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Research Article

AN ANALYSIS FOR MODE CHOICE PREFERENCES BETWEEN ANKARA AND ISTANBUL

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ABSTRACT

In this study we conduct a survey which asks the respondents to evaluate the transportation modes based on “trip time”, “trip cost”, “comfort”, “reliability” variables whether they use or not the mode. It is assumed that the choices made based on “utility theory” and Multinomial Logit Model (MLM) incorporated. Utility functions for all modes (air, intercity bus, rail and private car) that serve between Ankara and Istanbul incorporated to the model presented. The weights of variables that effects choice probabilities used in utility function are calculated and then aimed modal distributions with required probability expressions. Finally modal distribution percentages are calculated for HSR (High Speed Rail System) in-operation as well as other three modes. Calculated modal distribution percentages are 51,91 % for intercity bus, 20,70 % for private car, 19,96 % for air and 7,43 % for HSR. With this study, we aimed that decision makers will be able to make more realistic projections and to develop a useful tool to help them made best possible transportation investments. Also a contribution for the related literature via a case-study is another aim of this work.
Keywords: High speed rail, transportation mode choice, modal distribution, transportation planning, transportation modelling.

1. INTRODUCTION

Today transportation service users not only expect to fulfil their transportation needs by service suppliers, they also expect the most comfortable, the most reliable, the safest and the fastest possible services as long as possible. To meet these expectations various transportation systems developed. High Speed Rail (HSR) system, which is developed to meet these user expectations in railway mode, can be defined based on different criteria. HSR is a common name that given the rail systems, which are able to attain at least 250 kph for commercial services. Also infrastructures that can meet safely the dynamic effects of over 250 kph speed operation defined as high speed rail lines.

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HSR's are used in European countries as France, Germany, Spain, Italy and also some far Eastern Countries such as Japan, South Korea and China. More than 120 lines in the Japan transport almost 305 million passengers, which is the pioneering country of HSR's.

In Turkey Ankara-Eskisehir HSR line stated operation at March 13^{th} of 2009. Travel duration is nearly one and a half hour in this 245 km line. This line was the first leg of Ankara-Istanbul HSR. After the completion of the other two legs (Marmaray Crossing and Eskisehir-Istanbul line) it's been completed the first HSR system between Europe and Asia (1).

One of the prominent aim of modern society must be to promote sustainable transportation modes and also alleviate such problems of congestion, pollution, parking shortages which are emerge from over private car use. One of the success criteria for this goal may be to make public transportation systems more attractive than private transportation. For reaching this goal it is important to know potential user's decision criteria to use to whether to chose the system or not and his or her attributed weights for this criteria (2).

In this study modal split effects of HSR is analyzed based on a regional case. A modal split model developed based on Ankara-Istanbul HSR and it is expected that this model can be used to analyze similar lines. This study consists three main parts, at first part a brief literature survey about modal choice models given, in second part analyzed line and region and the used model for analyze defined and finally in the last part outputs and evaluations are presented.

2. LITERATURE REVIEW

Railway is known as a sustainable and environment friendly transportation mode because of the ability of implementing non-fossil derivative energy resources, high passenger and freight capacities, and low usage of floor areas. HSR however, besides these characteristics also offer better comfort, safety, reliability and speed to its users (3). When the superior characteristics of HSR such as speed and the other service level components considered it is obvious that HSR provide more productive service from conventional rail systems. So it will be wise to evaluate this operation alternative in front of the others while high capacities are required (4).

When an HSR system built then it has a great effect on passenger's mode choices. A lot of model developed for determining the distribution of trips among alternative modes and these models named as modal split or mode choice models. From the beginning oh 1980's different mode choice models developed to estimate the number of HSR passengers, some of them are evaluation Analytical hierarchy model, game theory and logit models (5)

The choice between HSR and other modes made based on binary logit model can be seen in Cohen et. al., Brand et. al., Marwick, Chu and Chen, Charles River Assoc. (6, 7, 8, 9, 10). There is only two alternative can be evaluated using binary logit model. For removing this shortage in the number of alternatives Multinomial Logit Model (MLM) developed by Grayson in 1981 and used frequently later on (11).

