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Abstract: This paper focuses on the choice valuation of traffic restrictions while entering Lisbon city based on individual preferences for noise, pollution and congestion. The analysis employs a questionnaire distributed in 2007 to ascertain the significant characteristics of traveling to Lisbon, with the aim of curbing the number of cars that enter the city daily. A random parameter logit model is used to analyze the characteristics (e.g. individual characteristics, motivations, type of transport used) that are associated with the probability of individuals supporting a fee on private cars entering the city. The model also takes into account the uncontrolled heterogeneity of the data. Some policy implications are also presented.

Keywords: Transportation, Lisbon, Mixed Logit Model, Public Policy.

1. Introduction

London and Durham were the first cities that introduced a fee to limit private cars from entering the main city. Subsequently restricting private cars from entering the city became a policy device contemplated at the European level (Blythe, 2005). Similar initiatives are currently spreading across Europe, such as the restrictions adopted in Stockholm (Hensher and Pucket, 2007). This policy device is being considered as future policy for all major European cities that are confronted with high levels of pollution, noise and congestion. Congestion affects traffic safety, (Noland and Quddus, 2005) while pollution and noise affect health. These factors therefore provide the motivation to restrict traffic inside the city. Lisbon is no exception and the media highlights this policy device regularly by making it part of its agenda. Based on this hypothesis, a questionnaire was distributed in Lisbon to individuals who live in the outskirts and need to travel everyday to the main part of the city. A mixed logit model was used to analyze individual preferences to introduce a fee on private cars entering the city.

This paper contributes to the literature by analyzing transportation in a market that has not been previously analyzed and focusing on the factors of congestion, noise and pollution to restrict traffic inside cities. Moreover, it demonstrates that individual heterogeneity requires analysis using adequate statistical models that allow the identification of this heterogeneity. This type of analysis should be developed with econometric models that perform this function, such as a mixed logit model (Train 2003). The mixed logit model has been used previously in transportation by Hess, Bierlaire and Polak (2005), Cirillo and Axhausen (2006), Greene and Hensher (2007), Pucket and Hensher (2007) and Hensher (2008).

The objective of this study was to understand the behavioral process that leads Lisbon citizens to value traffic negative externalities and support the imposition of a fee on traffic entering the city. In a causal perspective, factors collectively determine this decision. Some of these factors can be observed and others cannot. Among the observed variables, some are random, i.e., they vary along the sample in a random way and depend on the non-observed characteristics. The mixed logit model estimates individuals' preferences by deriving the distribution based on their known choices within the sample. The conditional density is estimated by simulation, allowing for different distributions of the error term (see Hensher, Rose and Greene, 2005 and Train, 2003, for details).

The mixed logit model is considered to be the most promising state-of-the-art discrete choice model currently available to analyze questionnaire data (Hensher and Greene 2003). The advantage of the mixed logit model over alternative models is based on two improvements to previous models. First, it allows the error term to combine different statistical distributions, which is an improvement on the alternative specifications model that relies on one specific distribution. Second, it allows for random taste variation parameters (parameters that describe characteristics not linked to observed characteristics), whereas the traditional logit model allows for taste variation related only to observed characteristics.

The mixed logit model is currently applied in different fields, such as terrorism (Barros and Proença 2005), agriculture (Alfnes 2004), transportation (Bath 1996, 1998, 2000; Brownstone and Train 1999; Brownstone, Bunch and Train 2000), recreation (Train 1998), energy (Revelt and Train 1998) and marketing (Bonnet and Simioni 2001). Therefore, this paper enriches previous research on transportation, adopting a novel approach which is the mixed logit model to analyze the probability to support preventive steps to ease traffic congestion inside Lisbon. A thorough survey of state choice methods and applications can be found in Louviere, Hensher and Swait (2000) and Hensher, Rose and Greene (2005).

This paper is organized as follows: in the next section we present the contextual setting. In section 3 we present the literature review; in section 4, we explain the theoretical framework; in section 5, the methodology is explained; in section 6 the research design is presented, and in section 7 the empirical study is described. The findings are discussed in section 7; and the conclusions, limitations and extensions of the research are presented in section 8.

