SUBURBAN PASSENGER'S MODE CHOICE BEHAVIOR BASED ON TRIP PURPOSE

[1]YAVUZ DELICE, [2]HALIT OZEN, [3]EHSAN AMIRNAZMIAFSHAR

[1]Department of Transportation Engineering, Faculty of Engineering, Yalova University Merkez Yerleşke, Çınarcık Yolu Uzeri 77200 Yalova, Turkey, [2]Department of Civil Engineering, Faculty of Civil Engineering, Yildiz Technical University, Davutpaşa Mah. Davutpaşa Caddesi 34220 Esenler, İstanbul, Turkey, [3](MSc Student), Department of Civil Engineering, Division of Transportation Engineering, Istanbul Technical University, Ayazağa Yerleşkesi İnşaat Fakültesi Binası, Maslak, 34469 İstanbul Turkey
E-mail: yavuz.delice@yalova.edu.tr, ozen@yildiz.edu.tr, amirnazmiafshar@itu.edu.tr

Abstract- The literature on urban transportation planning emphasizes mainly on cities and neglects suburb areas. This study will fill the part of the knowledge gap by focusing on passengers' mode choice behavior in the suburb area. By using micro-simulation model, aggregate data are obtained. The survey gives us disaggregate data collected from 975 respondents who have different attributes. These attributes include different age, income, driving license status, number of vehicle per household and employment situation. They choose the mode, which has various features such as different travel time and travel cost for the same distance. The result of the discrete choice model shows that the effect of each explanatory variable on mode choice is different for each trip purpose. For instance, 12 to 55 years old passengers on home-based work (HBW) and home-based other (HBO) trips prefer to choose public transit, but on home-based school (HBS) trips, prefer to select subscription bus.

Keywords- Discrete Choice Model, Mode Choice, Suburban, Trip Purpose.

I. INTRODUCTION

One of the main subjects in transportation engineering and planning is passenger's mode choice, which has a significant effect on policy-making [1]. The underestimation of future travel demand causes delay, traffic congestion, and accidents. On the other hand, the overestimation of travel demand leads to wasting the considerable money and prevent to be spent on other needed aspects of development [2]. To study the available transportation systems, predict, and provide the future requirements such as managing the demand, transportation engineers and planners focused on the modeling passenger's mode choice behavior to have a depth understanding of the factors, which have the critical influence on it. To have an accurate estimation of the level of usage for different transportation modes, such as public transit, private vehicle, walking and subscription bus, the focusing on mode choice analysis is required. The base of the most of the mode choice models is random utility maximization principle such as discrete choice model, which is applied in economics. [3].

II. LITERATURE

One of the most critical issues in transportation planning that is received much attention is mode choice which has a significant effect on the policy-making decisions. Al Ahmadi [2] used MNL model as an intercity mode choice model for Saudi Arabia. Results show that out of pocket cost, in-vehicle travel time, distance, income, travelers' nationality, number of cars owned by family and number of family members who travel together have a significant effect on intercity mode choice models. Mattson et al. [4] focused on the exploration of the attitude of would-be passengers in their mode choice and the factors that have the effect on the mode choice in small urban and rural areas. Results show that the van service was chosen more than rail and bus and the level of access and personal experience affect the mode selection. Abuhamoud et al. [5] worked on the binary logit mode choice models, and alternatives were bus and car in Libya. Results show that gender has a significant effect on the mode choice model. Cluster analysis was used in this study, and Multinomial Logit (MNL) was used as a mode choice model that included the walking time, waiting time, in-vehicle time, fare, comfort, travel time and cost. It was found that people from the different groups had very different characteristics. Hence, individual grouping improved the estimation. Aizezi et al. [6] used the Multinomial Logit model to find the effect of socio-demographic characteristics on travel mode choice of rural and urban areas. The results indicate that the income and gender are the factors, which are the reason for the difference bicycle travel between rural and urban areas; this factor for the motorcycle is age and for the car is income and travel purpose for walking.

