MULTI-ATTRIBUTE VALUATION USING RANDOM COEFFICIENT MODEL

Kumamoto University, Member, PARUMOG Michelle
Kumamoto University, Member, MIZOKAMI Shoshi

1. Introduction

When we think about environmental amenity, say road and roadside environment, various images inevitably enter our minds and is difficult to capture generally. An image can be a predominant or mixed picture of various environmental attributes such as landscape, perception of air or noise quality levels, and even the degree of safeness of road infrastructure. Stated-preference valuation survey leading to aggregated estimate of this effect may lead respondents to think lexicographically, giving priority to attributes he/she perceives more and thus lead to estimates that changes according to both attributes and individuals.

Various discrete choice models to accounting for taste heterogeneity, attitude, and correlation structure among alternatives have been developed. Such models are probit, GEV, latent class and the current pervasively used mixed logit models. Considering full parametric correlation structure will leave us probit and mixed logit, the later of which is easier to estimate and is not constrained to normal distribution.

To study the multi-attribute nature of environmental valuation, a stated choice conjoint experiment is performed and estimated using multinomial logit (MNL) model. To account for taste heterogeneity, a mixed multinomial logit (MMNL) model is estimated. Comparison of models' estimate robustness on the context of multi-attribute valuation is examined.

2. Stated choice experiment

The data used in this experiment was derived from a pre-test survey conducted of road and roadside environment in Metro Manila (MM) via internet survey. Respondents are workers from different business districts within MM. Valuations are done on the framework of binary route choice experiment. Environment attributes investigated are: (1) air pollution, (2) noise pollution, (3) landscape, and (4) road safety. At first, the respondent was asked to imagine that his/her regular working trip takes about is 60 minutes and average transportation cost of 30 pesos. Then, he/she was asked to choose between two route options offering environmental improvements. Each route choice problem contains two alternatives in which attribute levels are drawn randomly from the following set. Questionnaire in HTML was embedded with script randomizing attribute levels. The process was repeated three times. See www.civi.kumamoto-u.ac.jp/keikaku/ROADSIDEENV2.htm for questionnaire details.

Table 1. Attribute levels

Attributes	Attribute levels set
Travel time:	30 minutes, 45 minutes, 60 minutes, 75minutes
Travel Cost:	30 PhP, 40 PhP, 50 PhP, 100 PhP
Air Pollution:	20% improvement, 50% improvement
Noise Pollution:	20% improvement, 50% improvement
Landscape:	with improvement, without improvement
Accidents/year:	20 acc./year, 50 acc./year, 100 acc./year

A total of 176 data were used in the analysis. Majority of the respondents are employees in Makati and Ortigas CBD. Around 61% of the respondents are male and the average age is 30 years old.

3. Fixed Coefficient Model

To determine robustness of models incorporating taste heterogeneity, we first estimated binary MNL model with linear utility function for each *j* alternative specified linearly as:

$$V_j = \beta_1 TT_j + \beta_2 TC_j + f(\beta_{ATT}, ATT_j) + \varepsilon_j,\ j=1,2 \qquad (1)$$

where TT stands for travel time, TC stands for transportation cost and $f(\cdot)$ stands for the function describing environmental attributes effect which is assumed to follow the following linear form:

$$f(\theta, ATT) = \beta_3 AIR + \beta_4 NOISE + \beta_5 LA + \beta_6 ACC + \varepsilon_{ATT} \qquad (2)$$

In this function, AIR stands for air pollution level (1-% reduction), NOISE stands for noise pollution level (1-% reduction), LA is a dummy representing improvement (with or without) and ACC is number of accidents.

Assuming effects of attributes are captured in deterministic part (i.e. $\varepsilon_{ATT} = 0$), willingness to pay (WTP) indicator in this choice problem can be described by the subjective elasticity of attribute coefficient, say air pollution reduction (SVAIR), with respect to cost computed for each observation *i*. The value of a unit of air pollution reduction (VAIR) can then be computed by averaging subjective value over all observations.

$$SVAIR_i = \frac{\partial V / \partial AIR}{\partial V / \partial TC};\quad VAIR = \sum_{i=1}^{n} \frac{SVAIR_i}{n} \qquad (3)$$

For simplicity in notation, this shall be referred to as β_3 / β_2 in the following discussions.

4. Random Coefficient Model

Since perception per individual varies, it is not likely for the estimated coefficients to be fixed across individuals. To consider this, we estimated an MMNL model (Train, 2003) where not only stochastic part of the indirect utility, but also alternative attribute coefficients, varies randomly. Assuming for instance that β follows a continuous normal distribution the choice probability is specified as:

$$P = \int \left(\frac{e^{V_j}}{1+e^{V_j}} \right) \phi(\beta \mid b, \Omega) d\beta \qquad (4)$$

where $\phi(\beta \mid b, \Omega)$ is a normal density with mean *b* and covariance Ω. This can be estimated by maximum simulated likelihood where P is estimated by drawing values of β from assumed density, then calculating average to compute the simulated probability $\tilde{P}_{nj}$ as follows:

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Address : 2-39-1, Kurokami, Kumamoto City, Kumamoto, Japan 860-8555 TEL: +81-96-342-3541 FAX: +81-96-342-3541/3507

$$SSL = \sum_{n=1}^{N}\sum_{j=1}^{J} \theta_{nj} \ln \tilde{P}_{nj}$$

where θ_{ni} is the choice dummy.