2. Contextual Setting

Lisbon is an old city, with many buildings in bad condition due to a rent policy that has been in place for more than fifty years that limited rent increases thus inducing owners to abandon the refurbishment of buildings. Due to the dilapidated conditions of buildings inside the city, many workers live in new quarters in the outskirts and have to travel to the city daily. The intense traffic results in noise, pollution and congestion. Moreover, the number of accidents inside the city is high (number of deaths in 2005 due to road accidents was 41). No clear policy has been planned to restrict the traffic, and the sole policy presently in place is to implement speed limits inside the city.

The municipality has taken few steps to streamline traffic. Late 2007 the municipality established velocity limits inside the city. This policy does not resolve congestion, pollution and noise. Therefore, the media has emphasized the need to restrict traffic inside the city streets. At the same time, this agenda raises the problem of adequate public transport. Public transport in Lisbon mainly consists of a public bus company named Carris (www. Carris. Pt), and a public metro company. Road charges are levied only on highways. The country has no experience of the congestion charging scheme. However, many Lisbon citizens are aware of London’s charging fee because of publicity generated by the media.

3. Literature Review

Restriction on transportations, mainly air travel have been analyzed by Williams, Noland and Toumi (2002). They focus on air travel because of aircraft emissions and the creation of high altitude contrails. Deschinkel, Farges and Delahaye (2002) propose an heuristic algorithm for air traffic management. More in line with the present research, Blythe (2005) analyzes road user charging in the UK. Research using the mixed logit model focuses on the identification of heterogeneous individual preferences among travelers. Hess, Bierlaire and Polak (2005) analyze preferences about the value of travel-time savings with a mixed multinomial logit model. Cirillo and Axhausen (2006) analyze preferences related to the values of travel savings that are negative with a mixed logit with non Gaussian distributions. Hensher (2008) analyzes the role played by passengers in the value of travel-time savings of non-commuting car drivers with a mixed logit model to evaluate road toll related to the occupancy status of the car. Pucket and Hensher (2007) analyze individual preferences for travel packages permitting the implementation of distance-based road user charges. Greene and Hensher (2007) estimate elasticities on in-vehicle time for different types of traffic (rail and bus) adopting different specifications of the mixed logit model. It can be verified from this review that the topic that has been analyzed with mixed logit models are the individual preferences for the value of travel-time savings Jara Diaz and Guevara (2003) and Perez et al. (2003), Bhat (1998, 2000). Therefore, the focus on individual preferences for congestion, pollution and noise as motivations to restrict traffic inside cities is an innovation in this context. Hensher (2001a,b,c) analyse time saving valuations from commuters with the mixed logit.

4. Theoretical Framework

Transport services are those that can be described by a vector of different characteristics embodying, for example, time, costs and quality. Becker (1965) and Lancaster (1966) suggested that utility is derived from the characteristics of the service and not the service itself. When this theory is applied to transport, administrators can make a choice to ban cars from entering a city and use it as an input for studying individual preferences, alongside income and price.

5. Methodology

Consider the Lisbon travelers who enter the city daily. The main goal is to determine the probability that commuters will support a public policy restricting the entrance of cars into the city given some characteristics, denoted by the vector of x_i. To calculate the probability, *d*efine a binary random variable y_i, that verifies $y_i = 1$ if the traveler supports the restriction and $y_i = 0$ otherwise, then the aimed probability is $P(y_i = 1 \mid x_i)$.

