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Research Paper

Taste variation of the elderly mode choice: The role of socio-economic, attitude and behavior factors

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Abstract

Considering increasing population aging in many countries, it is necessary to pay more attention to the travel behavior of the elderly. Although previous studies show that attitudes play an important role in mode choice, few studies investigate the effect of these factors in mode choice of the elderly, practically, heterogeneity and its source. This research investigates the role of socio-economic and attitude factors on taste variation of the elderly in mode choice, and its main sources. Based on a total of 524 questionnaires distributed among the elderly in thirteen districts of Mashhad, Iran in January 2016, factor analysis is used to identifying attitude factors like environmental, safety, convenience, comfort, and flexibility. Mixed logit (MXL) and latent class (LC) models are employed to test heterogeneity among the elderly and also to determine its possible sources. Results of MXL show that several socio-economic, travel mode attributes and attitude factors have a significant effect on the elderly mode choice, which car ownership of the elderly and travel time of walking are heterogeneous variables among parameters with random normal distribution coefficient. Moreover, the results of latent class models show that flexibility is the main source of heterogeneity based on which individuals will fall into two classes. Results show that increasing the importance of the individual's attitude toward flexibility of travel mode, reduces the probability of individual's membership in class 1. Significant variables in class 1 include: having no accompanied, having a driving license, car ownership, flexibility, the travel time of walking and comfort. Findings suggest that identifying needs of the elderly and reducing travel time for non-mandatory trips encourage them to use public and walking mode. Also, incentive policies to reduce car ownership of the elderly and increase safety and comfort in other travel modes are essential factors in reducing the use of a private car for this age group.

Keywords: Attitude, Heterogeneity, The elderly, Mode choice, Latent class model, Mixed logit model

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1. Introduction

Paying attention to travel behavior is unavoidable due to the unsustainable growth of the population [Ewing et al. 2008; Schäfer, 2009; Sperling and Gordon, 2008]. Considering to travel behavior of the elderly is so essential since the tendency to use private car increases with aging, some traffic, and environmental impacts also emerge [Rosenbloom, 2001]. Therefore, it is necessary to consider mode choice of the elderly and understanding the effective factors in mode choice. According to the United Nations report, in the next 40 years, between 2010- 2050, life expectancy is expected to increase from 60 years to 80 years [Alsnih and Hensher, 2003]. Also according to information provided by the Iranian Statistics Center, the elderly were about 6% of total population of Iran in 2016, while it had 3% in 1986; which is anticipated to rise to 10% by 2030. So it seems Iran's people are getting older and it needs to be given closer attention to travel behavior of this age group.

On the other hands, Travel behavior is a phenomenon with psychological and social roots. Hence, attitudes and perceptions could play an important role in the decision-making process [McFadden, 1986; Jensen, 1999; Hagman, 2003; Walker and Li, 2007]. Trip attributes and individual socio-economic characteristics are the principal variables in the most of the mode choice models [Kim and Gudmundur 2004]. However, it seems that also latent variables such as attitudes play important roles in the travel behavior. Therefore, incorporate unobservable behavioral factors such as safety and flexibility in addition to observable variables could help to better understanding of mode choice process [Johansson et al. 2006]. Scheiner and Holz-Rau studied the relationship between socio-economic attributes, life situation, lifestyle, and choice of residential location with travel behavior of the individuals. Based on their results, lifestyle influences mode choice. In a study by Outwater et al., the attitudes of travel behaviors and the causal relationships between traveler`s socio-economic characteristics and traveler attitudes were investigated [Outwater et al. 2006]. In other studies by Van Acker et al., results indicated how residential and travel attitudes affect the decision of residential location and travel behavior. Their model explained a relatively large proportion of variance in car use. However, it also indicated that to fully understand car travel behavior other variables must also be taken into account [Van Acker Mokhtarian and Witlox , 2014].

Also, it has been shown that without neglecting the heterogeneity of the data a significant bias might arise in the estimations [Hosoda ,1999]. For example, some people are inherently time-centric while some others are less concerned with the subject. Therefore, ignoring the effect of latent individual attributes can be contemplative [Chamberlain , 1984]. Ignoring heterogeneity is caused by not having an accurate interpretation of travel behavior. Different studies have shown that travel behavior of the elderly is neither homogeneous nor

monolithic since they are different in many aspects such as health, wealth, age, lifestyle and so on [Frey, 1999]. In a study by Hildebrand, the elderly were classified according to their lifestyle. They found that there is diverse travel's behavior in different groups. Hence, it needs to pay closer attention to heterogeneity in the mode choice of the elderly [Hildebrand, 2003].

As mentioned, it is important to pay attention to the elderly's travel behavior, because of the high share of this group in future urban travels. Despite the attention paid to the travel behavior of elderly in previous studies, but the attitudinal and behavioral factors and its effect on taste variation in mode choice is not considered. So, in the present paper, two objectives are followed. First, it will be probe the effective factors in the elderly mode choice using the MNL model with a focus on latent factors such as environmental, comforTable, convenience, flexibility and safety as a baseline. Second, the effect of taste variation in the elderly mode choice will be investigated. So, in the first step, MXL will be used to identifying variables that have a random effect. In the next step, the LC model will be employed in identifying heterogeneity sources.

The remainder of this paper is organized as follows: The next section includes a literature review of travel behavior of the elderly and the effect of attitude in mode choice. The research methodology and data collection are stated in the third part. The statistical analysis of the data will be done in the fourth section. The results and discussion on heterogeneity and effective variables in mode choice of the elderly are described in the fifth section. Finally, the last part presents conclusions and suggestions.