Abdel-Aty and Abdelwahab [7] worked on three level Nested Logit model for Florida, USA. The significant variables, which include in the model, were household car ownership and fare, in-vehicle travel time, waiting time, access time, the number of travelers. Abdul Sukor and Asmah Hassan [8] focused on elderlies' mode choice in the rural area. The regression model used to find the factors that affect the elderly frequency of using motorcycle or car. Factors such as gender, vehicle ownership, and license ownership were found. Gong and Jin [9] used the evolutionary game model that is the dynamic replication mechanism to focus on the car owner's mode choice in the urban area. The results show that restriction policy for private travel and development of public transport system influence on car owner's choice proportion. The travel cost, travel time and comfort level affect mode choice model. The travelers select the modes regarding the benefits of the public transport and cars. In a study by Hu et al. [10], travel mode choice in small cities of China was focused, and Multinomial Logit regression was used to determine the impact of built environment and attitudinal factors on mode choice. Results show that the small cities need different transportation strategies and land use for design and planning. This study foresees in contributing more extra details on passenger's mode choice behavior. The scopes of this article are first, analyzing the effect of macroscopic factors on mode choice in the suburb area, which are attributes of alternatives and passenger's socioeconomic characteristics. Secondly, modeling and analyzing the mode choice behavior based on different trip purposes. The suburb area has the small population and includes mostly residential and industrial zones. In this study by conducting an accurate survey, analyzing the vast quantities of disaggregate data and modeling the mode choice behavior by discrete choice model, the knowledge gap in this area is filled. In the next section, the description of the study area, data analyzing and the method, which is used, is presented. Then, the result of the process will be clarified with a full conclusion in the last section of the article.

III. DATA

The city of Denizli is a province center in Aegean Region of Turkey with approximately one million inhabitants as seen in Fig.1. In Denizli, distribution of the population into the urban, suburban and rural is 57%, 4%, and 38% respectively. In this research, by using a survey, the disaggregate data collected from 975 respondents' trip which almost 4% of whole trips that occurs in suburban. In the research survey, passengers have different attributes such as different age, income, employment situation, driving license status and having the different number of vehicle per household. The aggregate data include the micro-simulation model calculates the cost, time, and distance for each mode.

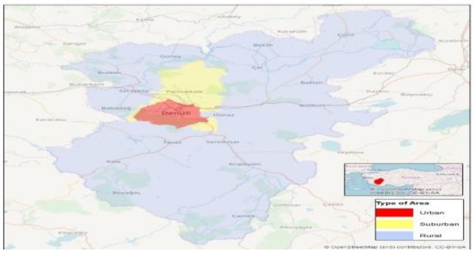

Fig. 1 Location and type of areas in Denizli

IV. DATA ANALYZE

There are nine independent variables, which are used to predict passengers' behavior and estimate their mode choice. These variables comprise two groups of data that the first one is passengers' properties including household size, passengers' age, income, occupation and driving license and the second group is related to features of alternative such as travel time, travel cost and the distance between origin and destination (O-D). In this study, 38 percent of passengers chose the walking mode, about 23 percent selected private vehicle, and 26 percent chose public transport and near to 13 percent selected subscription bus.

Passengers' properties have an important effect on their choice behavior base on the trip purposes, which are home-based work (HBW), home-based school (HBS), and home-based other (HBO). The explanatory variables related to passengers' features comprised in this study including passengers' age, occupation, driving license, income, and the number of vehicles for each household are shown in Table 1.

As it is shown in Table 1, the trips are classified into four different travel purposes including home-based other travelers that means all travels from home to every destination except school and work office. Home-based school travels are the travels from home to school. Home based work travels are the travel from home to work office.

Passengers' age classified into two age categories. One of the age categories is the passengers who are between twelve and fifty-five years old, that includes most of the students and employees passengers who are about 59.49 percent of travelers. The other group is under the age of twelve that they usually travel with their parents that just 12 percent of all travelers are included plus the travelers over 55 years old who are retirement and accounted for 39 percent of all passengers. The average age of passengers is 37 years old with minimum age 6 years old and maximum age 98 years old. As it is shown in Table 1, the highest percentage of trips of 12 to 55 years passengers is for the home-based work trip, which includes 70.35 percent of travels because most of them commute home to work and home to school. Therefore, they have less travel time for going to other places. Hence, the lowest rate of their travels is for home-based other trips which are 50.58 percent. The percentage of employed travelers is 27.38 and the rest 72.62 percent consists of unemployed travelers such as students, retired and homemakers. As it is mentioned in Table 1, the highest rate of trips for employed passengers is for home-based work with 45.23 percent and the lowest one is for home-based other with 21.18 percent.