Models to determine the probability of an event given a set of characteristics, x_i, can be derived based on a latent variable, y_i^*, that is not observed and verifies $y_i^* = \beta' x_i + \varepsilon_i$, where β is a vector of unknown parameters, and ε_i is an unobserved random variable allowing that individuals with the same characteristics x_i have different outcomes. To use the general framework of binary dependent models, let us simply suppose that $y_i = 1$ if $y_i^* > 0$ and $y_i = 0$ otherwise. Then $P(y_i = 1 \mid x_i) = P(\varepsilon_i > -\beta' x_i)$ and the desired probability depends on the statistical assumptions about ε_i. When ε_i is independent and identically distributed as extreme value type I the above probability is given by the highly popular logit model,

$$P(y_i = 1 \mid x_i) = P(\beta, x_i) = \frac{e^{\beta' x_i}}{1 + e^{\beta' x_i}} \quad (1)$$

McFadden (1974), Ben-Akiva and Lerman (1985) and Train (1986) used the logit model to relate the probability of making a choice to a set of variables reflecting the preferences of decision-maker.

Despite its popularity, the logit has some behavioral limitations. For instance, it does not allow for unobserved heterogeneity in the choice equation and imposes that the error components of the different alternatives are uncorrelated. A more general model is the random parameters logit (RPL) (also called mixed logit), which allows us to relax the assumption that the coefficients are the same for all terrorist events. Therefore, it assumes that an event *i*'s coefficient on some characteristic j, β_{ji}, is a random draw from some distribution where the family of the distribution is specified, but the mean and variance are unknown and have to be estimated. We consider $\beta_i \equiv \mu + \eta_i$ with $\eta_i \sim F(0, \Omega)$, independent of ε_i. When $F(\bullet)$ is symmetric, it is usually considered to be the normal, and less often, the uniform or triangular distribution. If, for example, the coefficient can only assume positive values with asymmetric distribution, $F(\bullet)$ is usually lognormal. The latent variable equation can be written as: $y_i^* = \mu' x_i + \eta_i' x_i + \varepsilon_i$, where the random unobserved component, $\eta_i' x_i + \varepsilon_i$, is heterogeneous, with heterogeneity depending on the explanatory variables.

The RPL probability of supporting a fee on entering Lisbon is the integral of the standard logit probability in (1) over the density of the parameters,

$$P_i = \int_{-\infty}^{+\infty} \ldots \int_{-\infty}^{+\infty} P(\beta, x_i) f(\beta / \mu, \Omega) d\beta . \quad (2)$$

The model estimates the coefficients mean, μ, and the covariance between them, Ω. Exact maximum-likelihood estimation is not possible, since the integral cannot be calculated analytically and requires simulation. Recently developed techniques for simulating probabilities (Train, 2003) have made it feasible to estimate such models. Applications include Train (1998), Revelt and Train (1998), Mcfadden and Train (2000) and Rouwendal and Meijer (2001). Observe that P_i is the expectation of, $P(\beta, x_i)$ so that it can be calculated by summing over R simulated $P(\beta_i, x_i)$ with β_i drawn from $F(\beta / \mu, \Omega)$. These draws can be obtained randomly using a pseudo-random generator but more recently, systematic methods, such as Halton draws, have proved to be more efficient (see Train (2003) for further details). The simulated probability is:

$$SP_i = \frac{1}{R} \sum_{r=1}^{R} P(\beta_i^r, x_i), \quad (3)$$

where β_i^r is the β from the rth draw from $F(\beta / \mu, \Omega)$ for event *i*. Thus the simulated log-likelihood function for the RPL is:

$$SL = \sum_{i=1}^{N} \log\left[SP_i^{y_i} \left(1 - SP_i\right)^{1-y_i} \right], \qquad (4)$$

which depends on μ and Ω. The maximum- likelihood estimates of those parameters (given their chosen initial values) are obtained with iterative numerical optimization procedures (see Train (2003) and Hensher and Greene (2003) for further explanations). Additionally, we remark that the mixed logit allows for heteroskedasticity in the error term, depending on the explanatory variables.

Unobserved heterogeneity has been a subject of concern and analysis in many recent works as, Chesher (1984), Chesher and Santos Silva (2002), and McFadden and Train (2000). Unobserved heterogeneity is frequent in the behavior of individuals and neglecting this aspect is likely to lead to inconsistent parameter estimates or more importantly, inconsistent fitted choice probabilities.