2. Background

2.1. The effect of Attitude and psychological attributes in mode choice

Classic models employed socio-economic variables and alternative attribute to explain the mode choice traveler's behavior. However, these are not the only variables that explain heterogeneity in the mode preferences. It has been well accepted that attitudes and perceptions play an important role in the decision-making process [McFadden, 1986]. So, using latent variables with observed variables provide more explanatory power [Walker and Ben-Akiva, 2002]. Several studies carried out on the effect of attitude, lifestyle, behavior and psychology factors on travel behavior. For example, Morikawa and Sasaki and Morikawa et al. considered to modal comfort and convenience in their analyses of mode choice [Morikawa and Sasaki, 1998], [Morikawa et al. 2002]. Furthermore, Golob used different models to explain how mode choice and attitudes regarding tolled high-occupancy vehicle lanes in San Diego differed over the population [Golob, 2001]. Study on the effect of attitude and lifestyle in vehicle type choice showed that attitudes, personality, and lifestyle are important to mode choice, in ways that are relevant to transportation planners and policy-makers as well as vehicle manufacturers [Choo and Mokhtarian, 2004]. Johansson et al. analyzed the effect of the behavioral and attitude

variables on mode choice of Swedish commuters. They reported that both attitudes towards flexibility and comfort, as well as being pro-environmentally inclined, have an important role in mode choice and enable policymakers to improve transportation systems with respect to the behavior of travelers [Johansson et al. 2006]. Walker and Li studied lifestyle preferences with a data from Portland, Oregon. They identified different latent classes of individuals that have different residential location choices, resulting from their lifestyle preferences [Walker and Li, 2007].

Atasoy et al. were employed to integrate latent attitudes of the individuals into a transport mode choice model through latent variable and LC models. First, they presented an integrated choice and latent variable (ICLV) models that consider attitude toward public transportation. Then, they presented an integrated choice and LC model, which identified two classes of individuals having different sensitivities to the attributes of the alternatives, resulting from their characteristics. The results showed the importance of attitudinal variables in the characterization of heterogeneity of mode preferences within the population [Atasoy Aurélie and Bierlaire, 2013]. Domarchi et al. investigated the effect of attitude on university workers. Results showed that these factors in addition to the effect on mode choice, help to improve the goodness of fit index [Domarchi, Alejandro and Angélica, 2008]. Galdames et al. studied on role psychological factors in mode choice for work trips. They used Triandis's theory of interpersonal behavior to identify the effect of an individual's attitude in mode choice. They reported that attitude has an important role in improving fitness index [Galdames, Camila, Alejandro and Juan-Antonio, 2011]. In a study by Sarkar on effect perception and attitudinal variables on mode choice in Agartala of India, It was shown that comforTable and flexibility factors affect individual's mode choice. Also, the outcome of ICLV model showed that perception and attitude have an important role in individual's mode choice [Sarkar and Mallikarjuna, 2017].

So, according to the studies mentioned above, attention to the attitude and behavior of the traveler and the relationship between these two factors will be important in determining the travel behavior, especially mode choice.

2.2. The impact of Socio-demographic factors on the elderly mode choice

The age of 60 or 65, roughly equivalent to retirement ages in most developed countries, is said to be the beginning of old age [Randel, German and Ewing, 2017]. We defined "the elderly" as people 65 or more years of age, based on Iran statistic center. There are several studies on traveler's behavior of the elderly. For example, concerning trip purpose, Benekohal et al. reported that shopping, work, and recreational trips are predominant trips purpose of the elderly [Benekohal et al. 1994]. In many studies, it has been reported that the elderly tend to private car mode choice either by driving it or as a passenger. Also, it has been shown that public transportation is the least popular mode of transportation for the elderly [Rosenbloom, 1995], [Rosenbloom, 1988];

[Scott et al. 2007]. Study of Pa´ez et al. on the elderly trip frequency showed that females have less trip frequency than males. Also, having a driving license and accessibility are important factors in trip frequency [Pa´ez et al. 2007]. Some studies also focus on effective socio-demographic factors in mode choice of the elderly. For instance, Kim and Ulfarsson found that the elderly with higher income tend to use private car or carpool more [Kim and Ulfarsson, 2004]. Regarding household size, Hess showed that single household elderly are more likely to use public transport [Hess, 2009]. Li et al. have shown that although private car is the most popular mode for the elderly, its share decrease as they get older [Li et al. 2012]. In London, Schmocker et al. investigated mode choice of a shopping trip for the elderly and observed that high income has a negative factor in public transport use [Schmocker et al. 2008]. A study on mode choice of the elderly in Denmark, Norway, and Sweden by Hjorthol et al. showed that women are less likely to use private car [Hjorthol et al. 2010]. Schwanen et al showed that the utility of car, walking, and cycling is less than public transport for leisure trips of the elderly. Also, they found the older women prefer using public transport. Concerning income, they reported that elderly people with lower income prefer to walk and cycle. Moreover, they elaborated that the utility of public transport is higher for the elderly with high education level than others [Schwanen et al. 2001]. Study of Van den Berg et al. confirms that elderly with lower education are more inclined to use private car mode for social trips [Berg et al. 2011]. In a study on mode choice of the elderly for shopping trips in London, by Su et al. investigated the travel behavior of the elderly. A multinomial and nested logit model was used to understand effective factors in mode choice. In their work, the nested logit model was used to investigate the relationship between mode choice of before and after the shopping trip. The results have shown that bus stop density is more important than the bus service's quality in mode choice of the elderly. Also, they found that use of walk mode to shopping and taking the bus to back is less frequent. Finally, they reported that if shopping tour were more complicated, more complex mode choice would be used [Su et al. 2009]. As with other studies, this study showed that elderly women are more likely to use public transport and the elderly with higher income prefer private car mode choice than public transport for retail shopping trips [Böcker, van Amen, et al. 2017]. A study conducted by Schmocker in mode choice of the elderly and disabled people for shopping trips in London revealed that health status and accessibility to public transport increase the likelihood of using public transport [Schmocker, 2008]. Bocker et al. analyzed the effects of socio-demographics, alternative attributes in mode choice, using two age groups (elderly and non-elderly). They found that women, especially elderly ones, are more likely to take a walk, go biking, and use the public transport, while men are more inclined to use a private car. Also, they elaborated that education and income level has a less effect on elderly mode choice, while car ownership