Passengers classified into two groups regarding their income range. The percentage of travelers in the first group comprises revenue less than 1750 Turkish Lira (TL) per month, which is equal to the poverty threshold, includes 76.31 percent of passengers. The second group allocated for travelers who earn more than 1750 TL, which includes the rest 23.69 percent of travelers.

TP*	12-55 Year- old	Male	E**	HDL ***	WP** **	Vehicle per Household					
						No	1	2	3	4	5
HBO	54.5	65.9	21.1	45.8	20.9	40.3	39.3	16.7	0.6	2.6	0.4
HBS	60.2	69.0	25.3	36.5	30.1	32.9	41.7	17.6	4.8	1.6	1.2
HBW	70.3	67.3	45.2	51.2	22.1	32.1	54.2	10.0	3.5	0.0	0.0

TABLE 1 THE PERCENTAGE OF EACH PASSENGERS' PROPERTIES FOR EACH TRIP PURPOSE

* Trip Purpose: TP **E: Employed ***Have Driving License: HDL ****Wealthy Passenger: WP

As it is shown in Table 1, the highest rate of trips for who are wealthy is home-based school travels, and the least of it is home-based other trips. The highest percentage of travels for passengers who have no vehicle is home-based other travel with 40.32 percent. 44.61 percent of passengers have the driving license. More than 97 percent of passengers who have the driving license is male, and about 65 percent of passengers who have the driving license, is at the age of twelve to fifty-five years. As it is presented in Table 1, the highest percentage of travels for passengers who have the driving license is for home-based work with 51.26 percent and the lowest rate is for home-based school travels with 36.55 percent.

Properties of alternatives have the primary effect on passenger choice behavior. In this study, trip time and cost of alternative modes and the distance between origin and destination of the trips are included as explanatory variables presented in Table 2 and 3.

Table 2 shows that for all travel purposes, the highest average of travel time among mode alternatives are traveling by walking mode and the lowest one is for tripping by private vehicle. The highest walking travel time selected by passengers is less than 60 minutes or the less than 5 kilometers distance in the survey.

Trip Purpose	Private Vehicle	Public Transit	Subscription Bus	Walking
HBO	4.79	5.69	6.23	62.21
HBS	5.03	5.79	6.54	63.32
HBW	5.68	6.36	7.39	69.51

TABLE 2
THE AVERAGE OF THE TRAVEL TIME (MINUTES) OF EACH MODE FOR EACH TRIP PURPOSE

Table 2 shows that for all travel purposes, the highest average of travel time among mode alternatives are traveling by walking mode and the lowest one is for tripping by private vehicle. The highest walking travel time selected by passengers is less than 60 minutes or the less than 5 kilometers distance in the survey.

In Table 3, the cost of subscription bus and the walking mode are not comprised because subscription bus provides free services since either employer or the government, pays the price in Turkey instead of passengers who are employees or students and traveling by walking mode has no cost.

As it is mentioned in Table 3, the highest average of travel cost for all travel purposes is for the private vehicle, which is about two times more than public transit. The travel distance for all modes is same in suburb areas.

Trip Purpose	Travel Cost (TL)		Distance (km)
	Private Vehicle	Public Transit	
HBO	2.21	1.04	5.18
HBS	2.26	1.05	5.28
HBW	2.51	1.16	5.79

TABLE 3
THE AVERAGE OF TRAVEL COST OF EACH ALTERNATIVE AND THE DISTANCE FOR EACH TRIP PURPOSE

V. METHODOLOGY

Discrete Choice Model is one of the best usage methods to predict passengers' choice behavior when the choice is between the two or more discrete alternatives [11]. The discrete choice models statistically focused on the decision made by each passenger related to the attributes of the alternative modes available to the passenger and the characteristics of the passenger. The correlation between selected independent variables in the model should be low. In this model non-parametric, parametric, semi-parametric and maximum likelihood methods are used [12]. In this study, some of the variables are generic variable that the coefficient of the variable is same in all utility of alternative modes such as pedestrians' value of time, driving license and distance. On the other hand, some variables are the alternative specific variable that the coefficient of the variable is different in the utility of modes such as age, employment, income and number of vehicles per household. The constants of the utilities are alternative specific constant because they are different in the utilities (ASC).