In this paper we have adopted the random coefficients logit or mixed logit of McFadden and Train (2000). The model needs sophisticated calculations and some assumptions in the form of the distribution of ν_i. It consistently estimates the parameters and the choice probabilities if the distributional assumptions are correctly stated.

6. Research Design

Let us now consider the individual who travels to Lisbon by car and declares that he/she supports a restriction on private cars entering the city. This declaration is based on the utility the individual receives from choosing to support the restrictions in comparison with the utility received from an alternative choice. This utility defines the following hypothesis:

Hypothesis 1: Individual travelers who choose to support the fee are those who are attracted by choice attributes related to pollution, noise and congestion. This is a traditional hypothesis in transportation demand models. Usually, the attributes are considered as the main choice determinant (Hensher and Puckett, 2006; Safirova, Gillingham and Houde, 2007).

Hypothesis 2: A commuter who chooses to support the fee on cars is characterized by socio-economic characteristics such as age, income, higher level of education, higher social class, married and with children. This is a traditional hypothesis of travel models based on questionnaire data (Srinivasan and Athuru, 2005)

Hypothesis 3: Travelers who choose to support the fee for cars are those who have been adequately informed. The perception formation derives from information previously obtained, which helps the travelers to clarify and to evaluate travel decisions. Testing information attributes within traffic restriction choices enables the researcher to derive managerial implications which are relative to the information management framework.

Hypothesis 4: Travelers who choose to support the fee are those who have temporal constraints and therefore less time to spend on travel, Espino, Román and Ortuzar (2006)

To test the underlined hypotheses, we used a mixed logit representation that assumes that the probability of supporting the fee instead of not supporting it can be described by a cumulative logit-probability function of the exogenous variables Xi, Prob (choice/type):

On the basis of this definition, we estimate the above-mentioned probability for choice i as,

$$\Pr(Choice_i \mid v_i) = \int_{-\infty}^{+\infty} P(\beta, v_i)\, N(\beta_5 \mid \mu_5, \sigma_5)\, d\beta_5 \qquad (5)$$

where $N(\bullet)$ is the normal distribution, and

$$v_i = \beta_0 + \beta_1 Pollution + \beta_2 Noise + \beta_3 Congestion + \beta_4 Income + \beta_5 Civilstate + \beta_6 Class + \\ + \beta_7 Education + \beta_8 Group + \beta_9 Newspaper + \beta_{10} TV + \beta_{11} Treserve + \varepsilon_i$$

(6)

We chose the variables from a questionnaire distributed among this population. We measure v_i by the probability that an individual declares that he supports the fee instead of not supporting it (Yes = 1, No = 0), and measure Xi as observed characteristics. First, we considered travel externalities (pollution, noise and congestion). Second, the individual socio-economic characteristics are examined. Third, the individual information characteristics and finally, temporal constraints are considered.

7. Empirical Study

The empirical study was carried out by means of the previously-mentioned questionnaire, which was presented to stratified, random sample travelers entering Lisbon in the morning traffic jam, with the central aim of determining the extent to which they would choose traffic restrictions in Lisbon. The sample was stratified by transport mode (Car, bus, Train and metro), using the traveler database available in the Traffic institute. Because of budgetary restrictions and the limited time available, it was decided to collect data from 3,000 questionnaires. The interviewers approached the passenger on the chosen modes, using a random procedure where the questionnaire was delivered along with a stamped envelope to return the filled questionnaire. The questionnaire resulted in 1652 returns letters received, which presents a response rate of 55%. Moreover, after sending the mail many respondents sent highly interested emails to know the results of this research study. Such interest is unusual in questionnaire procedures, and may reflect the social awareness related to this issue.

The rate response does not differ significantly among the population of the age variable (chi-square=8.53, p=0.05), nor for gender (chi-square=7.55, p=0.05). Therefore, we can assert that the 2000 travelers that answered the questionnaire are representative of Lisbon travelers.

