EVALUATION OF FACTORS AFFECTING MODE CHOICE OF HIGH-SPEED RAILWAY (HSR) USERS IN TURKEY

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submitted by **GÜLÇİN DALKIÇ** in partial fulfillment of the requirements for the degree of **Master of Science in Civil Engineering Department, Middle East Technical University, by**

Prof. Dr. Gülbin Dural Ünver _________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. İsmail Özgür Yaman _________________
Head of Department, **Civil Engineering Dept., METU**

Assoc. Prof. Dr. Hediye Tüydeş Yaman
Supervisor, **Civil Engineering Dept, METU** _________________

Examining Committee Members:

Prof. Dr. Ela Babalık Sutcliffe _________________
City and Regional Planning Dept., METU

Assoc. Prof. Dr. Hediye Tüydeş Yaman _________________
Civil Engineering Dept, METU

Assoc. Prof. Dr. Osman Balaban _________________
City and Regional Planning Dept., METU

Assoc. Prof. Dr. Ebru Vesile Öcalır Akünal _________________
City and Regional Planning Dept., Gazi University

Asst. Prof. Dr. Hande Işık Öztürk _________________
Civil Engineering Dept, METU

Date: 09.08.2017

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Gülçin Dalkıç

Signature:

ABSTRACT

EVALUATION OF FACTORS AFFECTING MODE CHOICE OF HIGH-SPEED RAILWAY (HSR) USERS IN TURKEY

Dalkıç, Gülçin

M.S., Department of Civil Engineering
Supervisor: Assoc. Prof. Dr. Hediye Tüydeş Yaman

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To change the current road dominancy in the intercity passenger transportation, Turkey has been establishing High-Speed Rail (HSR) services as a competitive mode since 2009. Currently there are four HSR lines connecting seven cities and three HSR lines under construction. In the scope of this study, a passenger survey was conducted at four stations of the currently serving HSR lines to obtain data on i) intercity mode choices of HSR users for different trip purposes, ii) alternative modes preferred in HSR corridors iii) realized HSR trip and iv) user perspectives on modal service attributes (i.e. travel time, cost, safety, etc.). Firstly, factors affecting HSR usage was determined by using descriptive statistics and the binary choice model (for HSR versus next best alternative). Binary logit model results enabled to calculate the probability of HSR preference for the current lines and to make predictions for the preference of HSR users were carried out for the upcoming lines. The results revealed that HSR users mostly have non-business trip purposes (tourism, family/friend visits, etc.) and travelers are very sensitive to pricing and the travel time of HSR, especially to the travel time reduction caused by HSR. Current low ticket pricing policy is one of the reason encouraging high HSR usage by low income travelers (i.e. students). Secondly, value of time (VoT) calculated for HSR passengers both for general case and specific cases, would change not only by HSR line but also among travelers based on different income levels. However, it is important to keep in perspective that majority of the currently operating lines have been serving in short distances and they did not have air as a strong alternative.

To increase ridership, the pricing policy must be developed carefully for each line based on competing alternative modes and the expected user profiles. Discounts made in HSR ticket prices for different traveler groups, such as seniors, students, etc. should be continued as these traveler groups were more likely the ones that are low income and sensitive to pricing. Similar evaluations and model development should be performed, when longer HSR lines (i.e. Ankara-İzmir, Bursa-İzmir or Konya-İzmir) which are under construction start to service in the near future.

Keywords: High Speed Railway, Turkey, Binary Logit Model, Probability, Value of Time.

ÖZ

TÜRKİYE’DE YÜKSEK HIZLI TREN (YHT) KULLANICILARININ TÜR SEÇİMİNİ ETKİLEYEN FAKTÖRLERİN DEĞERLENDİRİLMESİ

Dalkıç, Gülçin

Yüksek Lisans, İnşaat Mühendisliği
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Türkiye, şehirlerarası yolcu taşımacılığında mevcut karayolu hakimiyetini değiştirmek için 2009 yılından beri rekabetçi bir tür olarak Yüksek Hızlı Tren (YHT) hizmetlerini başlatmıştır. Mevcut durumda yedi şehri bağlayan dört YHT hattı bulunmakta ve 3 YHT hattı da inşaat aşamasındadır. Bu çalışma kapsamında 4 YHT istasyonunda yolcu anketi yapılmış olup, YHT yolcularının i) farklı seyahat amaçları için şehirlerarası tür seçimleri, ii) YHT koridorlarında tercih ettikleri alternatif ulaşım türleri, iii) gerçekleştirilen YHT seyahati ve iv) türel özellikler hakkında kullanıcı bakış açısı hakkında bilgi toplanması amaçlanmıştır. İlk olarak YHT kullanımını etkileyen faktörler betimleyici istatistikler ve ikili seçim modeli (YHT için bir sonraki en iyi alternatif) kullanılarak belirlenmiştir. İkili seçim modelleri kullanılarak mevcutta işletilen hatlar için YHT tercih olasılığı hesaplanmış ve yapım aşamasındaki hatlar için de tercih olasılığı tahmini yapılmıştır. Sonuçlar YHT kullanıcılarının çoğunlukla iş dışı (turizm, aile/arkadaş ziyareti vb.) amaçlarla seyahat ettiğini, maliyet ve seyahat süresinin yanı sıra YHT’nin sağladığı zaman tasarrufunun YHT seçimini etkilediğini göstermiştir.

Mevcut düşük fiyatlandırma politikası, daha çok düşük gelirli grupların YHT tercihini açıklamaktadır. Ayrıca, zaman değeri (ZD) hem tüm YHT kullanıcıları için genel olarak hem de özel durumlar için (hat ve gelir bazlı olarak) hesaplanmış ve mevcut YHT bilet seviyesinden daha yüksek değerler bulunmuştur. Ancak, mevcutta işletilen hatlarının çoğunluğunun kısa mesafelerde hizmet verdiği ve güçlü bir havayolu alternatiflerinin olmadığı göz önünde bulundurulmalıdır.

Yolcu sayısını arttırmak için, fiyatlandırma politikası her bir hat için rekabet içindeki alternatif ulaşım türleri ve kullanıcı profili göz önüne alınarak geliştirilmelidir. Yaşlılar, öğrenciler vb. gibi farklı kullanıcı grupları için YHT bilet fiyatlarında yapılan indirimler, bu gruplarının düşük gelirli ve fiyatlandırmaya daha duyarlı olması nedeniyle devam ettirilmelidir. İnşaat aşamasında olan daha uzun YHT hatları (Ankara-İzmir, Bursa-İzmir ve Konya-İzmir) işletmeye açıldığında benzer değerlendirmeler yapılmalı ve modeller geliştirilmelidir.

Anahtar Kelimeler: Yüksek Hızlı Demiryolu, Türkiye, İkili Giriş Modeli, Olasılık, Zamanın Değeri.

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CHAPTER 1

INTRODUCTION

High-Speed Rail (HSR) is an intercity passenger mode which competes with air and road transportation mainly due to its travel time, comfort and convenience (Harvey et al., 2006; Celikkol-Kocak, et al., 2017). With the start of the HSR services in Japan in 1964, intercity passenger modal shares have started to change significantly. Despite the success in Japan, the spread of the HSR services around the world was relatively slow (Givoni, 2006) as shown in Figure 1. The second country having HSR was France, which opened a line of 470 km in 1981 (Pagliara et al., 2014). It was followed by Italy and Germany in 1990. At the beginning of the 2000s, HSR networks covered much of Japan and Europe. By 2010, more countries from the Far East have invested in HSR, with an ambitious effort from China reaching a total of 12,253 km (International Union of Railways-UIC, 2015) in 2014.

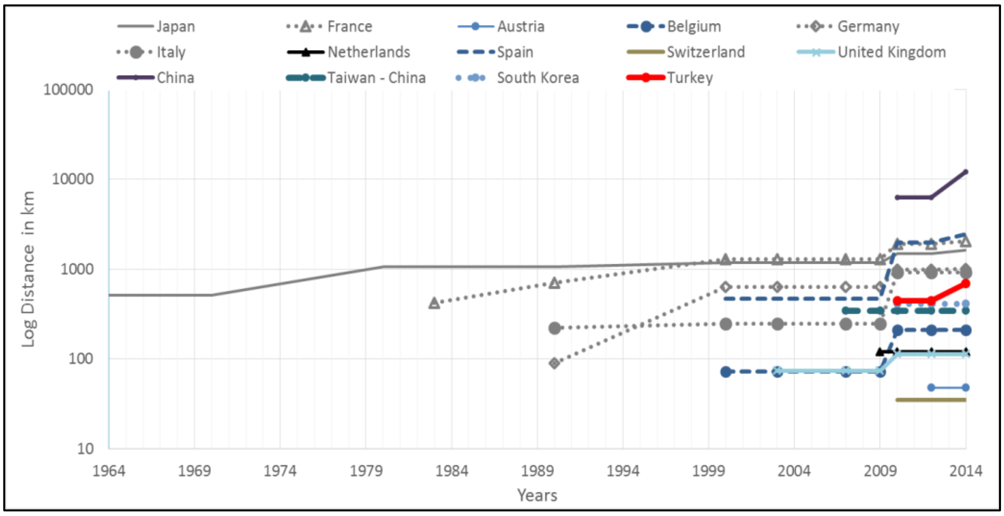

Figure 1. HSR Development Worldwide (UIC, 2015)

HSR causes changes in the modal shares of intercity passenger sector. For example, after the introduction of HSR on Paris–Lyon and Madrid–Seville corridors, the share of air transportation decreased by 24% and 27%, respectively, while modal share losses in private car and intercity bus were around 8% on these lines (Givoni, 2006). However, the preference for HSR depends on traveler characteristics and factors affecting the mode choice, which include travel time (as well as travel time reduction), cost, income, trip purpose, the number of travelers, access time to HSR stations, and so on. (Behrens & Pels, 2012; Ganji et al., 2013; Givoni & Dobruszkes, 2013; Cho, 2013; Wang et al., 2014).

In Turkey, extensive investments have been made to develop the HSR services not only to create a more sustainable transportation network, but also to integrate national railway network to Trans-European railway network (Babalik-Sutcliffe, 2007; Dalkic, 2014). As one of the 14 countries with HSR, Turkey has opened the first line in 2009 with a length of 888 km and reached a total of 1213 km by the end of 2014 (Turkish State Railways-TSR, 2014). Figure 2 shows the current HSR network with the alternative modes along the lines. Ankara-Eskişehir (ANK-ESK) HSR line operating at 250km/h started to serve in 2009, and it was followed by Ankara-Konya (ANK-KON) line in 2011. Currently there are four HSR lines connecting seven cities and the total number of HSR passengers reached to 5.9 million in 2016 (TSR, 2016). The existing HSR lines were also combined with the intercity bus and conventional rail services to reach five nearby cities. After the completion of three ongoing projects (Ankara-Sivas, Ankara-İzmir and Bursa-Bilecik), the total number of cities served by HSR will reach to 17. Furthermore, 13 new HSR projects are in the planning stage, which are expected to create an HSR network covering 47 cities by 2035 (TSR, 2014). When the upcoming and planned HSR lines are completed, HSR is expected to change the intercity passenger modal shares, significantly.

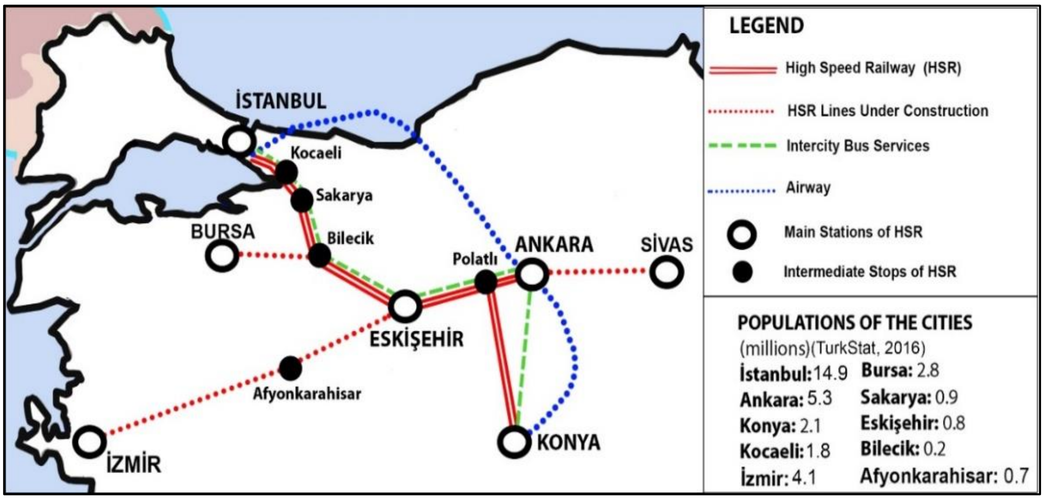

Figure 2. Intercity passenger alternatives along the current HSR network

1.1. Aim and Scope of the Study

As it is a newly introduced transportation mode in Turkey, the scientific research about HSR is very limited. Thus, this study mainly aims to shed light on the HSR preference in Turkey and the factors behind it. Thus, a survey was conducted with 421 HSR passengers at four HSR stations (Ankara, Eskişehir, İstanbul and Konya) and data were collected. In the scope of this thesis,

a) evaluation of the travel behavior of HSR users (including general intercity travel behavior, pricing preferences and stated versus revealed pricing levels for HSR usage)

b) determination of the key factors affecting travelers' preference of HSR over the 'next best alternative' modes via binary logit models

c) determination of the HSR preference probabilities for both current and upcoming HSR lines

d) estimation of the value of time (VoT) or Value of Travel Time Saving (VTTS) for HSR users will be realized. The evaluation of the travel behavior included the general intercity travel behavior of HSR users, their pricing preferences for HSR and the comparison of stated versus revealed pricing levels for HSR usage. Factors affecting HSR mode choice were investigated via binary logit models developed as HSR versus “next best alternative” mode choice in “no-HSR situation”. Most commonly referred parameters (such as travel time, cost, travel time reduction, income, etc.) and their variations were used in the binary logit models. Also, the developed models enabled to calculate the probability of HSR preference for current HSR lines and further to estimate the probabilities of HSR shares for the upcoming lines. As the modal preference data came from the HSR users only, the models allowed to estimate probability of HSR preference over the next best alternative, but not the modal share estimations for the HSR corridors. VoT was calculated based on the selected binary logit models. All the analyses were performed using the data from a face-to-face passenger survey conducted with HSR users at the stations.

The layout of this thesis is organized as follows: Chapter 2 presents a comprehensive literature on modal shift potential of HSR, factors affecting HSR mode choice and VoT estimation is summarized. Furthermore, general overview of railway sector in Turkey is given. In Chapter 3, after a detailed information about the survey study, the methodology for the binary logit modelling and VoT calculation are given. Chapter 4 presents the general evaluation of travel behavior of HSR users based on descriptive analyses of the survey data. It is divided into three main sections as participant profile and general intercity behavior, HSR preference under different pricing levels and the evaluation of stated versus revealed pricing preferences for HSR. In Chapter 5, the results of the binary choice model are given including the calculation of HSR preference probabilities for current and upcoming HSR lines. Also, estimation of VoT is presented in this chapter. Finally, Chapter 6 includes the conclusions and discussion part.

CHAPTER 2

BACKGROUND

As a background of the study, firstly, the existing literature on the modal shift potential of HSR and factors affecting HSR mode choice is presented. Then, studies on VoT/VTTS are given including the general formulation and the mathematical framework of VoT and VTTS estimation. Lastly, information about the railway development in Turkey and HSR network is presented with some statistics. As this study includes mode choice modelling, it is seen essential to give service characteristics of HSR and the alternative modes along HSR corridors.

2.1.Modal Shift Potential of HSR

In the countries it existed, HSR can be very competitive in the intercity passenger transportation sector and it may cause modal shift from other transportation modes mainly due to its shorter travel time, comfort and convenience. By nature, HSR has a potential of creating a modal shift from air and road transportation. There are many studies about the competitiveness of HSR versus other intercity travel modes. Two HSR services between Paris–Lyon and Madrid–Seville caused a decrease of 24% and 27% in air travel, respectively, while modal share loss in intercity car and bus passenger was around 8% in these lines (Givoni, 2006). For London-Paris corridor, Behrens and Pels (2012) sought the impact of HSR on passenger preferences and market shares of transportation alternatives. The survey was conducted to the passengers entering or leaving the UK through available transportation modes. Main determinants of the mode choice of travelers were found as the frequency of service, total travel time, and distance to the (UK) port. Business travelers were reported to tend to value time, whereas leisure travelers were more sensitive to fares, as expected. In another study, Cheng (2010) examined Taiwanese HSR system and found that one year after HSR began to serve, domestic air flights dropped dramatically and the air travel market share decreased from 13.0 % to 8.6 %.

In an evaluation of the global demand for motorized mobility between 1960 and 1990, Shafer (1996) showed the variability of modal shares in various countries supporting this phenomenon. Finally, a global intercity passenger modal share forecasts for 2020 foresaw as a dominant automobile share of 45-55% followed by bus (29%), rail (5%) and air (21%) modes. Within the rail, the projection for HSR share was 21%. However, based on 2011 statistics, in the European Union (EU-28) market, private car dominated land passenger transportation share at 76% (more than the forecasted average global shares), followed by air (9 %), bus and coach (8 %) and rail (6 %) (European Environment Agency-EEA, 2016).

Givoni and Dobruszkes (2013) used two kinds of data for the modal shift: 1) mode share before and after the introduction of HSR service and 2) changes in the number of passengers served by each mode before and after HSR service. They stated that (i) air market share decreased after the introduction of HSR (ii) road share was also affected, and (iii) in countries with developed conventional rail network, a portion of the shift was from the conventional rail. Furthermore, they found that HSR impacts automobile and bus use less than air travel, but it may change from route to route. Among the factors affecting the modal shift, travel time was found as the most important one. Additionally, travel time to/from the station/airport including the number of transfers was also found as important factors besides ticket fares and the number of passengers in the travel group.

2.2.Factors Affecting HSR Mode Choice

Discrete choice models that could capture disaggregate level behavior of individual travelers have been popular for mode choice studies since first suggested by Ben-Akiva and Lerman in 1985. In the literature of the intercity passenger transportation, factors affecting the usage of a newly introduced mode were listed as travel time, waiting/transfer times and cost (Cho, 2013). The studies that focused on mode choice for and the competitiveness of HSR in passenger market were summarized in Table 1.

It is seen that the majority of the studies used stated or revealed preference data and performed logistic models such as binary logit model and multinomial logit model. The studies which focused on mode choice behavior revealed that gender, income level, trip cost, travel time, travel time reduction, trip purpose, fare, education level, frequency of service and number of transfers are the primary factors affecting travelers' choice (Mandel et al., 1997; Gonzalez-Savignat, 2004; Kitagawa et al., 2005; Dobruszkes, 2011; Behrens & Pels, 2012; Chantruthai et al., 2014; Wang et al., 2014). Demand and modal shift potential of HSR were investigated as well, and it was emphasized that HSR may create induced demand in the corridors it operates (Cascetta et al., 2011; Givoni & Dobruszkes, 2013), and it may capture demand from air and conventional rail (Park & Ha, 2006; Behrens & Pels, 2012; Givoni & Dobruszkes, 2013). Additionally, it was found that the HSR network will change the intercity passenger transportation patterns such that there will be an intermodal chain to destinations beyond the HSR cities. For business trips, this chain may be limited to the medium-haul market, but for leisure trips it may extend to the long-haul market depending on the pricing strategy.

From the economy perspective, how much the society is willing to pay is the key point to forecast the preference for the HSR (Rus, 2011). According to Barron et al. (2009), more than 20,000 km of the worldwide railway network was devoted to providing high speed services to the passengers willing to pay for lower travel time and quality improvement in rail transportation. However, since the survey conducted in Turkey did not have any specific questions regarding willingness to pay, these studies were not discussed in this thesis.