and health is positively associated with using a private car. On the other hand, having access to public transport and incorporated public transport increase the likelihood of using public transport [Bocker et al. 2017]. Habib et al. investigated the travel behavior of the elderly in Canada regarding the simultaneous mode choice and travel distance. The results showed that the elderly are more dependent on the private car, biking and walking while public transportation is less popular in Canada. Also, they found that the distance between activity location and residence location is the main reason making the elderly car-oriented in the national capital region (NCR) of Canada [Habib et al. 2015]. Nguyen et al. studied the effect of topographical factors and heterogeneous response of this factors on mode choice of the elderly. A survey conducted by combined GPS and paper-based in Koyo Newtown in Hiroshima City. They reported that altitude difference and maximum slope are effective factors on mode choice [Nguyen et al. 2017]. Truong et al. conducted a study on the frequency of public transport use by the elderly in Adelaide, Australia. The results show that high perceived importance of public transport to residential locations and easy access to public transport play an important role in the frequency of public transport use [Truong et al. 2015].

With this background, most studies on the travel behavior of the elderly, however, are limited to either descriptive studies or determining effective factors in mode choice of this age group. However, it seems that two major issues have been neglected in the mode choice of the elderly. The first, investigating the effect of taste variation in mode choice. The second, determining the effect of attitude and behavior factors in mode choice. So in the first step, effective attitude and behavior factors are identified using factor analysis method. So the effect of these factors in mode choice is investigated using multinomial model (MNL). In the next step, the mixed logit model (MXL) and latent class (LC) model are employed due to its ability to identifying taste variation and heterogeneity among the elderly and heterogeneity source.

3. METHODOLOGY

3.1. Study design and sampling

The setting of this research is Mashhad, the second most populous city (more than 3.3 million in the 2016's census) in the Northeastern part of Iran and center of Khorasan Razavi province. According to the 2016 census, about 8 percent of Mashhad population is the elderly, which is expected to exceed 10% in the next ten years. Private car, taxi, mass transit, bus, biking, motorcycle, and walking are the dominant modes. Mashhad also has a 19 km mass transit line that provides inadequate transportation coverage (Figure1).

A pilot study was conducted to assess the correct functioning of study procedures and instruments, with a total of 150 questionnaires distributed among the elderly of Tehran and Mashhad. Data validation was undertaken by comparing the sample data with Mashhad and Tehran of comprehensive transportation studies. The pilot survey resulted in a minor revised of the

questionnaire (especially the attitude section). Distributed to more than 524 households in 13 districts of Mashhad (Fig 1).

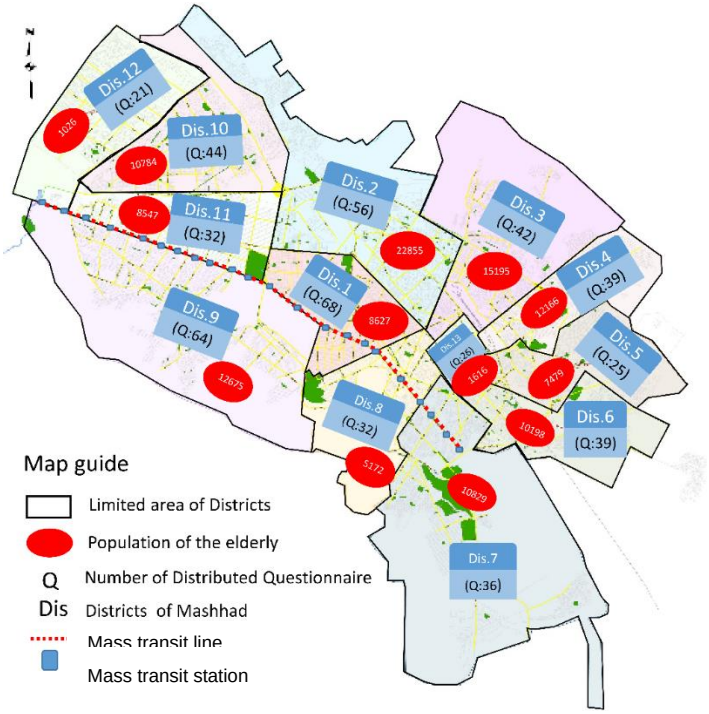


Figure 1. Map of Mashhad's districts (Iran) and the number of distributed questionnaires.