The passenger's choice depends on many factors, which include two parts that some of them observed and some of them not. The utility (U), which the passenger can get from selecting an alternative, obtained from these two parts as it is shown in (1) [13].

$$U_{ni} = B\,Z_{ni} + \varepsilon_{ni} \quad (1)$$

Z_{ni}; Vector of observed variables relating to alternative i for passenger n that depends on attributes of the alternative, x_{ni}, interacted perhaps with attributes of the passenger, s_n, such that it can be explained as $z_{ni} = z(x_{ni}, s_n)$ for some numerical function z,
B; Is a vector of coefficients of the observed variables, and
ε_{ni}; Captures the effect of all unobserved factors that affect the passenger's choice.

Some quantitative and qualitative variables coded and classified into two groups as a dummy variable. The dummy variable is zero or one in the model. Each dummy variable has its code definition that for age, the one means the passengers who are between 12 and 55 years old and otherwise zero. For employment, the code one implies that employee passenger and zero is for unemployment passenger. The code one for income means that passenger is middle or wealthy class and otherwise, its code is zero.

Equation (2) shows the probability of choosing of each alternative (P_{ni}), which is related to the feature of alternative and passengers features [14].

$$y_{ni} = \begin{cases} U_{ni} = BZ_{ni} + \varepsilon_{ni} \\ \varepsilon_{ni} \sim \text{iid extreme value} \end{cases} \Rightarrow P_{ni} = \frac{\exp(Bz_{ni})}{\sum_{j=1}^{J} \exp(Bz_{nj})} \quad (2)$$

Where;
J; The total number of alternatives
iid; Error term should be identically and independently distributed
The value of time (VOT) is the amount of money that passengers willing to pay for saving their time or the amount of money they would accept as compensation for lost time. For finding the VOT in this research, the cost is divided by time and its unit is Lira per minute. The travel time of public transit is equal to access time plus waiting time plus in-vehicle time plus egress time. The travel time of subscription bus is equivalent to just access time plus in-vehicle time for the morning trips that passengers go to their work or school and in-vehicle time plus egress time during the afternoon trips that passengers come back to their home from school or workplace. Travel time for the private vehicle is assumed in-vehicle time.
It is assumed that the travel cost of public transit is equal to its fare, and the travel cost of the private vehicle is equal to the fuel price. The utility Equations of alternative modes for the estimated model are presented in (3);

$$\begin{aligned}
U_W &= B_0 + B_1 \times \text{Age} + B_2 \times \text{Employment} + B_3 \times \text{Income} + B_4 \times \text{Number of Vehicle per Household} + B_5 \times \text{Distance} + B_6 \times \text{Driving License} + B_7 \times \text{Vale of Time} \\
U_{PV} &= B_8 + B_9 \times \text{Age} + B_{10} \times \text{Employment} + B_{11} \times \text{Income} + B_{12} \times \text{Number of Vehicle per Household} + B_5 \times \text{Distance} + B_6 \times \text{Driving License} + B_7 \times \text{Vale of Time} \\
U_{PT} &= B_{13} + B_{14} \times \text{Age} + B_{15} \times \text{Employment} + B_{16} \times \text{Income} + B_{17} \times \text{Number of Vehicle per Household} + B_5 \times \text{Distance} + B_6 \times \text{Driving License} + B_7 \times \text{Vale of Time} \\
U_{SB} &= 0
\end{aligned} \quad (3)$$

In dummy coding, the reference mode is set to zero whereas in effect coding base level is "-1". The number of new variables created is equal to the number of degrees of the attribute being code minus one because one of the levels is references level.
The utility equations of alternative modes for the base model, which only have constants in utilities (market share model), are shown in (4);

$$\begin{aligned} U_W &= B_0 \\ U_{PV} &= B_8 \\ U_{PT} &= B_{13} \\ U_{SB} &= 0 \end{aligned} \quad (4)$$

VI. RESULTS

The data, which were outliers, are eliminated, and the results of the best model among the all tested models are shown in Table 4, 5 and 6.
The coefficient and T-statistic of each variable in each mode utility equation for each trip purposes are presented in Table 4, 5, and 6.
As it is shown in Tables 4 to 6, the coefficients which are statistically significant at 95% level or greater, are in bold. The comparison level is subscription bus and all coefficients are in comparison to it. The distance and value of time have negative coefficients in all modes equation for all trips as it is expected, which shows that as much as the distance and the value of time increases, the probability of choosing the subscription bus will raise on all trip purposes.
As much as the number of vehicles per household increases, the likelihood of selecting the walking mode, private car and public transit for home-based other trips will decrease compared to the reference mode and for home-based work and home-based

school trips, will be lower compared to the reference mode.

