DEMAND ELASTICITY ESTIMATION FOR A PARK & RIDE FACILITY BY MEANS OF DISCRETE CHOICE MODELLING

EMILIO PICASSO - MARIANO BONOLI ESCOBAR - MARIA STEWART HARRIS - GONZALO PEÑA - OSVALDO MERMOZ (posthumous)
Facultad de Ingeniería-Universidad de Buenos Aires. ARGENTINA
epicasso@fi.uba.ar - mbonoli@fi.uba.ar - mariastewartharris@gmail.com - gonzalopena@ohpanel.com

Fecha Recepción: Setiembre 2013 - Fecha Aceptación: Abril 2014

ABSTRACT

Park & ride facilities have been proposed as a solution for the traffic problem of large cities prevalent around the world. In this article we define them as large parking facilities located in the surroundings of the city, with the purpose of deterring commuters from using their cars in the city centre. Building a park & ride facility requires a large investment. Demand estimation at various price levels is a critical input for the project evaluation.

In a previous article (Picasso *et al.*, 2012) we have modelled the demand for a park & ride facility in the north access to Buenos Aires city via discrete choice methods, determining its attractiveness for different segments of the target population. In this article we focus on the price sensitivity of demand. A predicting application was developed to estimate the demand at different price levels for a range of demographic characteristics. The value of time is also determined, by means of the compensated variation.

KEY WORDS: Discrete-choice – Park-and-ride – Demand estimation – Price-sensitivity – Elasticity

1. INTRODUCTION

The city of Buenos Aires, like most other large cities in the world, faces traffic congestion problems, particularly at peak hours, but also throughout the whole range of working hours in the centre.

The government has been working on the traffic flow improvement. Significant changes in public transportation have taken place recently, with the rapid development of the subway network and the concentration of the bus network in wider avenues. These changes have contributed to improve the traffic flow, however there is a second cause of traffic congestion that is yet to be addressed: the large traffic inflow from the greater Buenos Aires area.

There is a conflict of interest between the city district and the province, as the problem in the former is caused by lagging investment in transportation in the latter. Park & ride facilities represent a solution to this second cause of traffic congestion, as they would deter commuters from entering the city by car, by offering them convenient connection with other transportation means, namely railways, subway, bus and even charter vans (DIjk, 2011).

These park & ride facilities would require large scale investments, comprising several hectares of land, a multi-level building structure, railway and subway lines extension, etc. This calls for thorough demand estimation at different price levels (namely parking rates) to determine the optimal size, and the amount of subsidy required in case of negative business case.

The objective of this research project is to determine the demand curve for a park & ride facility located in the north access to Buenos Aires city under different conditions, by developing a predicting application based on a discrete choice model. We have used data from a choice experiment implemented and analyzed in Picasso *et al*. (2012) for that purpose.

The statistical methodology employed is discrete choice modelling. These models have been created to estimate the demand for a new transportation medium in the San Francisco Bay Area: the BART (Bay Area Railway Transit) (Mc Fadden, 1973, 1975), (Mc Fadden *et al*, 1977). The author was awarded the Nobel prize for this. Since then, discrete choice models have been widely applied to different transportation problems, reaching the scientific community recognition as the best practice (Ben-Akiva, 1985, 1993, 1999), (Bos, 2004), (Risa Hole, 2004).

The discrete choice models decipher the decision patterns of economic agents, individuals in this case, among a discrete set of alternatives. They are based on the theory of random utility (Thurstone, 1927). This theory establishes that economic agents always choose the alternative with the highest utility, where this utility is a function of the alternative characteristics, the individual characteristics, and the influence of a random component. The latter represents other non-controlled variables and bounded rationality effects.

The estimation of the model is performed on a sample of decisions of economic agents, either real (revealed preference) or experimental decisions (stated preference). The experimental approach was chosen in this research project, given the fact that there is no park & ride facility operating in Buenos Aires. The stated preference form is extremely interesting as it opens up the experimental field to the Economy science. However the experiment requires careful design and implementation via survey to a representative sample.

The prediction of results is not produced straightforward from the model estimates, as it would be in regression analysis, but a predictive application has to be developed. This application calculates the probability of choice for each alternative under different scenarios determined by alternative and individual characteristics, like travel distance, age, car type, parking rates at destination, parking rate in the park & ride facility, etc.

2. DEVELOPMENT

2.1 Discrete Choice Model

The population under study is the set of people living in the northern area of the Greater Buenos Aires, having a car, that travel to the city district at least once a week. The following alternatives for transportation are presented to them in the choice experiment:

- Car to destination: Travelling by car from home all the way to the destination in the city.
- Park & ride: Travelling by car from home to the park & ride facility, conveniently located in the northern border of the city district, and connecting to any of various transportation media to reach final destination: railway, subway, bus, etc.
- Train or bus: consolidated into a single alternative due to similarity and limited railway availability.
- Charter: Public transportation mode in vans, more comfortable and expensive than regular buses. It is only available for individuals living in San Isidro or farther away from the city.

The alternatives have the following characteristics:

- Price: Out-of pocket expenses realized during the trip: train/ bus fare, toll, and parking cost.
- Running costs: Fuel and car maintenance costs associated to the trip that are not necessarily paid during the trip. Only additional costs related to the trip were considered, and aggregated into a monthly figure according to each individual car type and travel frequency.
- Travel time: Door-to-door time from home to destination.

Each individual in the sample makes T = 15 choice tasks, among J = 4 alternatives in different price, cost and time conditions. The *Multinomial Logit* (MNL) model establishes the following random utility structure:

$$\tilde{U}_{jit} = {}^{T}\beta\, x_{jit} + \tilde{\varepsilon}_{jit} \qquad (1)$$

Where

U_{jit}: Utility (random) of alternative *j* for the individual *i* in the choice task *t*.
x_{jit}: *K*-dimensional vector of characteristics of the alternative *j* in the choice task *t* performed by individual *i*.

β: *K*-dimensional vector of partial utilities (or importance) of the characteristics of alternatives or individuals.

ε_{jit}: Random component of utility, distributed as Gumbel type I.

The wavy stripe on top of variables is employed to highlight their random nature.

