



Identification of some sources of heterogeneity in value of travel time of Tehran LEZ users

S. Kanaani¹, A. R. Mamdoohi^{2*}

¹Institute for Management and Planning Studies, Tehran, Iran

²Faculty of Civil and Environmental Engineering, Tarbiat Modares University, Tehran, Iran

ABSTRACT: Value of travel time (VOTT) plays a key role in the choices of travelers. Empirical studies have shown significant differences in VOTT estimates, which researchers attribute to several factors, including demographic, alternatives, trips, and regional economic characteristics. One of the policies reducing the use of the private car is congestion pricing of the low emission zone (LEZ). This study aims to estimate VOTT and analyze its heterogeneity among users of Tehran LEZ. We use stated preference (SP) data to calibrate mixed logit models, based on which, travelers' value of time is evaluated. The mean value of travel time is calculated 5788 Rials per hour. Results of the mixed logit model indicate a cost coefficient with triangle distribution (mean -0.00036) and a travel time coefficient with normal distribution (mean -0.20838). To investigate the source of VOTT heterogeneity, random coefficients analysis is used for the interaction between coefficients of time and cost and other variables revealing that only cost as a factor with three variables: number of the entrance to LEZ, number of household cars, and high education are significant.

Review History:

Received: Feb. 11, 2021

Revised: Aug. 08, 2021

Accepted: Aug. 09, 2021

Available Online: Jul. 30, 2022

Keywords:

Value of Travel Time

Congestion Pricing

Binary logit model

Mixed logit model

Heterogeneity

1- Introduction

Value of travel time (VOT) is one of the key inputs to travel demand models and is important for the management and appraisal of transport investment decisions. The value of travel time can be defined as the price people are willing to pay to acquire an additional unit of time [1]. The value of travel time has most often been determined by estimating mode choice models and evaluating the marginal rate of substitution between the cost and travel time of the alternative modes [2].

Low emission zone (LEZ) refers to the application of variable pricing on Tehran's central parts facilities to improve system efficiency. Users can pay tolls for reduced travel time, and their willingness to pay is often reflected as Value of Time (VOT).

Many studies have been conducted in estimating VOT, its sources of heterogeneity and investigate the influencing factors. In general, researchers attributed value of time variations to several aspects, including demographic characteristics, transportation alternative attributes, and regional economy [3]. Taste preference was mainly addressed by adopting advanced logit models, such as mixed logit, through the realization of random parameters [3].

This paper investigates Value of Time (VOT) heterogeneity and its changes with travel and individual socio-economic characteristics and applies mixed logit model to stated preference data on commuter choices of whether to use the car to enter LEZ and pay a toll for travel or have changed their travel. The data were obtained from Tehran low emission zone (LEZ) Stated Preference Survey, which focused on automobile drivers.

2- Methodology and case study

The main assumption of the mixed logit model is that the coefficients in the model are the realization of random variables. This assumption generalizes the standard multinomial logit model (MNL) and allows the coefficient to vary across decision-makers and scenarios. The variable property of coefficients allows the mixed logit model to conveniently capture user heterogeneity [4].

Mixed logit is a highly flexible model that can approximate any random utility model [5]. Mixed logit probabilities are the integrals of standard logit probabilities over a density of parameters. Stated more explicitly, a mixed logit model is any model whose choice probabilities can be expressed in the form of relation (1) [6]

*Corresponding author's email: armamdoohi@modares.ac.ir



$$p_{ni} = \int l_{ni}(\beta) f(\beta) d\beta \tag{1}$$

where $L_{ni}(\beta)$ is the logit probability evaluated at parameters β as shown in relation (2) [6].

$$l_{ni}(\beta) = \frac{\exp^{v_{ni}(\beta)}}{\sum_{j=1}^J \exp^{v_{nj}(\beta)}} \tag{2}$$

and $f(\beta)$ is a density function. $V_{ni}(\beta)$ is the observed portion of the utility, which depends on the parameters β [6].