Some examples of intercity mode choice models based on logit model are TMS/Benesch (12), Forinash and Koppelmann (13) and Bhat's works during 1990's (14, 15, 16). In Bhat's work (15) Toronto-Montreal corridor passengers are segmented based on some certain characteristics and separate mode choice models developed for these segments. For determined three segments the MLM used based on income, gender, trip day (day of the week), length of the trip parameters.

A study that investigated the share of HSR in transportation sector made by Gunn et. al. (17) in 1992. In this work, also financial performance and offered services analysed in Melbourne-Sydney HSR line. Mode choices between possible competitor transportation modes made based on MLM and evaluated with several different scenario analyses.

Gliebe and Kim (18) conducted a work about how individuals perceived the utilities of alternatives based on the time of the day using MLM. Another work done by Miller (19) in 2004 points out the shortages of intercity trip models and he suggests that above conventional variables such as time and cost new a pproaches should incorporate the number of individuals in a group if there is a group trip and finding the private automobile possibility at destination point.

Algers (20) on the other hand modelled a system that can produce estimations on trip productions, trip distributions and modal split. Modal splits in analyses calculated based on discrete choice models especially logit models. According to Algers using discrete choice models for trip choice modelling is a valid method for evaluating new transportation investments and for investigating variations in transportation systems.

In a study done by Hsu and Chung in 1996 (21) market shares of both conventional trains and HSR in a corridor researched. A new analytical model developed which based on an individual behaviour point of view.

In their work about Madrid-Sevilla HSR Rus and Inglada (22) found that 52 % of air passengers and 15 % of private car passengers are turn to HSR. A similar work done by Kim et. al. (23) on Korean Express Train (KTX) and they found that new train causes almost 35 % decrease in five major airports demands.

In a research made by Gonzalez-Savignat (24) competition possibilities of HSR with private car on Madrid-Zaragoza and Madrid-Barcelona lines investigated. A MLM developed based on a stated preference survey questionnaire. Another work done by Lopez-Pita and Robuste (25) for the same corridor they asked if there would be a new line constructed with 350 kph speed instead of the existing one they found that rail share could rise from 11% to around 53-63 %.

Lee et. al. (26) in their work pointed out that the studies based solely on revealed preferences (RP) or stated preferences (SP) of users are not sufficient to represent reality good enough and they recommend mixed logit model which bring together in a mixed questionnaire both RP's and SP's of respondents asked. With the model they analysed the effects of HSR service conditions' changes on passengers reactions in HoNam region.

First study which uses both RP and SP questionnaires together done by Morikawa et. al. in 1991 (27). This method used for modelling intercity trip choices. Another study done by Hung-Yen and Fu (28) they examined the perceptions of users of HSR effects by using discrete choice model theory. Individual choice model for this work produced by analysing airline pricing policies.

Fröidh (29) present a study about the evaluation HSR in general transportation sector in Swedish and Scandinavian region. Trip times and ticket fares are main parameters for this study and competition level among HSR, which is a new mode with domestic air modes, analysed in this context. Ben-Akiva et. al. developed three integrated demand models (30): statistics based "national demand increase" model, "mode/service choice model" that brings data about modal split rates between different cities and "adaptive demand" model. They calculated direct and cross elasticities for HSR.

In Chen's study (31) the effect of new Richmond (VA)-Washington D.C. HSR line effect on passenger' mode choices is analysed. He developed a nested logit model with two upper nest (air and land nests) and three lower nest (private car, intercity bus and rail) under the land nest.

In Barreira et. al. (32) they analysed Lisbon-Madrid HSR line and they found the most important variable is cost. They reached the conclusion of that the competition among modes would increase after the HSR will be operational.