This random component structure generates the Multinomial Logit model (MNL), with a closed form for the probability of choice (Train, 2009):

$$P_{jit} = \frac{\exp({}^{\mathrm{T}}\beta x_{jit})}{\sum_{l=1}^{J} \exp({}^{\mathrm{T}}\beta x_{lit})} \qquad (2)$$

The likelihood function includes as factors the probability for the chosen alternatives in each task:

$$\ln \mathcal{L} = \sum_{i=1}^{I} \sum_{t=1}^{T} \sum_{j=1}^{J} y_{jit} \ln P_{jit} \qquad (3)$$

Where y_{jit} = 1 when alternative *j* was chosen by individual *i* in task *t*, and y_{jit} = 0 otherwise.

The parameters β that best reproduce the decisions of the individuals in the sample are estimated by maximizing the likelihood function (Train, 2009).

The explanatory variables x_{jit} can include dummy variables for alternatives. In this case, their coefficients are called alternative specific constants. In the present case they represent the preference for the transport modes. Car to destination was chosen as the reference alternative for identification purposes.

Demand elasticity is calculated in a conventional way, between two extremes in a range:

$$\eta = \frac{\Delta P / \overline{P}}{\Delta x_k / \overline{x}_k} \qquad (4)$$

Where x_k is the price, delta refers to the difference between extremes of the range, and average is the mid-point of the range.

The MNL model is very robust and has proven very useful in many transportation problems. However it has some weaknesses.

One of them is the "independence of irrelevant alternatives" (IIA) property, that forces the model to keep probability of alternatives proportional when one of them is suppressed.

This may be artificial when alternatives are clustered by similarity. For instance, in our case there are two private transport modes and two public ones. Suppressing one of the private modes should favour the remaining private mode rather than evenly raise all probabilities. Another limitation surfaces at modelling respondent heterogeneity. Individual characteristics, like home-to-destination distance, can be included as variables, entering the model through interactions with alternatives, for identification purposes. However this systematic way of coping with heterogeneity is limited to the explanatory power of available demographic variables.

A more powerful way to cope with individual heterogeneity is by means of the *Mixed Logit* model (MXL), that establishes a *Logit* structure for each individual in the sample, but letting them be themselves in terms of preferences. Its random utility formulation is:

$$\tilde{U}_{jit} = {}^{T}\tilde{\beta}\, x_{jit} + \tilde{\varepsilon}_{jit} \qquad (5)$$

where the parameters randomly vary among individuals according to a pre-specified probability law f(β).

The choice probabilities are integrated across all possible values of the parameters:

$$P_{ji} = \int \prod_{t=1}^{T} \frac{\exp({}^{T}\beta\, x_{jit})}{\sum_{l=1}^{J} \exp({}^{T}\beta\, x_{lit})} \mathrm{f}(\beta)\, d\beta \qquad (6)$$

This class of models do also solve the other limitation of the MNL model mentioned before: the independence of irrelevant alternatives (IIA). It can be shown that the MXL model can represent any random utility model under general regularity conditions (Mc Fadden, 2000). The estimation of these models proceeds in two phases. The structural parameters (mean and standard deviation of β) are estimated in a first phase, via maximum likelihood or Monte Carlo methods (Train, 2009). Then, individual parameters are estimated by taking advantage of the Bayesian structure of the model, by calculating the following integrals via Monte Carlo methods (Train, 2009):

$$\beta_i = \frac{\int \beta\, P(y_i / x_i, \beta)\, \mathrm{f}(\beta / \theta)\, d\beta}{\int P(y_i / x_i, \beta)\, \mathrm{f}(\beta / \theta)\, d\beta} \qquad (7)$$

Where y_i is the set of choices done by individual *i* across all tasks, x_i are their characteristics, and θ represents the structural parameters previously determined.

Discrete choice models enable the estimation of the subjective value of time (*SVT*) for the population under study.

According to Ben-Akiva and Lerman (1985), the subjective value of time is defined as the marginal rate of substitution between travel time and the monetary vehicle:

$$SVT = \frac{\partial U/\partial t}{\partial U/\partial p} \qquad (8)$$

In this case there are two monetary vehicles: the price and the running cost, however the price is behaviourally better as it implies an instant out of pocket payment rather than a deferred aggregated expenditure. With a linear utility function this equals:

$$SVT = \frac{\beta_t}{\beta_p} \qquad (9)$$

Even under the simple MNL model the estimation of this parameter can be fairly complicated. The estimate for *SVT* is the quotient of two parameter estimates distributed asymptotically Normal, which can be correlated. Its distribution can be fairly complicated, especially if the denominator has significant probability mass around zero.

The MXL model framework brings an additional source of dispersion: The parameters in the numerator and denominator can be random variables, besides the sampling error of the structural parameters like in the MNL model. In the MXL model specified below, the probability law for both: numerator and denominator, is Log-Normal. Despite the difficulties brought by this long tailed distribution, as described by Hensher and Greene (2003), it has a convenient property: The Log-Normal distribution does not reach zero, and is preserved by division, then the distribution of *SVT* is also Log-Normal with the following structural parameters:

$$\ln \tilde{\beta}_t : \mathcal{N}(\mu_t, \sigma_t^2)$$
$$\ln \tilde{\beta}_p : \mathcal{N}(\mu_p, \sigma_p^2)$$
$$\ln SVT = \ln \tilde{\beta}_t - \ln \tilde{\beta}_p : \mathcal{N}(\mu_t - \mu_p, \sigma_t^2 + \sigma_p^2 - 2\rho\sigma_t\sigma_p)$$

where ρ is the coefficient of correlation between the logarithms of the individual parameters.

The mean of *SVT* can be severely affected by the long tails of the Log-Normal law. Therefore we describe the *SVT* by the median and two quantiles as lower and upper bounds: 10% and 90%, which can be obtained for a Log-Normal law from the following expression with τ = 0.5, 0.1, and 0.9 respectively:

$$SVT_\tau = \exp\left(\mu_t - \mu_p + (\sigma_t^2 + \sigma_p^2 - 2\rho\,\sigma_t\,\sigma_p)\,z_\tau\right) \qquad (10)$$

Where z_τ is the Normal corresponding quantile.