The general characteristics of these respondents were male (52%), with an average age of 45, with a college degree. This profile leads to an overall definition of the responding traveller as male, middle-aged and middle-class. Other characteristics of the sample are presented in table 1.

7.1 Reliability, Validity and Generalizability

Several steps were taken to ensure the validity and reliability of the data. First, the point of departure was a questionnaire already applied on transportation, (Srinivasan and Athuru, 2005), which was adapted for the present purpose, ensuring that prior research in the field had been considered and face validity was established. Second, all relevant literature was taken into consideration. Third, the questionnaire was pre-tested on students of economics at the Technical University of Lisbon. Following the administration of the final survey, a stratified random sub-set of 50 respondents were contacted by phone a second time to check if any problem persisted, but no problems were detected. These procedures ensured the content validity of the questionnaire, signifying that it was likely to measure what it intended to measure. Internal consistency was ensured by measuring the correlation between the variables. Reliability (internal consistency) of the scale used was analyzed with Cronbach's alphas of the original item scale, ranging from α=0.67 to α=0.94. Convergent validity of the original scale was established using exploratory factor analysis (principal axis factoring with varimax rotation). Fourth, the questionnaire used for a random sample, with a response rate of 55%, was considered an acceptable sample of respondents (Dillman 1978). This procedure ensured the generalizability of the data, meaning that the findings were applicable to a more general population. Fifth, the reliability of the data was examined, by analyzing it extensively with alternative methods and reaching the same conclusions, (Barros, 2008). The extensive examination of the survey validity, reliability and generalizability leads to the inference that nothing exists in the evaluation to suggest that it is either invalid or unreliable.

7.2 Questionnaire

Our objective was to evaluate the choice of travelers who travel from the outskirts to Lisbon everyday. To investigate this issue, a questionnaire was delivered to randomly selected travelers at randomly selected modes of entrances to Lisbon. An interviewer approached the travelers at their traveling mode (car, train, bus and metro) at the entrance. The questionnaire was pre-tested on students of economics at the Technical University of Lisbon.

The survey was developed to test the hypotheses. The survey includes three sections: the first one characterizes the travelers related to their social economic profile, and considers variables such as social class, age, gender, family and education. The second section presents the tripographic variables and constraints such as the following: budget, travel frequency, temporal constraints. The third section presents their preferences towards noise, pollution and congestion. The set of attributes of travelers' choice considered in this paper is that which is primarily quoted in literature (Srinivasan and Athuru, 2005; Greene and Hensher, 2007). A seven-point Likert-type scale assessed the policy attributes. This scale ranged from "without importance" (1) to "very important" (7).

Table 1 shows the observed variables that assume statistical significance in this model, the proposed questions and the corresponding scales.

Table 1. Characterization of the Variables

Variable	Description	Min[a]	Max[b]	Mean	Std. Dev
Fee	Do you suport a fee to restrict cars from entering the city: yes=1, No =0	0	1	0.490	—
	Destination attributes hypothesis				
Pollution	What was the importance of pollution in your decision? (1-without importance; 7-extremely important)	1	7	5.454	1.465
Noise	What was the importance of noise in your decision? (1-without importance; 7-extremely important)	1	7	5.923	1.368
Congestion	What was the importance of congestion in your decision? (1-without importance; 7-extremely important)	1	7	5.470	1.532
	Socio-demographic characteristics hypothesis				
Income	Travel monthly income (1-lower of 1000 euro; 5- equal or higher than 5000 euro)	1	5	1.981	1.140
Civilstate	Marital status (1-single; 2-married; 3-with children)	1	3	2.260	1.451
Class	Social class (1-lower; 2- middle; 3- upper-middle)	1	3	2.124	0.911
Education	Education (number of years of education) (4-primary school , 24 –PHd)	4	24	14.013	3.461
Group	Travel in groups	0	1	0.252	—
	Information hypothesis				
Newspaper	What was the importance of information obtained in newspapers in your decision? (1-without importance; 7-extremely important)	1	7	4.766	1.524
TV	What was the importance of TV information in your decision? (1-without importance; 7-extremely important)	1	7	4.038	1.483
	Temporal constraints hypothesis				
Long	How long is the travel? (1-less than 15 minutes; 2- 15 minutes or more, but less than a thirty minutes; 3- 1 more than thirty minutes or more; 4- More than 45 minutes ; 5-more than an hour)	1	5	4.036	1.018

