0003052		-0,0002966		-0,0002986
	Variación % P(tranvía)		0,0000600		0,0000493		0,0000358		0,0000258
	Variación % P(bicicleta pública)		0,0000571		0,0000633		0,0000413		0,0000278
	Variación % P(carsharing)		0,0000254		0,0000172		0,0000170		0,0000115
	Variación % P(bici privada)		0,0000354		0,0000172		0,0000661		0,0000529
	Variación % P(caminar)		0,0000018		0,0000006		0,0000186		0,0000109
Elasticidad de uso de un modo de transporte	Elasticidad de uso de auto		0,0378408		0,0321475		0,0558591		0,0445437
	Elasticidad de uso de moto		0,0379791		0,0326319		0,0560420		0,0484557
	Elasticidad de uso de taxi		0,0368690		0,0325739		0,0568007		0,0493599
	Elasticidad de uso de bus		-0,3031119		-0,3583686		-0,0641227		-0,0823116
	Elasticidad de uso de tranvía		0,0384753		0,0330563		0,0560769		0,0487349
	Elasticidad de uso de bicicleta pública		0,0379105		0,0354270		0,0568510		0,0492903
	Elasticidad de uso de carsharing		0,0374255		0,0349716		0,0561202		0,0486192
	Elasticidad de uso de bicicleta privada		0,0378858		0,0351099		0,0525247		0,0468191
	Elasticidad de caminar		0,0378000		0,0350033		0,0525748		0,0474835

As can be seen in Table 9, a 5% increase in the cost of the bus fare leads to a reduction in the probability of using the bus, as the economic theory states that as the price increases, demand is reduced; however, it can also be seen that, especially in the urban area, the probability of using the vehicle or the public bicycle increases. In the case of the public bicycle, the increase in the probability of use is understood, considering the proximity of the routes. It is also interesting that, at least on days without rain, the use of the streetcar would also increase. In the case of the rural sector, the increase in the price of the bus fare has an impact only on rainy days, increasing the use of the vehicle, as well as the use of cabs. On days without rain, the behavior in the rural sector is very similar to the base behavior, a situation that could be explained by the need to use this service, which makes it very inelastic. Table 9 shows the cross elasticities, where it is clear that the bus service in the urban sector is much more elastic than in the rural sector, i.e., when faced with small price variations in the urban sector, changes in demand will be felt, a situation that does not behave in the same way in the rural sector.