In this analysis we are assuming that the sampling error of the structural parameter estimates is negligible compared to the dispersion of the individual parameters. However the analysis could be improved, by taking this source of dispersion into account via simulation, as discussed in Hensher and Greene (2003).

2.2. The data

The characteristics of alternatives presented to individuals in each choice task respond to an experimental plan. Each individual in the sample performed *T* = 15 tasks in different conditions of price, running cost and travel time, fluctuating around base values. Realistic base values were determined for each individual by pivoting the experimental plan on the individual profile. The individual profile was determined by: most frequent trip origin and destination, the value of the car, the parking rate, the travelling frequency, and the time of the day. The base value for the park & ride rate was set at 25 Arg$/day[1]. Deviations from the base values followed the experimental plan:

- Price: -30%, -15%, 0, +15%, +30%.
- Running cost: -25%, +25%.
- Time: -30%, 0, +30%.

The experimental plan was generated by optimally fractioning the full factorial 5 x 2 x 3 into two blocks of 15 rows each. The design was developed to the 4 alternatives following the principles recommended by Huber and Zwerina (1996).

The sample was selected among residents in the northern zone of the Greater Buenos Aires having a car, by means of an Internet panel. The sample size was approximately 150 interviews.

The questionnaire, programmed into an online application, had three parts. The first part gathered socio-demographic descriptors as well as all the variables required to determine the base values for price, running cost, and travel time for each transportation mode.

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[1] Arg$ means Argentine peso of Feb 2010. Exchange rate at the time was 3.86 Arg$/ US dollar.

In the second part the individuals were exposed to the concept of the park & ride facility, something unknown to the public in Argentina. A functional description was done for that purpose, complemented with images of similar facilities in other parts of the world. Two potential geographic locations were proposed. The third part of the interview was devoted to the choice tasks. The alternatives were presented as in FIGURES 1 and 2, each one with its price, monthly running cost and travel time. These figures were automatically calculated by the interviewing application out of the base values determined in the first part.

The individual selected the preferred alternative in each task, by clicking with the mouse. The charter was only available to individuals living in San Isidro or farther away from the city.

Once the survey was finished, the database was processed and formatted in an appropriate way to input the "mlogit" package in R language.

2.3. Discussion of results

The first objective of this paper is to determine the demand curve and its elasticity for the park & ride facility in the north access to Buenos Aires city. For this purpose we have revisited the modelling strategy of Picasso *et al*. (2012), finding a superior model, and we have built a predictor application to calculate the probabilities of choice.

The experimental alternatives were selected with the empirical frequencies stated in TABLE 1, showing a great interest for the park & ride facility.

We have estimated a MXL model with the following explanatory variables: the transport modes, excluding car to destination that was used as the reference; price, running cost, and time. The random parameter specification was employed, with Normal probability law for transport mode constants and Log-Normal probability law for price, running cost and time coefficients. TABLE 2 summarizes the results of the estimation. The estimated structural parameters are shown: mean and standard deviation for each random parameter. The model achieved a maximum (log) likelihood of: -1683.7, performing slightly better than the best one in Picasso, Bonoli *et al*. (2012), which used the Normal law for all parameters. TABLE 2 also includes p-values for the null hypotheses on each structural parameter. All of them are statistically different from zero at 1% significance level. Significance of the means of transport modes means that all of them are considered different from Car-to-destination by the respondents. Significance of the means of price, running cost and time mean that the three variables are influencing choice behaviour. Significance of standard deviations means that there is heterogeneity among individuals in the relevance of all these variables.

Taking advantage of the Bayesian structure of the model we have estimated the partial utilities for each individual in the sample according to expression (7), by means of a piece of software developed ad hoc in R. Individual parameters are shown in TABLE 3, and summary statistics in TABLE 2.

A predictor application was developed to estimate the demand for each transport mode. The predictor calculates the probabilities according to the following expression (generalizing (2) for the heterogeneous case where partial utilities (β) are individual-specific):

$$P_{ji} = \frac{\exp({}^{\mathrm{T}}\beta_i x_{ji})}{\sum_{l=1}^{J} \exp({}^{\mathrm{T}}\beta_i x_{li})} \qquad (11)$$

The individual specific characteristics were used to calculate the explanatory variables for the model: trip origin and destination, parking rate (at destination), travel frequency, regular/ peak time, and the value of the car. The park & ride rate (including parking and subsequent transportation fare) is set at 25 Arg$ (base value). These variables are used in the calculation of the price, running cost and time of each alternative, by means of the same functions programmed in the data gathering instrument employed in the fieldwork. The logit probability of each transport mode is calculated for each individual in the sample by means of her individual partial utilities. The probabilities are averaged to calculate the market demand.

FIGURE 3 shows the market demand (probability of choice) as a function of the price for the park & ride facility which varies in the horizontal axis. The elasticity of the demand for the park & ride facility in these conditions and in the specified range (base price ± 30%) is: -0.49. This is quite low, meaning that a higher price could be set, bringing the payback for the investment closer in time. The cross elasticity for the other transport modes are: 0.29 for car to destination, 0.27 for train/ bus, and 0.29 for charter.

The demand for the park & ride facility is highly sensitive to the parking rate at destination, as shown in FIGURE 4. A 50% decrease in car parking rates at destination would reduce the demand of the park & ride facility by 55%, whereas a 50% increase in parking rates at destination would raise the park & ride facility demand by 62%. The price elasticity for the former case is -0.53 whereas in the latter case it is -0.46. This means that the people travelling to the centre of the city, where parking is more expensive, would not only be more willing to use the park & ride facility but they would also better withstand higher rates.

FIGURE 5 shows the demand for the park & ride facility for different trip origins.

The sample was partitioned in three groups for this analysis: Individuals living close to the city, far from the city, and midway. The breakpoints were determined to represent homogeneous geographic zones without unbalancing sample sizes too much in order to keep accuracy: 29, 63, and 42 respondents respectively. Individuals living nearby to the city show higher interest for the park & ride facility at all rates, having very low price elasticity (-0.37). It is worth to mention that the charter is not an available alternative in this zone, shifting upwards the demand curve for the park & ride facility.

On the other end, individuals living midway or farther away from the city show similar interest for the park & ride facility, with a higher elasticity (-0.55).