Table 1. Literature review on demand and mode choice for HSR

Study	Study area	Analysis/Models Included	Data type*	Main findings/outcomes
Mandel et al. (1997)	Germany	Logit Model (LM)	Database	**-Travel time reduction** affects the HSR mode choice.
Yao et al. (2002)	Japan	Nested Logit (NL) model	SP & RP	-The estimation share of HSR for business and private purpose is 51% and 42.2%, respectively. -Modal shift arises from the existing rail system to HSR.
Gonzalez-Savignat (2004)	Madrid-Barcelona	LM (HSR and private car)	SP	**-Cost, travel time and trip purpose** affect the HSR mode choice.
Kitagawa et al. (2005)	Keihanshin-Fukuoka	Binary Logit (BL) model (HSR and air transportation)	SP	**-Line haul cost, time out-of vehicle and the number of transfers** affect the mode choice.
Park and Ha (2006)	Korea	LM	SP	-Air traffic dropped by 20-30% after the introduction of HSR.
Roman et al. (2009)	Madrid-Zaragoza-Barcelona	NL model	SP & RP	-A low level of competition exists between HSR and air for the Madrid-Barcelona corridor.
Cascetta et al. (2011)	Rome-Naples	Multinomial Logit (MNL) and NL Models	RP	-Induced demand occurs due to the introduction of HSR.
Dobruszkes (2011)	Five city-pairs in Europe	No specific model used	Database and statistics	**-Travel time, frequencies, fares, airlines' hubs, and the geographical structures of urban regions** are important factors to compete with air.
Behrens and Pels (2012)	London–Paris	MNL and Mixed Logit (ML) models	RP	**-Frequency, total travel time, and distance to the UK port** affect the mode choice.
Barreira et al. (2013)	Lisbon-Madrid	LM	SP	-The intermodal chain to destinations beyond the HSR cities is important.
Givoni and Dobruszkes (2013)	----	No specific model used	The literature search	-10–20% induced demand occurs due to the introduction of HSR. -The rest is mode substitution generally from conventional rail.
Chantruthai et al. (2014)	Thailand	BL and MNL models (HSR and Low Cost Airlines)	RP	**-Travel time, fare difference, users' occupation, household income, education level and trip purposes** are significant factors for competition.
Wang et al. (2014)	Zhejiang, China	MNL and NL models	RP	**Increase in the income levels and longer distances** positively affect modal shift to HSR.

**Note: SP (Stated Preference Data), RP (Revealed Preference Data)*

2.3. Value of Time (VoT)

VoT is seen as a key parameter in both travel demand modeling and cost-benefit analysis and it was valuable in a wide range of public transportation policy and planning applications (Small, 2012). The VOT is defined as the maximum amount of money people are willing to pay for an additional unit of time, while the VTTS is defined as the maximum amount of money people are willing to pay for a reallocation of time between two alternative activities (Huq, 2010). VoT was usually considered as having two parts as the ‘‘pure time value’’, which reflected the opportunity cost of time as an input, and the direct utility (or disutility) of travel time (Becker, 1965; DeSerpa, 1971). The coefficients of the cost and the travel time capture the sensitivity of the travelers’ utility toward changes in the travel time and the cost and their ratio can be used to calculate the VoT (Antoniou et al., 2007).

However, VoT is a latent variable that cannot be measured directly. Martin (1997) stated that, in the logit model, the VoT was an effect that intervened only to explain the behavior or choice of modes by travelers and it was a psychological value; not a marginal productivity value. Also, Brand (1993) labeled this value as “implied values of time”. VoT changes from country to country, industry to industry and even from individual to individual (Antoniou et al., 2007). Individuals might have different preferences for spending time for travelling and their pleasure might vary from trip to trip such as whether the train provides internet access, etc. (Hultkrantz, 2013). In sum, VoT estimation depends on demographic characteristics of the traveling population (i.e. age, occupation), the transportation mode, time (i.e. working, non-working time), location, and purpose of travel (i.e. business, tourism) (US Department of Transportation, 2011). For example, businesses benefit from reduced travel times in a number of ways such as improved access to suppliers or customers, which increase productivity. Therefore, businesses are expected more willing to pay for quicker journeys which forms the basis of values of working travel time savings (UK Department of Transport, 2014).

2.3.1. Estimation of VoT

Following the mathematical framework of the logit model based on the theory of utility maximization as discussed in detail by Ben Akiva and Lerman (1985), a binary logit model was developed for HSR preference compared to the "next best alternative" mode (air, bus or private car as stated by each traveler) based on the formulas below:

$$V_i = \beta_0 + \beta_C * Cost_i + \beta_T * TT_i + \ldots \tag{1}$$

$$U_{in} = V_{in} + \varepsilon_{in} \qquad (i \in C_n) \tag{2}$$

$$F(\varepsilon_n) = \frac{1}{1+e^{-\mu\varepsilon_n}} \quad , \mu > 0, \quad -\infty < \varepsilon_n < \infty \tag{3}$$

$$\Pr_n(i) = \Pr(U_{in} \geq \max(U_{jn}); \ \forall j \in C_n, \ j \neq i) \tag{4}$$

where

U_{in} : utility function for traveler *n* selecting mode *i* from the choice set C_n

V_{in} : the systematic component of the utility that can be explained by the attributes considered

β : coefficients of the independent variables

C_i : cost of the *i* transportation alternative.

TT_i : travel time of the *i* transportation alternative.

ε_{in} : random part called the disturbances (assumed to be logistically distributed)

$P_n(i)$: the probability that traveler n chooses alternative *i* from the choice set C_n

It should be noted that $0 \leq P_n(i) \leq 1$ for all $i \in C_n$ and $\sum_{i \in C_n} P_n(i) = 1$. Also, for convenience, μ is generally assumed as equal to 1. For binary logit models with two alternatives, probability that a traveler chooses alternative *i* over *j* is equal to

$$P_n(i) = \frac{1}{1+e^{-\mu(V_{in}-V_{jn})}} = \frac{e^{\mu V_{in}}}{e^{\mu V_{in}} + e^{\mu V_{jn}}} \tag{5}$$

In general, the VoT is equal to the ratio between the derivative of utility with respect to time and the derivative of utility with respect to cost (Koppelman and Bhat, 2006). For a utility function which is linear in both time and cost and not interacted with any other variables (see Eqn.5), the VoT is given by

$$VoT = \frac{\frac{\partial V_i}{\partial TT_i}}{\frac{\partial V_i}{\partial Cost_i}} = \frac{\beta_{TT}}{\beta_{COST}} \tag{6}$$

This basic definition for VoT does not always produce realistics values, especially if the mode choice is not predominantly determined by travel time or cost, or may overestimate assuming a linear relation of both parameters in the utility function. To correct such problems, it is possible to introduce nonlinear terms or forms for both time and cost variables. While a more traditional approach is to introduce logarithmic transformation of time or cost, it is also possible to include additional non-linear cost terms, which is also referred as “cost damping” parameter. Cost damping can be performed based on distance (i.e. reducing the marginal impact of cost for longer distances), origin-destination (O-D specific scaling) and trip purpose (detailed segmentation by purpose) (Daly, 2010; Rich and Mabit, 2016).

2.3.2. *VoT Studies on Intercity Passenger Sector and HSR*

Due to practical reasons, most studies used logit models to measure VoT while recent studies (i.e. Bierlaire and Thémans, 2005) used more advanced models such as mixed logit. In these studies, stated-preference data was used frequently and socioeconomic characteristics were included into the model formulation (Antoniou et al., 2007). In a study on interurban travelers in Japan, VTTS variation over travel time was examined and it was found that VTTS decreased as travel time increased (Kato, 2009). Diamandis et al. (1997) estimated the VoT for Greek drivers based on a survey with revealed preferences made by travelers choosing alternative modes. Multinomial logit model was used and the estimated VoT for nonprofessional trips ranged between US \$3.72/hr and US \$4.32/hr and for professional trips between US \$5.42/hr and US \$6.42/hr. Hensher (1997) examined the VoT for Sydney-Canberra corridor and concluded that VoT ranged between 36$ and 74$ for business trips made by airway. In another study, combinations of revealed-preference and stated-preference data were analyzed to evaluate VoT for short and medium distance trips. Mixed logit model results revealed a high VoT for short-distance trips (Bierlaire and Thémans, 2005).

In particular to HSR, VoT was investigated to discuss the social profitability of three recently constructed or proposed HSR lines Oslo–Stockholm (Norway and Sweden), Stockholm–Göteborg (Sweden) and Beijing–Shanghai Hongqiao (China).The results emphasized the necessity of a sensitivity analysis for the possible changes in the composition of travelers with various values of travel time (Hultkrantz, 2013). In another study which was focused on HSR investments in China, a general time allocation model was proposed and the problems of large scale construction of HSR in China were analyzed. The most serious problem of HSR in China was detected as the operating conventional lines parallel to the HSR lines which resulted with a huge waste in carrying capacity high-speed dedicated passenger lines (Jian and Yunyi, 2013).

2.3.3. *Relation between VoT in Transportation and Wage Rate*

In the early binary probit model of urban commuter mode choice model which utility to be linear in cost and linear in travel time multiplied by wage rate, VoT was found as proportional to the wage rate (Lave, 1969; Small, 2012). Also, it was stated that VoT for commute trips seemed typically to average around one-half the gross wage rate, and varied by trip purposes (Lave, 1969; Small, 2012). In Becker's theory, time could be converted into money by assigning less time to consumption and more time to work. Therefore, it was stated that non-work time could be valued at the same level of the wage rate because consumption has a time cost of not earning money. This was seen as the first concept of wage rate approach of VOT (Becker, 1965; Jian and Yunyi, 2013). Another study showed that VoT might be lower than the wage rate because only some portion of the travel time can be used for work and productivity of laborer may change in different spaces (Hultkrantz, 2013).

Contrary to these studies, Donnea (1972) stated that as the total work time per period was an endogenous variable for the traveler wage rate appeared explicitly in the VoT formulation, it varied from individual to individual and might be different for each individual in each activity. Thus, it was stated that there was no fixed theoretical relationship between the wage rate and the VoT. Furthermore, it is emphasized that besides the travel time and cost variables included in VoT formulations, there might be other variables (comfort, safety, etc) affecting mode choice of individuals and thus their VoT (Donnea, 1972). Another study suggested that VoT was called as "value of working time" for the trips made within working hours and these trips could be compared with the "hourly wage rate" (Gonzalez, 1997). Shaw (1992) examined the relationship between VoT and the wage rate and focused on the difference between VoT and the opportunity cost of time by noting that there is an opportunity cost associated with engaging in leisure in terms of forgone earnings. The author found that the opportunity costs of time was much higher than the average wage rate of those in the sample who were employed. Thus, it was stated that the VoT and wage rate did not hold (Shaw, 1992 and Lascelles, 2006). Parallel to this view, Mackie et al. (2001) stated that the determinants of a value attached to travel savings lacks two other dimensions: i) variation of good consumption due to substitution of travel for other activities and ii) the possibility of re-timing activities in order to undertake them according to a preferred schedule which is likely to increase the value of travel time saving. Thus, there is no reason to expect that the willingness to pay for a reduction in travel time to be equal to wage rate (Mackie, 2001). Jian and Yunyi (2013) stated that VoT is a volatile concept. For example the VoT to catching an airplane or a train would be much higher than wage rate, thus the price you would like to pay for attending an important appointment or event might have a higher VoT.

2.4.HSR in Turkey

2.4.1. A Historical Overview to the Railway Development

The rail transportation experience of Turkey goes back to early railway era. The first rail line was constructed in 1856 during Ottoman times, and the network reached a total of 8,343 km (Yıldırım, 2002). However, after the collapse of the Ottoman Empire, the new-born Turkish Republic inherited only 4,112 km. The government gave priority to railway construction to increase the length of railways, provide national security and increase social and economic growth in the 1920s and the network length reached to 7,320 km by 1940s (Yıldırım, 2001). Between 1940 and 1950, railway construction decelerated because of the 2nd World War. 3,208 kilometers of the 3,578 kilometer rail road was constructed between 1923 and 1940.

After the 2nd World War, investments on railway development decelerated and for the following 50 years, road transportation has been the predominant mode in Turkey (Table 2). Thus, the 1950s is often considered as a turning point in transportation policy in Turkey since it marks the start of a road oriented policy for the country, which is still prevalent today (Babalık-Sutcliffe, 2007). While road and railway transportation shares were very close in 1950, the share of railways has begun to decrease, and the gap between road and rail shares have increased. The share of road transportation reached to 97.8 in 2010 and it has started to decrease. The recent statistics showed that it has a share of 89.3% currently (TSR, 2016). On the other hand, the impact of the deregulations in air transportation in 2000s can be seen by the increase in its share from 1.8% to 9.4 %.

In 2000s, there was only 10,922 km of conventional railway lines in Turkey; however, the majority of the lines was single track and not electrified, and has continuously lost market share. To overturn this imbalanced highway dominancy, a series of plans were made at the national level (Babalik, 2007) and investments on HSR were started in 2002 which will be discussed in the following chapter.

Table 2.Modal share for intercity passenger transportation between 1950-2014 (in %)

Years	Road	Railway	Maritime	Airway	Total
1950	50.3	42.2	7.5	0.0	100
1960	72.9	24.3	2.0	0.8	100
1970	91.4	7.6	0.3	0.7	100
2000	95.9	2.2	0.0	1.8	100
2010	97.8	1.6	0.7	---	100
2012	91.5	1.1	0.5	7.0	100
2014	89.8	1.1	0.6	8.5	100
2016	89.3	1.0	0.3	9.4	100

Source: TSR, 2016.

2.4.2. Development of HSR Services in Turkey

At the beginning of 2000s, with a strategic policy shift toward railway development, the first HSR line was planned to connect three major cities: Ankara, Eskişehir and İstanbul with the populations, approximately 5.1 million, 0.8 million and 14.4 million, respectively (Figure 2). Ankara-Eskişehir (ANK-ESK) part of it was 245 km in length and started services in 2009. With the construction of an additional 212 km, second HSR line was built for Ankara-Konya (ANK-KON) connection and started to serve in 2011. Konya-Eskişehir HSR services (KON-ESK) started in 2013. After the completion of 155 km line between Eskişehir and İstanbul (ESK-İST), Ankara-Eskişehir-İstanbul (ANK-IST) services started in 2014 and was followed by Konya-Eskişehir-İstanbul (KON-IST) services in the same year (TSR, 2014). Currently operating HSR lines are also combined with intercity bus services to reach Bursa (from Eskişehir), Karaman and Alanya/Antalya (from Konya), and offer transfer to conventional rail lines to Afyonkarahisar and Kütahya from Eskişehir. After the completion of three upcoming projects, the total number of cities served by HSR will reach to 17 (Table 3). Furthermore, when the 13 additional HSR lines, which are in the planning stage, this number is expected to reach to 47 cities by 2035 (TSR, 2014).

Table 3. The list HSR lines in Turkey by 2016

HSR Line	Cities served	Service Start Time
Operating Lines (Max. speed: 250 km/hr)		
Ankara-Eskişehir (ANK-ESK)	Ankara, Eskişehir	2009
Ankara-Konya (ANK-KON)	Ankara, Konya	2011
Konya-Eskişehir (KON-ESK)	Konya, Eskişehir	2013
Ankara-İstanbul (ANK-IST)	Ankara, Eskişehir, Bilecik, Sakarya, Kocaeli, İstanbul	2014
Konya-İstanbul (KON-IST)	Konya, Eskişehir, Bilecik, Sakarya, Kocaeli, İstanbul	2014
Lines Under Construction (Max. Speed:250 km/hr)		
Ankara-İzmir Line (ANK-IZM)	Ankara, Afyonkarahisar, Uşak, Manisa, İzmir	---
Ankara-Sivas Line (ANK-SIV)	Ankara, Kırıkkale, Yozgat, Sivas	---
Balıkesir-Bilecik (BAL-BIL)	Balıkesir, Bursa, Bilecik	---

In Table 4, total HSR line length, total passenger volume and total passenger km is given for the years between 2009 and 2016. According to the most recent TSR statistics (TSR, 2016), total ridership has been increased from about 1 million to 5.9 million trips in 8 years, with the opening of new HSR lines. Data showed that ANK-ESK has been the most demanded service with a constant increase in the first five years of operation. ANK-KON has also been used with an increasing demand in the first four years of operation. But, KON-ESK line has not created as big of demand as the other two lines (Table 4) and the direct services were cancelled for this line (currently it is served by KON-IST line) in 2015. Here, trip generation potential of cities has to be considered. In terms of population, Istanbul and Ankara are the two biggest cities served by HSR (Figure 2), followed by Konya with 2.1 million population, while Eskişehir has a population less than one million. Bursa has 2.8 million populations, but it is not directly served by HSR, yet.

Though the source has not clearly stated, the statistics showed drastic decreases in bus shares (from 55% to 10% in ANK-ESK, from 70% to 17% in ANK-KON), as well as private car shares (from 37% to 18% in ANK-ESK, from 29% to 17% in ANK-KON). The HSR shares in ANK-ESK and ANK-KON corridors reached 70%

and 66% and induced demand was generated in these two lines as 12% and 18%, respectively (TSR, 2016).

Table 4. HSR passenger volumes and passenger-km between 2009-2016 (TSR, 2016; TSR 2017)

Years	2009	2010	2011	2012	2013	2014	2015	2016
Total Line Length (km)	397	888	888	888	888	1,213	1,213	1,213
Total Passenger-Km ($x10^6$)	237	476	665	914	1,186	1,554	1,846	---
Total Ridership ($x10^9$)	0.94	1.89	2.56	3.35	4.21	5.09	5.70	5.90
Ridership by HSR lines **($x10^6$)**								
ANK-ESK	0.94	1.89	2.15	2.00	2.27	1.92	1.28	2.20
ANK-KON	---	---	0.41	1.39	1.75	1.89	1.80	0.68
KON-ESK	---	---	---	---	0.20	0.25	---	---
ANK-IST	---	---	---	---	---	0.99	1.96	2.20
KON-IST	---	---	---	---	---	0.31	0.66	0.68

2.4.3. HSR Studies in Turkey

Since the start of HSR services in Turkey, various studies on HSR conducted in different areas including i) customer satisfaction and service quality evaluations ii) environmental impact evaluations (emission reduction, life cycle assessment etc.), iii) HSR preference and VoT studies. Before the opening of ANK-KON, a stated preference survey was conducted with 633 people living in Konya. The data was used to estimate VoT and linear regression analysis was performed. According to the results, VoT was found as 8.04 TL/hr on average (Doğan, 2012). However, this study did not include development of a utility function, nor estimation of VoT from any probabilistic formulation, thus could not provide any results comparable to those in the literature. In 2010, a study on the reasons for choosing HSR was investigated for ANK-ESK line by a survey conducted with 800 passengers (Kılıçlar et al., 2010). The evaluation was based on the question that rated for the reasons behind HSR preference on 5 point Likert scale from 1 (definitely, not agree) to 5 (definitely agree). According to the descriptive statistical analyses results, travel time saving was found as the most important factor affecting passengers' preference and it was followed by comfort of the trains, punctuality of the service and reasonable prices.

Dalkic (2014) focused on user perspectives of potential HSR users. Data were collected in the Public Participation Meetings (which was a part of Environmental Impact Assessment procedure) with 212 potential HSR users of 4 different HSR lines in feasibility stages. The survey included the questions on intercity mode choices, importance of modal characteristics of a transportation mode, past HSR experience and ticket price preferences to choose HSR. The results of the study emphasized that potential users of HSR had a positive perception for this system as almost all of the respondents (99,1%) were willing to use HSRs if an investment was made to connect their city to the HSR network. Also, a passenger shift was possible from road to railways as a result of these HSR investments particularly when connections were made to remote parts of the country, such as south-eastern Turkey where intercity travels are often long-distance. However, it was not desirable that HSR ticket price was more expensive than travelling with intercity buses. In addition to the pricing, safety was found as the most important parameter that potential passengers consider in their intercity trips. While the survey used in this study included some of the questions regarding user perspective on HSR service characteristics (which were kept out of the scope of this study), the survey in this follow-up study differed significantly including questions on user behavior of current HSR travelers and their alternative mode choice preference for "no-HSR" situation.