3.2. Measurement instruments

The aim of the survey was to collect trip information as a travel sequence (mode choice of before and after the purpose of the trip) for people over the age of 65 years. The survey included three parts: 1- travel information such as present and next mode choice and purpose of travel, travel time, number of entourage and frequency of trip; 2- socio-economic factors (household information including the car ownership and household size, as well as individual socio-demographic information such as age, gender, occupational status, driving license status, educational level); 3- attitude of people toward the mode choice was questioned indirectly. According to a study by Johnson, two different methods were used for constructing the latent variables [Johnson, 2006]. Comfort, convenience, and flexibility were erected by attitudinal indicator variables, and behavioral indicator variables were used for constructing safety and environmental preference variables. The behavioral questions like using seat belts, bike helmets, and recycling habits have directly related to safety and environmental preferences. This matter led to that these variables are exogenous to the individual mode choice. Also, these questions were scored on a Likert scale ranging from 1 indicating never to 5 indicating always. Unlike behavioral indicators, attitude

indicators could be affected by chosen mode. So, attitude variables may be endogenous to the selected mode. Attitude indicators also were scored on the Likert scale from 1 indicating not important to 5 indicating very important.

3.3. Modeling Approach

Principal components analysis (PCA) of attitude and behavioral variables along with socio-economic and alternative attribute were used as explanatory variables in the discrete choice modeling of the elderly trip modes like the private car, public transportation, and walking modes. Because failure to collect built environmental variable data, it was not used in models (Figure 2).

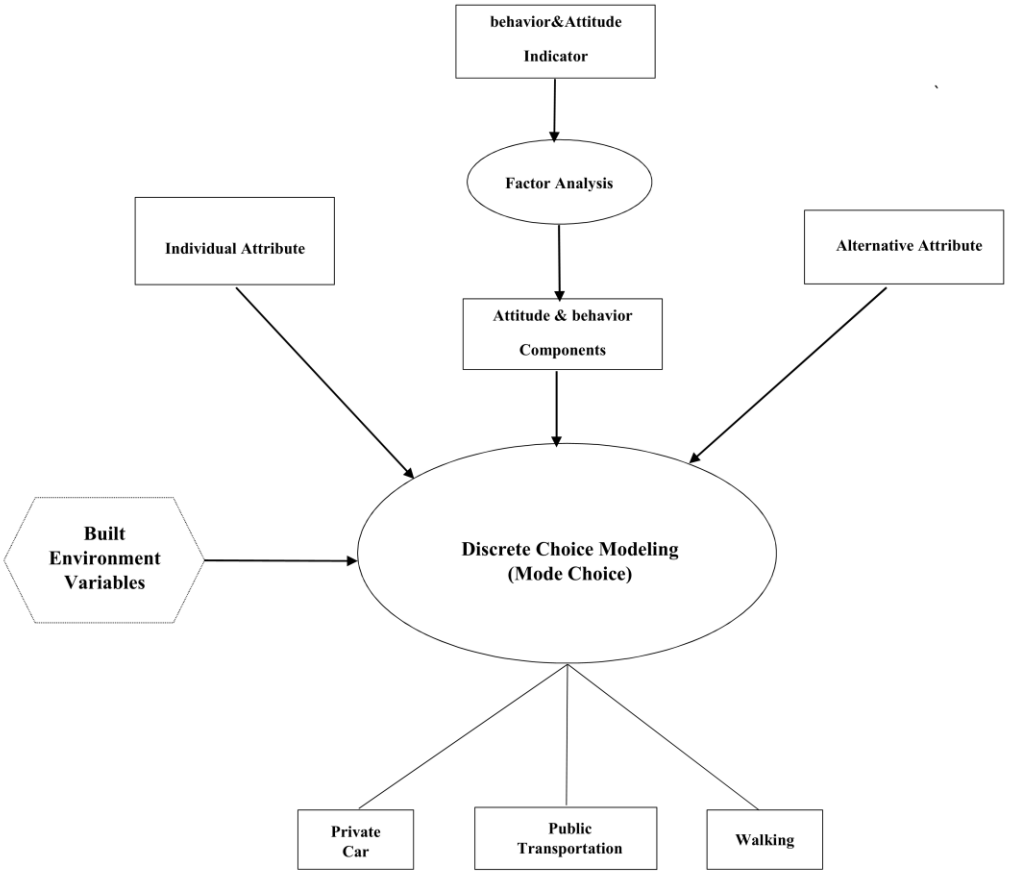


Figure 2. Proposed Conceptual Framework of current research

3.4. Factor Analysis

PCA method focuses on reducing dimensions and finding relationships between variables. In other words, it creates underlying dimensions between measured variables and latent constructs [Thompson, 2004]. Factor analysis includes two main categories: Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). The exploratory analysis factor is used when there

is no particular theory, and there is little information about the subject, while the confirmatory factor is based on previous theories. In this study, Latent variables attained using EFA method based on collected data of questions of the third part of the questionnaire (measured indicators) [Thompson, 2004]. Based on Johansson et al. study, to determine attitude and behavior on mode choice, Principal component analysis (PCA) with varimax orthogonal rotation as one of EFA methods was used. Individual attitude and behavior PCA (Table 7 in Appendix) reflected five components including flexibility, comfort, convenience, environmental and safety.