5% increase in car parking fees

Table 10 Elasticities in scenario 2

Source: Own elaboration

Aumento de un 5% en el costo de estacionamiento del auto									
		Urbano				Rural			
		Sin lluvia		Con lluvia		Sin lluvia		Con lluvia	
Parámetro	Descripción	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario
Tarifa de estacionamiento	Tarifa de estacionamiento Auto	3,00	3,15	3,00	3,15	3,00	3,15	3,00	3,15
Probabilidad de uso de un modo de transporte	P(auto)	22,15%	22,12%	27,02%	26,95%	2,78%	2,76%	23,30%	23,17%
	P(moto)	11,68%	11,68%	12,64%	12,66%	11,78%	11,78%	8,98%	8,99%
	P(taxi)	7,81%	7,81%	9,05%	9,06%	6,40%	6,40%	4,55%	4,56%
	P(bus)	11,11%	11,11%	8,52%	8,52%	46,26%	46,27%	36,28%	36,34%
	P(tranvía)	15,59%	15,60%	14,93%	14,94%	6,39%	6,39%	5,29%	5,30%
	P(bicicleta pública)	15,06%	15,07%	17,87%	17,88%	7,27%	7,27%	5,64%	5,65%
	P(carsharing)	6,79%	6,79%	4,91%	4,92%	3,02%	3,02%	2,36%	2,37%
	P(bici privada)	9,35%	9,35%	4,91%	4,91%	12,58%	12,58%	11,30%	11,31%
	P(caminar)	0,47%	0,47%	0,16%	0,16%	3,54%	3,54%	2,30%	2,30%
Variación en la probabilidad de uso de un modo de transporte	Variación % P(auto)		-0,0003218		-0,0006628		-0,0001935		-0,0012900
	Variación % P(moto)		0,0000483		0,0001160		0,0000234		0,0001472
	Variación % P(taxi)		0,0000313		0,0000821		0,0000130		0,0000758
	Variación % P(bus)		0,0000465		0,0000772		0,0000945		0,0006092
	Variación % P(tranvía)		0,0000653		0,0001387		0,0000130		0,0000884
	Variación % P(bicicleta pública)		0,0000626		0,0001613		0,0000149		0,0000953
	Variación % P(carsharing)		0,0000266		0,0000421		0,0000061		0,0000394
	Variación % P(bici privada)		0,0000392		0,0000440		0,0000222		0,0001950
	Variación % P(caminar)		0,0000020		0,0000014		0,0000063		0,0000397
Elasticidad de uso de un modo de transporte	Elasticidad de uso de auto		-0,1453153		-0,2453432		-0,6959726		-0,5536545
	Elasticidad de uso de moto		0,0413932		0,0917591		0,0198949		0,1639940
	Elasticidad de uso de taxi		0,0400983		0,0907656		0,0202755		0,1665156
	Elasticidad de uso de bus		0,0418313		0,0906327		0,0204292		0,1678988
	Elasticidad de uso de tranvía		0,0419133		0,0929083		0,0204107		0,1669951
	Elasticidad de uso de bicicleta pública		0,0415404		0,0902610		0,0205011		0,1690354
	Elasticidad de uso de carsharing		0,0391576		0,0857167		0,0202389		0,1667151
	Elasticidad de uso de bicicleta privada		0,0419813		0,0895925		0,0176880		0,1726071
	Elasticidad de caminar		0,0424343		0,0916497		0,0177231		0,1728390

When analyzed with a scenario of a 5% increase in the cost of vehicle parking, it can be seen that in general, the probability of car use decreases in all cases, however, this reduction is not very high. In the case of a day without rain in the urban sector, it can be seen that the probability of using a vehicle is reduced and the possibility of using the streetcar or public bicycle increases, precisely because of the short trips that occur; in the case of days with rain, the use of motorcycles, cabs, streetcars, public bicycles and car sharing increases. It can be seen that in the case of a rainy day in the urban sector, the elasticity is higher, indicating that the price variation has a greater influence on the behavior of demand, in this case, a decrease. For the rural sector, it can be seen that on a day without rain, the increase in the cost of parking the good only influences the demand for it; however, on a day with rain, this situation also causes an increase in the use of motorcycles, cabs, buses and streetcars. Finally, the behavior of demand is more elastic inthe rural sector than in the urban sector. In rural areas, it affects more on a day without rain than on a rainy day, while in urban areas the opposite is true.

Increase in cab travel time by 10%.