[a] Min – Minimum; [b] Max – Maximum

7.3 Results

The survey has three types of variables: dichotomous, continuous and qualitative (7-item Likert scale). Focusing on the adequacy of the mixed logit model, the results display evidence of unobserved heterogeneity depending on income and education common to the three segments analyzed. The survey also shows heterogeneity on the effect of noise on car drivers inducing the estimation of a mixed logit model with random coefficients for these variables. The final results can be seen in Table 2.

Table 2. Mixed Logit Parameter Estimates and t-statistics (dependent variable: Do you support a fee on cars entering Lisbon: Yes=1, No=0)

	Mixed logit-segment : car drivers	Mixed logit-segment : Train commuters	Mixed logit-segment : bus commuters
Variables	Coefficients (t-ratio)	Coefficients (t-ratio)	Coefficients (t-ratio)
Intercept	2.498 (1.882)***	3.212 (21.089)*	4.135 (11.473)*
Pollution	0.163 (3.281)*	0.132 (3.930)*	0.218 (4.498)*
Noise		0.051 (2.836)*	0.412 (3.844)*
Congestion	0.174 (3.229)*	0.213 (2.934)*	0.351 (3.209)*
Income	—	—	—
Civilstate	0.204 (2.188)**	0.317 (2.955)**	0.128 (2.928)**
Class	0.427 (2.679)*	0.512 (3.658)*	0.612 (2.407)**
Education	—	—	—
Group	-0.083 (-2.001)*	0.052 (2.712)*	0.051 (1.804)
Newspaper	0.086 (0.862)	0.512 (0.743)	0.213 (1.862)***
TV	0.152 (0.985)	0.012 (3.201)	0.123 (0.820)
Long	-0.196 (-2.397)*	-0.135 (-2.249)*	-0.035 (-2.212)**
Random Effects			
Noise	0.379 (2.605)*	—	—
Income	0.255 (2.036)**	0.315 (2.030)	0.591 (3.969)**
Education	0.032 (3.113)	0.051 (2.273)	0.125 (3.227)
Observations	642	568	442
LogLikelihood	-294.75	-295.316	-299.967

(Dependent variable: choosing to restrict cars from entering the city)

****means statistically significant at 1%; ** means statistically significant at 5%.

The results of the mixed logit model by different types of transportation mode are presented in Table 2. The parameter estimation and their significance for all the variables are reported. The log likelihood value of the estimated mixed logit model for car drivers is -294.75. The overall fit of this model was reasonably good with Chi-square statistic square value of 19.5 with 41 degrees of freedom and level of significance of 0.0067. The other models display similar values.

The variables are, for the most part, statistically significant and three heterogeneous variables are identified, two common to all travel mode types, education and income. One, specific to car drives which was noise.

7. Findings

The findings pointed to a significant correlation between the probability of supporting a fee on cars with the exogenous variables. For the mixed logit framework, the probability of supporting a fee increases with most of the variables. The probability of supporting a fee decreases with groups traveling in cars and with long travel in all types of transport.