3.5. Mixed Logit Model (MXL)

The assumption random utility theory is used when choosing between several alternatives. Based on this theory, the probability of an individual's choice the alternatives are more for the alternative with the highest utility. The individual's derived utility consists of a deterministic and a random component. The general form of the utility functions assigned to alternative j by individual n is as follow:

$$U_{nj} = \theta_{jn} + \beta_n X_{jn} + \varepsilon_{jn} \quad (1)$$

Where Unj is the utility of alternative mode j for person n, θjn is estimable alternative-specific constants, βn is parameters, and εjn is a random error which for multinomial logit model is independently and identically distributed) Gumbel distribution.

Also, General form of the probability function for the multinomial logit model will be as follows [Sahibuddin et al. 2014]:

$$P_{nj} = \frac{\exp(\theta_j + \beta X_{jn})}{\sum_{j'=1}^{J} \exp(\theta_{j'} + \beta X_{j'n})} \quad (2)$$

MNL model is simple. However, it has disadvantages. One of the disadvantages is ignoring non-systematics taste variations of individuals. The MXL model is a highly flexible model that has the ability to approximate different models with random utility and allows model parameters to vary over individuals. Mixed logit model or random parameters logit is one of the famous approaches to investigating the variation in tastes across individuals. McFadden and Train showed that the MXL model could approximate different models with random utility [Taherdoost et al. 2014]. In the MXL model, some parameters are estimated as random values with distinctive distribution. The general form of the MXL Model is as follows [Train, 1980]:

$$P_{nj} = \int L_{nj}(\beta)\, f(\beta)\, d(\beta) \quad (3)$$

Where P_{ni} is the probability that an individual n chooses alternative i, L_{ni} is the probability that an individual n chooses alternative i in MNL model that is a function of β parameter and f(β) is density function. Therefore:

$$L_{ni} = \frac{\exp(\theta_j + \beta X_{jn})}{\sum_{j=1}^{J} \exp(\theta_{j'} + \beta X_{j'n})} \quad (4)$$

Where $\theta_j + \beta X_{jn}$ is a utility function that is depend on β parameter.

3.6. Latent Class (LC) model

Although the use of continuous mixed distribution improves the goodness of fit index of the model, the primary source of this heterogeneity is not very clear [Train, 1980]. One of the other criticisms that apply to these models is an analysis needs to be done before assuming a random distribution for the variable [McFadden and Train, 2000]. LC model is therefore introduced to overcome

some limitation of the mixed model and to provide insights into individual preferences.
In the LC model, instead of using continuous distribution, individuals are divided into a homogeneous class based on preferences. Hence, each class has its specific parameters for variables in a behavioral model. Assuming the conditional probability for n, the choice of alternative i in class S (s=1, 2,…, S), the probability function will be as follows:

$$P_{(nj|S)} = \frac{\exp(\theta_j + \beta_s X_{jn})}{\sum_j^J \exp(\theta_{j'} + \beta_s X_{j'n})} \qquad (5)$$

Where $P_{(nj|S)}$is probthe ability that an individual n in class S, chooses alternative j and X_{in} is variables.
One of the important issues in the LC model is to determine "correct" the number of class. Typically, the Bayesian Information Criterion (BIC) or the Akaike Information Criterion (AIC) are two criteria to determine the number of the class in the LC model. In this study, both of the BIC and AIC was used to determine the number of class. The general form of these criteria is as follow:

$$BIC = -2.\{LL(\beta)\} + p.\log(N) \qquad (6)$$

$$AIC = -2.\{LL(\beta) - p\} \qquad (7)$$

Where LL (β) is the log-likelihood value at convergence, p is a number of parameters, and N is the number of samples [McFadden and Train, 2000].

4. Data Analysis

According to Mashhad Municipality Transport and Traffic Statistics, private car, public transportation, walking, two wheels (motorcycle and cycling) have 43%, 35%, 15%, 8% share of mode choice in Mashhad, respectively. In this study, to investigating effective factors and finding Main sources of heterogeneity in mode choice of the elderly, as mentioned, 524 questionnaires distributed among the elderly, data analysis on mode choice of the elderly showed that motorcycle and bicycle have the low share (less of 5 percent). So, the data related to these people were removed, and analysis and modeling were performed based on 412 records. Based on the data analysis, mode choice classified in three groups (private car, public transportation, and walking). Descriptive statistics of socio-economic variables showed that the average age of respondents is 69.85 years. In terms of gender, 52.67% of responders were male, and the rest were female. A total of 51.70 percent of responders had a driving license (Table 1). Further, households owned no car have a minimum share (1.2), while households with on car ownership have a maximum share (56.08 percent). Moreover, 83.98 percent were retired, while 16.02 percent had a part-time or full-time job. Also, 18.45 percent of responders have a College education. Analysis data showed that 49.75 percent of responders have Less than 1 million Tomans income and only 2.68 percent of responders have more than 3 million Tomans. Also, only 9% of the elderly with low income (<=1 million Tomans) prefer to use public transportation and walk mode, while the elderly with high income are more inclined to use the private car. Data analysis in term household size showed that the share of one-two households is 72.09 percent.

Table 1. Frequency analysis of socio-economic characteristics of the research sample

gender	Male	217 (52.67)
driving license status	Has	213 (51.70)
occupational status	Retired	346 (83.98)
Educational status	Under high school diploma	261 (63.35)
	High school diploma	75 (18.2)
	B.s	58 (14.08)
	M.s & higher	18 (4.37)
Number of private cars owned	0	5 (1.20)
	1	231 (56.08)
	2	143 (34.71)
	3 or more	33 (8.01)
households' monthly Income	Less than 1 million Tomans	205 (49.75)
	1 to 2 million Tomans	140 (33.98)
	2 to 3 million Tomans	56 (13.59)
	More than 3 million Tomans	11 (2.68)
HouseHold Size	1	180 (43.69)
	2	117 (28.40)
	3	36 (8.74)
	4 or more	79 (19.17)

*Numbers in parentheses are relative frequency (percent)
**Us dollar was 3800 Toman (01/02/2016)

Results of frequency analysis (Table 2) show that public mode share is highest (38 percent), while private car share is the lowest (28 percent Investigation of the effect of mode choice of the pre- activity on mode choice of the post- activity shows that the mode choice is often the same before and after the activity which is bolder for private car (Table 3).