The probability of choosing walking mode is the highest on for the employee on their all trips except the home-based work trips. The probability of choosing private vehicle is the lowest one when it is selected by passengers who are between 12 and 55 years old on their home-based work and home-based school trips and for middle and wealthy class passengers on their home-based school trips. The probability of choosing public transit is the highest one when 12 and 55 years old passengers select it on their home-based work and home-based other trips. For middle and wealthy class passengers on their home-based other, the probability of choosing subscription bus is the highest one when 12 to 55 years old passengers prefer it on their home-based school trips and for the employee on their home based-work trips. It has the lowest probability when middle and wealthy class passengers select it on their home-based work trips and for passengers who have the driving license on their all trips.

Variables	Alternative Modes					
	Walking		Private Vehicle		Public Transit	
	Coeff. *	T-sta**	Coeff	T-sta	Coeff.	T-sta
Age	-0.53	-0.93	-0.94	-1.41	0.01	0.004
Employment	-2.15	-3.41	-0.7	-1.06	-2.07	-3.28
Income	0.98	1.44	0.75	-1.08	0.65	0.92
Number of Vehicle per Household	0.02	0.07	0.55	1.52	0.08	0.24
Distance	-0.03	-0.68	-0.03	-0.68	-0.03	-0.68
Driving License	2.12	3.49	3.29	5.14	2.28	3.70
Value of Time	-0.65	-0.47	-0.65	-0.47	-0.65	-0.47
Constant	0.82	1.61	-0.47	-0.53	0.32	0.53

TABLE 4
THE COEFFICIENT AND T-STATISTIC OF EACH ALTERNATIVE MODE FOR THE HOME-BASED WORK TRIPS

*COEFFICIENT: COEFF **T-STA: T-STATISTIC

The age, income, number of vehicle per household, distance and value of time are insignificant variables in all utility modes for all trip purposes. Their T-Statistic are between 2 critical numbers, which are minus 1.96, and 1.96 for 0.05 significance levels and we fail to reject the hypothesis that the population means the difference is zero. Employment is insignificant variables in all utility modes for all trips except for home-based work trips. In this study, all of these variables are kept in the model because they have the influence even if it is the insignificant effect.

Variables	Alternative Modes					
	Walking		Private Vehicle		Public Transit	
	Coeff. *	T-sta**	Coeff.	T-sta	Coeff.	T-sta
Age	-0.42	-1.02	-0.65	0.57	-0.40	0.45
Employment	-0.21	-0.26	2.09	0.81	0.76	0.77
Income	0.66	1.33	-0.04	0.63	0.35	0.53
Number of Vehicle per Household	0.11	0.46	0.44	0.29	0.14	0.25
Distance	-0.07	-1.94	-0.07	-1.94	-0.07	-1.94
Driving License	2.07	2.5	3.74	0.87	1.79	0.85
Value of Time	-0.10	-0.06	-0.10	-0.06	-0.10	-0.06
Constant	0.96	2.36	-1.09	0.89	0.56	0.51

TABLE 5
THE COEFFICIENT AND T-STATISTIC OF EACH ALTERNATIVE MODE FOR THE HOME-BASED SCHOOL TRIPS

*COEFFICIENT: COEFF **T-STA: T-STATISTIC

Variables	Alternative Modes					
	Walking		Private Vehicle		Public Transit	
	Coeff. *	T-sta**	Coeff.	T-sta	Coeff.	T-sta
Age	-0.57	-1.44	-0.50	-1.08	0.28	0.69
Employment	-0.69	-1.31	0.13	0.24	-0.36	0.52
Income	0.90	1.70	0.85	1.48	-0.32	0.59
Number of Vehicle per Household	-0.25	-1.14	-0.03	-0.11	-0.48	0.24
Distance	-0.03	-0.98	-0.03	-0.98	-0.03	-0.98
Driving License	1.30	2.77	2.54	4.94	1.41	2.94
Value of Time	-0.90	-1.01	-0.90	-1.01	-0.90	-1.01
Constant	1.89	5.11	0.34	0.60	1.45	3.46