Table 11 Elasticities in scenario 3

Source: Own elaboration

Aumento del tiempo de viaje de taxi en un 10%									
		Urbano				Rural			
		Sin lluvia		Con lluvia		Sin lluvia		Con lluvia	
Parámetro	Descripción	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario
Tiempo de viaje	Tiempo de viaje Taxi (minutos)	15	17	15	17	15	17	15	17
Probabilidad de uso de un modo de transporte	P(auto)	22,15%	22,16%	27,02%	27,04%	2,78%	2,78%	23,30%	23,30%
	P(moto)	11,68%	11,69%	12,64%	12,66%	11,78%	11,78%	8,98%	8,98%
	P(taxi)	7,81%	7,75%	9,05%	8,95%	6,40%	6,38%	4,55%	4,53%
	P(bus)	11,11%	11,11%	8,52%	8,53%	46,26%	46,27%	36,28%	36,29%
	P(tranvía)	15,59%	15,60%	14,93%	14,94%	6,39%	6,39%	5,29%	5,29%
	P(bicicleta pública)	15,06%	15,07%	17,87%	17,89%	7,27%	7,27%	5,64%	5,64%
	P(carsharing)	6,79%	6,79%	4,91%	4,92%	3,02%	3,02%	2,36%	2,36%
	P(bici privada)	9,35%	9,35%	4,91%	4,91%	12,58%	12,58%	11,30%	11,30%
	P(caminar)	0,47%	0,47%	0,16%	0,16%	3,54%	3,54%	2,30%	2,30%
Variación en la probabilidad de uso de un modo de transporte	Variación % P(auto)		0,0000049		0,0002776		0,0000050		0,0000485
	Variación % P(moto)		0,0000216		0,0001455		0,0000219		0,0000222
	Variación % P(taxi)		-0,0001680		-0,0009905		-0,0001699		-0,0002243
	Variación % P(bus)		0,0000891		0,0000915		0,0000903		0,0000940
	Variación % P(tranvía)		0,0000125		0,0001662		0,0000127		0,0000141
	Variación % P(bicicleta pública)		0,0000139		0,0002001		0,0000141		0,0000145
	Variación % P(carsharing)		0,0000055		0,0000543		0,0000055		0,0000057
	Variación % P(bici privada)		0,0000158		0,0000538		0,0000158		0,0000206
	Variación % P(caminar)		0,0000046		0,0000016		0,0000045		0,0000047
Elasticidad de uso de un modo de transporte	Elasticidad de uso de auto		0,0541732		0,1027491		0,0181540		0,0208225
	Elasticidad de uso de moto		0,0587937		0,1150282		0,0186056		0,0246784
	Elasticidad de uso de taxi		-0,6790597		-1,0945389		-0,2654013		-0,4924479
	Elasticidad de uso de bus		0,0572760		0,1074155		0,0195233		0,0259159
	Elasticidad de uso de tranvía		0,0579063		0,1113375		0,0198878		0,0266237
	Elasticidad de uso de bicicleta pública		0,0620684		0,1119680		0,0193693		0,0256473
	Elasticidad de uso de carsharing		0,0583630		0,1105054		0,0182687		0,0241688
	Elasticidad de uso de bicicleta privada		0,0554842		0,1096841		0,0125792		0,0182428
	Elasticidad de caminar		0,0541417		0,1018835		0,0127033		0,0205993

Table 11 shows that with an increase in cab travel time, the probability of taxi use is reduced in all cases. In the case of the urban sector, this scenario causes an increase in theprobability of using private vehicles. In addition, in the urban sector, the probability of using other modes of transport, such as motorcycles, streetcars and public bicycles, is alsoincreased, both on days with and without rain. On days with rain to more than those indicated also increases the probability of use of bus and car sharing. In the case of the rural area, only the probability of using the bus increases, both on days with and without rain. The same table shows a higher elasticity in the urban area than in the rural area, for both weather scenarios; however, in the case of days with rain, the elasticity also increases, compared to days without rain.

Increased bus waiting time by 10%.