FIGURE 6 shows the demand for the park & ride facility for different car values (price of a new car similar to the main one of the household). The value of the car is a proxy of socioeconomic level. On the other hand, the value of the car can be correlated with distance, as individuals living farther away may want to invest in better cars. The demand curves reveal that individuals having more expensive cars have a higher interest for the park & ride facility and they behave less elastically (-0.36). Lower value car owners are the least interested. Their elasticity is -0.59. Mean car value owners show intermediate interest for the park & ride facility, however their elasticity is even higher than for the low value car owners (-0.62). These findings suggest addressing the strategy of the park & ride facility toward the high income segment. The facility should have a rich set of ancillary services, as these users would tend to be more demanding, and fast connection with high speed public transportation would be mandatory.

The second objective of this paper is to estimate the subjective value of travel time for the population under study. We estimate the quantiles of the *SVT* according to expression (9) (The coefficient of correlation is estimated from the individual parameters). The median is 0.85 Arg$/min, or 0.22 USD/min. This represents approximately 8500 Arg$/Month in terms of working time, what is commensurate with the average income of the population. The *SVT* is quite disperse, bounded by 0.15 Arg$/min and 4.77 Arg$/min with 80% probability. Hence the value of travel time is between 1500 and 48000 Arg$/Month. It would be interesting to look at the correlation between *SVT* and income, however we do not have a precise measure of the latter, and impatience is an intervening variable that should also be measured. This is an interesting direction for future research: to develop a measurement instrument for impatience and to correlate *SVT* with both: income and impatience.

Making the same calculations with the running cost instead of the price results in a median of 11.77 (Arg$/Month)/(min/trip), what adequately converted by means of the empirical average trip frequency (3.17 trips/Week) results in: 0.86 Arg$/min. Both results are remarkably close.

The standard deviation of the structural parameters is approximately 10 times smaller than the standard deviation of the random parameters, hence it is appropriate to use expression (10).

3. CONCLUSIONS

In this article we have modelled the demand for a park & ride facility in the north access to Buenos Aires city via discrete choice methods, focusing on the price sensitivity and the subjective value of time.

We have estimated a MXL model with the following explanatory variables: the transport modes: park & ride, train or bus, and charter (car to destination was set as the reference); price (out of pocket), running cost, and time. The random parameter specification was employed, with Normal probability law for transport mode constants and Log-Normal probability law for price, running cost and time coefficients. The model achieves sound statistical properties. We have also estimated individual parameters for each variable and developed a predicting application to estimate the demand at different price levels, i.e. the demand curve.

The demand for the park & ride facility has low price sensitivity, meaning that the public would accept higher prices. In addition the demand is highly sensitive to the parking rate at destination (substitute). This fact anticipates a growing interest for the park & ride facility as parking space in the city becomes gradually more scarce and expensive. The people living closer to the city are more interested in the park & ride facility, and show lower price elasticity. The demand is stronger for higher income individuals, who also show lower price elasticity. This suggests addressing the strategy of the park & ride facility toward the high income segment, by offering a rich set of ancillary services and fast connection with high speed public transportation.

The subjective value of travel time was estimated for different individuals in the sample ranging from 0.15 Arg$/min to 4.77 Arg$/min with 80% probability. The median is 0.85 Arg$/minute, what is comparable to average income of the population. A deeper understanding of the heterogeneity in the value of travel time can be the subject for future research, by measuring impatience, income and other potential explanatory variables.