In a study on passengers' perspective on service quality of HSR, Sarı et al. (2011) interviewed 762 passengers. Data were analyzed by ANOVA and T tests. The results suggested that cleanliness of the seats and smiling and helpful manners of the staff were the most important factors for satisfaction of customers and varied based on occupation, education and travel purposes of passengers. Dölarslan (2014) determined the relative effects of perceived value and customer satisfaction on customer loyalty behaviors via 780 surveys conducted with HSR passengers. Both customer satisfaction and perceived value directly influenced the loyalty behaviors of Turkish railway passengers. However, customer satisfaction was found to be a more important predictor of repurchase intention than perceived service value. The association between customer satisfaction and loyalty behaviors was stronger for females, youths and those customers at the lower range of income and education. Alpu (2015) interviewed 420 passengers for customer service and satisfaction on ANK-IST HSR line. The results indicated that the attitudes and behavior of personnel, physical conditions, food services, information and advertisement services were found as the most contributor factors to satisfaction level of passengers. In another study on the service quality of HSR (ANK-ESK line), 900 surveys were conducted with passengers, and impact score technique was used in the analysis. The results revealed that there should be enhancements in especially in the seat design of the vehicles and service scheduling. (Ayyildiz-Alçura et al., 2016).

Banar and Özdemir (2015) studied HSR and conventional rail services from environmental and economic point of view, via Life Cycle Assessment and Life Cycle Cost methodologies. The results revealed that the total environmental load of HSR is shared by infrastructure and operations, with percentages of 58% and 42%, respectively. On the other hand, for conventional rail, infrastructure created 39% of the total environmental load, while operations had 61%. Regarding cost, the impact in HSR resulted from infrastructure and operations, with percentages of 69% and 31%, respectively. In the conventional rail system, infrastructure caused 21% of the total cost impact while operations led to 69%. In another study, Dalkic et al. (2017) investigated emission reduction impact of HSR lines for ANK-ESK and ANK-KON HSR lines. Also, emission reduction potential of upcoming HSR lines were calculated. The results suggested that HSR caused a total reduction of 24.3 ktCO_2 currently on two study corridors, and may even result in a reduction of 452.7 ktCO_2 in 2023, if estimated ridership is realized in all lines. Line based analyses showed that HSR performance in reducing CO_2 emissions was limited as highly demanded HSR lines currently served short routes and mostly caused modal shift from bus services, which were also efficient compared to car. The CO_2 emissions reduction potential of future HSR services can be higher if a) new HSR lines can create a network effect along the main corridor and b) supplementary policies can be developed to generate high HSR demand that would be shifted from car, and even air, on the longer routes.

CHAPTER 3

METHODOLOGY

3.1.HSR Passenger Survey

In the scope of this study, an HSR passenger survey was designed and conducted with passengers at four HSR stations (Ankara, Eskişehir, İstanbul and Konya). Due to the cost and time limitations, randomly selected 421 HSR users were surveyed face-to-face. There were many travelers surveyed in Ankara, as it is the hub of the HSR services, but the distribution of the number of surveys among different HSR lines was balanced when compared to the known ridership levels (see Table 4 and Table 5).

The survey was included seven parts with multiple questions as summarized in Table 5 (see Appendix for the original version of survey in Turkish). It did not include open-ended questions. The socio-demographic data (Part A) included basic traveler information such as age, gender, household income. Monthly income levels were grouped as: a) 'very low' (<550$), b) 'low' (550$-1100$), and c) 'middle/high' (>1100$) which were selected based on the most recent published average monthly household income level of 613$/month (Turkish Statistical Institute, 2013). Part B included a series of questions investigations user's importance on selected intercity travel factors, which were not discussed in this study, at all. In Part C, participants were asked to state their preferred mode choice in the intercity travels in general where the options were classified as 1) private car, 2) bus, 3) railway and 4) airway. As the general mode choice may vary by trip purpose, this question was repeated for three selected intercity trip purposes of i) business, ii) tourism and iii) other purposes (i.e. leisure, education, health, family visits, etc.). In Part D, HSR travel characteristics of users were sought after via questions regarding i) frequency of HSR usage, ii) general HSR trip purpose (business, education, tourism, other), iii) usage of other HSR lines and iv) alternative mode (private car, bus, railway and air) for the HSR trip they were making. In Part G, questions regarding the realized HSR trip were asked seeking details on the origin and destination of the trip, size of the travel group, ticket type, and trip cost. Also, the alternative mode for no-HSR situation was asked in this part, which enabled to develop binary logit models later.

Table 5. Summary of survey study

Survey Dates: October-December 2014 **Sample Size:** 421 participants **Participation by HSR lines:** ANK-ESK (124); ANK-KON (186); ANK-IST (83); ESK-IST (22); ESK-KON (4); KON-IST (2)	
Survey Parts	**Details**
A) Socio-demographic information	City of residence, occupation, work status, age, gender, income, education
B) Importance of selected factors in intercity travel	Travel time, cost, reliability, punctuality, comfort and environmental sensitivity
C)Preferred intercity mode choice	Asked separately for business, tourism and other purposes
D) HSR usage	Frequency; General trip purpose (business, education, tourism, other); Usage of other HSR lines and their alternative modes(private car, bus , railway and air)
E)Preference of HSR	For pricing levels of HSR i) more than bus, ($P>P_{bus}$), ii) equal to bus ($P=P_{bus}$), iii) less than bus ($P<P_{bus}$), iv) more than air, ($P>P_{air}$), v) equal to air ($P=P_{air}$), vi) less than air ($P<P_{air}$)
F) Importance of selected factors in HSR usage	Travel time, cost, reliability, punctuality, comfort and environmental sensitivity
G) Current Trip Data	O-D, trip purpose, size of travel group, ticket type and trip cost, alternative mode and its cost

Participant Profile

Among the 421 participants, more than 60% of the respondents were male (see Table 6) though selected randomly. A significant portion of the travelers were in the age group of 13-26 years old (who were eligible for young traveler discount), and in 27-45 years group; the mean age of the sample was 32.84 (SD 15.94). The majority of the participants had middle/high income level (Mean: 624.06$, SD

401.83$). Most of the HSR users (76.7%) had past HSR experience, while a significant number of travelers (23%) were using it for the first time.

Table 6. Socio-demographic profile of respondents

		N	***%***			***N***	***%***
	Total	***421***	***100***		***Total***	***421***	***100***
Gender	Male	265	62.9	***Monthly Income Level***	No response	2	0.5
	Female	156	37.1		Very low	110	26.1
Age	No response	1	0.2		Low	117	27.8
	13-26	173	41.1		Middle/High	192	45.6
	27-45	147	34.9	***HSR Experience***	Past experience	323	76.7
	45-60	63	15		No experience	98	23.3
	60-64	20	4.8				
	≥65	17	4				

3.2.Binary Logit Models for HSR versus Alternative Mode

As used in many studies in the literature, logit models are commonly used in mode choice studies because of their ability to represent complex aspects of travel decisions of individuals by assuming a non-linear relationship between independent and dependent variables (Bin Miskeen, et al., 2013). In this study, binary logit model was chosen to explain the factors affecting HSR mode choice in Turkey. The reasons behind choosing this model were i) meeting the assumptions of binary logit model ii) low number of sample size which did not allow to develop more complex models (such as Nested Logit Model, Multinomial Logit Model).

Table 7 represents the set of variables used in the logit models. While traveler characteristics and trip purpose information were obtained from the survey data, travel time and cost information for the trips were taken from national portal, NTP, for each mode and origin-destination pair (NTP, 2016). Besides the travel time (TT), natural logarithm of it, Ln(TT), was also introduced in the models to capture the possible diminishing effects. Additionally, the travel time reduction by HSR

(TT_R) was studied as used in the literature (Ganji et al., 2013; Brownstone et al., 2003). Income values (Inc) were assumed as mid-interval values for the stated income levels. In addition to cost (Cost), cost per income (Cost/Inc) variable was generated. Additionally, different dummy variables (Dum_xxx) that have value of '1' for specific cases, and '0' for all others, were generated to study the impact of gender, different trip purposes, occupation statues (workers or students) and private car ownership/usage.

Table 7.Variables included in the models

Trip Characteristics	Variable	Description
Travel Time	*TT (min)*	Travel time
	Ln(TT)	Natural Logarithm of Travel Time
	TT_R (min)	Travel time reduction by HSR
Cost*	*Cost (TL)*	Cost
	Cost/Inc	Cost per income
Trip Purpose	*DUM_Busin*	Dummy variable for business trips
	DUM _Educ	Dummy variable for education trips
	DUM _Tourism	Dummy variable for tourism trips
Traveler Characteristics	**Variable**	**Description**
Gender	*DUM _Female*	Dummy variable for female participants
Income	*Inc (TL)*	Average monthly income
Occupation	*DUM _Stud*	Dummy variable for student
	DUM _Work	Dummy variable for worker
Private Car	*DUM _PCown*	Dummy variable for private car ownership
	DUM _PCuse	Dummy variable for private car usage (Always)
	DUM _DL	Dummy variable for driving license ownership

*In Binary Logit Models airway ticket price was taken as "average of low cost airway tickets" and showed with $Cost_A$ (Alternative A). To show the cost sensitivity in VoT analyses, "average of economy class airway ticket prices were also used and showed with $Cost_B$ (Alternative B)..

Models including all the possible combinations of variables in Table 7 were tried in IBM SPSS Statistics V23 program by using binary logistic regression analysis module. Based on their performance in '-2 log-likelihood (-2LL)' and R^2 values, discussion of a subset of them is selected for further evaluation. In these models, the value reflects the prediction deviation (error) by the model (Bin-Miskeen et al., 2013), and is regarded as an important performance measure of these models, as well as R^2 values (Steyerberg et al., 2010). SPSS provides two R^2 measurements to estimate how much of the variation was accounted for model. While Cox and Snell's R^2 imitates the linear regression R^2 based on the likelihood, Nagelkerke's R^2 is a modification of the Cox and Snells coefficient to ensure that it varies only from 0 to 1 (Bin-Miskeen et al., 2013). The larger the R^2 value indicates a better fitted model (Wang et al., 2013). Furthermore, each model with considerably high performance values, should be further discussed for variable coefficients to decide whether the sign or significance of them were meaningful and acceptable.

Modal characteristics of HSR and the Alternatives Modes

Trip characteristics (travel time and cost information of HSR, bus and air alternatives) that are used in mode choice models were compiled from the National Transportation Portal (web site of Ministry of Transport-MoT) for each HSR corridor (MoT, 2016) as shown in Table 8. Additionally, the weekly service frequencies for all three modes were gathered to give an idea about the size of the intercity passenger sector for these corridors (Service is defined as the number of round-trips for a given corridor). ANK-ESK was the most frequently served HSR line with 77 services in a week. The second highest service frequency was observed on ESK-IST line with 56 services a week. KON-ESK and KON-IST are the least served HSR lines with only 14 services a week (corresponding to 2 round-trips a day). These service frequencies are highly correlated with the annual ridership values of the HSR lines, but it is not possible to comment on the causality of the relation, that is, whether low service frequencies cause low ridership, or vice versa. While bus transportation is an available alternative for all the corridors, its service frequency varies greatly among the corridors: On ANK-IST corridor, which connects the two most populated cities in Turkey, İstanbul (14.4 million) and Ankara (5.1 million), there are 854 services a week. The second highest service frequency was observed along ANK-ESK corridor (511 services a week), but it should be noted here that Eskişehir stands as an intermediate service point on the routes of many intercity buses.

Table 8. Service attributes of available modes along the HSR lines

HSR Lines	Road Distance (km)	Weekly Service Frequency (One-way Trips)			Average Ticket Cost (TL)			Travel Time ** (minutes)		
(in operation)		**HSR**	**Bus**	**Air**	**HSR**	**Bus**	**Air***	**HSR**	**Bus**	**Air**
ANK-KON	262	42	442	30	30.0 (0.0)	28.6 (1.2)	236.0 (31.8)	115	222 (22)	288 (82)
ANK-ESK	235	77	511	---	30.0 (0.0)	25.7 (2.7)	---	95 (2)	191 (20)	---
ANK-IST	450	42	854	350	70.0 (0.0)	58.9 (11.8)	154.2 (73.7)	249 (5)	386 (30)	72 (9)
KON-ESK	340	14	84	---	38.5 (0.0)	42.9 (2.5)	---	100	304 (9)	---
ESK-IST	310	56	359	---	45.0 (0.0)	33.6 (5.8)	---	152 (4)	331 (23)	---
KON-IST	712	14	259	64	85.0 (0.0)	71.2 (4.8)	129.4 (45.2)	260	620 (48)	82 (7)
(under construction)										
ANK-BUR	387	---	492	5	---	47.7 (7.7)	98.0 98.0	*135*	300 (19)	50
ANK-SIV	440	---	279	---	---	44.2 (3.8)	---	*120*	394 (20)	---
ANK-IZM	585	---	358	237	---	61.0 (11.2)	214.8 (93.2)	*210*	501 (24)	209 (109)

(*) Airway ticket prices were given for "Average of Low Cost Airway Ticket Prices" and denoted as Alternative A in the analyses.
(**) Travel time values were rounded up to the whole numbers.
Notes: Average ticket cost and travel time data were calculated for one-week schedule of each mode (for the dates of 28.11.2016-04.12.2017).

Air transportation is available for the three HSR corridors (ANK-KON, ANK-IST and KON-IST) and there is no air alternative for travelers in Eskişehir due to the proximity of the city to the nearby major cities (Ankara, Konya, and İstanbul). Both the legacy and low-cost airline services on the ANK-KON corridor include a must-transfer at İstanbul airport, which increases the cost and travel time significantly ($68.6 and 288 min., respectively) and which makes air alternative unattractive on this corridor. However, there are direct air services for the ANK-IST and KON-IST corridors.

In order to compare the costs of the HSR, intercity bus and air services and the ticket prices of all services in a week were averaged to get the corridor based values in Table 8 with the standard deviations (SD) shown in parenthesis. The highest variation was observed on ANK-IST corridor which had an average cost of 17.1$ (for one-way travel) with 3.4$ SD, which might have resulted from different service qualities (i.e., directness of the service, carrier, type of the coach bus, etc.) provided by the private companies in the sector. However, it should be noted that bus ticket prices were constant among traveler groups and there was no discount for special traveler groups. To be compatible, average ticket prices for HSR and air were given based on the full ticket price in economy class, although there were significant discounts (up to 50%) over the ticket prices for different traveler groups (i.e. frequent users, seniors, and teachers/students, etc.) traveling by HSR and air. The SD in average ticket prices of air represents the variation in full economy ticket price for different service times and days.

When the travel times of the alternative modes were examined, it was seen that HSR had very little or no variability, whereas SD in bus services were up to 48 minutes for longer corridors, and differences in actual travel times can be longer than one hour between direct and non-direct services for a given corridor. The significant SD value for air travel time on ANK-KON corridor comes from variability of the must-transfer times at İstanbul airport. Compared to bus and air, HSR travel times are almost constant with only a few minutes of difference stemming from scheduling details.

Upcoming HSR services will serve much longer corridors of ANK-BUR, ANK-SIV and ANK-IZM, which are currently served by bus in 300 minutes, 394 minutes and 501 minutes, respectively. Air transportation is an option for ANK-BUR and ANK-IZM travelers, which connect the capital to the two big cities, Bursa (2.8 million population) and İzmir (4.2 million population), but the major air corridor is the latter with 237 trips per week (many of which are indirect trips, whereas direct trips take 75 minutes on average). Bus services along these new lines are priced similar to the other corridors (Note: HSR travel times for these corridors are those expected times based on project details as announced by the TSR).

In addition to travel time and ticket costs, it is also critical to check the travel time reduction by HSR over bus. For example, on KON-ESK corridor, the average bus travel time is 304 minutes, which is traveled in 100 minutes by HSR. Among the upcoming HSR lines, it is expected that a significant amount of time will be saved on ANK-IZM corridor, where an HSR trip of 210 minutes would offer a travel time reduction of 300 minutes (5 hours) over a traditional bus travel.

3.3.Value of Time Estimation for HSR Users

As discussed before, the VoT is equal to the ratio between the derivative of utility with respect to time and the derivative of utility with respect to cost. It is used for any models including combinations of travel time and cost (Koppelman and Bhat, 2006). In Table 9, VoT equations are given for different models which will be useful for this study as well.

Table 9. VoT equations for different set of models

Model Variations	VoT Equations
Model A $V_i = \beta_0 + \beta_{TT} * TT_i + \beta_{Cost} * Cost_i + ...$	$VoT = \frac{\beta_{TT}}{\beta_{Cost}}$ (8a)
Model B $V_i = \beta_0 + \beta_{TT} * TT_i + \beta_{\frac{Cost}{Inc}} * \frac{Cost_i}{Inc} + ...$	$VoT = \frac{\beta_{TT}}{\beta_{\frac{Cost}{Inc}}} * Inc$ (8b)
Model C $V_i = \beta_0 + \beta_{Ln(TT)} * Ln(TT_i) + \beta_{Cost} * Cost_i + ...$	$VoT = \frac{\beta_{TT}}{\beta_{Cost}} * \frac{1}{TT}$ (8c)
Model D* $V_i = \beta_0 + \beta_{TT\_R} * TT\_R_i + \beta_{\frac{Cost}{Inc}} * \frac{Cost_i}{Inc} + ...$	$VoT = \frac{\beta_{TT\_R}}{\beta_{\frac{Cost}{Inc}}} * Inc$ (8d)

*In Model D, TT_R variable was used for calculating “Value of Travel Time Saving”.

Non-linearity in the impact of cost in the utiliy function can be introduced in several ways. Besides the linear-in-cost formulations in Model A and Model C, it is possible to introduce "Cost/Income" as in Model B and Model D; further it is to introduce a damping parameter.

To further evaluate the non-linearities in VoT, cost damping parameters of a) Box-Cox formulation and b) logarithmic transformation of cost were introduced for selected models. As an example, modifications of the VoT formulations with cost damping are presented below:

Model A (with cost damping)

$$V_i = \beta_0 + \beta_{TT} * TT_i + \beta_{Cost} * Cost_i + \beta_{Cdamp} * CDamp_i$$

$$V_i^{'} = \beta_0 + \beta_{TT} * TT_i + \beta_{Cost} * Cost_i + \beta^{*}_{CDamp} * (Cost^2{}_i - 1)/2 \quad \text{(Box-Cox)}$$

$$V_i^{"} = \beta_0 + \beta_{TT} * TT_i + \beta_{Cost} * Cost_i + \beta_{Ln(Cost)} * \ln(Cost_i) \quad \text{(Log-cost)}$$

$$VoT^{'} = \frac{\beta_{TT}}{\beta_{Cost} + \beta^{*}_{CDamp} * Cost} \quad \text{and} \quad VoT^{"} = \frac{\beta_{TT}}{\beta_{Cost} + \beta_{Ln(Cost)} / Cost}$$

CHAPTER 4

EVALUATION OF THE TRAVEL BEHAVIOR OF HSR PASSENGERS

This chapter is dedicated to the descriptive analysis of the survey results focusing on the travel behavior of HSR users, and it is divided into three main sections. Firstly, general intercity travel behavior characteristics of HSR users will be presented. Secondly, HSR preference for different income levels will be given. Finally, stated versus revealed pricing levels for HSR preference will be analyzed.