What do the results mean for the hypotheses proposed? First, the model identifies homogenous and heterogeneous variables that explain the probability of accepting the fee. Second, relative to the hypothesis, we accept hypothesis 1 since the three environmental variables are positively related with the probability of supporting the fee and are statistically significant. However, noise is random and therefore reflects heterogeneous opinion among the car drivers. We do not accept hypothesis 2, since the socio-economic variables are for the most part positive, but two of them are heterogeneous (income and education), class and civil state are also positive and statistically significant, but homogenous. However, the group variable is negative for cars. This mixed result makes hypothesis 2 unacceptable. Moreover, we accept hypothesis 3 since TV and newspaper are both positive and statistically significant. Additionally, we do not accept hypothesis 4 because long is negative for all attributes. Finally, how do we interpret these results? These results signify that a high level of support for traffic restrictions exists among travelers with the wealthier and more educated heterogeneously supporting the restriction. Moreover, commuters are highly sensitive to the health effects of pollution, noise and congestion; however, relative to noise this variable is not homogenous among car drivers. Furthermore, socio-economic characteristics support an average the fee, with the exception of the group variable that is negative for cars. Environmental awareness is supported on the information obtained from newspapers and television. The length of travel negatively affects the fee support. Therefore, it is concluded that, on average, travelers support the fee in Lisbon, but car drivers that travel in groups are against it, as are persons with long travel in all types of transport. This leads to the conclusion that such people that are focus on their activity and do not want to be affected by a fee.

8. Conclusions

This paper uses a mixed logit model to analyze the probability of individuals to support a ban on cars entering Lisbon. The data was obtained in a questionnaire undertaken in 2007. The conclusions are that travelers entering the city support a ban in a heterogeneous way.

What is the policy implication of the present research? The policy implication is for the municipality to impose a fee, restricting traffic inside the city. However, the heterogeneity identified signifies that the fee should be allocated in a homogenous way, but rather differentiated according individual preferences. A fee allocated according individual preferences is validated by the individual who pays it.

More research is needed to confirm these results.

References

Alfnes, F., 2004. State Preferences for Imported and Hormone-Treated Beef: Application of a Mixed Logit Model. European Review of Agricultural Economics, 31, 19-37.

Barros, C., and I. Proença, I. , 2005. Mixed Logit Estimation of Radical Islamic Terrorism in Europe and North America. The Journal of Conflict Resolution, 49, 298-314.

Barros, C.P., 2008. Willingness to accept traffic restrictions in Lisbon. Unpublished mimeograph.

Becker, G., 1965. A Theory of the Allocation of Time. Economic Journal 75: 493

517.

Ben-Akiva, M., and Lerman, S., 1985. *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, MA: MIT Press.

Bath, C., 1996. An Endogenous Mode Choice Model with an Application to Intercity Travel. *Transportation Science,* 31, 34-48.

Bhat, C., 1998. Accommodating variations in responsiveness to level of service variables in travel mode choice models, Transportation Research A 32, 455-507.

Bhat, C., 2000. Incorporating observed and unobserved heterogeneity in urban work model choice modeling, Transportation Science 34, 228238.
Becker, G. (1965) A Theory of allocation of time. Economic Journal, 75,493-517.

Blythe, P.T., 2005. Congestion charging: Technical Options for the delivery of future UK policy. Transportation Research Part A, 39, 571-587.

Bonnet, C., and Simioni, M.2001. Assessing Consumer Response to Protected Designation of Origin Labeling: a Mixed Multinomial Logit Approach. *European Review of Agricultural Economics*, 28,433-449.

Brownstone, D., and Train , K.1999. Forecasting New Product Penetration with Flexible Substitution Patterns. *Journal of Econometrics*, 89,109-129.

Brownstone, D., Bunch, D.and Train, K.2000. Joint Mixed Logit Models of State and Revealed Preferences for Alternative-fuel Vehicles.” *Transportation Research Part B*, 34,315-338.

Chesher, A., 1984. Testing for Neglected Heterogeneity. Econometric*a,* 52, 865-872.

Chesher, A. and Santos-Silva, J. 2002. Taste Variation in Discrete Choice Models. *Review of Economic Studies,* 69:147-68.

Cirillo, C. and Axhausen, K.W., 2006. Evidence of the distribution of values of travel time savings from a six-week diary. Transportation Research Part A, 40, 444-457.

Deschinkel; K., Farges, J.L. and Delahaye, D., 2002. Optimizing and assigning price levels for air traffic management. Transportation Research Part E, 38, 3-4, 221-237

Dillman, D., ed. 1978. *Mail and Telephone Surveys: The Total Design Method.* New York: Wiley.