Two types of the random coefficient model are estimated, one considering cost coefficient constant (MMNL) and the other holding the cost coefficient fixed (MMNL-FC). Cost parameter was considered fixed to facilitate easier interpretation of substitution pattern which is more important in valuation problem (Hess et.al., 2005).

5. Results and Discussion

Models MNL, MMNL and MMNL-FC was estimated using a non-commercial estimation package BIOGEME 1.2 by Bierlaire (2003). Pseudo random numbers were used to simulate normal distribution of the coefficients. Table 1 shows parameter estimates of the different models, t-statistics are shown in the parentheses.

Table 1. MNL, MMNL and MMNL-FC models

	MNL	MMNL	MMNL-FC
α_2	-0.302 (-1.47)	-0.430 (-0.80)	-1.935 (-0.79)
β_1 (Travel time)	-0.048 (-5.35)	-0.135 (-1.36)	-1.052 (-1.13)
σ_1		0.086 (0.82)	0.808 (1.13)
β_2 (Travel cost)	-0.023 (-3.88)	-0.057 (-1.62)	-0.393 (-1.13)
σ_2		-0.011 (0.04)	
β_3 (Air pollution)	-0.032 (-3.02)	-2.590 (-0.85)	-0.525 (-1.08)
σ_3		-0.514 (-1.05)	-0.230 (-1.03)
β_4 (Noise pollution)	-0.009 (-0.93)	0.149 (0.95)	-0.277 (-1.07)
σ_4		-0.297 (-0.97)	-0.198 (-1.08)
β_5 (Landscape)	-0.345 (-1.17)	-0.365 (-1.00)	-0.344 (-0.12)
σ_5		-0.343 (-0.95)	0.444 (0.16)
β_6 (Road safety)	-0.027 (-5.18)	0.451 (1.01)	-0.919 -(1.13)
σ_6		-0.075 (-0.74)	-1.044 (-1.13)
Parameters	7	13	12
N	176	176	176
LR	83.375	100.480	106.255
Adjusted ρ^2	0.284	0.305	0.337

Based on goodness of fit indicator adjusted ρ^2, random coefficient models provide more robust than the fixed parameter model. MMNL model shows that cost parameter did not significantly vary across individuals. The explanatory power of the landscape and noise parameters is marginal across all models. Estimates of WTP for the different road environment attributes based on equation 3 and its confidence interval are shown in Table 2.

Table 2. WTP estimates and confidence intervals

	MNL	MMNL	MMNL-FC
β_1 / β_2 (PhP/minute)	0.63 (0.60-0.67)	0.84 (0.82-0.86)	0.61 (0.58-0.64)
β_3 / β_2 (PhP/1%improvement in air)	1.27 (1.24-1.30)	1.13 (1.11-1.14)	1.19 (1.17-1.21)
β_4 / β_2 (PhP/1%improvement in noise)	1.27 (1.24-1.30)	1.10 (1.08-1.11)	1.19 (1.17-1.21)
β_5 / β_2 (PhP/landscape improvement)	1.30 (1.27-1.33)	1.10 (1.09-1.11)	1.19 (1.17-1.21)
β_6 / β_2 (PhP/accident)	1.00 (0.96-1.04)	0.45 (0.42-0.48)	0.81 (0.77-0.84)

*1PhP=2JPY

Except for the valuation of road safety, estimates show somewhat consistent estimates. Tighter confidence intervals are produced by the random coefficient than the MNL model.

Correlation structure based on the computed covariance matrix in MMNL model along with the t-statistics of its estimate in parenthesis is presented in Table 3. None of the correlation coefficient is found to be significant. This correlation in parameter may be avoided by designing better attribute levels in Table 1.

Table 3. Correlation structure of estimated parameters

	α_2	β_1	β_2	β_3	β_4	β_5
β_1	0.85 (-0.78)					
β_2	0.83 (-0.82)	0.96 (-1.10)				
β_3	0.86 (-0.82)	0.40 (-0.94)	0.96 (0.41)			
β_4	0.49 (-0.83)	0.85 (-0.96)	0.40 (-0.79)	0.43 (-0.81)		
β_5	0.74 (0.55)	0.99 (0.97)	0.85 (0.98)	0.84 (0.98)	0.42 (0.99)	
β_6	0.85 (-0.82)	0.43 (-1.07)	0.99 (-0.67)	0.96 (-0.67)	0.86 (0.76)	0.86 (-0.99)

6. Conclusion

Carrying out stated choice experiment via internet survey is found to be convenient as choice attributes can be easily randomized. Sampling, however, must be carefully designed in this type of survey.

Though the pre-test data used in this survey is very limited, random coefficient models and estimate provided more robust estimate than fixed model. It should be noted however that run time of random coefficient model is significantly longer than that of fixed parameter. In terms of multi-attribute analysis of environmental change, better interpretation of the model can be done using random coefficient model on the context of: (1) how choice attribute parameter varies across individual, (2) inherent correlation structure depicting how respondent perceived multi-attribute choice. Random coefficient models are therefore better estimated in project evaluation involving multi-attribute environmental change

From the application done in this paper, clearly a lot has to be improved in terms of design of the random attribute levels and representation of the different attribute (i.e. noise and landscape)

From the different WTP values estimated in the models various indicators of environmental impact of transportation can be valued for policy analysis. Extension of the models to include socio-economic variables, attitude data and environmental level perception will be done in final survey.

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