4.1.General Intercity Travel Behavior of the HSR Users

The analysis of the general intercity mode choice preferences of the HSR travelers revealed that for business trips, one third (31.3%) of the HSR users stated bus as their preferred intercity mode, while 28.7% and 18.3% stated private car and air, respectively; and rail choice (including HSR) was 21.6% (see Table 10). However, for tourism trips, the share of private car and bus choices increased to 42.2%, while the shares of rail and air significantly dropped to 9.6% and 10.4%, respectively. The higher preference for private car in these trips is expected to stem from the bigger size of travel group for family vacations: Average household size was 3.6 for Turkey in 2014 (TurkStat, 2017), which would make private car more economical when cost/traveler is considered. For all the other trip purposes (visiting relatives/friends, health, etc.), bus was preferred by the 40.3% of the participants followed by preference for rail by 28.3%. As can be seen from the total numbers, not all the HSR users stated a preferred mode for all trip purposes; about half of the travelers did not state a mode for business or other trips; but, almost all the travelers stated their mode choices for tourism trips. The road dominancy (private car and bus) in intercity trips was clearly visible in this survey with 60% share for business trips, 80% share for tourism trips, and 61.1% share for other trips. These are smaller than the 89.2% road share in the overall passenger transportation in Turkey (MoT, 2015) and the survey was conducted among HSR users who may have higher tendency to use rail.

Preference for private car and air increased with the income level for all trip purposes (Table 10). Bus was preferred by very low and low income people mostly for tourism and other trips. On the other hand, rail was preferred mostly by middle/high income people for business trips. It was also clear that air was not an affordable mode for the majority of the very low and low income people (who are mostly students and retirees). Private car and bus shares showed that road transportation was the dominant transportation system preferred by all income groups in the intercity trips, and private car was more preferable for tourism trips.

Table 10. General intercity mode choice of the participants by income (N=421)

Modes	Responses by Income			Total Responses	
	Very low	Low	Middle/ High	N	%
Business Trips					
Private Car	7	21	48	77	28.7
Bus	16	26	42	84	31.3
Rail	6	22	30	58	21.6
Air	3	4	42	49	18.3
Total Responses	***32***	***73***	***162***	***268***	***100.0***
Tourism Trips					
Private Car	28	41	101	171	42.2
Bus	59	49	45	153	37.8
Rail	13	13	13	39	9.6
Air	3	10	29	42	10.4
Total Responses	***103***	***113***	***188***	***405***	***100.0***
Other Trips					
Private Car	6	15	26	47	20.8
Bus	33	25	33	91	40.3
Rail	25	14	25	64	28.3
Air	1	9	14	24	10.6
Total Responses	***65***	***63***	***98***	***226***	***100.0***

4.2. HSR Preference for Different Ticket Pricing Scenarios

4.2.1. General Evaluation

HSR users were asked to state "in which pricing level they prefer to use HSR". For the HSR ticket price less than bus or air ticket prices ($P<P_{bus}$ or $P<P_{air}$), almost all users stated that they use HSR (more than 90%). When it was equal to bus ticket price ($P=P_{bus}$), the percentage of the participants preferring HSR was still 91.9%, and only 5% stated that they would not prefer to use HSR. On the other hand, only 56.8% of the participants stated that they would prefer to use HSR if HSR ticket price is higher than bus ticket price ($P>P_{bus}$). Also, 29.2% of the participants stated they would not prefer and 14% were not sure.

When HSR ticket price was compared to air ticket prices, it was revealed that more than half of the participants were reluctant (not sure or not preferring) to use HSR, while only 40% stated that they would prefer HSR if its price is equal to the air ticket price (P=Pair). In the case that HSR ticket price is higher than air ticket price (P>Pair), the majority of the respondents (75.1%) stated that they would not prefer HSR, while 6.2% of the participants were not sure and only the remaining (18.7%) stated their preference for HSR. This also indicates that people's perception of air ticket prices was significantly higher than bus prices. However, this may not be an outcome of a simple cost effect because air service was also perceived as a "comfortable and fast" mode, which would be preferred more than HSR in case of an equal cost case, as commented by many respondents during the survey.

4.2.2. Income Based Evaluation

When the responses were reprocessed for different income groups (very low, low and middle/high income) separately, more insights were gained, which can be summarized as follows:

- Travelers from every income level showed interest in using HSR when $P=P_{bus}$ (Figure 3b), similar to the overall trend.
- A higher percentage of travelers among very low and low income groups (40.0% and 38.5%) rejected to use HSR if $P>P_{bus}$, while this share was almost half (17.2%) among the middle/high income travelers (Figure 3a), as expected.

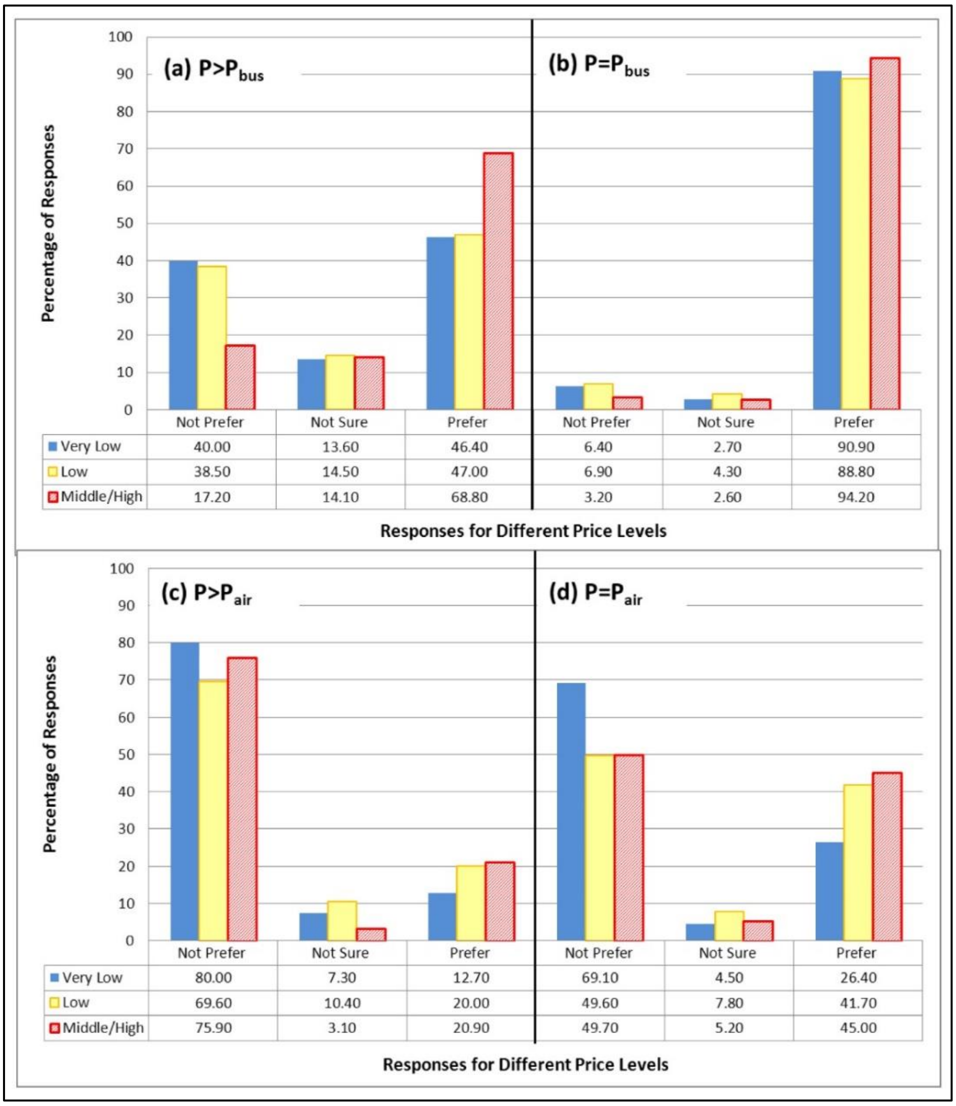

Figure 3.Preference for HSR by different income levels (very low, low and middle/high) if a) P>Pbus b) P=Pbus, c) P>Pair and d) P=Pair

- For $P=P_{air}$ case, more than 70% of the very low income travelers stated that they would not prefer HSR, while only 50% of the low or middle/high income travelers had the same negative opinion (Figure 3d).
- The majority of the travelers preferred not to use HSR for $P> P_{air}$ case, regardless of their income levels, as in the general case. However, preference to use HSR increased with increase in income, reaching to 20.9% among the middle/high income travelers (Figure 3c).

4.2.3. Road User Evaluation

As the TSR statistics suggested significant shift from bus and private car to HSR, it was worthwhile to check the existence of a similar trend among these road transportation (private car and bus) users surveyed in this study. Since the mode choices of intercity travel were asked separately for work, tourism and other purposes and with options of private car, bus, railway and airway, a subset of participants was created based on the two road mode users. The HSR preference for the travelers was cross-tabulated in Table 11. The results show that if $P>P_{bus}$, for work, tourism and other trips private car users are more willing to use HSR than bus users. More than 60% of the participants prefer HSR while bus users are more reluctant. If $P=P_{bus}$, the majority of private car and bus users (more than 85%) stated that they would prefer using HSR. When the same analysis was conducted for the pricing levels relatively to air ticket prices, it is seen that more than 65% of the road transportation users were not stated to prefer HSR for all trip purposes if its price is more expensive than air ticket prices. However, it is seen that private car users (for work and other types of trips) are more willing to prefer HSR. If $P=P_{air}$, about half of the people are not willing to use HSR for all types of trips. At the same time, it could be stated that people highly prefer to use HSR for work trips and private car users are more inclined to prefer HSR in their work and other type of trips (see Table 12).

Table 11. Road transport user's HSR preference relatively to bus ticket prices

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{bus}$	**Mode**				
Work	Private Car	21.3	15.0	3.8	100.0
	Bus	37.5	18.2	44.3	100.0
Tourism	Private Car	22.2	17.5	60.2	100.0
	Bus	37.9	13.7	48.4	100.0
Other	Private Car	19.1	12.8	68.1	100.0
	Bus	42.9	9.9	47.3	100.0
$P=P_{bus}$					
Work	Private Car	7.5	3.8	88.8	100.0
	Bus	5.7	6.9	87.4	100.0
Tourism	Private Car	2.4	3.6	94.1	100.0
	Bus	6.5	0.7	92.8	100.0
Other	Private Car	10.9	0.0	89.1	100.0
	Bus	4.4	1.1	94.4	100.0

Table 12. Road transport user's HSR preference relatively to air ticket prices

		Not prefer	Not sure	Prefer	TOTAL
$P>P_{air}$	**Mode**				
Work	Private Car	68.8	8.8	22.5	100.0
	Bus	78.2	8.0	13.8	100.0
Tourism	Private Car	73.5	8.2	18.2	100.0
	Bus	73.7	5.3	21.1	100.0
Other	Private Car	69.6	6.5	23.9	100.0
	Bus	80.2	4.4	15.4	100.0
$P=P_{air}$					
Work	Private Car	45.0	8.8	46.3	100.0
	Bus	50.6	6.9	42.5	100.0
Tourism	Private Car	52.3	7.6	38.8	100.0
	Bus	55.3	3.9	40.8	100.0
Other	Private Car	60.9	4.3	34.8	100.0
	Bus	63.7	3.3	33.0	100.0

4.3. Evaluation of the Stated Versus Revealed Pricing Levels for HSR Preference

To investigate the potential difference between the “stated” and “revealed” pricing preferences, paid ticket cost (P_{HSR}) for the realized trip (from Part G) was compared to the stated HSR preference for different pricing levels (P_stated) obtained from Part E of the survey. As bus is one of the most dominant transportation alternatives and has ticket prices close to HSR, the stated HSR preferences of travelers based on bus ticket pricing levels were studied against the revealed ticket prices as shown in Figure 4. Here, for a selected HSR line (i.e. ANK-KON), paid ticket cost for each participant, P_{HSR}, (which varies by ticket class and discount eligibility) was graphed with the solid blue line in Figure 4, whereas the minimum, average and maximum bus ticket prices for this corridor were shown with the dashed lines. The stated preferred HSR prices were denoted by the shaded green areas, such that TravelerIDs on the left-hand side of the graphed belonged to those that would prefer HSR, even if $P > P_{bus}$. Similarly, travelers who would prefer HSR if $P < P_{bus}$ were shown in the right-hand side of the same graph.

Most of the travelers were paying lower ticket prices than the amount that they stated (where the solid line is below the shaded area), and some travelers were traveling at a ticket cost equal to what they preferred (where solid line is within the shaded area). However, some people paid higher HSR ticket prices than they preferred (where solid line is above the shared region and denoted by the dashed circles in Figure 4), creating an inconsistency between the revealed and stated preferences.

For ANK-KON line, the majority of the 178 travelers (about 96 %) paid less than or equal to the amount that they stated, while there were 7 travelers who paid higher ticket prices than they stated. On ANK-ESK line, about 90% of the travelers paid less than or equal to the amount that they stated, while 12 of the 120 travelers used HSR even though its price was more than their stated preference. On ANK-IST line, 6 of the 78 travelers used HSR by paying a higher amount than their stated pricing preference.

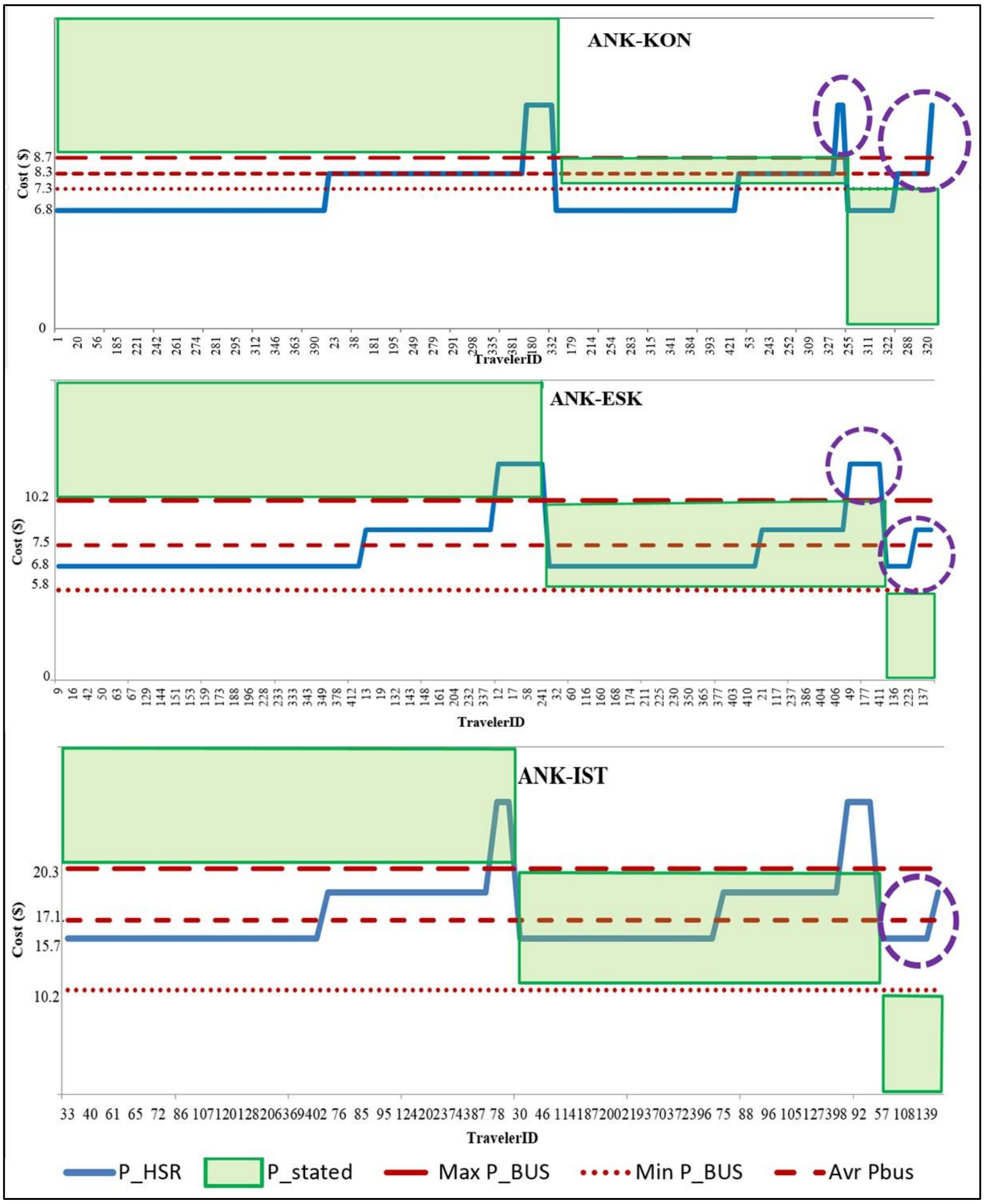

Figure 4. Revealed HSR price versus maximum price level stated for HSR preference

4.4.Findings & Discussion

This chapter focused on the results of the descriptive analyses performed using the survey data. In this chapter, firstly, participant profile was presented. After that travel behavior of the HSR users was investigated in terms of general intercity mode choices, HSR preferences under different pricing levels and comparison of the stated versus revealed pricing levels of HSR users.

A significant share of first-time HSR users showed the growing demand of HSR as a transportation mode in Turkey. There were many business or education related trips observed. In the short corridors (i.e. Ankara-Eskişehir), the modal shift was mainly from road transportation, while in Ankara-Istanbul corridor, shift from air to HSR was also observed.

Due to the survey question (on preference of HSR under different pricing levels) was asked in the form of a general comparison of ticket fares without giving the real numbers, the responses included a personal evaluation depending on the ticket fare information (for bus and air tickets), the discounts that the person may benefited and the perception of user. People with very low income were more reluctant to use HSR, if its ticket price was equal to or higher than bus ticket price. This may be more critical for the lines that have high student user or educational trips. Middle or high income level travelers were more inclined to use HSR, even if its ticket price was equal to or more than bus. However, when HSR ticket prices were equal to or more than air ticket prices, travelers showed reluctance to use HSR. Among the respondents, private car users were more inclined to prefer HSR than bus travelers, regardless of their trip purpose. Even though, it was not possible to perform willingness to pay analyses due to the related question, the results had a potential to catch long-lasting comments on HSR preference without being affected by the price change in the intercity bus services. The other limitation is that the question did not allow the determination of the willingness to pay because the level of preference was not asked.

The results also showed that there were some inconsistencies between the stated and revealed pricing levels for HSR preference (for no more than 10% of the travelers), most of the travelers were consistent in their modal preference for given price level comparison.

CHAPTER 5

FACTORS AFFECTING HSR MODE CHOICE AND VoT ESTIMATION FOR HSR USERS

In this chapter, firstly, binary logit models that were developed using different kind of variables were presented. Among these models, the selected ones were used to calculate the HSR preference probabilities for current and upcoming HSR lines based on different income levels. In addition, for some of the models, VoT and SSTD were calculated for both general HSR users and different groups of users.

5.1. Binary Logit Model Results

To understand the mode choice affecting factors in Turkey, a series of binary logit models were developed explaining HSR preference compared to the 'next best alternative' of travelers stated. In the preparation of the model data, trips that would have been made if HSR was not available were omitted, as there were no 'next best alternative' mode information. Additionally, the trips with conventional rail alternative were excluded, as it is not an available mode except for ANK-ESK line, anymore. As a result, trip and traveler data for 397 trips with known 'next best alternative' were included in the modeling study. Based on the general performance criteria, 13 models with relatively significant values are presented here. For the sake of easiness in evaluation, these models were grouped in three main sets, which included 1) travel time (TT), 2) logarithm of travel time (Ln(TT)) and 3) travel time reduction (TT_R), as the main time variables, and presented in Tables 13 through 15, respectively. In these tables, models with only travel time variable were represented with single number in the name (i.e. Model 1, Model 2 and Model 3). Models with $Cost_A$ and $Cost_A$/Inc are designated with lower case 'a', 'b' showing their existence in the models (i.e. Model 2a_b, which had both $Cost_A$ and $Cost_A$/Inc in the model). Finally, roman numerals were added to show variations regarding other dummy variables included. In the variables part, in addition to the coefficients, odds ratio, *Exp(β)*, were also provided that show the change in the probability with 1-unit increase in the independent variable.

