نشریه مهندسی عمران امیرکبیر

Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 49(3) (2017) 179-182
DOI: 10.22060/ceej.2016.685

Mixed Logit Model Application in Mode Choice: Case of Mashhad Work Trips

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ABSTRACT: Modal split models, as the third step in the four-step transportation modeling framework, determine the share of different travel modes. Choice models as probability models have been used in recent decades and have faced significant progress. The mixed logit model has been known for many years, but has only become fully applicable since the advent of computer and simulation technology. This model can approximate various random utility models according to the accuracy required, through adopting appropriate distributions for attributes coefficients in the utility function. The purpose of this research is to present a mixed logit model structure for mode choice, in order to describe the taste variation among individuals and the source of the variation in response to the various attributes that influence the mode choice. The required data is from Mashhad O-D survey in 1387 and model calibration is executed in Biogeme software. Results of mixed logit model indicates among passengers a taste variation in choosing between a personal car and motorcycle, based on car and motorcycle ownership. The source of this taste variation is modeled and captured through random coefficient analysis. Finally, it is shown that mixed logit models are superior to multinomial logit model with a confidence level of 99 percent. The superiority is however small, partly due to the inadequacy of the aggregate data.

Review History:
Received: 16 October 2014
Revised: 14 August 2016
Accepted: 3 September 2016
Available Online: 8 December 2016

Keywords:
Mixed Logit
Random Coefficients
Multinomial Logit
Work Trips
Mode Choice

1- Introduction

By far the easiest and most widely used discrete choice model is logit [1, 2]. Its popularity is due to the fact that the formula for the choice probabilities takes a closed form and is readily interpretable. The mixed logit model can provide abundant behavioral and physical interpretations [3]. Like probit, the mixed logit model has been known for many years, but has only become fully applicable since the advent of computer and simulation technology [3, 4]. McFadden and Train[5] showed that the mixed logit model can approximate various random utility models according to the accuracy required, through adopting appropriate distributions for attributes coefficients in the utility function.

The purpose of this research is to present a mixed logit model structure for the mode choice modeling, in order to describe the taste variation between individuals and the source of these taste variation in response to the various attributes that influence the mode choice.

2- Methodology

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

$$P_{ni} = \int L_{ni}(\beta)\, \mathrm{f}(\beta)\, \mathrm{d}\,\beta \qquad (1)$$

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Where L_ni (β) is the logit probability evaluated at parameters β:

$$L_{ni}(\beta) = \frac{\exp(V_{ni}(\beta))}{\sum_{j=1}^{J} \exp(\mathrm{V}_{nj}(\beta))} \qquad (2)$$

and f(β) is a density function. V_ni (β) is the observed portion of the utility, which depends on the parameters β. The mixed logit probability is a weighted average of the logit formula evaluated at different values of β, with the weights given by the density f(β) [3, 6, 7].

3- Results and Conclusion

In this study, the process of mode choice modelling for Mashhad work trips (The required data is from Mashhad O-D survey from 1387 and model calibration is executed in Biogeme software [8]) was performed in three steps [9]. In the first step, the superior model was selected after implementation of more than 150 multinomial logit models (Table 1). In the second step, by considering random coefficients for selected model and by implementing more than 25 models, the superior model was presented for showing the taste variation between individuals (Table 2). In the third step, by decomposing the random coefficients of last step's selected model and by implementing more than 15 models, the superior model was presented for showing the presence or absence of systematic heterogeneity around average of random coefficients (Table 3).

Table 1. Vehicle utility function for Mashhad work trips on the basis of multinomial logit model

Vehicle type	Utility function
Automobile	-0.864 + 11.6(Aco) - 0.231(lnTc)
Taxi	-1.75 +7.15(Aco) – 0.208((1-D5)(lnNdst))
Bus	-1.81 + 2.84(Amo) + 0.673(lnTc) - 0.277(lnNbrd) - 0.492(PCBD) - 0.0146((Tin+Tout))
Motorcycle	-1.5(Aco) + 8.06(Amo) - 0.234(lnNdst) - 0.0112(Tin+Tout) - 0.112(lnBusStop)

Table 2. Vehicle utility function for Mashhad work trips on the basis of random coefficient model

Vehicle type	Utility function
Automobile	-1.12 + (17.1 + 8.71.u*).Aco - 0.473.lnTc
Taxi	-1.6 +6.13.Aco – 0.205.(1-D5).lnNdst
Bus	-1.73 + 4.02.Amo + 0.645.lnTc - 0.379.ln-Nbrd - 0.503.PCBD - 0.0187.(Tin+Tout)
Motorcycle	-4.06Aco + (23.2 + 121.6.n**).Amo - 0.419.lnNdst - 0.0144.(Tin+Tout) - 0.101. lnBusStop

*Random value with uniform distribution, average=1, standard deviation=1. (standard uniform distribution)
**Random value with normal logarithmic distribution, average=0, standard deviation=1.

Table 3. Vehicle utility function for Mashhad work trips on the basis of mixed logit model with random coefficient decomposing

Vehicle type	Utility function
Automobile	-0.77 + (16.8 + 0.877.ACBD + 8.6.u*).Aco - 0.562.lnTc
Taxi	-1.48 +6.16.Aco - 0.219.(1-D5).lnNdst
Bus	-1.61 + 3.87.Amo + 0.678.lnTc - 0.403.ln-Nbrd - 0.509.PCBD - 0.0211.(Tin+Tout)
Motorcycle	-4.49Aco + (25.6 + 66.4.n** - 6.19.lnNdst). Amo - 0.0226.(Tin+Tout) - 0.123.lnBusStop

*Random value with uniform distribution, average=1, standard deviation=1. (standard uniform distribution)
**Random value with normal logarithmic distribution, average=0, standard deviation=1.

In this study, the structure of mixed logit model has been used for modelling the mode choice of Mashhad work trips. The main results are as follows:

1- Regarding to the better results of mixed logit model implementation (random coefficients and their decompositions) compared to the results of standard logit model, it can be concluded that there are different tastes between travelers in the field of personal car ownership (Aco) per capita and personal motorcycle ownership (Amo) per capita. The mixed logit model can explain this difference for current study's case (better than multinomial logit assuming a constant coefficient for all variables).

2- According to the results of mixed logit model implementation with decomposition of random coefficients, the existing taste difference in the field of Aco and Amo for choice of personal car and personal motorcycle respectively is explainable in the case of travelling to the CBD and using the logarithm of distance between grid origin-destination pair (InNdst). The positive sign of Aco, and ACDB mixed term (their multiplication) coefficient in the utility function shows the increment of Aco's effect on the personal car choice in the case of travelling to CBD. Also the negative sign of Amo, and InNdst mixed term (their multiplication) coefficient shows the reduction of Amo's effect on the motorcycle choice (for Mashhad work trips) in the case of increment of distance between origin-destination pair.

3- The he mixed logit models present better results than standard logit models (random coefficient against constant coefficient for all individuals) in terms of fitness for choice of vehicle of Mashhad work trips. The logarithm value of likelihood function for logit standard models, mixed logit models with random coefficients, and their coefficients with synergistic data is 14806, 14755, and 14747 respectively (at the 99 percent confidence level and by using the likelihood-ratio test).

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Please cite this article using:
A. R. Mamdoohi, S. A. Mirmohammadi, "Mixed logit model application in mode choice: case of Mashhad work trips", *Amirkabir J. Civil Eng.*, 49(3) (2017) 581-592.
DOI: 10.22060/ceej.2016.685