So, they seem that mode choice in first activity will be affected mode choice for other activities and it is imperative that policymakers pay attention to the mode choice for the first activity.

Females tend to use public transportation, while males prefer to use the private car (Figure3 (a)) and in line with results of previous studies, females less prefer to take a walk than males. In Fig 3(b), the frequency of mode choice is shown regarding active type. Investigating mode choice based on type of activities (mandatory, non-mandatory) shows that the elderly tend to use public transport and walk for non-mandatory activities and prefer to use a private car for mandatory activities. Going to work, going to education centers and essential personal work (going to the hospital) are defined as mandatory activities, while others (e.g., leisure,

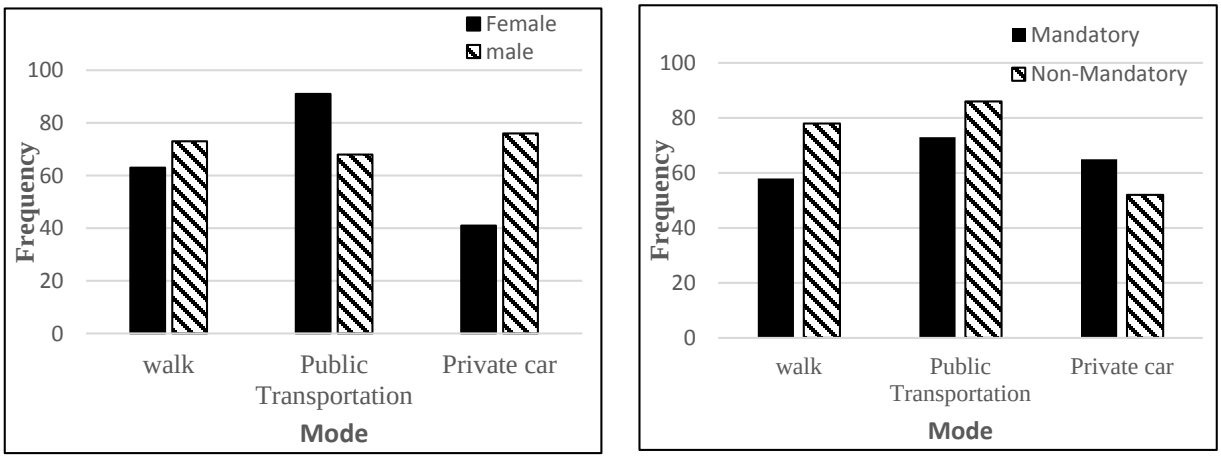
shopping) are considered as non-mandatory activities.

Table 2. Frequency analysis of the elderly travel mode

Mode	Frequency	
	Absolute	Relative (Percent)
Private Car	117	28
Public transportation (bus or metro)	159	38
Walking	136	34
Sum	**412**	**100**

Table 3. mode choice frequency before and after activity

		Mode Choice frequency After the activity		
		Private Car	Public Transportation	Walking
Mode Choice Before the activity	Private Car	103	3	11
	Public Transportation	5	127	27
	Walking	3	31	102



(a) **(b)**

Figure 3. The frequency of mode choice of the elderly (a) by gender (b) by activity type
Model results

Table 4. Variables description and symbol by category

Category name	Symbol	Value
Personal /household information	Nalong	1: having no accompanied; 0: otherwise
	lice	1: if the elderly have driving license; 0: otherwise
	Nvpriv	Number of car ownership the elderly
Trip attribute	Tveh	Travel time (minute)
	Nmandatory	1: if the purpose of the trip is optional ; 0: otherwise
Attitude	Safety	Safety attitude
	Flex	The flexibility of vehicle for performing different activity
	comf	Comfort in accessibility and mobility of travel mode

In this study, the MNL model is used to determine effective factors on mode choice of the elderly, and, the effect of taste variation on mode choice is investigated by MXL model. Source of heterogeneity source is identified using LC model and the independent explanatory variables were: socio-economic, alternative attributes, and attitude and behavioral variables (Table 4).

4.1. The baseline (multinomial logit) model

As mentioned, the first stage of this research aimed to examine the role of socio-economic and psychological factors in the elderly mode choice. Based on about 500 different model were calibrated. In the final model.