Table 13. Binary logit model estimations with TT (Set 1) (N=397)

Summary of Statistics	**Model 1**		**Model 1a**		**Model 1a_b**	
-2 LL	780.739		776.642		769.215	
Cox & Snell R^2	0.332		0.335		0.340	
Nagelkerke R^2	0.442		0.447		0.453	
Variables	***β***	***Exp(β)***	***β***	***Exp(β)***	***β***	***Exp(β)***
TT (min)	-0.021**	0.980	-0.020**	0.980	-0.020**	0.980
$Cost_A$(TL)	---	---	-0.006**	0.993	-0.009**	0.991
$Cost_A$/Inc	---	---	---	---	5.470*	237.432
Constant	3.597**	36.486	3.770**	43.371	3.764**	43.122

Note: $p < 0.10$; ** $p < 0.05$*

Based on the general performance criteria, it is seen that that travel time reduction effected choice of HSR more than travel time or natural logarithm of it. Models with Ln(TT) in Set 2 produced slightly better results than those with TT in Set 1; however, models with TT_R (Set 3) produced much better results with -2LL values. Model 3 which had only TT_R, itself had -2LL value of 496.565, and it was improved to -2LLvalue of 490.442, when $Cost_A$/Inc were introduced with dummy variables for business trip (DUM_Busin) and private car ownership (DUM_PCown) in Model 3b_V.The evaluations based on R^2 also supported the success of this model that had Cox and Snell's R^2 =0.538 and Nagelkerke's R^2= 0.718 (which explained about 72% of the variation in the dependent variable).

Negative coefficients for TT and Ln(TT) and $Cost_A$ implied disutility and were as expected. On the other hand, TT_R and Inc variables had positive coefficients, suggesting utility in mode choice modeling. Among the dummy variables, being student and having education trip purpose were negatively associated HSR preference, while being a worker, having business trip purpose and private car ownership had positive coefficients indicating positive impact on HSR choice. It should be noted here that, there are positive correlations between private car ownership and income level, also between student and education trip purpose, which led to similar behaviors of these variable couples.

When models were evaluated at variable level, it can be seen they were not statistically significant or not at the same level in every model. In the Model Set 1, TT, $Cost_A$ and $Cost_A$/Inc variables were always statistically significant with $p<0.05$ (Model 1, Model 1a and Model 1a_b). In models with Ln(TT), $Cost_A$ and $Cost_A$/Inc were behaving in the same way with similar coefficients and they were statistically significant, but odds ratio for the latter was much smaller (Model 2a_b). While dummy variables for students and educational trips improved overall predictive performance value of -2LL compared to Model 2 and Model 2a, they were not statistically significant at $p<0.10$ levels (see Table 14).

In the third set of models with TT_R, $Cost_A$ variable did not have statistically significant coefficient, even though it had the correct negative coefficient, thus not presented in Table 15. In the absence of $Cost_A$ variable, $Cost_A$/Inc had negative coefficient, most likely representing the disutility of the $Cost_A$ itself. While dummy variable for private car ownership were significant and had an odds ratios of 1.702 in Model 3b_IV, introduction of the dummy variable for business trips improved the models slightly more, though this variable was not statistically significant at $p<0.10$ level. The logistics regression formula for this best model, Model 3b_V, can be written as

$$U_{HSR} = -2.193 + 0.043 * TT\_R - 6.509 * Cost_A / Inc + 0.253 * DUM\_\mathrm{Busin} + 0.506 * DUM\_PCown$$

Table 14. Binary logit model estimations with Ln(TT) (Set 2) (N=397)

Summary of Statistics	Model 2		Model 2a		Model 2a_b		Model 2a_I		Model 2a_II	
-2 LL	757.477		754.109		747.276		752.252		752.891	
Cox-Snell R^2	0.351		0.354		0.358		0.355		0.355	
Nagelkerke R^2	0.468		0.472		0.477		0.474		0.473	
Variables	***B***	***Exp(β)***	***β***	***Exp(β)***	***β***	***Exp(β)***	***B***	***Exp(β)***	***β***	***Exp(β)***
Ln(TT)	-3.493**	0.030	-3.374**	0.034	-3.433**	0.032	-3.374**	.034	-3.380**	0.034
$Cost_A$(TL)	---	---	-0.006*	0.994	-0.008**	0.992	-0.007**	.993	-0.007*	0.993
$Cost_A$/Inc	---	---	---	---	5.047*	155.619	---	---	---	---
DUM_Stud	---	---	---	---	---	---	-0.280	.756	---	---
DUM_Educ	---	---	---	---	---	---	---	---	-0.255	0.775
Constant	17.781**	5.27E+07	17.445**	3.77E+07	17.671**	4.73E+07	17.567**	4.26E+07	17.544**	4.16E+07

Table 15. Binary logit model estimations with TT_Reduction (Set 3) (N=397)

Summary of Statistics	Model 3		Model 3b		Model 3b_III		Model 3b_IV		Model 3b_V	
-2 LL	496.565		490.442		489.103		486.890		486.035	
Cox-Snell R^2	0.533		0.536		0.536		0.538		0.538	
Nagelkerke R^2	0.710		0.714		0.715		0.717		0.718	
Variables	***B***	***Exp(β)***	***β***	***Exp(β)***	***β***	***Exp(β)***	***β***	***Exp(β)***	***β***	***Exp(β)***
TT_R (min)	0.043**	1.044	0.043**	1.044	0.043**	1.044	0.043**	1.044	0.043**	1.044
$Cost_A$/Inc	---	---	-8.570*	0.000	-6.372	0.002	-7.381*	0.001	-6.509	0.001
DUM_Work	---	---	---	---	0.306	1.358	---	---	---	---
DUM_Busin	---	---	---	---	---	---	---	---	0.253	1.288
DUM_PCown	---	---	---	---	---	---	0.532*	1.702	0.506*	1.658
Constant	-1.927**	0.146	-1.664**	0.189	-1.912**	0.148	-2.109**	0.121	-2.193**	0.112

Note: $p < 0.10$; ** $p < 0.05$*

5.2. Probability of HSR Preferences

In order to calculate HSR preference probability for the current and upcoming lines, three models were selected from each set of binary logit models with TT, Ln(TT) and TT_R, considering the criteria of having statistically significant coefficient. Having one model from each set enabled to understand the impact of different transformations of travel time. Also, including "$Cost_A$/Inc" variable helped to understand income impact in HSR preference probability. Models selected for probability calculations are show in bordered with double lines in Tables 13-15.

5.2.1. Estimation of HSR Preference Probability for Current Lines

Using the selected models probability of HSR preference, *Pr(HSR*), over "the next best alternative" was calculated for current lines. The probabilities for different income level travelers and HSR lines separately as shown in Table 16. For example, Model 1a_b predicted that a low income traveler on ANK-KON corridor with the next best alternative of bus would have utilities as

$$U_{HSR} = 3.764 - 0.020 * 115 - 0.009 * 30 + 5.470 * (30/1500) = 1.30$$

$$U_{bus} = 3.764 - 0.020 * 222.2 - 0.009 * 30 + 5.470 * (30/1500) = -0.83$$

$$\Pr(HSR)_{bus} = \frac{e^{U_{HSR}}}{e^{U_{HSR}} + e^{U_{Bus}}} = \frac{e^{1.30}}{e^{1.30} + e^{-0.83}} = 0.89$$

over bus, where the subscript showed the next best alternative mode. The results showed that on each corridor, travelers with bus alternative would have a strong HSR preference, with more than 80% probability regardless of their income level. When evaluated from the perspective of saving time (Model 3b), HSR preference among users was expected to reach almost 100% (at 2-digit significance) due to major travel time reductions by HSR.

For travelers with air alternative, HSR was expected to capture most of the ANK-KON air travelers as cost and time values and savings are always greater. However, on ANK-IST and KON-IST corridors, HSR preference probabilities were expected as 1-2% or even lower; this may be due to the fact that direct air flights on ANK-IST and KON-IST create very short travel times, and existence of low cost airlines on these corridors also create a great advantage, cutting down the competitive power of HSR over air.

To emphasize the variability of preference probabilities over different HSR lines and models, the calculated probabilities for "low" income traveler group was presented in Figure 5. Compared to bus, all models predicted very high HSR preference for ANK-ESK corridor, but, for the longer corridors, ANK-IST and KON-IST, the estimated probabilities varied more based on the time variable used in the model: Using *Ln(TT),* Model 2 estimated lower probabilities as the impact of longer travel times diminished by the Ln transformation, whereas Model 3b estimated much higher probabilities due to the use of the travel time reduction parameter, TT_R, as the main indicator. Probabilities for HSR preference over air show dramatic changes; however, they are very consistent among models as discussed above.

Table 16. Estimated probabilities, $\Pr(HSR)$, for different income levels over bus and air alternatives

HSR Lines	Model 1a_b*	Model 2a_b*	Model 3b*
HSR versus Bus			
ANK-KON	0.90; **0.89**; 0.89	0.91; **0.90**; 0.90	0.99; **0.99**; 0.99
ANK-ESK	0.87; **0.87**; 0.87	0.92; **0.92**; 0.92	0.98; **0.98**; 0.98
ANK-IST	0.94; **0.94**; 0.94	0.82; **0.81**; 0.81	1.00; **1.00**; 1.00
ESK-IST	0.97; **0.97**; 0.97	0.94; **0.93**; 0.93	1.00; **1.00;** 1.00
KON-IST	1.00; **1.00**; 1.00	0.95; **0.95**; 0.95	1.00; **1.00**; 1.00
KON-ESK	0.98; **0.98**; 0.98	0.98; **0.98**; 0.98	1.00; **1.00**; 1.00
HSR versus Air			
ANK-KON	0.97; **0.99**; 0.99	0.96; **0.99**; 0.99	1.00; **1.00**; 1.00
ANK-IST	0.03; **0.04**; 0.05	0.01; **0.02**; 0.02	0.00; **0.00**; 0.00
KON-IST	0.03; **0.03**; 0.04	0.02; **0.02**; 0.02	0.00; **0.00**; 0.00

*Probabilities are given for “Very low; Low; Middle/High” income levels, respectively.

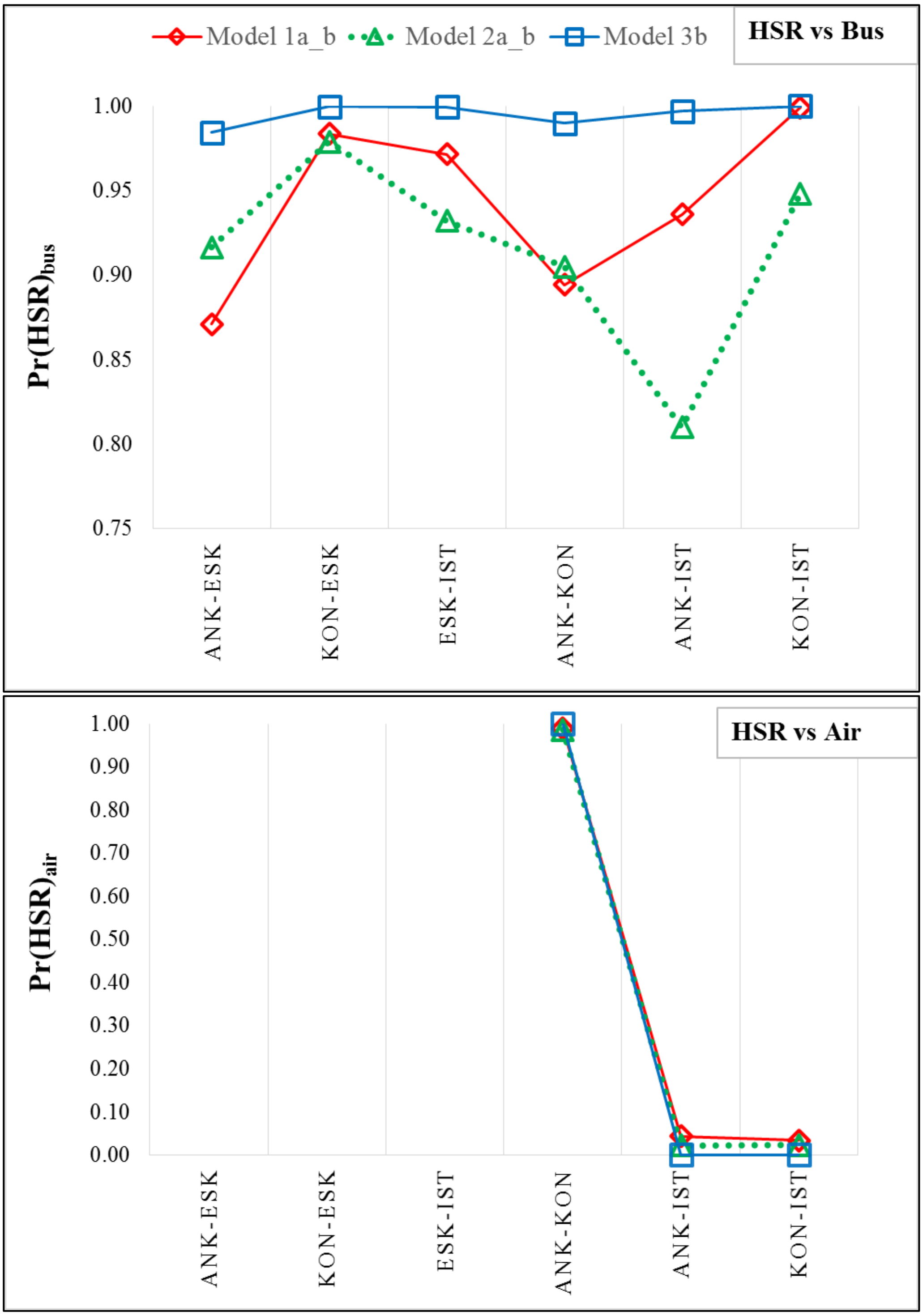

Figure 5. Estimated probabilities for low income level by the selected models

5.2.2. HSR Preference Probabilities for the Upcoming Lines

Again using the selected models, preference probabilities of upcoming HSR lines; ANK-BUR, ANK-SIV and ANK-IZM; were calculated. As the ticket prices of these lines have not been determined yet, five pricing scenarios considering existing bus and air ticket prices were designed as:

- $P=P_{bus}$: HSR ticket price is equal to bus ticket price
- $P=1.15P_{bus}$: HSR ticket price is 15% more than bus ticket price
- $P=1.30P_{bus:}$ HSR ticket price is 30% more than bus ticket price
- $P=0.70P_{air}$: HSR ticket price is 30% less than air ticket price
- $P=0.85P_{air}$: HSR ticket price is 15% less than air ticket price

The monetary terms of these ticket price scenarios are illustrated in Table 17 with current average bus and air ticket prices for these lines. First, three scenarios which were based on bus ticket prices were developed to analyze HSR preference over bus alternative for the three upcoming lines, while $P=1.30P_{bus}$ scenario and two air ticket-based scenarios were developed for HSR preference over air along two lines, ANK-IZM and ANK-BUR.

Table 17. Pricing scenarios developed for probability estimations

	Ticket Price Scenarios (in TL)				
Upcoming Lines	**$P=P_{bus}$**	**$P=1.15P_{bus}$**	**$P=1.30P_{bus}$**	**$P=0.70P_{air}$**	**$P=0.85P_{air}$**
ANK-BUR	47.8	55.0	62.2	68.6	83.4
ANK-IZM	60.9	70.0	79.2	150.3	182.5
ANK-SIV	44.4	51.0	57.7	---	---
	← HSR versus Bus →				
			← HSR versus Air →		

Using the assumed HSR ticket prices and three models, Model 1a_b through Model 3b, probabilities of HSR preference over bus and air transportation were calculated (see Table 18). For ticket prices up to 30% more than the bus ticket prices, the probability of HSR preference over bus was found to be more than 93% for all corridors, suggesting that HSR would have high competitive power against bus regardless of the income of the travelers.

When the probability of HSR mode choice over air transportation was investigated, the probability of HSR preference was expected to be lower for ANK-BUR corridor than ANK-IZM corridor (Table 18). The variation of HSR preference based on different income levels and scenarios was more remarkable for ANK-IZM corridor. The probability of HSR preference over air for ANK-BUR corridor was expected to be only as high as 18% by Model 1a_b, and much lower by the other two models. This might be due to a very short air travel time of direct flights although they were very few in terms of weekly frequency; but modal characteristics such as service frequency was not covered in the simple cost-travel time models. ANK-IZM corridor was more sensitive to price and traveler income levels, predicting an HSR probability between 0.49 (by very low income travelers for $P=0.85P_{air}$ by Model 1a_b) and 0.81 (by very low income travelers for $P=1.30P_{bus}$ by Model 3b). When the cost of HSR ticket was increased, the probability of choosing HSR decreased as expected. The probability of HSR preferences over bus and air alternatives was visualized for "low" income level to see the variation among different scenarios and was presented in Figure 6 and Figure 7.

Table 18. Predicted probabilities, $\Pr(HSR)$, for upcoming HSR lines based on different income levels

Lines	Price Scenarios	Model 1a_b*	Model 2a_b*	Model 3b*
HSR versus Bus				
ANK-BUR	**1.30P$_{bus}$**	0.96; **0.96**; 0.96	0.94; **0.94**; 0.93	1.00; **1.00**; 1.00
	1.15P$_{bus}$	0.96; **0.96**; 0.96	0.94; **0.94**; 0.94	1.00; **1.00**; 1.00
	P$_{bus}$	0.96; **0.96**; 0.96	0.94; **0.94**; 0.94	1.00; **1.00**; 1.00
ANK-IZM	**1.30P$_{bus}$**	1.00; **1.00**; 1.00	0.95; **0.95**; 0.95	1.00; **1.00**; 1.00
	1.15P$_{bus}$	1.00; **1.00**; 1.00	0.95; **0.95**; 0.95	1.00; **1.00**; 1.00
	P$_{bus}$	1.00; **1.00**; 1.00	0.95; **0.95**; 0.95	1.00; **1.00**; 1.00
ANK-SIV	**1.30P$_{bus}$**	1.00; **1.00**; 1.00	0.98; **0.98**; 0.98	1.00; **1.00**; 1.00
	1.15P$_{bus}$	1.00; **1.00**; 1.00	0.98; **0.98**; 0.98	1.00; **1.00**; 1.00
	P$_{bus}$	1.00; **1.00**; 1.00	0.98; **0.98**; 0.98	1.00; **1.00**; 1.00
HSR versus Air				
ANK-BUR	**1.30P$_{bus}$**	0.16; **0.18**; 0.19	0.03; **0.04**; 0.04	0.04; **0.03**; 0.03
	0.70P$_{air}$	0.16; **0.18**; 0.18	0.03; **0.04**; 0.04	0.03; **0.03**; 0.03
	0.85P$_{air}$	0.15; **0.17**; 0.17	0.03; **0.04**; 0.04	0.03; **0.03**; 0.03
ANK-IZM	**1.30P$_{bus}$**	0.50; **0.67**; 0.70	0.51; **0.66**; 0.69	0.81; **0.59**; 0.53
	0.70P$_{air}$	0.50; **0.58**; 0.59	0.50; **0.58**; 0.59	0.66; **0.53**; 0.51
	0.85P$_{air}$	0.49; **0.54**; 0.54	0.50; **0.54**; 0.54	0.57; **0.51**; 0.50

*Probabilities are given for "Very low; Low; Middle/High" income levels respectively.