The mixed logit probability can be derived from utility-maximizing behavior in several ways that are formally equivalent but provide different interpretations. The most straightforward derivation, and most widely used in recent applications, is based on random coefficients. The decision maker faces a choice among J alternatives. The utility of person n from alternative j is specified as relation (3) [6].

$$U_{nj}(\beta) = \beta X_{nj} + \varepsilon_{nj} \tag{3}$$

where X_{nj} are observed variables that relate to the alternative and decision maker, β_n is a vector of coefficients of these variables for person n representing that person's tastes, and ε_{nj} is a random term that is iid extreme value. The coefficients vary over decision-makers in the population with density $f(\beta)$. This density is a function of parameters θ that represent, for example, the mean and covariance of the β 's in the population. This specification is the same as for standard logit except that β varies over decision-makers rather than being fixed [6].

The study used data obtained from Tehran LEZ Stated Preference Survey conducted between December 11 and 21, 2011. The survey gathered information from automobile drivers who recently made a trip in the LEZ. The survey gathered information from 1004 respondents. Each respondent faced nine SP scenarios. The final dataset contains 2 choice alternatives, including Changing or Do not change the trip

The mixed logit model revealed significant standard deviation values for two random parameters, indicating the existence of taste heterogeneity among the users.

Interaction effects were added to the model to further identify the potential sources of heterogeneity for travel time and cost in the dataset. Various socioeconomic demographic characteristics and trip attributes were tested in the model, such as age, gender, Number of household employees, trip purpose, Number of entrances in month and employee in zone* occupancy. Table 1 lists the variables used in the final

Table 1. Variables used in the final mixed model

Variable	Description
Month	Number of entrances in month
Pubac	Access to public transportation
Nhhemp	Number of household employee
Maxwtp	Maximum willingness to pay
Cpacp	Congestion pricing acceptance
Pasjob	employee in zone* occupancy
Eoacp	Acceptance of EO zone omission
Jobdolati	government job
Retired	Retirement
Jobazad	Freelance
Prpsjb	The purpose of the business trip
Ennum	Number of entrances in last trip
Nhhcar	Number of household car
Academi	Having a university education
Atime	Travel time
aprice	Travel cost

mixed model.

Accordingly, instead of approximating random parameters with their mean values for all observations, they help the analyst develop a theoretical formula for each of the random parameters based on its loading on each source of heterogeneity.

3- Results and Discussion

Travel time and travel cost were treated as random parameters. As shown in Table 2 according to many models result, ρ_2 and $LL(\beta)$, Normal distribution was assumed for time, parameter while a triangular distribution was assumed for the cost parameter.

Table 2. Choosing random parameters distribution

Time Distribution	Cost Distribution	ρ_2	$LL(\beta)$
Normal	Uniform	0.1322	-5424.74
	Triangular	0.1324	-5424.03
Uniform	Normal	0.1321	-5424.6
	Triangular	0.1323	-5424.42
Triangular	Normal	0.1321	-5425.47
	Uniform	0.1324	-5424.66

According to the Mixed logit model results given in the Table 3 indicated an average value of 5788 Rials per hour with significant heterogeneity among the travelers, the model showed that in general: Individuals with academic education have 304.6 Rials per hour value of time less than others. As shown in Figure 1 and Figure 2 Number of household car and the Number of entrances in last trip to LEZ have a direct effect on VOT and Respectively increase it up to 4134.5 and 28941.7 Rials per hour.

Table 3. Final mixed logit model results

	Variable	Coefficient		
		value		
	constant	2.13		
Non-random independent variables	Month	0.02	3.66	
	Pubac	-0.26	-3.95	
	Nhhemp	0.07	1.77	
	Maxwtp	0.00002	3.3	
	Cpacp	0.90	8.77	
	Pasjob	0.13	3.02	
	Eoacp	0.32	3.71	
	Jobdolati	-0.39	-3.55	
	Retired	-0.64	-4.85	
	Jobazad	-0.64	-3.16	
	Prpsjb	-0.13	-1.73	
	Heterogeneity	Ennum	0.00003	6.66
		Nhhcar	0.00005	7.02
Academi		-0.00002	-2.54	
Random parameters Mean	Atime	-0.20838	-3.8	
	aprice	-0.00036	-12.32	
Random parameters Standard deviation	Atime	0.10419	3.8	
	aprice	0.00038	6.77	
Model evaluation results	observations	9036		
	p2adj	0.1329		
	p2	0.1346		
	LL(β)	5419.99		
	LL(c)	6220.75		
	LL(0)	6263.28		
	Percent Correct	67.44		
	VOT	5788.30		