Having no accompanied has a negative effect on private car and public transportation choice. Implying that the elderly are less likely to use the private car and public transportation in long distance when traveling alone. This could be due to safety issues and weakness of the elderly. Results also show that having a driving license has a positive impact on private car choice, which is in line with previous studies [Levin, et al. 2010; Böcker et al. 2017]. Car ownership of the elderly has a positive effect on private car choice, is consistent with Bocker et al. study. Having a driving license (lice; +1.15) increases the probability of choosing a private car over other modes. Concerning the effect of attitudes in mode choice of the elderly, results show that the coefficient of safety attitude towards modes (safety: +0.37) show that this attitude would increase the probability of choosing private car mode over other modes. The reason behind this finding may be due to the physical inability of the elderly which decreases their willingness to take a walk and use public transportation due to their vulnerability. Concerning the coefficient of flexibility variable (flex; -0.13) in public transport showed that the desire for flexibility significantly decreases the propensity to use the public transportation over other modes exclusively. Besides, as expected, travel time has an adverse effect on walking and public transportation mode choice. The constant was only statistically significant for private mode, and constant was not expressed in other modes because it was not statistically significant. A comparison between the travel time variable coefficient in both walking and public

transportation modes showed that the elderly are more sensitive to travel time for walking mode choice than public transportation. Generally speaking, trips are categorized into two class regarding the trip purpose: mandatory and non-mandatory. Investigating the effect of trip purpose showed that the elderly tend to use walking when the purpose of the trip is non-mandatory. Another variable frequently addressed in previous studies for other ages is the variable of comfort. Results show that comfort variable has a positive effect on walking mode choice probably because wait time in the bus stop and finding parking lot are negative factors in short-distance trips. Therefore, the elderly prefer to walk mode choice.

Table 5. Multinomial logit model results for mode choice of the elderly

Variable	Private car		Public Transportation		walk	
	coeff	t-stat.	coeff	t-stat.	coeff	t-stat.
Constant	-3.15***	-6.39				
Nalong	-2.19***	-5.83	-0.99***	-3.36		
lice	1.15***	2.59		`		
Nvpriv	1.03***	4.08				
Safety	0.37**	1.99				
Tveh			-0.00011***	-4.05	-0.076***	-8.92
Flex			-0.13*	-1.73		
Comf					0.30**	2.18
Nmandatory					0.58**	2.12
Number of observations	412					
Log-likelihood at zero	-299.4261					
Log-likelihood at convergence	-452.6029					
McFadden Pseudo R-squared	0.3384					
-2[LL(0)-LL(β)]	306.3216					
-2[LL(C)-LL(β)]	299.9366					

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 6. MXL model results for mode choice of the elderly

Variable	Distribution of parameter	car		bus		walk	
		coeff	t-stat.	coeff	t-stat.	coeff	t-stat.
Random parameters in utility functions							
Nv private	**Normal**	1.40***	3.38				
Tveh $_w$	**Normal**					-.104***	-5.35
Nonrandom parameters in utility functions							
Constant		-3.97***	-5.36				
Nalong		-2.78***	-4.70	-1.13***	-3.19		
lice		1.18**	2.23				
Safety		0.47*	1.97				
Tveh				-.00016***	-4.00		
Flex				-0.16*	-1.92		
Comf`						.33**	2.05
Nmandatory						.63**	1.89
The standard deviation of random parameters							
NS- nv private		.67*	1.95				
Ns-tveh						0.032**	2.14
Number of observation		412					
Log-likelihood at zero		-295.4863					
Log-likelihood at convergence		-449.4104					
McFadden Pseudo R-squared		0.3425					
`-2[LL(c)-LL(β)]= 306.404				$\mathcal{X}^2_{13}(d.f)$ =314.28			
-2[LL(c)-LL(β)]= 299.968				$\mathcal{X}^2_{13}(d.f)$ =314.28			

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 7. LC model results for mode choice of the elderly

Mode Alternative	Variable	Class 1		Class 2	
		Coefficient	t-stat	Coefficient	t-stat.
Private Car	constant	-5.7192***	-3.19	-	-
	nalong	-3.5003**	-2.03	-8.8597***	-5.20
	ylice	-	-	2.9523**	2.14
	nvprive	1.1036*	1.69	1.3232***	3.26
	safety	-0.0796	-0.15	0.0891	0.24
Public Transportation	$tveh_p$	-0.0467	-0.71	0.00042***	2.91
	nalong	-2.7868	-1.02	-7.2498***	-4.28
	flex	-4.0943**	-2.44	-	-
Walking	$tveh_w$	-0.1327***	-3.46	-0.1694***	-4.60
	comf	1.2662***	2.86	0.1514	0.47
	Nmandatory	2.0006*	1.78	0.0925	0.14
This is THETA (01) in the class probability model.					
Constant		-0.6719	-3.60***	-	-
FLEX|1		-0.2576	-1.71*	-	-
Number of observation		412			
Log-likelihood at zero		-292.7456			
Log-likelihood at convergence		-452.6283			
McFadden Pseudo R-squared		0.3532			
`-2[LL(c)-LL(β)]= 319.76			$\mathcal{X}_{13}^2(d.f)$ =314.28		
-2[LL(c)-LL(β)]= 313.13			$\mathcal{X}_{13}^2(d.f)$ =314.28		

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

4.2. LC and MXL models results

LC model and MXL are two popular models for performing a heterogeneous analysis, each with its limitations and strengths. Random taste variation (heterogeneity) in variables among parameters is identified using MXL and LC models applied to determine the source of heterogeneity. Based on the pseudo square (ρ2), MXL model is better than the others (MNL and LC models

As expected, the MXL model also shows that similar results to MNL. Results show that car ownership and walking travel time are heterogeneous variables: their effect is different. For instance, although the effect of car ownership the elderly variable is positive for the elderly and with the increase in car ownership the elderly, the willingness of individuals to use private car mode increases, this effect is different for each according to the distribution indicated in Table 5. Besides, travel time is heterogeneous in the utility function of walking mode choice. Thus, it can be stated that the negative effect of travel time on walking is not the same for all the elderly. This finding might be explained by the differences in the physical ability of individuals.