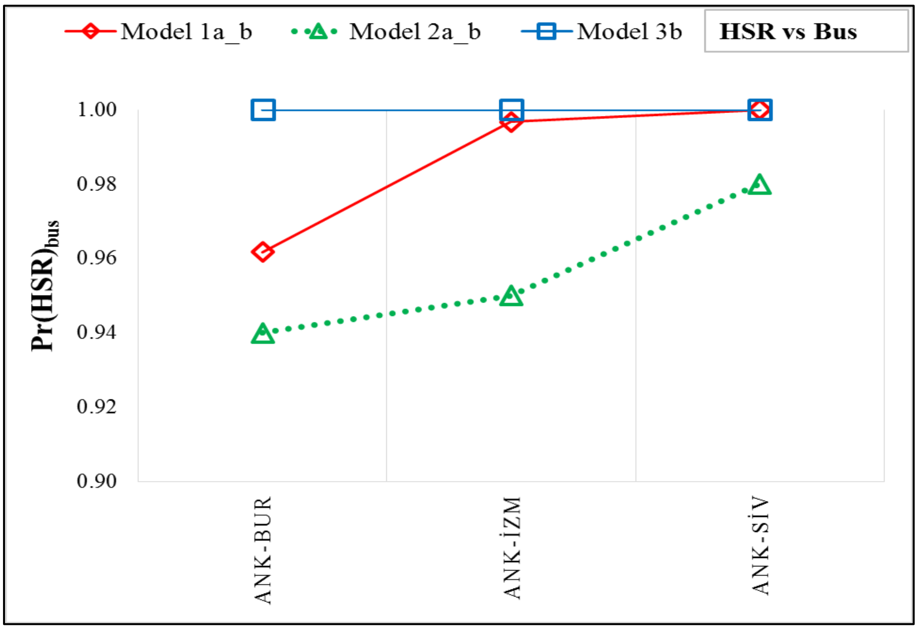

Figure 6. Predicted probabilities of HSR preference over bus for upcoming lines (for low income travelers)

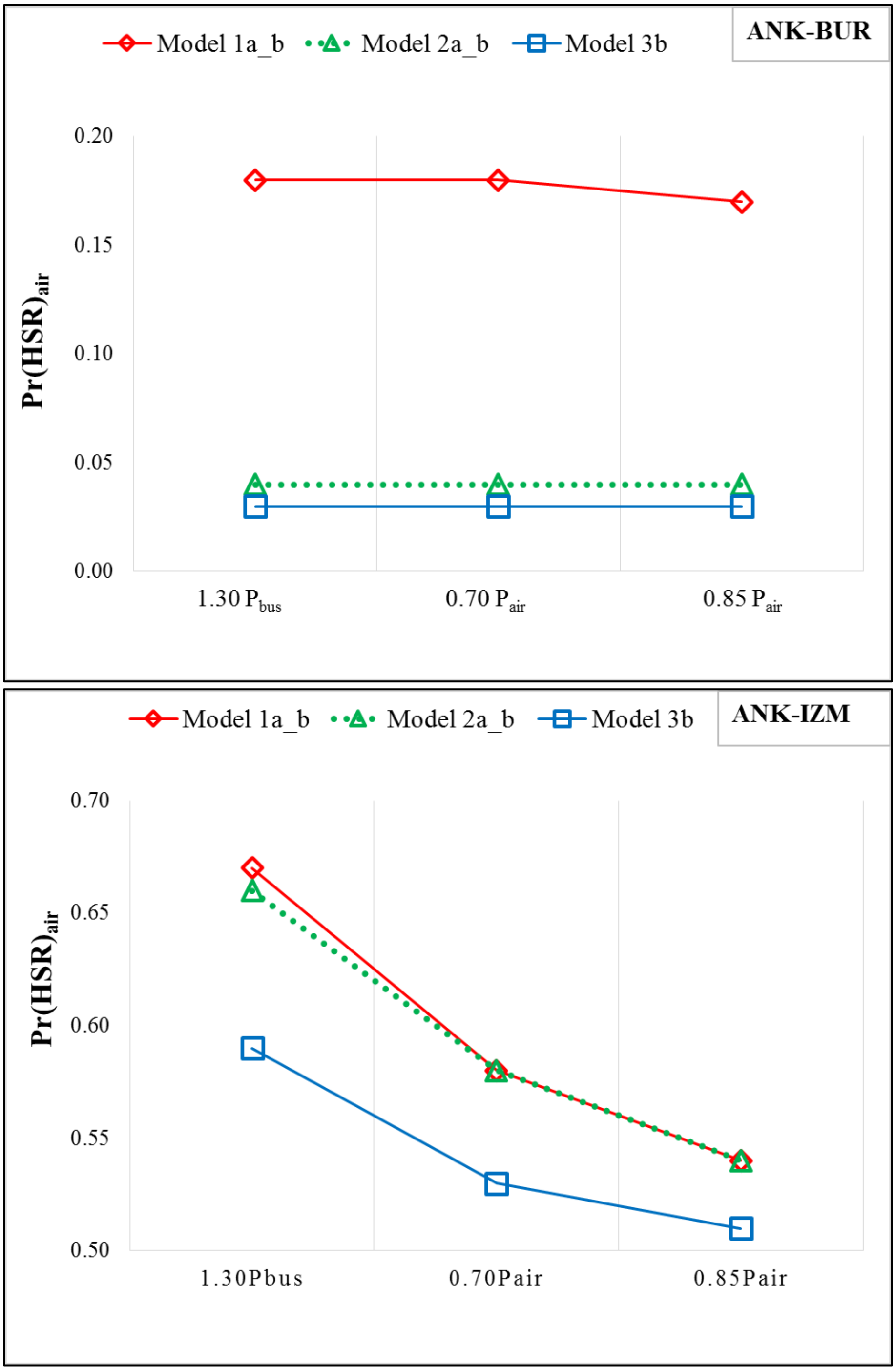

Figure 7. Predicted probabilities of HSR preference over air for the upcoming lines (for low income travelers)

5.3. Value of Time (VoT) Estimation

Among the 14 models given statistically significant results (Table 13-15), considering the general VoT formulations given before (Table 9), Model 1a, Model 2a and Model 3b were chosen for this study. Model 1a included TT and Cost variables which enabled to calculate a general VoT value for all HSR users. Model 2a included Ln(TT) and Cost variables and it was used to calculate VoT of HSR users separately for each HSR line. Model 3b with TT_R and Cost/Inc provided an income level based VTTS calculation. However, as there are many different parameters in determining airway ticket prices (ticketing time, air service types, etc), two different air cost levels were determined as average of: i) low cost airline ticket price (Alternative A), ii) economy class ticket price (Alternative B). Binary logit regression model results for Alternative B is given as Table 19.

Table 19. Model sensitivity to Airway Cost (Alternative B)

Summary of Statistics (N=397)	**Model 1a**		**Model 2a**		**Model 3b**	
-2 LL	760.029		732.855		489.597	
Cox & Snell R^2	0.349		0.371		0.536	
Nagelkerke R^2	0.465		0.494		0.715	
Variables	**β**	**Exp(β**	**β**	**Exp(β)**	**β**	**Exp(β**
TT (min)	-	0.980	---	---	---	---
Ln(TT)	---	---	-	0.035	---	---
TT_R (min)	---	---	---	---	0.043**	1.044
$Cost_B$(TL)	-	0.988	-	0.985	---	---
$Cost_B$/Inc	---	---	---	---	-	0.000
Constant	4.063**	58.156	17.763*	5.18E+0	-	0.194

Note: p < 0.10; ** p < 0.05*

5.3.1. *VoT Sensitivity to Airline Ticket Prices*

Based on the coefficients of Model 1a (Table 13 and Table 19), general VoTs for Alternatives A and B, were calculated for HSR users as

$$VoT_{1a\_A} = \frac{\beta_{TT}}{\beta_{Cost_A}} = \frac{-0.020}{-0.006} = 3.33\,\mathrm{TL/min} = 200 TL/hr \rightarrow 66.7\$/hr$$

$$VoT_{1a\_B} = \frac{\beta_{TT}}{\beta_{Cost_B}} = \frac{-0.020}{-0.012} = 1.66\mathrm{TL/min} = 99 TL/hr \rightarrow 33.0\$/hr$$

As VoT may change according to many factors (US Department of Transportation, 2011), line based and income based estimations were also calculated with two alternative air price data using the formulations below:

$$VoT_{2a\_A} = \frac{\beta_{Ln(TT)}}{\beta_{Cost_A}} * \frac{1}{TT} = \frac{-3.374}{-0.006} * \frac{1}{TT} \tag{9a}$$

$$VoT_{2a\_B} = \frac{\beta_{Ln(TT)}}{\beta_{Cost_B}} * \frac{1}{TT} = \frac{-3.361}{-0.015} * \frac{1}{TT} \tag{9b}$$

$$VTTS_{3b\_A} = \frac{\beta_{TT\_R}}{\beta_{Cost_A/Inc}} * Inc = \frac{0.043}{-8.570} * Inc \tag{9c}$$

$$VTTS_{3b\_B} = \frac{\beta_{TT\_R}}{\beta_{Cost_B/Inc}} * Inc = \frac{0.043}{-9.040} * Inc \tag{9d}$$

According to the formulation, VoT was decreasing with the increase in travel time. For KON-IST line with 4.5 hr travel time, VoTs were calculated as 121 TL/hr (36 $) and 49 TL/hr (14 $, with the currency rate of 3.4 $/TL in 10.09.2017) with Alternative A and Alternative B, respectively. On the other hand, for ANK-ESK line with a travel time of 1.5 hr, VoT was found as 392 TL/hr (115 $) with Alternative A, and 157 TL/hr (46$) with Alternative B. To further illustrate the variance of estimated VoT, Figure 8a was given below. As seen in the Figure, VoT was much higher for short corridors (i.e. ANK-ESK, KON-ESK) than the longer corridors (i.e. KON-IST and ANK-IST) parallel to the literature (Athira et al., 2016; Kato and Onoda, 2009). Model 3b which included TT_R and Cost/Inc variables, enabled us to make Value of Travel Time Saving (VTTS) calculation which was stated in the literature (Ganji et al., 2013; Brownstone et al., 2003).

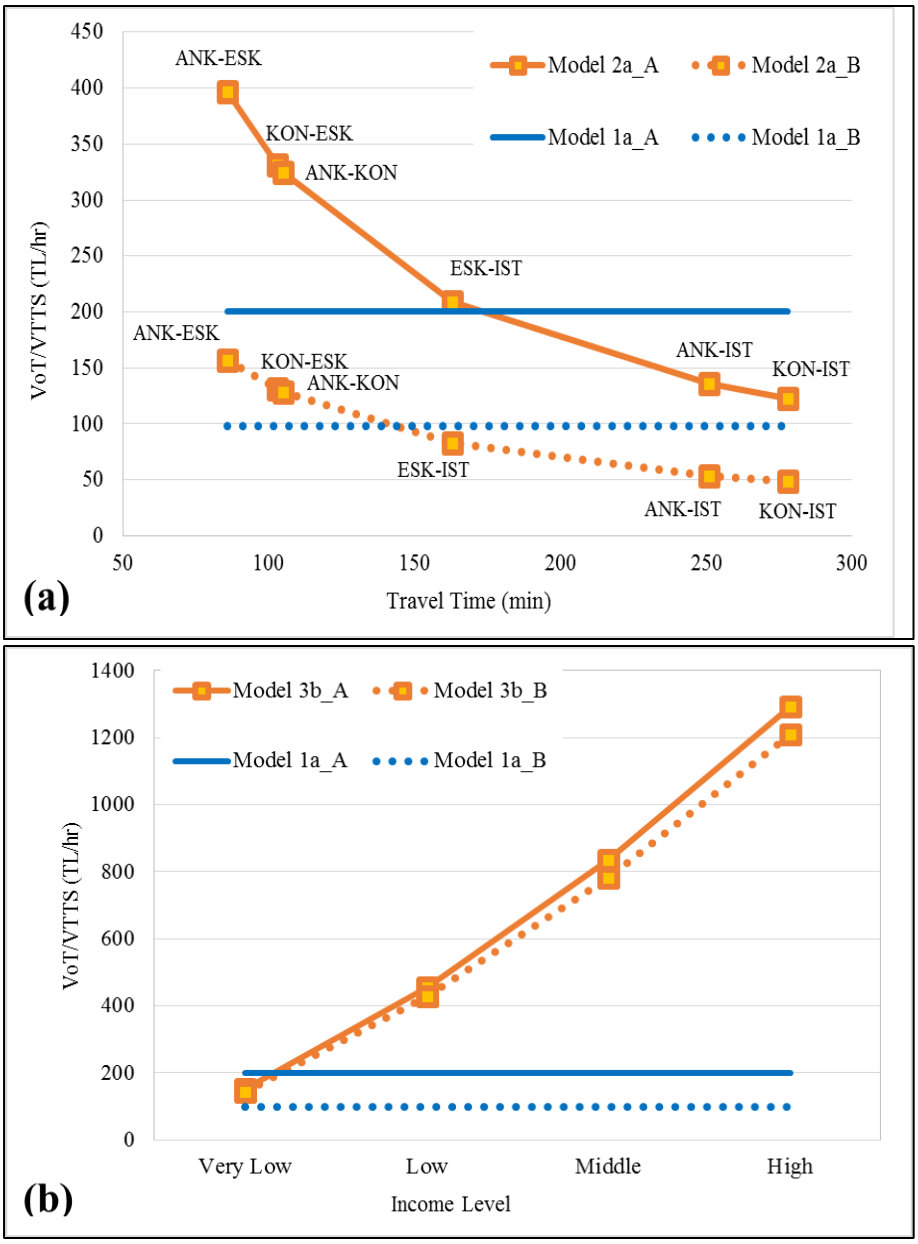

Figure 8. VoT and SSTD Estimations with Alternative A and Alternative B a) Model 1a ve Model 2a b) Model 1a ve Model 3b

According to the results, for the people with very low income level (<550$), VTTS was calculated as 151 TL/hr (44 $) and 142 TL/hr (42$) with Alternative A and Alternative B, respectively (Figure 8b). The results showed that VTTS increased with the increase in income level as stated in literature as well (Athira et al., 2016; Donnea, 1972). As seen in the Figure 8, variation in the airway ticket price has a considerable impact in general and line based VoT calculations. VoT which was calculated with Alternative B presented lower values compared to the values calculated by Alternative A. However, there is a slight difference between the VTTS values calculated by Alternative A and B for the Model 3b including Cost variable proportional to the income level.

5.3.2. *Cost Damping Effect on VoT Values*

In order to show model sensitivity to cost damping, two methods were used as: a) Box-Cox transformation and b) cost damping with Ln(Cost). Using these methods, binary logit models were repeated for Model 1a and Model 2a (Table 20). It is seen that models had lower -2LL values and higher R^2 values compared to the results given before, so it could be stated that cost damping application improved the general performance of the models.

Table 20. Model sensitivity to Cost Damping with a) Box-Cox and b) Ln(Cost) (N=397)

Summary of Statistics	**Model 1a′**		**Model 2a′**	
-2 LL	33.999		31.941	
Cox & Snell R^2	0.739		0.740	
Nagelkerke R^2	0.985		0.986	
Variables	**β**	**Exp(β)**	**β**	**Exp(β)**
TT (min)	-0.122**	0.885	---	---
Ln(TT)	---	---	-25.216**	0.000
$Cost_A$(TL)	2.352**	10.505	2.534**	12.600
$C.Damp_A$ (TL^2)	-0.040**	0.961	-0.042**	0.959
Constant	-31.513**	0.000	69.690**	1.84E+30
Summary of Statistics	**Model 1a″**		**Model 2a″**	
-2 LL	58.987		71.951[a]	
Cox & Snell R^2	.731		.726	
Nagelkerke R^2	.974		.968	
Variables	**β**	**Exp(β)**	**β**	**Exp(β)**
TT (min)	-0.183**	0.833	---	---
Ln(TT)	---	---	-36.240**	0.000
$Cost_A$(TL)	-3.108**	0.045	-3.793**	0.023
Ln($Cost_A$)	168.275**	1.21E+73	204.840**	9.14E+88
Constant	-448.180**	0.000	-401.543**	0.000

Note: $^{*} p < 0.10$; $^{**} p < 0.05$

Besides the Model 1a′ given in Section 3.3., the VoT formulation for Model 2a′ was developed as follows:

$$VoT_{2a'} = \frac{\dfrac{\beta_{Ln(TT)}}{TT}}{\beta_{Cost_A} + \dfrac{\beta^{*}_{CDamp}}{2} * (2 * Cost_A)} = \frac{\beta_{Ln(TT)}}{\beta_{Cost_A} + \beta^{*}_{CDamp} Cost_A} * \frac{1}{TT}$$

Similarly, using Ln(Cost) damping, VoT for Model 2a″ was determined as follows:

$$VoT_{2a''} = \frac{\dfrac{\beta_{Ln(TT)}}{TT}}{\beta_{Cost_A} + \dfrac{\beta_{Ln(Cost_A)}}{Cost_A}}$$

The results of the VoT calculations were given in Table 21. It is seen that performing cost damping to the binary logit models reduced the VoT even to the negative values, except two cases. VoT values calculated by Model 1a″ and Model 2a″ for ANK-IST and KON-IST had positive values.

Table 21. Line based VoT Results after the Cost Damping (TL/hr)

	Box-Cox Transformation		Cost Damping with Ln(Cost)	
HSR Lines	**Model 1a′**	**Model 2a′**	**Model 1a″**	**Model 2a″**
ANK-KON	-69.1	-6.4	-3.6	-5.7
ANK-ESK	-69.1	-7.8	-3.6	-6.9
ANK-IST	-171.1	-3.1	**15.6**	**10.0**
ESK-IST	-111.1	-4.4	-17.4	-17.6
KON-ESK	-95.5	-6.7	-8.7	-13.8
KON-IST	-207.1	-2.9	**9.7**	**5.7**

5.3.3. *Assessment of VoT Values*

A comparative set of assessment was needed to perform how meaningful or valid logistic model based VoT estimates.

- First of all, if an average "hourly cost" was calculated by dividing the costs by the travel time of the transportation modes serving in each HSR corridor (based on the prices and the currency rate in survey period), the highest levels were seen on the KON-ESK line (22.4 TL/hr) and on the ANK-ESK line (20.9 TL/hr) (see Table 22).These values were much below the VoT values predicted by the logistic model. But, when the airway alternatives ANK-KON, ANK-IST and KON-IST lines are examined, it can be seen that the hourly costs of the airlines can reach 200TL/hr (considering the adult ticket in low cost airline prices); when the airline ticket prices were assumed at the economy ticket prices, the VoT value around 100TL/hr is still closer to the airline hourly cost. However, considering the HSR travel time reductions (1.5 hours of time on short lines such as ANK-IST, KON-IST and more than 2 hours in long lines), it can acceptable to estimate high VoT values, which are not a paid value in reality but only a perceived one, closer to airline hourly .

Table 22. Hourly costs of transportation modes (TL/hr) *

	ANK-KON	ANK-ESK	ANK-IST	KON-ESK	KON-IST	ESK-IST
YHT	17.1	20.9	16.7	22.4	18.3	16.6
Otobüs	9.3	9.3	12.0	9.0	8.9	0.0
Havayolu	128.6	---	200.0	---	140.0	---

- Secondly, there are many road infrastructure investments going on Turkey, and majority of them are built with build-operate-transfer method. For example, Osmangazi Bridge that reduces 78 km distance and provides 1.5 hr travel time reduction, has been opened to service in 2017. The toll of Osmangazi Bridge was determined as 123TL+tax (35$+tax) for the passenger cars (1st class vehicle type) at the beginning of the operation. This value includes mainly the VoT and fuel consumption of vehicles. When the fuel cost of a passenger car (C-segment) for 78 km is considered (about 4 lt gasoline=18TL), it can be deduced that the VoT used to determine the toll has been very high. However, as it was stated before, VoT does not shows the real values to be paid, in application the toll was regulated by considering the income levels and the prices were reduced by the subsidy of government. Currently, while the toll charged from the passenger car is determined as 66 TL, it is 105 TL for the 2^{nd} class vehicle type that includes light duty vehicles (General Directorate of Highways-KGM, 2017). This example shows that VoT and VTTS calculated with the models could not be always comparable to the average hourly wage or out-of-pocket tolls, and are assumed much higher in the cost-benefit analyses and feasibility reports, even though they were not payable.

- Lastly, it was seen as important to examine the HSR ticket prices in other countries. When some of the HSR lines in the countries having a long HSR experience (Japan, France and Italy) is evaluated, it is seen that “low” and “middle” level HSR ticket prices are close to the economy class airway ticket prices. However, “high” level HSR ticket price may be close to or more than business class airway ticket price (Table 23). A similar pricing policy was observed in China that has HSR service since 2008. Despite these HSR ticket prices, it is seen that HSR usage is high in those countries. Parallel to the literature, it can be stated that, latent variables (such as comfort, punctuality and safety, etc.) that are included in the error term in mode choice models may be influential in these pricing levels.