4. FIGURES, TABLES, AND NOTES

FIGURE 1. Data collection software

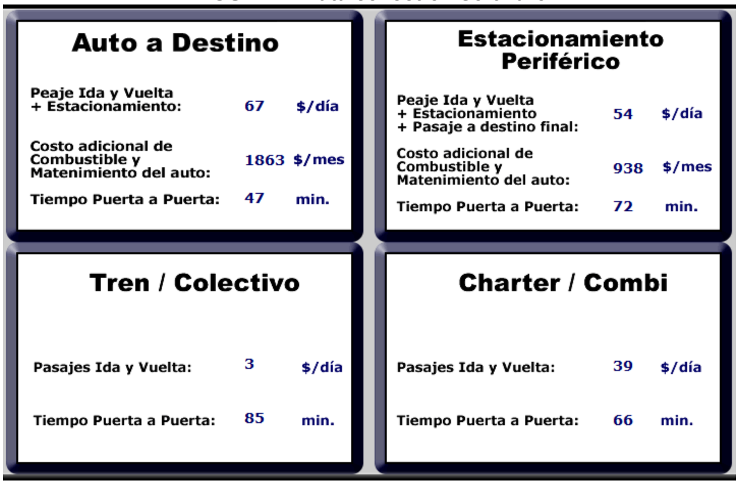

FIGURE 2. Data collection software

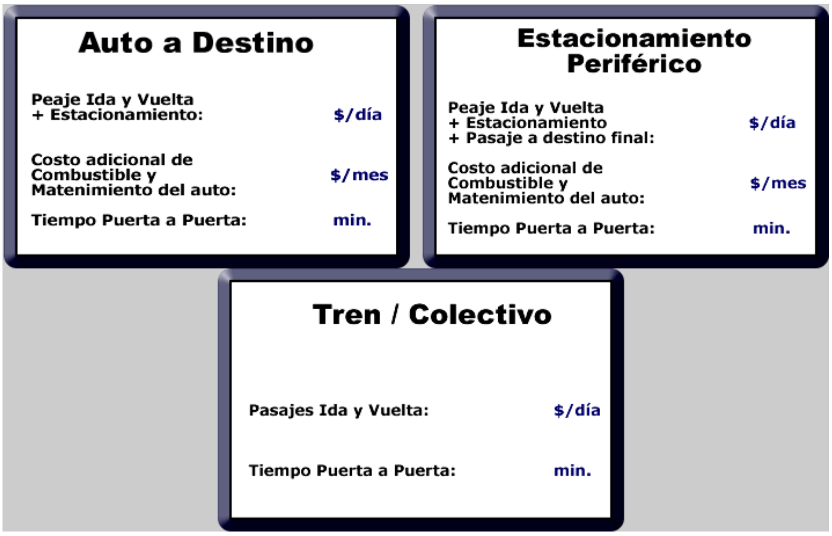

FIGURE 3. Park & ride demand curve

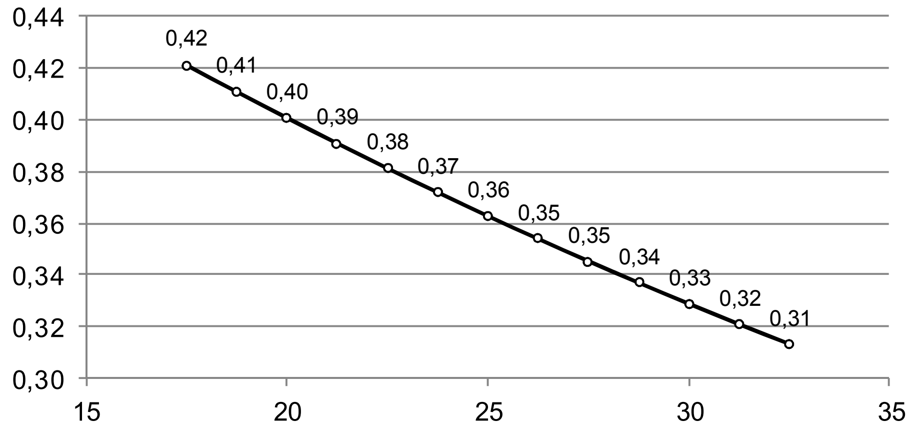

FIGURE 4. Park & ride demand for different parking rates at destination

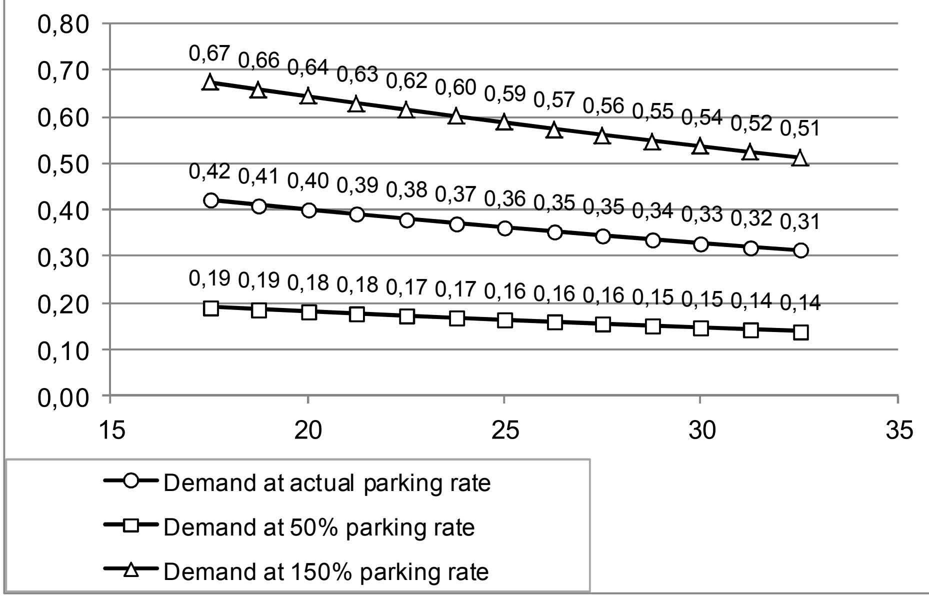

FIGURE 5. Park & ride demand for different trip origins

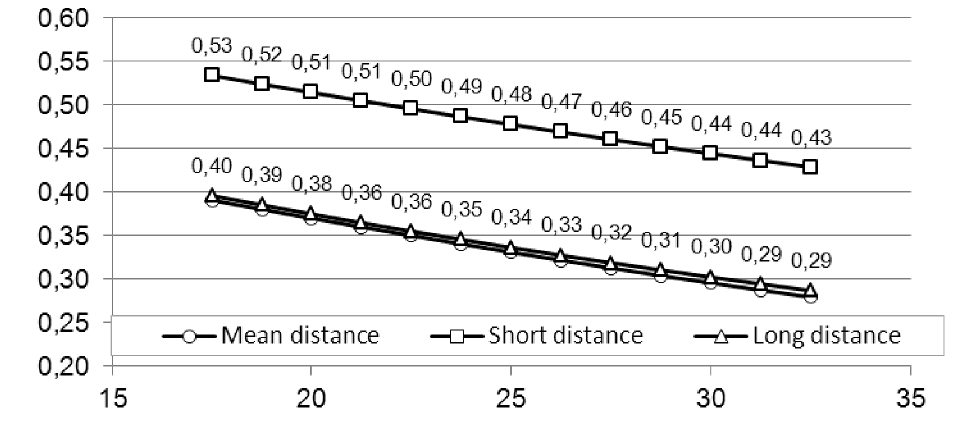

FIGURE 6. Park & ride demand for different car values

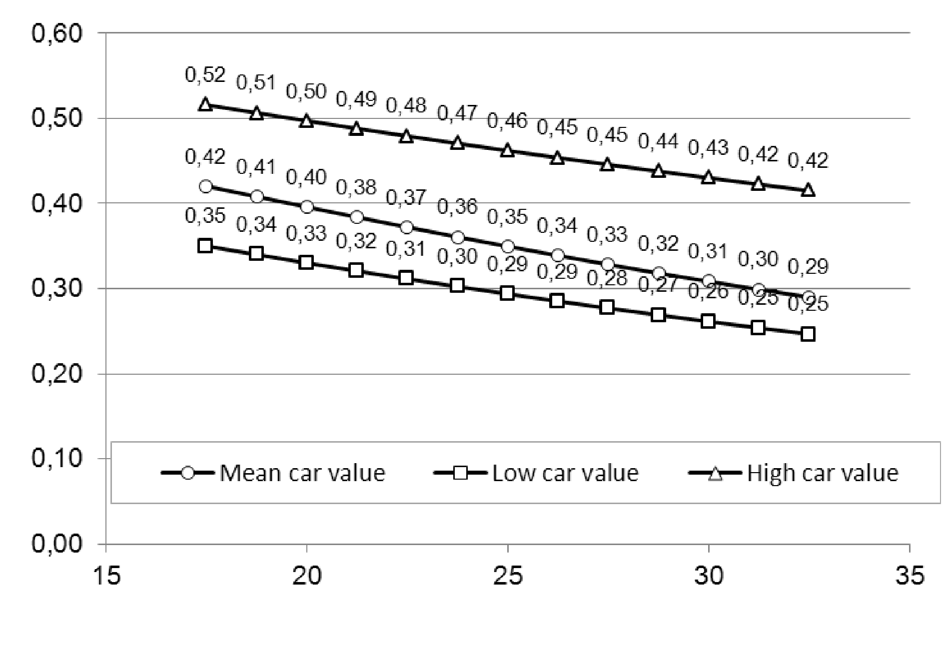

TABLE 1. Empirical frequency of alternatives	
Alternative	**Frequency**
Car to destination	0.29
Park & ride	0.37
Train/ bus	0.21
Charter	0.13

TABLE 2. Estimation of the MXL model					
Variable	**Prob. Law of coefficient**	**Partial Utility**			
		Mean	***p***	**S.D.**	***p***
Park & ride	**Normal**	-0.962	<0.01	1.48	<0.01
Train/ bus	**Normal**	-6.59	<0.01	3.15	<0.01
Charter	**Normal**	-3.34	<0.01	2.03	<0.01
Price	**Log- Normal**	-3.327 [1]	<0.01	0.855 [1]	<0.01
Running Cost	**Log- Normal**	-5.956 [1]	<0.01	1.118 [1]	<0.01
Time	**Log- Normal**	-3.490 [1]	<0.01	0.838 [1]	<0.01

[1] **Mean and standard deviation of the logarithm of the Log-Normal distribution.**

TABLE 3. Partial utility and WTP per individual							
Indiv.	**Partial utility**						**WTP**
id	P&R	Tr/bus	Charter	Price	Cost	Time	