Behrens and Pels (33) examined the competition among modes and intra-modes between the years 2003 and 2009 for London-Paris trips. They defined the conditions for HSR is a viable alternative to air mode. In their work they determined train frequency, total journey time (door to door) and the distance to airports at London side as main decision criteria for passenger preferences

Bergantino et. al. (34) try to present the effects of a newly introduced transportation service in their study. For this purpose they firstly examined intra-mode price and capacity effects and then they again examined the effects of HSR competition on other modes. As a result they concluded that HSR causes a decrease on air ticket fares on same line and capacity and frequency variables are both effective on service preference.

3. STUDY CASE

3.1. Survey Study

It is hoped that the questionnaire would give us meaningful opinions for the behaviors of all passengers at most possible level. Data was collected by questionnaires during November 2015. The main body of the study consists of the people that travel between Ankara and Istanbul. For that reason the survey site selected as the biggest squares of both cities. Based on 99.7 % confidence level a sample size of 900 determined (35). These sample size also re-distributed by cities' population, age distribution and gender between both cities. Population values used for calculating sample size and determined questionnaire numbers can be seen in Table 1.

Table 1. Number of questionnaires answered by passengers 18 years and over at Ankara and Istanbul

Regional population of age18 years and over (Person)	Total Population (Person)	Rate %	No of questionnaires
İSTANBUL Region 1 (November 1st, 2015) : 3718621 İSTANBUL Region 2 (November 1st, 2015) : 3059084 İSTANBUL Region 3 (November 1st, 2015) : 3534833	10312538	73,4	734
ANKARA Region 1 (November 1st, 2015) : 2097017 ANKARA Region 2 (November 1st, 2015) : 1646606	3743623	26,6	266
Total	14056161	100,0	1000

Our questionnaire has two parts; at first part there are 10 questions. These questions aimed to measure of passengers' perceptions on the parameters which are used by them preferred mode and possible alternative modes as well as evaluating all alternative modes. 5 point Likert scale used for the qualitative characteristics such as comfort and reliability. At the second part of the questionnaire various specifications of samples are determined. Demographic data such as age, gender, income and profession are accumulated at this part. Regions for both İstanbul and Ankara are selected based on general electoral system of Turkish Republic regioning system (See Table 1).

3.2. Sample Characteristics

Descriptive statistics and demographic characteristics for total of 1004 units sample (the number of total responses of the questionnaire) which will be used in analyses given in Table 2. Average age calculated as 37.67 for all respondents. If we analyzed this data in detail than we see that 15.9 % of the respondents are between 18 and 23 years old, 17.5 % of them are between 24 and 27 years old, 21.5 % of them are between 28 and 35 years old, 21.1 % of them are between 36 and 45 years old, 11.7 % of them are between 46 and 55 years old, 7.8 % of them are between 56 and 65 years old and the rest 4.5 % are above 65 years old. 45 % of survey participants are females. For measuring income levels both personnel incomes and household incomes are asked.

So these figures are determined as 2,213.19 Turkish Liras and 2,629.62 Turkish Liras respectively (at time of survey conducted 1 US Dollar was equal to 2.60 Turkish Liras).

Table 2. Sample Characteristics

Characteristics	Statistics
1. Gender	Male (55%), Female (45%)
2. Age	18-23 (15.9%), 24-27 (17.5%), 28-35 (21.5%), 36-45 (21.1%), 46-55 (11.7%), 56-65 (7.8%), >65 (4.5%)
3. Income level	Average personal income 2213.19 Turkish Liras Average household income 2629.62 Turkish Liras
4. Direction of journey	Ankara-Istanbul 18.3% Istanbul-Ankara 81.7%
5. Frequency of journey	Every day (9.56%), Several times a week (17%), Several times a month (46%), Several times a year (25.67%)
6. Scope of journey	Visits (48.8%), Recreational (18.7%), Work (24.5%), School (6.3%), Other (1.7%)
7. Car ownership	Have own car (36.44%), Have a family car (41%), No car (21.56%)
8. Transportation mode used in the last trip	Bus (50.9%), Private car (21.5%), Airways (20.1%), HSR (7.5%)
9. Transportation mode that will be preferred after completion of HSR integration	Bus (7.6%), Private car (7.4%), Airways (15.4%), HSR (69.6%)