5.4. Discussion of the Modeling Results and Limitations

A series of binary logit models were developed to explain the factors affecting HSR preference compared to the ‘next best alternative’ of travelers stated. Modelling results revealed that travel time reduction effected HSR mode choice more than travel time or natural logarithm of it. Negative coefficients for TT and Ln(TT) and

Table 23. Comparison of the Modal Characteristics of HSR with Air Services in Other Countries

HSR Corridors		HSR Low*	HSR Middle*	HSR High*	Airway Economy	Airway Business
Tokyo-Osaka	Travel Time		**150 min**		**80 min**	
	Cost ($)	49	80	100	55	236
	Hourly cost ($/hr)	*20*	*32*	*40*	*41*	*177*
Tokyo-Nagoya	Travel Time		**100 min**		**65 min**	
	Cost ($)	42	57	77	68	186
	Hourly cost ($/hr)	*17*	*23*	*31*	*51*	*140*
Tokyo-Okayama	Travel Time		**205 min**		**75 min**	
	Cost ($)	58	95	116	122	193
	Hourly cost ($/hr)	*23*	*38*	*46*	*92*	*145*
Rome-Milan	Travel Time		**180 min**		**70 min**	
	Cost ($)	47	105	257	59	142
	Hourly cost ($/hr)	*19*	*42*	*103*	*44*	*107*
Rome-Venice	Travel Time		**210 min**		**60 min**	
	Cost ($)	58	137	227	118	200
	Hourly cost ($/hr)	*23*	*55*	*91*	*89*	*150*
Paris-Lyon	Travel Time		**117 min**		**70 min**	
	Cost ($)	29	145	---	133	383
	Hourly cost ($/hr)	*12*	*58*	---	*100*	*287*
Shangai-Bejing	Travel Time		**330 min**		**130 min**	
	Cost ($)	83	140	262	80	194
	Hourly cost ($/hr)	*33*	*56*	*105*	*60*	*146*

Note 1: * In Japan, HSR ticket levels called as basic (for low level), super express surcharge (for middle level) and reserved seat (for high level). In other countries, low, middle and high level ticket prices shows economy, business and executive ticket classes.
Sources: Skyscanner (2017), Trenitalia (2017), Japan HSR Tickets (2017), TGV HSR Tickets (2017), China HSR Tickets (2017).

Cost implied disutility and were as expected. On the other hand, TT_R and Inc variables had positive coefficients, suggesting utility in mode choice modeling. Among the dummy variables, being student and having education trip purpose were negatively associated HSR preference, while being a worker, having business trip purpose and private car ownership had positive coefficients indicating positive impact on HSR choice. Based on the general performance criteria the best model included the parameters of travel time reduction, cost per income having private car and having business trips. When the HSR preference probability is examined, it is seen that probability naturally dropped by increase in the ticket price. HSR competes with and preferred over bus strongly if the HSR ticket prices do not exceed bus ticket price more than 30%. HSR preference over air depends on the corridor characteristics for the upcoming lines. For ANK-BUR line, it may not have a high competitive power against air, but for ANK-IZM line, where the travel time reductions would be significant, it will have more captive ridership than air.

However, it must be kept in mind that the best models in this study included very limited basic attributes and enabled the depiction of the major issues in a traveler's decision making process. The impact of the service frequency (in HSR or any other mode), traveling group size, private car ownership, etc. could not be investigated, as they were not statistically significant in the models. Secondly, the developed models captured the current conditions in essence and may fall short to predict the major changes in the sector. For example, most of the currently made HSR trips are either tourism or education related ones, and thus, higher number low and very low income travelers participated in the survey. As a natural result, higher preference was estimated/predicted for low ticket price levels. However, if the HSR lines trigger more business trips in the future (by increased number of destinations, train services, in-train amenities, etc.), probability of preference at higher ticket prices would increase.

In addition, in this study, VoT and VTTS were calculated based on some selected models. In order to see the impact of airway ticket price impact, two different air ticket prices were used in the models. It was seen that, for the average economy ticket price (Alternative B), lower VoT and VTTS values were observed. It should be noted here that current HSR ticket prices are close to the bus ticket prices which makes the airway ticket price significant in the models. As discussed in the previous chapter, the VoT and VTTS values calculated with transportation models were not paid values in reality, however, they were used in the cost-benefit analyses and feasibility reports of the projects. When compared with the hourly costs of transportation modes, it was seen that the VoT values were close to the airway hourly costs in some corridors. Also, as a recent example, the toll of Osmangazi Bridge has examined which provided 1.5 hr travel time reduction and it was revelaed that the price determined when it was started to serve is high as 35$+tax which is close to the VoT value calculated by this study. In addition to that HSR ticket prices in the world was close to the airway ticket prices. Even the highest level HSR ticket price was close to the business airway ticket price. It can be concluded that this study showed a calculation method of VoT and VTTS and even though the values showed high prices to pay, they were applicable in the cost-benefit analyses and feasibility reports.

In addition to the price sensitivity analyses, Box-Cox transformation and Ln(Cost) were tried for Model 1a and Model 2a, as cost damping mechanisms. The model results had better general performance values compared to previous models. On the other hand, application of cost damping pushed the VoT to through the negative values which are not realistic, for the majority of HSR lines. However, there is an interval of damping for cost as seen in Figure 9. Thus, cost damping mechanisms that both enhance the model and keep the VoT in the acceptable limits, should be tried. Thus, with larger data, different combinations of cost damping mechanisms should be tried and VoT values should be calibrated, accordingly.

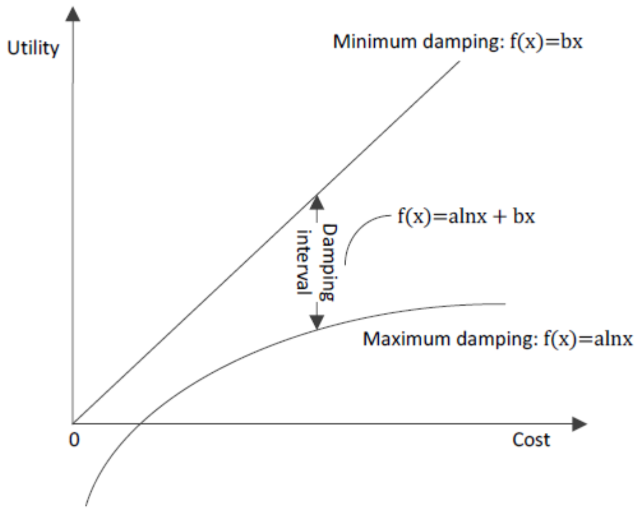

Figure 9. Illustration of Minimum and Maximum Damping (Rich and Mabit, 2016)

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

HSR is a recently introduced mode for intercity passenger transportation in Turkey. Though it has a very limited network with only four operating lines, there is an aggressive development plan to increase the HSR network in Turkey for the next two decades. Thus, this study aimed to shed light on the preference of HSR as an intercity passenger transportation mode and user perspectives based on i) evaluation of the travel behavior ii) factors affecting HSR mode choice iii) HSR preference probabilities for both current and upcoming HSR lines and iv) VoT and VTTS estimations, at this early development stage. For this purpose, a survey seeking information on HSR traveler characteristics and their modal choices was conducted with the current users at HSR stations. Using the data collected, a series of analyses were performed and binary logit models were developed further used for preference probability calculations and value of time estimations. The findings are described in the section below.

6.1. Major Research Findings

The results of the descriptive analyses performed in the scope of the study showed that the current pricing policy was designed to attract the new users to use HSR services and increase the ridership in this early stage of HSR development. The questions regarding pricing preference for HSR services revealed that:

- People with very low income were more reluctant to use HSR, if its ticket price was equal to or higher than bus ticket price. This may be more critical for the lines that have high student user or educational trips. Middle or high income level travelers were more inclined to use HSR, even if its ticket price was equal to or more than bus. However, when HSR ticket prices were equal to or more than air ticket prices, travelers showed reluctance to use HSR.

- Among the respondents, private car users were more inclined to prefer HSR than bus travelers, regardless of their trip purpose. Furthermore, private car ownership had a positive coefficient with high statistical significance. However, it should be remembered that, these factor may also reveal the impact of high income indirectly.
- The results of the study also showed that there were some inconsistencies between the stated and revealed pricing levels for HSR preference (for no more than 10% of the travelers), most of the travelers were consistent in their modal preference for given price level comparison.

The available survey data enabled the development of binary logit models with basic modal attributes of cost and travel time, and their variations. The model results suggested that the travel time reduction by HSR was more influential in the preference of HSR than travel time or natural logarithm of it. Also, cost per income can be more revealing than cost or income variables individually, supporting the findings in the descriptive analyses. Though there were some differences between certain subgroups of travelers, such as students, workers and some trip purposes, such as educational or business trips, they were not statistically significant for the current data set.

The probability of HSR mode choice results showed that on current lines, travelers with bus alternative would have a strong HSR preference, with more than 80% probability regardless of their income level. When evaluated from the perspective of travel time reduction, HSR preference among users was expected to reach almost 100% (at 2-digit significance) due to major travel time reductions by HSR. On the other hand, the use of the selected three models for the prediction of the HSR preference for the upcoming lines under five HSR ticket price scenarios predicted that

- the HSR preferability will naturally drop by increase in the ticket price.
- HSR will be competing with and preferred over bus strongly if the HSR ticket prices do not exceed bus ticket price more than 30%.
- HSR preference over air will depend on the corridor characteristics as it is the case now. For ANK-BUR line, it may not have a high competitive power against air, but for ANK-IZM line, where the travel time reductions would be significant, it will have more captive ridership than air.

In addition, VoT and VTTS were calculated based on some selected models. VoT estimates obtained from selected binary logit models also provided parallel trends in the literature. The results showed higher VoT values for the shorter lines (such as ANK-ESK and ANK-KON) while giving lower VoT estimate on longer lines. For the corridors with air alternatives, VoT and VTTS values were found as close to hourly cost of air service. Besides, VoT sensitivity to the air ticket prices and cost damping (Box-Cox and Ln(Cost) transformations) were investigated. Cost damping model results had better general performance values compared to previous models. On the other hand, application of cost damping pushed the VoT values to through the negative values which are not realistic, for the majority of HSR lines. However, it is clear that cost damping mechanisms can be used to get better fitted models and thus more realistic VoT values, but the calibration should be applied to the results. Also, in this study, due to the limited sampling, the calculation of VoT for different user groups (by travel group size, trip purpose, etc.) was not possible but income based VoT results were able to be calculated.

6.2. Policy Recommendations

It is clear that there is a lack of inter-city transportation alternative in Turkey. Road transportation has a high share among other alternatives whereas airway has been increasing its share with newly built airports in the cities. However, at the beginning of 2000s, HSR investments came into the policy agenda and received an increasing emphasis. It is expected that there will be a strong HSR network in the future when the upcoming and planned lines are completed. However, it should be noted here that National Transportation Plan is being developed, currently, that will present travel demand analyses on the main corridors and be a guide for the future transportation investments. Thus, travel demand forecasts made within the context of National Transportation Plan should be considered in the decision making process of future HSR investments.

This study showed that cost and travel time reduction have a significant impact on the usage of HSR systems. Currently, the ticket prices of HSR services are very close to bus ticket prices that aims to keep ridership high and provide an opportunity to experience this system for all income groups. However, remembering the fact that HSR was introduced for sustainable transportation purposes, it is necessary to consider the economic sustainability of the HSR operations. In order to keep the ridership high, pricing and operating policies should be properly defined for each line based on the existence of alternative modes, trip purposes and expected passenger profiles.

Current HSR lines are mostly serving in short-haul distances except KON-IST and ANK-IST. However, as these lines do not have a strong air alternative, the competition is not visible, yet. With the opening of new HSR lines in the near future, longer HSR lines (i.e. ANK-IZM, ANK-BUR) will start to serve and they will have air alternatives. Thus, it is important to give policy recommendations for short-haul and long-haul lines, seperately.

Policy Recommendations for Short-Haul Lines

As short-haul lines; ANK-ESK and ANK-KON had reached high ridership levels after they started to serve. As it was mentioned before, the majority of the trips in these corridors had tourism or education purposes. Also, there are people using HSR for their commute trips that increase the train occupancy in the weekdays (especially in early-morning and evening hours). Thus, for the upcoming HSR lines, it is recommended that tourism trips should be encouraged based on the city characteristics (i.e. having cultural and recreational areas, event organizations etc.).

Also, for the commute travelers, it is important to provide inter-modality in train stations that ease the intra-city transportation. Discounts made in HSR ticket prices for different traveler groups, such as seniors, students, etc. could be continued in such a way that it helps to keep the train occupancies high, but does not endanger the overall profitability of the system. Lastly, HSR services need to be managed in appropriate ways to keep travel time savings by HSR significantly high and to provide combined transportation options (HSR+bus or HSR+conventional rail) to towns or cities nearby HSR stations.

Policy Recommendations for Long-Haul Lines

As a major policy, HSR should be built on the longer routes where passenger demand is high. To do so, it is important to determine the trip generation potential of the cities. In Turkey, tourist and holiday destinations generate a high volume of passenger traffic throughout a year and thus they might be an important target for the future HSR investments. As these lines will have airway alternative, HSR and airway competition is expected to be visible. From the environmental sustainability aspect, to deepen emission mitigation effect of HSR investments in Turkey, high ridership levels should be achieved in HSR lines by attracting more airway users. Thus, HSR services need to be managed in appropriate ways to keep travel time savings by HSR significantly high. Moreover, when compared to road based modes, accessibility to terminals (HSR station and airports) is a major challenge in most Turkish cities in terms of time and cost of travel, which has to be included in the estimation of modal shift due to HSR, as well as in the policy development stage. Provision of better HSR station accessibility in cities may help to attract riders from both car and air transportation users.

From the pricing aspect, for HSR lines competing with air, ticket pricing should be definitely lower than air ticket prices, unless travel time reduction by HSR was significantly large that can compensate equal ticket pricing scheme between the two modes. Also, discounts made in HSR ticket prices for different traveler groups, such as seniors, students, etc. could be continued which is important for equity of accessibility to transportation services.

6.3.Future Research

Currently, there is a limited research on HSR services in Turkey. Also, the data is limited to develop travel demand models. For the further studies, it is suggested that additional surveys, with high sampling rates, can be conducted with both HSR passengers and alternative mode users (such as in bus terminals, airports, etc.) in order to develop more complex mode choice models and thus VoT calculations. These models can be used for modal split evaluations to determine the modal shift to HSR from other modes and the induced demand created by HSR. Also, VoT/VTTS studies are important in transportation demand and cost-benefit analyses. Thus, VoT and VTTS should be calculated for HSR lines (distance, trip purpose and income based calculations). Cost damping mechanisms are recommended to use to get more realistic VoT and VTTS results.

As one of the main aim of HSR development is to create a sustainable transportation network, it is important to guarantee its economic, environmental and social sustainability. Currently, the ticket prices of HSR for different corridors are close to bus ticket which encourages people to experience it. However, to maintain its economic sustainability, it is important to develop a pricing policy. Thus, willingness to pay analyses are seen as important to determine it and should be included in the HSR surveys. Also, VoT estimations should be considered in pricing policy studies. From the perspective of environmental sustainability, the emission reduction potential of HSR lines should be investigated as well, considering both the current and upcoming HSR lines. Based on the data availability, life cycle assessment of these investments can be studied.

Majority of the currently operating lines have been serving in short distances and they do not have air as a strong alternative. When the longer HSR lines (i.e. Ankara-İzmir, İstanbul-İzmir or Konya-İzmir) with airway alternative are started to serve, the competitiveness of HSR with airway will be more visible. For the further studies, it is recommended that competitiveness of HSR with airway can be studied which will contribute to the existing literature, as it will be one of the first from Turkey case.

Also, it is expected that there will be a network effect on the main HSR corridor with the opening of the new HSR lines. For the intermediate stops on the main HSR corridor, the trip generation potential can be studied in terms of ridership potential. Also, to increase the ridership, the scheduling of HSR and the frequency of it can be in accord with the other intercity passenger transportation modes which will increase the inter-modality.

Another research recommendation is to evaluate the impact of HSR on tourism sector for the cities with tourism potential such as Eskişehir and Konya. Also for the upcoming HSR cities, the potential impact of HSR should be evaluated which will be a guide for the possible implementations in stations or trains.

HSR lines are currently combined with intercity bus and conventional railway for some corridors (i.e. Ankara-Eskişehir-Bursa, Ankara-Konya-Karaman). However, if travel time sensitivity of HSR users is determined, it is possible to increase the combined transportation services to other cities. As a further research, the cities that can be connected with combined transportation services can be investigated. Also, the potential role of Intelligent Transportation Systems services (such as intelligent reservation systems) and para transit alternatives (such as shuttles, minibuses) in combined transportation can be evaluated.

REFERENCES

Alpu, O. (2015). A Methodology for Evaluating Satisfaction with High-Speed Train Services: A Case Study in Turkey. Transport Policy, 44, pp. 151–157.

Antoniou, C., Matsoukis, E., Roussi, P. (2007). A Methodology for the Estimation of Value-of-Time Using State-of-the-Art Econometric Models. Journal of Public Transportation, 10(3).

Athira I. C., Muneera C. P., Krishnamurthy K., Anjaneyulu M. V. L. R. (2016). Estimation of Value of Travel Time for Work Trips, Transportation Research Procedia, 17, pp.116-123.

Ayyildiz-Alçura, G., Kusakcı, S.Ş., Gölbası-Simsek, G.,Gürsoy, M., Tanrıverdi, S.C. (2016). Impact Score Technique for Analyzing the Service Quality of a High-Speed Rail System. Transportation Research Record: Journal of the Transportation Research Board, 2541, Transportation Research Board, Washington, D.C., 2016, pp. 64–72.

Babalik-Sutcliffe, E. (2007). Pro-rail Policies in Turkey: A Policy Shift? Transport Reviews: A Transnational Transdisciplinary Journal. 27(4), pp. 485-498.

Banar, M., Özdemir, A. (2015). An evaluation of railway passenger transport in Turkey using life cycle assessment and life cycle cost methods. Transportation Research Part D, 41, pp. 88–105.

Barreira, A., V. Reis, and R. Macário. 2013. Competitiveness of High-Speed Rail Analysis for Corridor Between Lisbon, Portugal, and Madrid, Spain, Based on

Discrete Choice Models. Transportation Research Record: Journal of the Transportation Research Board, 2374, pp. 9–16,. DOI: 10.3141/2374-02.

Barron I., Campos, J., Gagnepain, P., Nash, C., Ulied, A., & Vickerman, R. (2009). Economic Analysis of High Speed Rail in Europe. Economia y Sociedad, Spain.

Becker, G. (1965). A Theory of the Allocation of Time. The Economic Journal, 75(299), pp. 493-517.

Behrens, C. & Pels, E. (2012). Intermodal Competition in the London– Paris Passenger Market: High-Speed Rail and Air Transport. Journal of Urban Economics,71(3), pp. 278–288.

Ben-Akiva, M. & Lerman S. R. (1985). Discrete Choice Analysis, MIT: Cambridge, Mass.

Bierlaire M. & Thémans, M. (2005). Development of Swiss Models for Transportation Demand Prediction in Response to Real-Time Traffic Information. Proceedings of the 5th Swiss Transport Research Conference, Ascona.

Bin-Miskeen, M.A.A., Alhodairi, A. M. & Rahmat, R.A.A.B.O.K. (2013). Modeling of Intercity Transport Mode Choice Behavior in Libya: a Binary Logit Model for Business Trips by Private Car and Intercity Bus. Australian Journal of Basic and Applied Sciences, 7(1), pp.302-311.

Brand D. (1993). Forecasting High Speed Rail Ridership in the Canadian Corridor: Quebec-Montreal-Toronto-Windsor, The Colloquim Villes et TGV, Lyon, France.