TABLE 6
THE COEFFICIENT AND T-STATISTIC OF EACH ALTERNATIVE MODE FOR THE HOME-BASED OTHER TRIPS

*COEFFICIENT: COEFF **T-STA: T-STATISTIC

To compare the estimated model for home-based work trips (LLestimated) with the base model, which is market share model with only constants (LLM), -2LL is calculated in the (5).

$$-2LL = -2 \times (LL_{Base} - LL_{estimated})$$
$$-2LL = -2 \times (-274.15 - (-234.49)) = 79.32 \quad (5)$$

17 coefficients in the estimated model minus three constants in the base model (a market share model with only constants (LLM)) equals to 14.

At the level of 5% significance, χ 2 is computed 23.685 which is less than 79.32 from the Chi-Square distribution table. Therefore, the model is improved compared to the base model.

The Pseudo ($\rho2$) is calculated to measure the goodness-of-fit and in this analysis as presented in (6).

$$\rho^2 = 1 - \frac{LL_{Estimated}}{LL_{Bse}}$$
$$\rho^2 = 1 - \frac{-234.49}{-274.15} = 0.144674 \quad (6)$$

The compression results, which is between each trip purpose choice model and base model and the ρ^2 of each of them is presented in Table 7.

As it is shown in Table 7, choice models are improved compared to their base model and have the acceptable goodness of fit for all trip purpose.

Trip purpose	$LL_{estimated}$	LL_{Base}	-2LL	Improved or Not Improved	ρ^2
HBW	-234.4	-274.1	79.3	Improved	0.14
HBS	-278.6	-334.6	111.9	Improved	0.17
HBO	-555.8	-613.4	115.2	Improved	0.10

TABLE 7
COMPARISON BETWEEN MODELS OF TRIP PURPOSE MODE CHOICE AND THEIR BASE MODELS

For finding out the passengers' mode choice difference in the suburb area, the average of the percentage of the probability of selecting each mode for each trip purpose is presented in Table 8.

Trip Purpose	Walking	Private Vehicle	Public Transit	Subscription Bus
HBW	28.14	28.14	23.12	20.60
HBS	36.14	24.10	24.10	15.66
HBO	42.77	19.55	29.33	8.35

TABLE 8
THE AVERAGE OF THE PERCENTAGE OF THE PROBABILITY OF CHOOSING THE MODE FOR EACH TRIP PURPOSE FROM MODELS

On all trip purposes, the highest average of the probability of choosing mode is for walking except on home-based work trips that the likelihood of selecting the walking and private vehicles are same and the lowest one is the subscription bus on all trip purposes. The highest probability of choosing the walking mode is on home-based other trips, and the lowest one is on home-based work trips. The highest one for the private vehicle is on home-based work trips, and the lowest one is on the home-based other trips. The lowest average of the probability of selecting the public transit is on home-based work trips. The highest and the lowest ones for subscription bus are on home-based work trips and home-based other trips respectively. The average probabilıty of choosing the private vehicle and public transit are equal on home-based school trips and the average probability of selecting the walking mode and private car are similar to on home-based work trips.