In the questionnaire there are some questions to collect information about users' trip experiences. For example 18.3 % of respondents told us that their last trip was toward Ankara to Istanbul. When we made a list according to their trip purposes then we see that 48.8 % of all trips made for vacation, 24.5 % of them are business trips, 18.7 % of them are recreational trips, 6.3 % of them are educational and the rest 1.7 % are made for other reasons. The distribution of the mode preferred for the last trip seen as 50.9 % are intercity bus services, 21.5 % are private cars, 20.1 % are air and 7.5 % are HSR. Within questionnaire also if the integration of HSR with the European side of Istanbul provided than what would be your mode choice question asked. Their responds' distribution for this hypothetical situation were 69.9 % HSR, 15.4 % air, 7.6 % intercity bus and 7.4 % private car.

4. MODEL ANALYSIS

Choice is a fundamental component of trip decision-making process. Potential passengers usually have to make a choice among various transportation modes, which have different characteristics. Modelling trip choices does not known exactly and it is a quite complex area which is very fundamental to estimation of passenger or freight traffic. Even the number of passenger who preferred a mode could reflect the mode choice; the percentage rates of mode preferences accepted a more reliable criterion in the literature. Using percentages it would be easy to make evaluations free from population (36).

Choice models grouped under two categories; at individual level with the aid of meaningful rules there are deterministic choice models can be developed, and stochastic choice models that are based on some certain choice group's and/or population's preference possibilities. This latter one used for the evaluation of group behaviours.

While deterministic modelling of transportation choices gives inefficient results because of real life conditions could not reflect in detail stochastic modelling on the other hand able to give more realistic results. Three main reasons of stochastic modelling preferred more than deterministic ones are;

1. Individuals does not make rational decisions all the time (idiosyncrasies),
2. All the parameters that have effect on the decision could not include the model every time,
3. A passenger cannot have full information about a possible trip (36).

Discrete Choice Model (DCM) is a regression technic that developed to estimate which alternative would be chosen among two or more discrete alternatives (37). Here "discrete" means that from the alternatives cluster only one alternative can be chosen, more than one alternative cannot be chosen simultaneously. With discrete choice models if we chose one among two alternatives this is called a binary choice model, on the other hand if we chose among more than two alternatives than this is called Multinomial Choice Model.

In discrete choice models it is assumed that decision maker seeking to maximize his/her utility while making choices. These models are stochastic and their utility functions have two main parts. V_i in equation *1* is the deterministic part of utility function (U_i). ε_i on the other hand called as "error term" and it is the stochastic component of utility function (U_i), (37, 38, 39).

$$U_i = V_i + \varepsilon_i \qquad \text{(Equation 1)}$$

For mode choice analyses the most appropriate models are Discrete Choice Models (DCM) because they gives opportunity to developing more consistent relationship between demand function and consumer theory (39). In DCM the expression of the possibility of being chosen any alternative i (P_i) among C alternatives set given as below:

$$P_i = \Pr (V_i + \varepsilon_i \geq V_j + \varepsilon_j;\ i \in C,\ j \in C,\ i \neq j) \qquad \text{(Equation 2)}$$

It is possible to obtain various choice models based on different joint-possibility distributions that accepted for variances of ε_i and ε_j values that are the stochastic terms of equation 2 (37, 39). If these stochastic components based on normal distribution we obtain "probit model" and if these stochastic components based on an extreme values distribution we obtain "logit model" (40).

DCM's are models to be used for the calculation of preference possibilities of all alternatives with the aid of existing preference values that are used to calculation of parameter values of utility functions. This models used frequently in transportation demand modelling.

DCM is both a choice probability calculation model for every alternative and estimating model of utility function parameters' coefficients with the aid of existing choice values. It is very important to estimate route and mode choices of users correctly because of the necessity of keeping costs at minimum levels. In this study we obtain modal choice values for HSR, intercity bus, air and private car with the aid of MLM modelling method.