130	-1.625	-9.246	-4.839	-0.0318	-0.0010	-0.0124	0.390
136	-1.770	-8.444		-0.0497	-0.0052	-0.0222	0.447
141	0.924	-4.526		-0.0361	-0.0077	-0.0238	0.660
164	-0.351	-8.902	-1.458	-0.0927	-0.0029	-0.0199	0.214
201	-2.799	-9.457	-3.921	-0.0163	-0.0015	-0.0369	2.263
267	-2.393	-9.481	-3.245	-0.0566	-0.0020	-0.0392	0.693
279	-1.812	-9.576	-3.628	-0.0229	-0.0009	-0.0287	1.252
284	-1.577	-1.427	-4.180	-0.1205	-0.0082	-0.0481	0.399
304	-0.487	-5.279		-0.1129	-0.0042	-0.0945	0.838
310	-1.474	-1.873	-4.046	-0.0912	-0.0038	-0.0333	0.365
329	0.113	-5.164		-0.0465	-0.0045	-0.1210	2.603
343	0.473	-6.088	-4.218	-0.0521	-0.0026	-0.1170	2.246
346	-1.286	-8.805		-0.0626	-0.0032	-0.0190	0.303
364	-1.833	-2.952	-5.103	-0.0455	-0.0062	-0.0242	0.532
404	0.905	-0.956	-3.767	-0.0299	-0.0124	-0.0432	1.447
412	-0.577	-6.158	-5.029	-0.0376	-0.0057	-0.0104	0.277
431	-1.011	-8.908		-0.0399	-0.0046	-0.0275	0.691
434	-0.182	-8.881	-2.134	-0.0443	-0.0022	-0.0641	1.447
475	1.155	-8.604		-0.0355	-0.0040	-0.0466	1.311
476	-1.481	-8.395	-1.584	-0.0248	-0.0017	-0.0241	0.969
484	-1.613	-8.233	-3.962	-0.1032	-0.0019	-0.0277	0.268
503	0.002	-8.686	-1.307	-0.0395	-0.0018	-0.0551	1.394
512	-1.311	-2.717	-5.115	-0.0302	-0.0022	-0.0134	0.443
529	-1.724	-8.299	-3.703	-0.0227	-0.0017	-0.0390	1.719
532	-0.549	-3.824	-4.946	-0.1854	-0.0045	-0.0565	0.305
539	-1.751	-8.498		-0.0249	-0.0048	-0.0580	2.331
540	-2.768	-8.674		-0.0441	-0.0032	-0.0213	0.483