Table 12 Elasticities in Scenario 4

Source: Own elaboration

Aumento del tiempo de espera de bus en un 10%									
		Urbano				Rural			
		Sin lluvia		Con lluvia		Sin lluvia		Con lluvia	
Parámetro	Descripción	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario
Tiempo de espera	Tiempo de espera bus (minutos)	30	33	30	33	30	33	30	33
Probabilidad de uso de un modo de transporte	P(auto)	22,15%	22,17%	27,02%	27,05%	2,78%	2,78%	23,30%	23,35%
	P(moto)	11,68%	11,69%	12,64%	12,66%	11,78%	11,79%	8,98%	9,00%
	P(taxi)	7,81%	7,81%	9,05%	9,06%	6,40%	6,41%	4,55%	4,57%
	P(bus)	11,11%	11,00%	8,52%	8,40%	46,26%	46,21%	36,28%	36,14%
	P(tranvía)	15,59%	15,61%	14,93%	14,95%	6,39%	6,39%	5,29%	5,31%
	P(bicicleta pública)	15,06%	15,08%	17,87%	17,89%	7,27%	7,27%	5,64%	5,65%
	P(carsharing)	6,79%	6,80%	4,91%	4,92%	3,02%	3,02%	2,36%	2,37%
	P(bici privada)	9,35%	9,36%	4,91%	4,91%	12,58%	12,59%	11,30%	11,32%
	P(caminar)	0,47%	0,47%	0,16%	0,16%	3,54%	3,54%	2,30%	2,30%
Variación en la probabilidad de uso de un modo de transporte	Variación % P(auto)		0,0000263		0,0003253		0,0000267		0,0004947
	Variación % P(moto)		0,0001135		0,0001565		0,0001140		0,0002103
	Variación % P(taxi)		0,0000619		0,0001118		0,0000622		0,0001075
	Variación % P(bus)		-0,0005096		-0,0011442		-0,0005099		-0,0014312
	Variación % P(tranvía)		0,0000629		0,0001865		0,0000632		0,0001280
	Variación % P(bicicleta pública)		0,0000699		0,0002311		0,0000702		0,0001326
	Variación % P(carsharing)		0,0000290		0,0000666		0,0000291		0,0000551
	Variación % P(bici privada)		0,0001130		0,0000643		0,0001127		0,0002510
	Variación % P(caminar)		0,0000330		0,0000021		0,0000317		0,0000519
Elasticidad de uso de un modo de transporte	Elasticidad de uso de auto		0,1128968		0,1203933		0,0961057		0,2123303
	Elasticidad de uso de moto		0,1150657		0,1237531		0,0968095		0,2343226
	Elasticidad de uso de taxi		0,1118871		0,1235932		0,0972113		0,2359379
	Elasticidad de uso de bus		-0,9108606		-1,3435320		-0,1102306		-0,3944618
	Elasticidad de uso de tranvía		0,1154672		0,1249608		0,0990201		0,2418332
	Elasticidad de uso de bicicleta pública		0,1118362		0,1293468		0,0966630		0,2351697
	Elasticidad de uso de carsharing		0,1174533		0,1354854		0,0962561		0,2331747
	Elasticidad de uso de bicicleta privada		0,1137068		0,1310865		0,0895841		0,2222212
	Elasticidad de caminar		0,1132244		0,1312272		0,0896988		0,2259213

As the waiting time for the bus increases, the probability of using the bus logically decreases in both sectors, regardless of the weather conditions, that is, on rainy and non-rainy days. In the urban area, both on rainy and non-rainy days, the use of private vehicles, motorcycles, streetcars, public bicycles and car sharing increases. On days without rain, the use of private bicycles also increases. On rainy days, the use of cabs alsoincreases. In the case of the rural sector, regardless of the condition of the day, the probability of motorcycle, cab and private bicycle use increases, however, more than indicated on a rainy day, the use of private vehicles, streetcar, public bicycles and carsharing also increases. A higher elasticity is shown in the urban area compared to the rural area and on rainy days compared to non-rainy days.

1. Increase in the cost of streetcar travel by 5% and decrease in the cost of carsharing travel by 5%.

Table 13 Elasticities in scenario 5

Source: Own elaboration

Aumento del costo de viaje del tranvía en un 5% y disminución del costo de viaje del carsharing en un 5%								
		Urbano				Rural		
		Sin lluvia		Con lluvia		Sin lluvia		Con ll
Parámetro	Descripción	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situación base	Aplicación escenario	Situació b
Tarifa de viaje	Tarifa de viaje tranvía	0,60	0,63	0,60	0,63	0,60	0,63	
	Tarifa de viaje carsharing	3,33	3,17	3,33	3,17	3,33	3,17	
Probabilidad de uso de un modo de transporte	P(auto)	22,15%	22,14%	27,02%	27,01%	2,78%		
	P(moto)	11,68%	11,67%	12,64%	12,64%	11,78%		
	P(taxi)	7,81%	7,80%	9,05%	9,05%	6,4		
	P(bus)	11,11%	11,10%	8,52%	8,51%			
	P(tranvía)	15,59%	15,53%	14,93%	14,87%			
	P(bicicleta pública)	15,06%	15,06%	17,87%	17,86			
	P(carsharing)	6,79%	6,88%	4,91%				
	P(bici privada)	9,35%	9,34%	4,91%				
	P(caminar)	0,47%	0,47%	0,16				
Variación en la probabilidad de uso de un modo de transporte	Variación % P(auto)		-0,0000095					
	Variación % P(moto)		-0,0000409					
	Variación % P(taxi)		-0,000022					
	Variación % P(bus)		-0,000					
	Variación % P(tranvía)		-					
	Variación % P(bicicleta pública)							
	Variación % P(carsharing)							
	Variación % P(bici privada)							
	Variación % P(caminar)							
Elasticidad de uso de un modo de transporte	Elasticidad de uso de auto							
	Elasticidad de uso de m							
	Elasticidad de uso d							
	Elasticidad de							
	Elasticida							
	Elast							