While in Binary Choice Models with only two alternatives, the probability of choice is computed by the help of Equation 3.3; in the MLM with more than two alternatives, the probability of choice (P_i) is calculated by the help of Equation 3.4.

If there are two options $(j = 2)$, the probability of choosing option *1*;

$$P1 = \frac{e^{\mu.V_1}}{e^{\mu.V_1} + e^{\mu.V_2}} \qquad \text{(Equation 3.3)}$$

In case of there are J options $(j = 1, 2, \ldots j)$, the probability of choosing the option i;

$$P(i) = \frac{e^{\mu.V_i}}{\sum_j e^{\mu.V_j}} \qquad \text{(Equation 3.4)}$$

In both equations, μ is the scale parameter, ε_n is the error term which is the logistic probability component, and it is assumed that this term fits the Gumbell (log-Weibull) distribution in the logit model (Ben-Akiva, 2008).

$$\mu = \frac{1}{\sqrt{Var(\varepsilon_n)}} = \frac{1}{\sigma} \qquad \text{(Equation 3.5)}$$

$Var(\varepsilon n) = Var(\varepsilon 2n \ -\varepsilon 1n) = \pi^2/6\mu^2$ (Equation 3.6)

DCM (Discrete Choice Model) is the model type for calculating the coefficients and calculating the probabilities of choice for each alternative of the parameters in the utility function on the base of existing preference values. With this aspect, it is a method that is applied frequently in the field of transportation. In the area of transportation, where there are quite number of choice combinations, the most accurate estimation of the real choices, such as the mode or route of transportation preferred by the passengers, is momentous in terms of minimizing the costs. In this study, parameter coefficients and modal shares of airline, bus, HSR and automobile, are obtained by MLM analysis.

- S*i*: Constant for utility function of the mode “i”,
- TTIME*i*: Total travel and access times for the mode “i” (Total journey time) (min),
- C/Ii: The ratio of trip cost to household income for the mode “i”,
- AGE (1, 2, 3, 4, 5, 6, 7): Age of passengers for the mode “i” (1. Age group: 18-23, 2. Age group: 24-27, 3. Age group: 28-35, 4. Age group: 36-45, 5. Age group:46-55, 6. Age group: 56-65, 7. Age group: 65+),
- TINC (1, 2, 3, 4, 5, 6, 7, 8, 9, 10): Household income (Turkish Lira) (1. Income group: 0-999, 2. Income group: 1000-1300, 3. Income group: 1301-1999, 4. Income group: 2000-2999, 5. Income group:3000-3999, 6. Income group: 4000-4999, 7. Income group: 5000-5999 8. Income group: 6000-6999,9. Income group:7000-8999, 10. Income group: 9000+)
- COM*i* (1, 2, 3, 4, 5): Comfort range value for the mode “i” (1. Comfort range: The worst 5. Comfort range: The best; 5-ary likert scale)
- SAF*i* (1, 2, 3, 4, 5): Safety range value for the mode “i”, (1. Safety range: Teh worst 5. Safety range: The best; 5-ary likert scale)
- ACC*i* (1, 2, 3,4, 5): Accecibility range value for the mode “i”, (1. Accecibility range: The worst 5. Accecibility range: The best; 5-ary likert scale)

After determining the parameters in DCMs, a base mode is determined and all the other utility functions are defined according to this type. This base mode choice does not make a difference on the preference percentages. Just a mere, the obtained coefficients of the benefit functions are determined in proportion to the base mode (Tezcan, 2016). The base mode is determined as automobile within the scope of the project was chosen. After determining the base mode, the utility functions are generated.

While generating the utility functions that include the specified parameters, it was decided to model these parameters as generic parameters, considering that the AGE, TINC parameters do not change according to the modes. General parameters take constant coefficients regardless of the alternative. Within this project, constant coefficients that do not change according to alternatives are determined as AGE (1, 2, 3, 4, 5, 6) and TINC (1, 2, 3, 4, 5, 6, 7, 8, 9). Option as TTIME, C/I, COM (1, 2, 3, 4, 5), SAF (1, 2, 3, 4, 5), ACC (1, 2, 3, 4, 5) parameters vary by type Modeled as an alternative specific parameter. Option-based parameters take different coefficients for each alternative type. For example, TTIME takes the TTIME1 coefficient for alternative alternative type HSR, while the 2nd alternative type takes the TTIME2 coefficient for airline.