Espino, R., Román, C., Ortuzar, J de D., 2006. Analysing demand for suburban trips: A mixed RP/SP model with latent variables and interaction effects. Transportation, 33, 241-261.

Greene, E.H. and Hensher, D.A., 2007. Heteroscedastic control for random coefficients and error components in mixed logit. Transportation Research part E, 610-623.

Hensher, D.A., 2008. Influence of vehicle occupancy on the valuation of car driver's travel time savings: Identifying important behavioural segments. Transportation Research Part A, 42, 67-76.

Hensher, D.A., 2001a. Measurement of the valuation of travel time savings. Journal of Transport Economics and Policy, 35, 71-98.

Hensher, D.A., 2001b. The sensitivity of the values of travel time savings to the specification of unobserved effects. Transportation Research, 37E, 129-142.

Hensher, D.A. 2001c. The valuation of commuter travel time savings for car drivers: evaluating alternative model specification. Transportation, 28, 101-118.

Hensher, D.A. and Puckett, S.M., 2007. Congestion and variable user charging as an effective travel demand management instrument. Transportation Research Part A, 41, 615-626.

Hensher, D.A., Rose, J.M., and Greene, W., 2005. *Applied Choice Analysis: A Primer.* Cambridge, U.K., Cambridge University Press.

Hensher, D.A. and Greene, W.H. 2003. The mixed logit model: the state of practice. Transportation, 30, (2), 133-176.

Hess, S.; Bierlaire, M., Polak, J.W. 2005. Estimation of value of travel-time savings using mixed logit models. Transportation Research Part A, 39, 221-236.

Jara-Diaz, S.R., Guevara, C.A., 2003.Behind the subjective value of travel time savings- the perception of work, leisure, and travel from a joint mode choice activity model. Journal of Transportation Economics and Policy, 37, 29-46.

Lancaster, K.J., 1966. A new approach to consumer theory. Journal of Political Economy, 74,2, 132-157.

Louviere, J.J., Hensher, D.A., and Swait, J.D., 2000. *State Choice Methods: Analysis and Applications*. Cambridge, Cambridge University Press.

McFadden, D., 1974. Conditional Logit Analysis of Qualitative Choice Behavior", in *Frontiers in econometrics*, edited by P. Zarembka, 105-42. New York: Academic Press.

McFadden, D. and Train, K., 2000. Mixed MNL Models of Discrete Response. *Journal of Applied Econometrics* 15, 447-70.

Noland, R.B., Quddus, M.A., 2005. Congestion and safety: A spatial analysis of London. Transportation Research Part A, 39, 737-754.

Perez, P.E., Martinez, F.J., Ortuzar, J. de D., 2003. Microeconomic formulation and estimation of a residential location choice model: implications for the value of time. Journal of Regional Science, 43,4, 771-789.

Puckett, S.M., Hensher, D.A., 2007. The role of attribute processing strategies in estimating the preferences of road freight stakeholders. Transportation Research Part E (forthcoming).

Revelt, D. and Train, K.1998. Mixed Logit with Repeated Choices: Household's Choices of Appliance Efficiency Level. Review of Economics and Statistics, 80, 647-57.

Safirova, E., Gillingham, K., Houde, S., 2007. Measuring marginal congestion costs of urban transportation: do networks matter? Transportation Research Part A, 41, 734-749.

Srinivasan, K.K. and Athuru, S.R., 2005. Analysis of within-household effects and between-household differences in maintenance activity allocation. Transportation, 32,5, 495-521.

Train, K.,2003. Discrete choice methods with simulation, Cambridge, Cambridge University Press.

Train, K.,1998. Recreational Demand Models with Taste Variation. Land Economics, 74: 230-39.

Train, K.,1986. Qualitative Choice Analysis. Cambridge, MA: MIT Press.

Williams, V.; Noland, R.B., Toumi, R., 2002. Reducing the climate change impacts of aviation by restricting cruise altitudes. Transportation Research Part D, 7, 6, 451-464.