542	-1.162	-6.721	-2.087	-0.0328	-0.0176	-0.0473	1.443
546	-1.682	-8.954		-0.0369	-0.0058	-0.0184	0.498
597	-0.696	-8.636		-0.0244	-0.0016	-0.0495	2.032
600	-2.262	-3.297	-2.890	-0.0632	-0.0036	-0.0396	0.626
619	-1.526	-8.684	-3.067	-0.0236	-0.0035	-0.0328	1.394
641	-0.423	-6.682	-2.334	-0.1452	-0.0077	-0.0481	0.331
655	-2.280	-0.478	-4.189	-0.0343	-0.0019	-0.0368	1.072
660	-3.051	-4.197	-6.442	-0.0459	-0.0015	-0.0192	0.420
717	-2.520	-8.872		-0.0194	-0.0033	-0.0290	1.498
720	-1.695	-5.458		-0.0221	-0.0025	-0.0363	1.640
722	-1.814	-8.896	-5.614	-0.0301	-0.0014	-0.0262	0.870
724	-0.324	-8.506	-2.573	-0.0334	-0.0104	-0.0246	0.737
727	-0.289	-8.254	-5.330	-0.0205	-0.0012	-0.0225	1.098
731	-1.524	0.548	-4.288	-0.1211	-0.0083	-0.0407	0.336
734	-2.573	-1.307	-3.666	-0.0432	-0.0040	-0.0492	1.138
740	-2.895	-8.505	-4.292	-0.0503	-0.0013	-0.0257	0.511
751	0.311	-8.179	-4.791	-0.0443	-0.0014	-0.0130	0.294
752	-0.589	-9.384	-5.337	-0.0228	-0.0029	-0.0127	0.557
767	0.687	-7.682	-1.688	-0.0237	-0.0045	-0.0184	0.778
768	-0.348	-9.383		-0.0487	-0.0014	-0.0244	0.501
772	-0.228	-4.283	-2.965	-0.0475	-0.0030	-0.0163	0.344
777	-1.535	-3.545	-2.633	-0.0384	-0.0065	-0.0267	0.697
780	-1.500	-8.448	-3.707	-0.0294	-0.0030	-0.0642	2.181
787	-0.592	-6.197	-1.588	-0.0618	-0.0054	-0.0315	0.509
801	0.115	-9.216	-2.894	-0.0618	-0.0018	-0.0684	1.107
815	-0.486	-10.85	-1.920	-0.1599	-0.0013	-0.0303	0.190
822	-0.307	-4.187		-0.0619	-0.0020	-0.2634	4.252
828	-1.031	-0.017		-0.0701	-0.0060	-0.0484	0.691
834	-1.532	-2.580	-3.250	-0.0868	-0.0016	-0.0225	0.259
836	-0.724	-4.888	-2.483	-0.2550	-0.0141	-0.0407	0.159
844	0.644	-5.825		-0.0584	-0.0035	-0.0307	0.526
846	-1.043	-5.349	-0.214	-0.0907	-0.0165	-0.0602	0.664
852	-3.126	-5.036	-3.861	-0.0400	-0.0045	-0.0225	0.563
853	1.016	-9.075	-5.094	-0.0322	-0.0028	-0.0405	1.257
854	-1.117	-5.538	-2.135	-0.0371	-0.0050	-0.1111	2.996
857	-0.521	-8.198		-0.0240	-0.0039	-0.0444	1.845
866	1.055	-2.601		-0.0438	-0.0062	-0.1016	2.319
870	-0.689	-8.759		-0.0300	-0.0040	-0.0452	1.510
879	0.820	-8.845		-0.0470	-0.0041	-0.0450	0.957
886	-0.651	-1.937	-3.828	-0.0282	-0.0123	-0.0439	1.557
903	-0.646	-9.887		-0.0402	-0.0160	-0.0244	0.607
924	-0.223	-4.294		-0.1608	-0.0028	-0.0585	0.364
931	-1.045	-4.534		-0.0672	-0.0074	-0.0727	1.082
936	0.287	-1.813	-4.000	-0.0471	-0.0030	-0.1010	2.145
950	-0.510	-4.297		-0.0983	-0.0026	-0.0392	0.398
954	-1.075	-8.057		-0.0349	-0.0036	-0.0412	1.179
958	-1.621	-8.690	-6.472	-0.0203	-0.0021	-0.0166	0.816
962	0.192	-8.784		-0.0392	-0.0050	-0.0374	0.953
966	-2.544	-5.464		-0.0241	-0.0044	-0.0366	1.516
1073	-2.042	-8.555	-5.022	-0.0349	-0.0015	-0.0218	0.624
1106	-1.530	-5.676	-0.280	-0.0635	-0.0041	-0.0364	0.573

1121	-2.141	-9.084	-2.900	-0.0341	-0.0019	-0.0382	1.119
1130	-1.208	-8.381		-0.0350	-0.0028	-0.0379	1.082
1163	-1.556	-1.026	-4.186	-0.0712	-0.0103	-0.0639	0.898
1180	-2.556	-4.132	-2.084	-0.0400	-0.0076	-0.0183	0.458
1195	-0.649	-6.291		-0.0420	-0.0108	-0.0315	0.750
1230	-0.525	-4.016	-5.471	-0.0647	-0.0035	-0.0194	0.299
1235	-0.348	-2.568		-0.0216	-0.0039	-0.1382	6.410
1278	-1.013	-8.548		-0.0402	-0.0020	-0.0590	1.468
1286	0.776	-6.349	-4.484	-0.1291	-0.0034	-0.0173	0.134
1318	-2.502	-5.227	-2.669	-0.0157	-0.0043	-0.0145	0.921
1325	0.139	-9.280		-0.0354	-0.0037	-0.0426	1.203
1331	-2.506	-8.523	-3.989	-0.0399	-0.0015	-0.0442	1.106
1332	-1.784	-8.007		-0.0284	-0.0025	-0.0411	1.449
1333	-2.364	-8.937	-3.523	-0.0297	-0.0018	-0.0346	1.166
1364	-1.485	-9.529	-3.140	-0.0638	-0.0017	-0.1536	2.409
1370	-1.033	-8.829		-0.0522	-0.0027	-0.0179	0.344
1373	-0.808	-5.978		-0.0520	-0.0041	-0.0954	1.835
1415	-0.956	-6.401	-2.649	-0.0914	-0.0025	-0.0456	0.500
1419	-2.125	-8.319	-4.565	-0.0833	-0.0018	-0.0246	0.295
1422	-1.413	-3.015	-2.428	-0.0255	-0.0016	-0.0311	1.217
1423	-1.297	-7.813		-0.0208	-0.0023	-0.0257	1.235
1449	-2.069	-4.666	-2.803	-0.0482	-0.0020	-0.0341	0.708
1456	-1.956	-7.099		-0.0677	-0.0034	-0.0287	0.424
1457	-1.036	-6.109		-0.0318	-0.0065	-0.0520	1.637
1460	0.130	-5.390		-0.0481	-0.0065	-0.0583	1.211
1468	0.997	-8.234	-4.700	-0.0618	-0.0020	-0.0228	0.369
1471	-0.984	-6.849		-0.0329	-0.0118	-0.0650	1.973
1474	-2.836	-6.125	-2.546	-0.0291	-0.0100	-0.0662	2.271
1482	-2.063	-8.559	-5.212	-0.0214	-0.0007	-0.0213	0.997
1485	-1.696	-3.150	-1.231	-0.0489	-0.0233	-0.0654	1.338
1486	-1.697	-5.905	-2.637	-0.0395	-0.0071	-0.0366	0.927
1493	-1.314	-9.528	-5.587	-0.0979	-0.0015	-0.0178	0.181
1495	-1.940	-10.06		-0.0257	-0.0043	-0.0756	2.946
1506	-2.579	-5.466		-0.0920	-0.0035	-0.0394	0.428
1518	-0.732	-4.941		-0.1157	-0.0062	-0.0501	0.433
1519	-2.790	-8.315		-0.0174	-0.0024	-0.0504	2.891
1521	-2.575	-8.595		-0.0490	-0.0030	-0.0240	0.489
1531	-3.591	-4.298		-0.0808	-0.0077	-0.0152	0.188
1532	-3.368	-8.701	-4.942	-0.0272	-0.0016	-0.0173	0.637
1534	-1.302	-1.615		-0.0384	-0.0056	-0.0469	1.221
1535	-1.124	-2.264		-0.0269	-0.0224	-0.0756	2.807
1536	0.823	-8.528	-1.461	-0.0237	-0.0068	-0.0307	1.294
1537	0.550	-4.907		-0.0299	-0.0206	-0.0223	0.745
1538	0.143	-8.435	-1.870	-0.0179	-0.0107	-0.0185	1.029
1539	0.253	-2.297		-0.0580	-0.0144	-0.0322	0.555
1540	-0.602	-5.658	-1.011	-0.0575	-0.0078	-0.0322	0.561
1541	-0.860	-4.640	-1.367	-0.0765	-0.0064	-0.0228	0.298
1542	-0.770	-6.813	-0.840	-0.1510	-0.0028	-0.0159	0.105
1543	0.037	-2.647		-0.1839	-0.0066	-0.0386	0.210
1544	0.838	-4.316		-0.1102	-0.0039	-0.0258	0.234
1545	0.613	-4.322		-0.0363	-0.0196	-0.0308	0.848