When the coefficients are analyzed, it is observed that the “cost/income” variable has a negative coefficient for all transportation modes. In other words, the increase in “cost/income” value leads to a decrease in the choice probability of the mode. Likewise, as the travel time increases, the utility value of the related mode decreases and depending on this value the choice probability for the mode decreases. TTIME refers to the coefficient of the travel time parameter, and is negative for each mode. Besides, it could be stated that the coefficient of the “cost/income parameter” in all modes is greater than the coefficient of the “travel time” parameter; in other words, the cost has a greater importance than the travel time for the choice of passengers.

When the weights of comfort, security and accessibility variables are examined, it is found out that the passengers make an assumption that; “safety” for HSR, “comfort” for airline and “accessibility” for bus, are already high while making their inter-city transportation mode choice.

4.1. Model Results

The utility functions determined from data gathered from questionnaires is analysed by a computer program which works with MLM (numbers are assigned to systems as, HSR: 1, Airways: 2, Bus: 3, Private car: 4). The parameters that might have effect on trips for passengers are determined from literature studies and evaluated by 1004 respondents. The parameters of which the coefficients will be determined are; equation coefficients (S), the ratio of trip cost to household income (C/I), age (AGE), household income (TINC), and comfort (COM), security (SAF), and accessibility (ACC). Trip duration and cost values are directly determined values. Comfort, trust and accessibility ratings are asked in a 5 point Likert scale; 1 representing the worst, 5 for the best. Age of passengers is asked to be selected from 7 intervals (between 18-23, 24-27, 28-35, 36-45, 46-55, 56-65 and greater than 65), household income in 10 intervals (between: 0-999, 1000-1300, 1301-1999, 2000-2999, 3000-3999, 4000-4999, 5000-5999, 6000-6999, 7000-8999 and greater than 9000 Turkish Liras).

In Discrete Choice Models, after determining the parameters, a control transport mode is selected and utility functions are defined according to this mode. The selected mode does not have any effect on preference ratios, only the utility function coefficients are determined as a ratio with reference to this mode. The control mode is selected as private car for this study.

Determined utility functions are analysed in a computer program with 942 (valid and reliable amount of questionnaires for modeling which is less than the original amount of 1004) data available for application. The coefficients derived with the aid of the computer program are shown in Table 3.

Table 3. The coefficients of modal split utility function of Ankara-İstanbul

	Coefficient	Standart Error	T	p
General				
AGE1	0,366807	0,465802	0,787	0,431
AGE2	0,311151	0,45688	0,681	0,4958
AGE3	0,229082	0,446887	0,513	0,6082
AGE4	-0,18252	0,438078	-0,417	0,6769
AGE5	-0,12392	0,465417	-0,266	0,79
AGE6	-0,0475	0,50658	-0,094	0,9253
HINC1	-1,03809	1,864683	-0,557	0,5777
HINC2	1,431302	1,046904	1,367	0,1716
HINC 3	0,433575	0,605246	0,716	0,4738
HINC4	-0,29825	0,43775	-0,681	0,4957
HINC5	-0,18349	0,400396	-0,458	0,6468
HINC6	0,004712	0,400004	0,012	0,9906
HINC7	-0,19732	0,422168	-0,467	0,6402
HINC8	**-1,17118**	**0,497581**	**-2,354***	**0,0186**
HINC9	-0,67226	0,513078	-1,31	0,1901
HSR				
S1	-1,14701	1,002594	-1,144	0,2526
TTIME1	-0,00148	0,00195	-0,76	0,4472