The last scenario proposed shows an increase in the value of the streetcar and a decrease in the value of carsharing, which generates an increase in the possibility of using carsharing, in all cases, regardless of the weather conditions of the day. In addition, this situation leads to a decrease in the probability of using private vehicles, buses, streetcars and private bicycles in urban areas, both on rainy and non-rainy days; additionally, on non-rainy days, the use of motorcycles and cabs also increases. In the case of rainy days, the use of public bicycles also increases. For the rural area, on a day without rain, the probability of motorcycle, bus and streetcar use is reduced. On days with rain, only the probability of private bicycle use is reduced.

CONCLUSIONS

The choice set consisted of the 9 modes of transport considered (car, motorcycle, cab, bus, streetcar, public bicycle, private bicycle, carsharing and walking), with linear utility functions in all cases. The explanatory variables of transport service related to attributes of the transport modes were: travel time, waiting time, travel cost, parking cost and blocks walked; all the variables were introduced with generic parameters and, in addition, a modal constant was included for each of the alternatives, except for the constant of the walking alternative, which was taken as a reference.

The demand estimate shows that for a day without rain in the urban area, the value of travel time savings is $3.00 per hour on a day without rain, while on a day with rain,these savings increase to $4.20 per hour. In rural areas, the savings per hour on a day without rain is $2.40, while with rain, the savings increase to $3.60 per hour. In the caseof the waiting value, the time savings per hour is $4.20 on a day without rain, and $5.40

on a day with rain, all this in the urban area, while in the rural area, the savings is $1.80 per hour on a day without rain and $4.20 on a day with rain. These estimates are useful since in most transportation projects travel time savings are the main source of social benefits, which is determinant in the evaluation results, since transportation demand models that make their predictions based on observable variables such as price do not value certain elements such as travel time, waiting time and blocks walked and, therefore,do not have a value that covers all of the above and can be used in the evaluation.

The results show that on a rainy day, both in urban and rural areas, people value more their travel time, waiting time and blocks walked, as shown in Table 6, demonstrating thatthe calculation of subjective valuations of savings in travel time, waiting time and blocks walked are sensitive to the specification of the estimated econometric model and that weather variations have a significant influence on the decisions and valuation of the transportation service variables.

In order to consider the different cross effects between the attributes that characterize the different modes of transport, a situation very difficult to achieve through direct observation of individuals' choices, elasticities of transport modes were calculated in 5 policy scenarios with their respective probability variations, percentage and absolute variations.

The research has shown that an increase in the tramway fare would cause a substantial decrease in its demand that could make the operation of this service unsustainable, also an increase in the bus waiting time would generate a significant decrease in demand whose forecast would respond to the planning problem of increasing the capacity of the system to cope with the expected demand; Likewise, if the cost of bus travel is increased, there would be a strong substitution effect from buses to the streetcar; likewise, increases in parking costs for private vehicles could be efficient in democratizing public space and reducing vehicle congestion, since the probability of using them decreases.

Finally, it is necessary to emphasize that the behavior of most goods and their response to some variations is elastic in most cases since there is a behavior according to economic theory, where the higher the price, the lower the demand and vice versa, while improvements in services, or a shorter time, the probability and interest in the use of the good increases significantly.

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