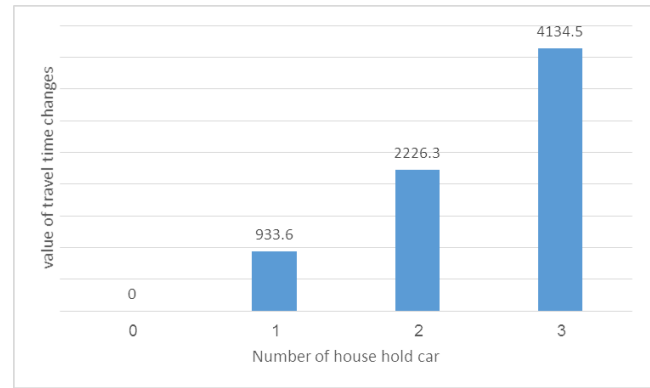


Fig. 1. VOT changes with increasing number of household cars

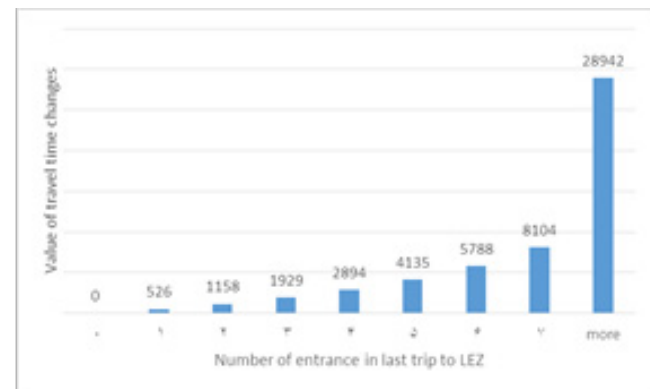


Fig. 2. VOT changes with the increasing number of the entrance to zone in the last tripe to LEZ

4- Conclusions

In general, the appropriate appraisal of almost any transport system requires monetary estimates of the value of travel time. The proposed data and model introduce some sources of heterogeneity in the value of travel time of Tehran LEZ users with 1004 respondents which faced nine SP scenarios. Various socioeconomic demographic characteristics and trip attributes were tested in the model. An average value of 5788 Rials per hour among travelers. According to the results of the mixed logit model with interaction effects, the potential sources of heterogeneity for travel cost in the dataset are Academic education, Number of household car and Number of entrance to zone that totally change VOT up to 33380.8 Rials per hour

References

[1] T.C. Lam, K.A. Small, The value of time and reliability: measurement from a value pricing experiment, *Transportation Research Part E: Logistics and Transportation Review*, 37(2) (2001) 231-251.
 [2] I.C. Athira, C.P. Muneera, K. Krishnamurthy, M.V.L.R.

- Anjaneyulu, Estimation of Value of Travel Time for Work Trips, *Transportation Research Procedia*, 17 (2016) 116-123.
- [3] M.S. Hossan, H. Asgari, X. Jin, Investigating preference heterogeneity in Value of Time (VOT) and Value of Reliability (VOR) estimation for managed lanes, *Transportation Research Part A: Policy and Practice*, 94 (2016) 638-649.
- [4] D. Hensher, J. Rose, W. Greene, *Applied Choice Analysis*, 2005.
- [5] D. McFadden, K. Train, Mixed MNL models for discrete response, *Journal of Applied Econometrics*, 15(5) (2000) 447-470.
- [6] K.E. Train, *Discrete choice methods with simulation*, Cambridge university press, 2009.

HOW TO CITE THIS ARTICLE

S. Kanaani, A. R. Mamdoohi, *Identification of some sources of heterogeneity in value of travel time of Tehran LEZ users*, *Amirkabir J. Civil Eng.*, 54(11) (2023) 829-832.

DOI: 10.22060/ceej.2022.19624.7213

