

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

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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 that to several factors, including: demographic, alternatives, trip, and regional economic characteristics. One of the policies reducing use of 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 mixed logit model indicate cost coefficient with triangle distribution (mean -0.00036) and 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 entrance to LEZ, number of house hold cars, and high education are significant.

KEYWORDS

Value of Travel Time, Congestion Pricing, Binary logit model, Mixed logit model, Heterogeneity

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1. Introduction

Value of travel time (VOT) is one of the key inputs to travel demand models and is important for 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]. Value of travel time has most often been determined by estimating mode choice models and evaluating marginal rate of substitution between the cost and travel time of the alternative modes[2].

Low emission zone (LEZ) refer to the application of various 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 investigating 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 the travel and individual socio-economic characteristics and applies mixed logit model to stated preference data on commuter choices of whether to use car to enter LEZ and pay a toll for travel or have change 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 mixed logit model is that the coefficients in the model are 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 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].

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

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

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

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]

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

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 house hold employee, trip purpose, Number of entrance

in month and employee in zone* occupancy. "Table 1" lists the variables used in the final mixed model.

Table 1. Variables used in the final mixed model

Variable	Description
Month	Number of entrance in month
Pubac	Access to public transportation
Nhhemp	Number of house hold 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 entrance in last trip
Nhhcar	Number of house hold car
Academi	Having a university education
Atime	Travel time
aprice	Travel cost

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 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 house hold car and Number of entrance 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	
Non-random independent variables	constant	2.13	
	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
Heterogeneity	Jobazad	-0.64	-3.16
	Prpsjb	-0.13	-1.73
	Ennum	0.00003	6.66
	Nhhcar	0.00005	7.02
Random parameters Mean	Academi	-	-2.54
	Atime	-	-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	
	ρ^2_{adj}	0.1329	
	ρ^2	0.1346	
	$LL(\beta)$	-	
	$LL(c)$	5419.99	
	$LL(0)$	-	
	Percent Correct	6220.75	
	VOT	-	
		6263.28	
		67.44	
	5788.30		

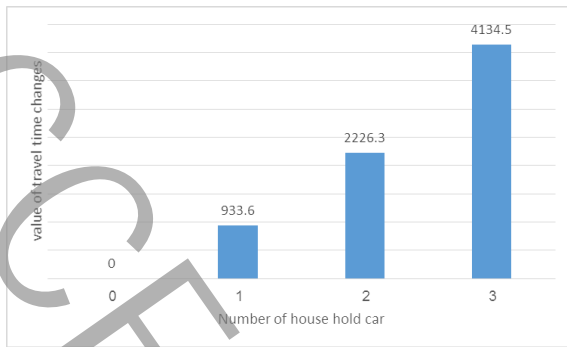


Figure 1. VOT changes with increasing number of household cars

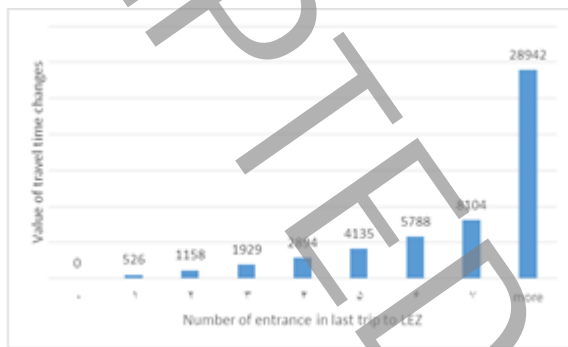


Figure 2. VOT changes with increasing number of entrance to zone in last tripe to LEZ

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 introduces some sources of heterogeneity in 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 the travelers. According to results of mixed logit model with interaction effects the potential sources of heterogeneity for travel cost in the dataset are Academic education, Number of house hold car and Number of entrance to zone that totally change VOT up to 33380.8 Rials per hour

5. References

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