TCOST1	-7,00869	12,00033	-0,584	0,5592
KON31	**-1,12948**	**0,611226**	**-1,848****	**0,0646**
KON41	-0,53564	0,366521	-1,461	0,1439
GUV31	-0,78043	0,558855	-1,396	0,1626
GUV41	**-0,64112**	**0,355938**	**-1,801****	**0,0717**
ACC11	-1,00029	0,76373	-1,31	0,1903
ACC21	-0,06383	0,483677	-0,132	0,895
ACC31	-0,32727	0,413583	-0,791	0,4288
ACC41	-0,33349	0,322732	-1,033	0,3015
AIR				
S2	0,515563	0,855471	0,603	0,5467
TTIME2	**-0,00901**	**0,002189**	**-4,115***	**0**
TCOST2	-7,62705	5,345789	-1,427	0,1537
COM22	0,276817	0,875842	0,316	0,752
COM32	0,527775	0,376082	1,403	0,1605
COM42	0,054204	0,257179	0,211	0,8331
SAF22	**-1,47561**	**0,648796**	**-2,274***	**0,0229**
SAF32	**-0,93153**	**0,363008**	**-2,566***	**0,0103**
SAF42	**-0,61134**	**0,240453**	**-2,542***	**0,011**
ACC12	0,341612	0,713412	0,479	0,6321
ACC22	-0,45373	0,400513	-1,133	0,2573
ACC32	**-0,46671**	**0,259823**	**-1,796****	**0,0725**
ACC42	-0,30188	0,233765	-1,291	0,1966
BUS				
S3	**2,108284**	**0,78378**	**2,69***	**0,0071**
TTIME3	**-0,00444**	**0,001131**	**-3,922***	**0,0001**
TCOST3	-0,56225	10,7115	-0,052	0,9581
COM13	-0,96067	0,827354	-1,161	0,2456
COM23	**-1,14347**	**0,31588**	**-3,62***	**0,0003**
COM33	-0,37925	0,272904	-1,39	0,1646
KON43	**-0,59639**	**0,236852**	**-2,518***	**0,0118**
SAF13	-0,27959	0,781399	-0,358	0,7205
SAF23	**-0,77325**	**0,331786**	**-2,331***	**0,0198**
SAF33	**-0,84584**	**0,285603**	**-2,962***	**0,0031**
SAF43	**-0,77001**	**0,252784**	**-3,046***	**0,0023**
ACC13	-1,01867	0,776108	-1,313	0,1893
ACC23	**0,531111**	**0,296794**	**1,789****	**0,0735**
ACC33	**0,406108**	**0,227907**	**1,782****	**0,0748**
ACC43	0,237037	0,205766	1,152	0,2493
AUTO				
HTIME4	**-0,00356**	**0,001501**	**-2,372***	**0,0177**
TCOST4	-2,18972	4,29546	-0,51	0,6102

Here “GENERAL” implies utility function parameters based on socio-demographic characteristics while the other four should be considered as mode specific utility functions’ parameters. When the coefficients are analysed, it can be seen that for all transport modes, if cost/income ratio increases the possibility of choosing the mode decreases. In other words, cost/income ratio has a negative sign (TCOST is the coefficient of C/I parameter and is found negative for all modes). In a similar way, increment in trip duration causes mode utility value to decrease, and through utility value, possibility of mode selection decreases (TTIME coefficient is found negative for all modes). It is found that coefficient of C/I parameter is greater than TTIME coefficient, which means that cost is more important than trip duration for passengers when deciding which transport mode to choose. The general parameter AGE shows that younger ages (the first 3 age interval) of passengers have a positive effect on trip utility, while older ages (the last 4 interval) have negative effects. When TINC, another general parameter is analysed, it is seen that being in the income groups (TINC1 and TINC2) closer to average household income increases utility and the other income groups effect utility negatively. SAF takes negative coefficients for all modes. It shows that preferability of all modes is less than the control transport mode, private car in terms of security. According to COM parameter values the airway mode has positive value while the other modes have positive value, meaning that comfort decreases utility for modes other than airways. The dummy variable ACC proves that accessibility of bus system increases utility compared to private car but accessibility of other modes decrease it.