1546	-0.566	-4.185		-0.1730	-0.0066	-0.0255	0.147
1547	-0.106	-8.395	-0.202	-0.0743	-0.0036	-0.0191	0.257
1548	-0.745	-3.913		-0.1551	-0.0054	-0.0263	0.170
1549	-0.911	-3.206		-0.0855	-0.0053	-0.0397	0.464
1550	1.083	-7.698	-4.634	-0.0366	-0.0034	-0.0637	1.742

5. REFERENCES

- BEN-AKIVA, M.; LERMAN, S. (1985): DISCRETE CHOICE ANALYSIS: THEORY AND APPLICATION TO TRAVEL DEMAND. MIT Press. Cambridge, MA.

- BEN-AKIVA, M.; BIERLAIRE, M. (1999): “DISCRETE CHOICE METHODS AND THEIR APPLICATION IN SHORT TERM TRAVEL DECISIONS”. In Hall R. (1999): The handbook of transportation science. Kluwer, Dordrecht, The Netherlands, 5-33.

- BEN-AKIVA, M.; BOLDUC, D.; BRADLEY, M. (1993): “ESTIMATION OF TRAVEL MODE CHOICE MODELS WITH RANDOMLY DISTRIBUTED VALUES OF TIME”. Transportation Research Record, 1413, 88-97.

- BOS, I. D. M.; VAN DER HEIJDEN, R. E. C. M.; MOLIN, E. J. E.; TIMMERMANS, H. J. P. (2004): “THE CHOICE OF PARK AND RIDE FACILITIES: AN ANALYSIS USING A CONTEXT-DEPENDENT HIERARCHICAL CHOICE EXPERIMENT”. Environment and Planning A, 36 (9): 1673-1686.

- DIJK, M.; MONTALVO, C. (2011): “POLICY FRAMES OF PARK-AND-RIDE IN EUROPE”. Journal of Transport Geography, 19 (6): 1106-1119.

- HENSHER, D. A. (1976): “THE VALUE OF COMMUTER TRAVEL TIME SAVINGS: EMPIRICAL ESTIMATION USING AN ALTERNATIVE VALUATION MODEL”. Jour. Of Transport Economics and Policy, 10(2): 167-176.

- HENSHER, D. A. (1994): “STATED PREFERENCE ANALYSIS OF TRAVEL CHOICES: THE STATE OF THE PRACTICE”. Transportation, 21: 107-33.

- HENSHER, D. A.; GREENE W. H. (2003): “THE MIXED LOGIT MODEL: THE STATE OF PRACTICE”. Transportation 30: 133-176.

- HUBER, J.; ZWERINA, K. (1996): “THE IMPORTANCE OF UTILITY BALANCE IN EFFICIENT CHOICE DESIGNS”. Journal of Marketing Research, 33 (August): 307-317.

- MC FADDEN, D. (1973): "CONDITIONAL LOGIT ANALYSIS OF QUALITATIVE CHOICE BEHAVIOR". In Zarembka P. (ed.): Frontiers of Econometrics, Academic Press, New York.

- MC FADDEN, D. (1975): "THE MEASUREMENT OF URBAN TRAVEL DEMAND". University of California, Berkeley, USA.

- MC FADDEN, D.; TALVITIE, A.; COSSLETT, S.; HASSAN, I.; JOHNSON, M.; REID, F.; TRAIN, K. E. (1977): "DEMAND MODEL ESTIMATION AND VALIDATION". Final Report, Volume V, Urban travel demand forecasting project. Institute of Transportation Statistics, Univ. of California, Berkeley.

- MC FADDEN, D.; TRAIN, K. E. (2000): "MIXED MNL MODELS FOR DISCRETE RESPONSE". Journal of Applied Econometrics, 81: 447-770.

- PICASSO, E. P.; BONOLI, M.; PEÑA, G.; MERMOZ, O. (2012): "ESTIMACIÓN DE LA DEMANDA DE N ESTACIONAMIENTO PERIFÉRICO MEDIANTE MODELOS DE ELECCIÓN DISCRETA". Anales de la Escuela de Perfeccionamiento de Investigación Operativa, ISSN 1863-9777.

- RISA HOLE, A. (2004): "FORECASTING THE DEMAND FOR AN EMPLOYEE PARK AND RIDE SERVICE USING COMMUTERS' STATED CHOICES". Transport Policy, 11 (4): 355-362.

- THURSTONE, L. L. (1927). "A LAW OF COMPARATIVE JUDGMENT". Psychological Review, 34: 273-286.

- TRAIN, K. E. (2009): "DISCRETE CHOICE METHODS WITH SIMULATION". Cambridge Univ. Press.