Brownstone, D., Ghosh, A., Golob, T.F., Kazimi, C. & Van A. D. (2003) Drivers' Willingness-to-Pay to Reduce Travel Time: Evidence from the San Diego I-15 Congestion Pricing Project. Transportation Research A, 37, pp.373–38.

Cascetta, E., Papola, A., Pagliara, F. & Marzano, V. (2011). Analysis of Mobility Impacts of the High Speed Rome–Naples Rail Link Using Within Day Dynamic Mode Service Choice Models. Journal of Transport Geography,19, pp.635–643.

Celikkol-Kocak, T., Dalkic, G., Tuydes-Yaman, H. (2017). High-Speed Rail (HSR) Users and Travel Characteristics in Turkey. Procedia Engineering, 187, pp. 212-221.

Chantruthai, P., Taneerananon, S. & Taneerananon, P. (2014). A Study of Competitiveness between Low Cost Airlines and High-Speed-Rail: A Case Study of Southern Corridor in Thailand. Engineering Journal, 18(2). DOI: 10.4186/ej.2014.18.2.141

Cheng, Y.H. (2010). High-Speed Rail in Taiwan: New Experience and Issues for Future Development. Transport Policy, 17(2), 51–63.

China HSR Tickets. (2017). Retrieved 18/08/2017 from the web site: http://english.ctrip.com/trains.

Cho, H. D. (2013). Factors that Affect Long-Distance Travel Mode Choice Decisions and Their Implications For Transportation Policy (PhD Dissertation), University of Florida.

Dalkic, G. (2014). High Speed Rail Development in Turkey: Government Policy, Investments and Users Perspective (Master dissertation), Middle East Technical University.

Dalkic, G., Balaban, O., Tuydes-Yaman, H., Celikkol-Kocak, T. (2017). An Assessment of the CO_2 Emissions Reduction in High Speed Rail Lines: Two Case Studies from Turkey. Journal of Cleaner Production, 165, pp.746-761.

Daly, A. (2010). Cost Damping in Travel Demand Models Report of a study for the Department for Transport. Prepared for the UK Department for Transport.

De Rus, G. (2011). The BCA of HSR: Should the Government Invest in High Speed Rail Infrastructure? Journal of Benefit-Cost Analysis, 2(1). DOI: 10.2202/2152-2812.1058

De Serpa, A. (1971). A Theory of the Economics of Time. The Economic Journal, 81, pp.828-846.

Diamandis, P. F., Kouretas, G. P. &Tzanetos, P. (1997). Modelling the Choice of the Value of Travel Time Savings for the Case of the Rion Antirion Suspension Bridge in Greece. The Annals of Regional Science: Springer Verlag, pp.473–489.

Dobruszkes, F. (2011). High-Speed Rail and Air Transport Competition in Western Europe: A Supply-Oriented Perspective. Transport Policy, 18, pp.870–879. DOI:10.1016/j.tranpol.2011.06.002

Doğan, M. (2012). Ankara-Konya Yüksek Hızlı Tren Projesi Kapsamında Konya Ili Yolculuk Zaman Değeri. Akademik Bakış Dergisi, 33.

Donnea F. X. (1972). Consumer Behaviour, Transport Mode Choice and Value of Time: Some Micro-Economic Models, Regional and Urban Economics, 1(4), pp. 355-382.

Dölarslan, E. Ş. (2014). Assessing the Effects of Satisfaction and Value on Customer Loyalty Behaviors in Service Environments. Management Research Review, 37(8), pp. 706-727.

European Environment Agency, Passenger Transport Demand. Retrieved April 2016, from European Environment Agency Web site:

http://www.eea.europa.eu/data-and-maps/indicators/passenger-transport-demand-version-2/assessment-5.

Ganji, M., Eftekhar, H., Shokri, F., Ismail, A., Atiq, O.K.R. (2013). The Comparison of Mode Choice Sensitivity to the Reduction of Travel Time and Cost in Multimodal Trip. Research Journal of Applied Sciences, Engineering and Technology, 6(9), pp.1680-1684.

General Directorate of Highways (2017). YİD Projeleri 2017 Yılı Osmangazi Köprüsü Geçiş Ücretleri. Accessed from the web site: http://www.kgm.gov.tr/Sayfalar/KGM/SiteTr/Otoyollar/OtoyolKopruUcret/OsmangaziKopruGecisUcret.aspx, Date: 15/08/2017

Givoni, M. (2006). Development and Impact of the Modern High-Speed Train: A Review. Transport Reviews, 26(5), pp.593–611.

Givoni, M. & F. Dobruszkes. (2013). A Review of Ex-Post Evidence for Mode Substitution and Induced Demand Following the Introduction of High–Speed Rail. Transport Review, 33(6), pp. 593.

Gonzalez, R.M. (1997). The Value of Time: A Theoretical Review. Transport Reviews, 17(3), 245-266. DOI: 10.1080/01441649708716984

González-Savignat, M. (2004). Will the High-Speed Train Compete Against the Private Vehicle? Transport Reviews, 24(3), 293–316.

Harvey, J., Thorpe, N., Caygill, M., Namdeo, A. (2006). Public Attitudes to and Perceptions of High Speed Rail in the UK. Transport Policy, 36, pp.70-78.

Hensher D.A. (1997). A Practical Approach to Identifying the Market Potential For Hıgh Speed Rail: A Case Study in the Sydney-Canberra Corrido, Transportation Research Part A, 31(6), pp. 431-446.

Hultkrantz, L. (2013). A Note on High-Speed Rail Investments and Travelers' Value of time. Journal of Rail Transport Planning & Management, 3, 14–21.

Huq M. (2007). Theoretical Analysis on Valuation of Time Saving, Department of Economics University of Saskatchewan Saskatoon, Canada.

International Union of Railways-UIC. (2015). High Speed Lines in the World, Retrieved October 15, 2015, from UIC High Speed Department web site: http://www.uic.org/highspeed.

Japan HSR Tickets. (2017). Retrieved 18/08/2017 from the web site http://english.jr-central.co.jp/info/fare/_pdf/hikari_kodama.pdf.

Jian, Z. &Yunyi, Z. (2013).The Value of Travel Time Savings and the High Speed Rail in China. World Conference on Transport Research.

Kato, H. & Onoda, K. (2009) Investigation of Whether Value of Travel Time Increases as Travel Time Increases: Case Study of Modal Choice of Interurban Travelers in Japan. Transportation Research Record: Journal of the Transportation Research Board, 2135, pp.10–16.

Kılıçlar, A., Sarı, Y., Seçilmiş, C. (2010). Yolcularin Ulaşim Araci Olarak Yüksek Hizli Treni Tercih Nedenleri Üzerine Bir Araştirma. Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi,11(2), pp. 195-216.

Kitagawa T., Terabe,S., Saratchai, O. (2005). Various Factors Affecting Modal Choice Behavior of the Inter-City Passenger between Keihanshin and Fukuoka. Proceedings of the Eastern Asia Society for Transportation Studies, 5: 199 – 208.

Koppelman F.S & Bhat, C. (2006). Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models. U.S. Department of Transportation Federal Transit Administration.

Lascelles A.E. (2006). Alternative Methods of Eliciting Individual Willingness to Pay for Travel Time Savings: A Pilot Study, Master Dissertation, University of Central Florida.

Lave, Charles A. (1969). A Behavioral Approach to Modal Split Forecasting. Transportation Research 3, 463-480.

Mackie P. J., Jara-Diaz S., Fowkes A. S. (2001). The Value of Travel Time Savings in Evaluation, Transportation Research Part E, 37, pp.91-106.

Mandel, B., Gaudry, M. & Rothengatter, W. (1997). A Disaggregate Box-Cox Logit Mode Choice Model of Intercity Passenger Travel in Germany and Its Implications for High-Speed Rail Demand Forecasts. Annals of Regional Science, 31, pp.99–120.

Martin F. (1997). Justifying a High-Speed Rail Project: Social Value vs. Regional Growth, Annals of Regional Science, 31, pp.155–174.

Ministry of Transport (MoT). (2015). Statistics of Transportation for 2003-2015. Ankara, Turkey.

Ministry of Transport (MoT) (2016). National Transport Portal, Retrieved July 10, 2016 from Ministry of Transport Web site: https://www. ulasim.gov.tr.

Pagliara, F., Delaplace, M. & Vassallo, J.M. (2014). High Speed Trains and Tourists: What is the Link? Evidence from the French and Spanish Capitals. Urban Transport, 20.

Park, Y., and Ha, H. K. (2006). Analysis of the Impact of High-speed Railroad Service on Air Transport Demand. Transportation Research Part E: Logistics and Transportation Review,42(2), pp. 95–104.

Rich, J., Mabit, Stefan Lindhard. (2016). Cost damping and functional form in transport models. Transportation, 43(5), 889–912. DOI: 10.1007/s11116-015-9628-8

Roman, C., Espino, R., Martín, J.C. (2009). Analyzing Competition between the High Speed Train and Alternative Modes. The Case of the Madrid-Zaragoza-Barcelona Corridor. Journal of Choice Modelling, 3(1), pp. 84-108

Sarı, Y., Kılıçlar, A., Seçilmiş, C. (2011). Yüksek Hızlı Tren (YHT) Yolcularının Kişisel Değişkenler Açısından Memnuniyet Algılamalarının Değerlendirilmesi. Anatolia: Turizm Araştırmaları Dergisi, 22(2), pp. 127-138.

Schafer, A. (1996). The Global Demand for Motorized Mobility. Transportation Research Part A: Policy and Practice, 32(6), pp.455-477.

Shaw Dougles W. (1992). Searching for the Opportunity Cost of an Individual's Time, Land Economics, 68(1), pp. 107-115.

Skyscanner. (2017). Airway Ticket Prices. Retrieved 18/08/2017 from the web site: www.scyscanner.com.tr.

Small, K.A. (2012). Valuation of Travel Time. Economics of Transportation, 1(1).

Steyerberg, E. W., Vickers, A. J., Cook, N. R., Gerds, T., Gonen, M., Obuchowski, N. & Kattan, M. W. (2010). Assessing the Performance of Prediction Models: A Framework for Some Traditional and Novel Measures. Epidemiology, 21(1), pp. 128–138.

TGV HSR Ticket Prices. (2017). Retrieved 18/08/2017 from the web site: https://en.voyages-sncf.com/en/?redirect=yes.

Trenitalia. (2017). Italy HSR Ticket Prices. Retrieved 18/08/2017 from the web site: http://www.trenitalia.com.

Turkish State Railways (TSR). (2014). Turkish State Railways Annual Statistics 2010–2014. General Directorate of State Railways Administration, Ankara.

Turkish State Railways (TSR). (2016). Turkish State Railways Annual Statistics 2012–2016. General Directorate of State Railways Administration, Ankara.

Turkish Statistical Institute (TurkStat). (2017). Family Statistics 2014 Vol. 18624, Retrieved March 11, 2017 from Turkish Statistical Institute web site: http://www.tuik.gov.tr/PreHaberBultenleri.do?id=18624

Turkish Statistical Institute (TurkStat), Research on Income and Living Conditions 2013 Vol.16083. Retrieved July 25, 2015 from Turkish Statistical Institute web site: http://www.tuik.gov.tr/PreHaberBultenleri.do?id=16083.

UK Department of Transportation.(2014). User and Provider Impacts, Retrieved July 30, 2015 from UK Department of Transportation Web site: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/603749/webtag-tag-unit-a1-3-user-and-provider-impacts-november-2014.pdf

US Department of Transportation. (2011). Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, Retrieved July 30, 2015 from US Department of Transportation Web site: https://www.transportation.gov/sites/dot.gov/files/docs/2016%20Revised%20Value%20of%20Travel%20Time%20Guidance.pdf2011.

Wang, Y., Li, L., Wang, L., Moore, A., Staley, S. & Li, Z. (2014). Modeling Traveler Mode Choice Behavior of a New High-Speed Rail Corridor in China. Transportation Planning and Technology, 37(5), pp.466-483.

Yao, E., Morikawa, T., Kurauchi,S., Tokida T. (2002). A Study on Nested Logit Mode Choice Model for Intercity High-Speed Rail System with Combined RP/SP Data. Intercity Conference on Traffic and Transportation Studies, Guilin, China, July 23-25, pp. 612-619.

Yıldırım, İ. (2002). An Assay on the Railway Policies of Ottoman, Fırat University Journal of Social Science, 12(1), pp.311-324.

Yıldırım, İ. (2001). Cumhuriyet Döneminde Demiryolları, Atatürk Araştırma Merkezi.

APPENDIX

HSR PASSENGER SURVEY (Original Version in Turkish)

Anket No: **Tarih:** **Yer:**

A. ŞEHİRLERARASI ULAŞIMA DAİR SORULAR

1. Şehirlerarası ulaşımda aşağıdaki kriterleri size göre önem derecesini belirterek işaretleyebilir misiniz?

	Çok önemli	Oldukça önemli	Çok önemli değil	Önemli değil
Seyahat süresi				
Maliyet				
Güvenlik				
Dakiklik				
Konfor				
Çevreye duyarlılık				

2. Şehirlerarası ulaşımı çoğunlukla hangi ulaşım türü ile sağladığınızı, aşağıda verilen yolculuk amaçlarına/türlerine göre belirtebilir misiniz?

İş	Turizm	Diğer (lütfen belirtiniz)...........
( ) Özel Araç	( ) Özel Araç	( ) Özel Araç
( ) Otobüs	( ) Otobüs	( ) Otobüs
( ) Demiryolu	( ) Demiryolu	( ) Demiryolu
( ) Havayolu	( ) Havayolu	( ) Havayolu

B. YHT HİZMETLERİNE DAİR SORULAR

3. Şu an .... nereye seyahat etmektesiniz ? ....

Direk	**Ankara'dan**	**Konya'dan**	**Eskişehir'den**	**İstanbul'dan**
	( ) Eskişehir	( ) Ankara	( ) Ankara	( ) Ankara
	( ) Konya	( ) Eskişehir	( ) Konya	( ) Polatlı
	( ) Polatlı	( ) Polatlı	( ) Polatlı	( ) Konya
	( ) İst(Pendik)	( ) İst(Pendik)	( ) İst(Pendik)	( ) Eskişehir
	( ) İst(.................)	( ) İst(.................)	( ) İst(.................)	
Bağlantı	( ) Bursa ( ) Afyon ( ) Kütahya ( ) Karaman-Ereğli ( ) Alanya-Erdemli	( ) Bursa ( ) Afyon ( ) Kütahya	( ) Karaman-Ereğli ( ) Alanya-Erdemli	( ) Bursa ( ) Afyon ( ) Kütahya ( ) Karaman-Ereğli ( ) Alanya-Erdemli
Diğer				

4. Bu YHT seyatinizin amacı aşağıdakiler hangisidir?
( ) İş ( ) Okul/eğitim ( ) Turizm ( ) Diğer (Lütfen Belirtiniz) ....

5. Sizinle birlikte seyahat eden kaç kişi var?
( ) Sadece kendim( ) 2 kişi( ) 3 kişi( ) 4 veya daha fazla

6. YHT ile yaptığınız bu yolculuğunuzda hangi sınıfta seyahat edeceksiniz?
( ) 1. Sınıf (Business) ( ) Ekonomi ( ) Farketmez

7. Bu yolculuk için KİŞİ BAŞI ne kadar bilet ücreti ödediniz? ....
Ya da ( ) Tam ( ) İndirimli ( ) Bedava

8. YHT hizmeti olmasaydı bu seyahatinizi hangi ulaşım türüyle yapardınız?

a.	Özel Araç	Bu seçeneğin toplam maliyeti ne olurdu? .... TL YA DA kişi başı maliyeti ne olurdu? ( ) <30 TL ( ) 30-50 TL ( ) 50-70 TL ( ) 70- 100 TL ( ) 100 TL ve üzeri
b.	Otobüs	
c.	Demiryolu	
d.	Havayolu	
e.	Diğer (Lütfen belirtiniz.........................)	
f.	Yapmazdım	

9. Hangi sıklıkla YHT ile seyahat etmektesiniz?
( )İlk kez kullanıyorum **(13. Sorudan devam et)**
( ) Yılda birkaç kez
( ) Ayda bir kez ( ) Ayda birkaç kez
( ) Haftada bir kez ( ) Haftada birkaç kez ( )Haftada 4 veya daha fazla

10. **Bu hat dışında hangi şehirler arasında YHT hizmetini kullandınız ve bu şehirler arasındaYHT hizmeti olmazsa hangi ulaşım türünü kullanıyorsunuz?**

Şehir1	Şehir2	Daha önce kullanım	Alternatif ulaşım türü
( ) Başka hat kullanmadım..			
Ankara	Eskişehir		
Ankara	Konya		
Ankara	İst-Pendik		
Ankara	İst (................................)		
Ankara	Diğer (............................)		
Eskişehir	Konya		
Eskişehir	İst (Pendik)		
Eskişehir	İst (...............................)		
Eskişehir	Diğer (............................)		
Konya	Diğer (............................)		

11. **YHT hizmetini *__en çok__* hangi amaçlı seyahatlerinizde kullanıyorsunuz (birden fazla seçenek belirtebilirsiniz)?**
   a) İş
   b) Okul/Eğitim
   c) Turizm
   d) Diğer (Lütfen Belirtiniz) ....

12. **YHT ile yolculuklarınızda *__genelde__* hangi sınıfta seyahat etmektesiniz?**
   ( ) 1. Sınıf (Business) ( ) Ekonomi ( ) Farketmez

13. **YHT yolculukları için aşağıdaki kriterleri size göre önem derecesini belirterek işaretleyebilir misiniz?**

	Çok önemli	Oldukça önemli	Çok önemli değil	Önemli değil
Seyahat süresi				
Maliyet				
Güvenlik				
Dakiklik				
Konfor				
Çevreye duyarlılık				

14. **YHT seferlerinin ücretlendirmesi hakkındaki genel görüşünüz nedir?**

Yüksek Hızlı Tren hizmetini kullanma konusunda	Tercih ederim	Tercih etmem	Kararsızım
tren bilet ücreti **otobüs** bilet ücretinden az olursa			
tren bilet ücreti **otobüs** bilet ücretine eşit olursa			
tren bilet ücreti **otobüs** bilet ücretinden fazla olsa bile			
tren bilet ücreti **uçak** bilet ücretinden az olursa			
tren bilet ücreti **uçak** bilet ücretine eşit olursa			
tren bilet ücreti **uçak** bilet ücretinden fazla olsa bile			

15. **Şu anda inşaat aşamasında olan Ankara-İzmirve Ankara-Sivas YHT hatlarını kullanım konusunda ne düşünüyorsunuz?**

Yüksek Hızlı Tren	Tercih ederim	Tercih etmem	Kararsızım
Ankara-İzmir			
Ankara-Sivas			

C. KİŞİSEL BİLGİLER

Yaşadığınız Şehir:
Meslek :
Şu anda çalışıyor musunuz:
( )Evet ( ) Hayır
Yaş: ( )0-13 ( )13-26 ( )27-45
( )45-60( )60-64( )>65
Cinsiyet: ( )Bay ( ) Bayan
Ailenizle mi yalnız mı yaşıyorsunuz?:
( )Yalnız ( )Aile ile
Aylık Gelir : ( ) <1000 TL
( )1000 TL-2000 TL
( )2000 TL -3500 TL
( )>3500 TL

Öğrenim Durumu: ( )İlkokul ( )Ortaokul
( )İlköğretim ( )Lise
( )Ön Lisans ( )Lisans ( )Lisansüstü
Sürücü ehliyetiniz var mı? ( )Evet ( ) Hayır
Siz ya da aileniz özel araç sahibi misiniz? ( ) Evet ( ) Hayır
Evet ise,**i)** <u>kaç adet özel aracınız bulunmakta?</u>
( ) 1 ( ) 2 ( ) 2'den fazla
ii)<u>şehirlerarası yolcuklarda ne sıklıkta kullanıyorsunuz?</u>
( ) Her zaman ( ) Bazen ( ) Hiç bir zaman