In the next stage, the LC model was estimated to determine the source of heterogeneity. So all of the variables were examined in finding the source of heterogeneity. The optimum number of classes was discovered two classes. The result shows that flexibility of modes is the primary source of heterogeneity for the elderly. The sign of parameter of flex variable indicates that by increasing the flexibility of the travel mode, the probability of being in class 1 decreases. Also, having no accompanied, having driving license, number of car ownership, attitude of individuals over flexibility of travel mode, time duration of walking and attitude of individuals over comforTable are effective factors in mode choice of the elderly in class 1 and having no accompanied, having driving license, number of car ownership, time duration of walking and travel time of public transportation are in class 2.

5. CONCLUSIONS AND SUGGESTIONS

Population pyramids of the different countries show that the age of the population is increasing. For example, According to the US Census, the frequency of individuals in the age group above 65 years will increase to 100% rate from the year 2000 to 2030 [Enam et al. 2017]. Thus, the share of travel of the elderly increased and considering to travel behavior is essential. There are many studies in mode choice of the elderly, but most of the previous studies have investigated the effect of socio-demographic factors in mode choice. However, the literature review shows that the effect of taste variation in mode choice with a focus on latent variables is not taken into account for this age group. Therefore, the present research was identified as effective latent variables in the elderly mode choice, so it was investigated the effect of attitude variables on mode choice. Hence, the multinomial logit model was used for identifying effective socio-demographic, trip attributes, and attitude factors in mode choices of the elderly. Attitude variables were obtained from the factor analysis. Besides, the effect of taste variation in mode choice was investigated using MXL model. Also, the source of this heterogeneity was found using the LC model. The study was conducted in the city of Mashhad, as the second most populous city in Iran and the regional capital of Khorasan Razavi Province. Also, data for the analysis has

employed a questionnaire from elderly in Mashhad. Based on the results of this study, the following conclusions can be drawn:

The result shows that the elderly tend to public transportation mode choice, especially in non-mandatory trips. It was also found that males tend to private car mode choice, while females prefer using public transportation (bus and metro) mode. Besides, concerning income, our findings showed that the elderly with higher income are more likely to private car mode choice. Using walking and public transportation mode for the non-mandatory show that policymakers should close more attention to the purpose of Non-mandatory activity travel of the elderly, and policies to reduce travel time should be considered for these activities.

Investigating of before and after of the activity mode choice showed that individuals have steady mode choice for before and after the activity. In other words, in the travel sequence, mode choice on the first leg is effective in mode choice of other legs. So policymakers should pay more attention to the first mode choice for activities.

The analysis suggests that having no accompanied has a significant and negative effect on private car and public transportation mode choice while having license driving and the car ownership private car of the elderly in the household has a positive effect on private car mode choice. Furthermore, the travel time has a negative effect on both public transport and walking mode choices. A comparison between the effect of travel time shows that the elderly are more sensitive to time walking trip. Moreover, the elderly were more likely to use walk mode for non-mandatory trips.

It was also found that safety, flexibility, and comfort attitude variables are effective in the private car, public transportation, and walking mode choices of the elderly, respectively. So, related policies to increase safety and comfort in walking and public transportation mode and reduce of car ownership of the elderly will be an important factor in reducing the use of private for the elderly.

Another finding is that number car owned by the elderly in the household, and Time walking are heterogeneous among parameters, and the effect of these variables is not the same in all the elderly. Also, results showed that the LC model has slightly higher explanatory power than the MNL and MXL model.

Also, the result of the LC model showed that attitude towards the flexibility of travel mode is the primary source of heterogeneity in the elderly of Mashhad. In other words, effective variables in mode choice of the elderly depend on the flexibility of mode of the trip.

Because not many studies have been conducted in mode choice of the elderly, comparing the effect of the taste variation in mode choice for different age groups is suggested for further research. This research could also be extended to a hybrid choice model to examine the simultaneous effect of observed and latent variables in mode choice of the elderly.

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Appendix

Table 8. Construct of Attitude and Behavior factors in exploratory factor analysis

A measure of Attitude and behavior individuals for mode choice	Factor loading	Cronbach's α	Aiic
based on Vredin Johansson et al. (2006)			
Component 1. 'Environment'		0.734	0.51
The sound pollution and the air around your place are very important	0.724		
I feel responsible for recycling materials like paper, bottle,etc	0.671		
Component 2. 'Safety'		0.733	0.58
Wearing a bike helmet when riding a bike is important to me.	0.892		
I habit of adhering to the prevailing speed limit when driving.	0.911		
Safety belts in cars (Also in the rear seats). Is important for me	0.674		
Component 3. 'comfort'		0.641	0.55
Traveling in a calm, non-noisy environment is important to me	0.698		
Being able to rest or read while traveling is important to me	0.727		
being able to work while traveling is important to me	0.569		
Component 3. 'convenience'		0.591	0.41
not having to wait for another travel mode while traveling is important to me	0.823		
It's important to know the length of time traveling	0.645		
avoiding queues and congestion while traveling is important to me	0.821		
having little or no variation in her daily travel time is important to me	0.711		
Component 5. 'Flexibility'		0.739	0.48
The respondent's appreciation of being able to shop or run errands while traveling to/from work.	0.808		
The respondent's appreciation of being able to leave/collect children at school or similar while traveling to/from work.	0.617		

Aiic average corrected inter-item correlations

Aiic values above 0.30 are considered adequate

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