Calculated t-statistics values (coefficient/standard error) are shown in Table 3. For deciding whether the parameters that their coefficients calculated beforehand have a major effect on utility functions it is expected that the calculated values are greater than the critical values. In this study, the critical T-statistics is determined as 1.645 for 90% level of significance. Although some parameters fails during the test yet they have not been removed. The reason for this choice is significance analysis based on individual variables is not sufficient itself also these tests are just statistical suggestions. Besides the thought of these parameters could reflect major characteristics of trips makes us to keep these variables in our model.

In order to determine the significance level of the established model as a whole, t-statistics are not sufficient enough. Also, the methods for testing the validity of the model *(goodness of fit tests)* should be used. For this study, Chi-Square validity test *(-2LL test)* is conducted. In this test, it is searched if the calculated model is an improved model or not, according to a base model (a model with no coefficients or comprised of only coefficients). In such a situation, null hypothesis shows that the base and developed model are the same. In this study, LL model, LL base model and *–2LL* are found as -1024.220, -1113.690 and 178.9393, respectively. The value found is greater than the threshold value for 95% confidence interval which proves that the models an improved model. In order to calculate how improved the model is, another goodness of fit index, ρ^2 *(Pseudo-*R^2) is found as 0.08. It shows that the model is 8% improved according to the base model.

Table 4 shows the utility functions determined by the computer program and the calculated modal split values with this utility. These values are found very close to the values stated in the questionnaires by the passengers as expected. So we may say that our model represent the real life conditions.

Table 4. Modal Split rates according to the analysis

Type	Model	Questionnaire
HSR	%7,55	%7,43
Airways	%19,97	%19,96
Bus	%51,87	%51,91
Private car	%20,62	%20,70

5. CONCLUSIONS

In this study, a modal split model is established that can be used by decision makers. The distribution of modes used between Ankara and Istanbul is determined with using the model. Also, it can be taken as a preliminary study providing information about the effects it will have and the amount of shifts expected between modes when HSR system is integrated with European region of Istanbul. It will be possible to determine similar structured models by extending the variables like age, trip duration, cost, comfort and security.

The utility functions are determined by a software which works with logit model logic. With these functions, it is possible to represent the amount of change in possibility of a mode to be chosen by any changes in the variables.

The energy consumption in the world has exceed the amount of renewable level. For this reason, it is our aim to minimize the energy consumed for transportation, to motive people to walk or ride with bike as much as possible and to make public transportation more attractive and wide spread. Increasing the network of HSR system is one of these strategies and it is important to provide satisfying service to passengers to succeed attracting them to HSR systems. In this study, parameters like comfort, accessibility and security are evaluated in the utility model and their effects on mode choice are estimated.

Results of the questionnaire and the model show that approximately half amount (51.91 %) of the trips between Ankara and Istanbul are held by bus. This system is followed by private car, airways and HSR systems with amounts of 20.70%, 19.96% and 7.43%, respectively. Although systems like airways and HSR have advantages like comfort and trip duration, the difficulty in accessibility of these systems make them fall behind the others (the accessibility variable is found to have negative sign for airways and HSR systems while it is positive for bus system.) The integration of HSR system with European region of Istanbul will increase the accessibility of the system and make it possible to attract more passengers from the other systems. A forecast on modal shift is done with the help of the question "which transportation system will you choose between Ankara and Istanbul when the integration of HSR system is completed?" asked in the stated preference based questionnaire. It is expected that the ratio of choosing bus system which is 51.91% in actual state will decrease to 7.63%. The ratio of passengers who prefer private car is expected to drop to 7.43% from 20.70% and the airways from 19.96 to 15.26%. With these modal shifts, the preference percentage of HSR system between Ankara and Istanbul is expected to be 69.68%.

As a result, the model established in this study will make it easier to analyse the effect of modal distribution of trips. The model will also provide opportunity to find the optimum pricing by using demand forecasts for similar routes. It is hoped that this paper which can be developed by more variables and combinations will contribute to further studies about transportation planning and modelling.

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