CONCLUSION

Because of the importance of mode choice behavior in transportation planning and policy-making, it gets much attention from transportation planners and engineers in recent years. Because of being just a few studies about mode choice in suburban, the purpose of this study is filling the knowledge gaps and giving comprehensive and accurate results, which show the passengers' behavior for choosing the modes that have different travel time, travel cost and value of time for the same trip distance. The aggregate data are obtained from macro-simulation model (PTV Visum software). Also since the disaggregate data obtained from the big survey, this study focused on different passengers' properties and found their effect on the mode choice process. These properties including ages, income, number of vehicles per household, occupation situation and driving license. For reaching this purpose, this study focuses on the passengers' mode choice behavior by working with the combination of near to thousand disaggregate data, which are obtained from survey and aggregate data that are gained from the micro-simulation model. By using the discrete choice model, which is one of the best choice models, a very comprehensive and accurate model is obtained to explain the passenger's behavior and estimate their choice on each type of trip purpose by the discrete choice model. The results show that although the passengers rather walk less than 60 minutes, the walking mode has the highest probability for being selected by passengers on all trip purposes and on home-based work trips; it is equal to the private vehicle. The subscription bus has the lowest probability of being used by travelers compared to the other modes in suburban. Public transit and the private vehicle have the same probability to be selected by passengers on home-based school trips. The studies for each trip purpose shows that 12 to 55 years old passengers prefer to travel by public transit on home-based work and home-based other trips, by subscription bus on home-based school trips. Employees rather travel by subscription bus on home-based work trips, by public transit to home-based school trips including trips from home to the school and university, by private vehicle on home-based other trips. Middle-income level and wealthy class passengers prefer to travel by public transit on home-based work, home-based school, and home-based other trips. Travelers who have driving license prefer to choose the private vehicle for all of the trip purposes. Hence, each explanatory variable can have the different effect on passengers' mode choice on each trip purpose.

In future, studies, the difference between the passengers' mode choice behavior in suburban and their behavior in other areas such as urban or rural can be studied with different new models to compare their results with this study for having the more comprehensive information on passenger's behavior difference, which is related to their locations. They can also focus on the more passengers' properties and attributes of alternatives to find their effect on the passengers' mode choice with more details.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support given by Denizli Greater Municipality.

REFERENCE

[1] [1]. Willumsen LG. MODELLING. 2011.
[2] [2]. Al-Ahmadi H. Development of Intercity Mode Choice Models for Saudi Arabia. J King Abdulaziz Univ Sci [Internet]. 2006;17(1):3–20. Available from: http://prod.kau.edu.sa/centers/spc/jkau/Data/Review_Artical.aspx?No=2198
[3] [3]. Zenina N, Borisov A. Transportation Mode Choice Analysis Based on Classification Methods. Sci J Riga Tech Univ Comput Sci [Internet]. 2011;45(1):2–6. Available from: http://www.degruyter.com/view/j/rtucs.2011.45.issue--1/v10143-011-0041-2/v10143-011-0041-2.xml
[4] [4]. Mattson J. Assessing Demand for Rural Intercity Transportation in a Changing Environment. Direct. 2010;(May).
[5] [5]. Abuhamoud MAA, Rahmat RAOK, Ismail A. Modeling of transport mode in Libya: A binary Logit model for government transportation encouragement. Aust J Basic Appl Sci [Internet]. 2011;5(5):1291–6. Available from: http://www.scopus.com/inward/record.url?eid=2-s2.0-

84867713589&partnerID=40&md5=c58c32c52c68c44f2158bc0d9bbefbc4
[6] [6]. Cictp 2017 2893. 2017;(2000):2893–901.
[7] [7]. Abdel-Aty M, Abdelwahab H. Calibration of Nested-Logit Mode-Choice Models for Florida. 2001;(November):104. Available from: http://trid.trb.org/view.aspx?id=713245
[8] [8]. Abdul Sukor NS, Basri NK, Hassan SA. Travel behaviour modification technique – A framework for awareness on carbon footprint towards adolescents in developing country. J Teknol. 2015;76(14):43–8.
[9] [9]. Gong H, Jin W. Analysis of urban car owners commute mode choice based on evolutionary game model. J Control Sci Eng. 2015;2015.
[10] [10]. Hu H, Xu J, Shen Q, Shi F, Chen Y. Travel mode choices in small cities of China: A case study of Changting. Transp Res Part D Transp Environ [Internet]. 2018;59:361–74. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1361920917306004
[11] [11]. Division TP. Mode Choice Analysis : the Data , the Models and. 2014;4(3):269–85.
[12] [12]. Park BU, Simar L, Zelenyuk V. Nonparametric estimation of dynamic discrete choice models for time series data. Comput Stat Data Anal [Internet]. 2017;108:97–120. Available from: http://dx.doi.org/10.1016/j.csda.2016.10.024
[13] [13]. Koppelman FS, Bhat C. A Self Instructing Course in Mode Choice Modeling : Multinomial and Nested Logit Models by with technical support from Table of Contents. Elements. 2006;28(3):501–12.
[14] [14]. Ben-Akiva ME, Lerman SR. Discrete choice analysis: theory and application to travel demand. MIT press; 1985.

★★★