INVESTIGATING THE EFFECTS OF TRANSIT INFORMATION SYSTEMS ON DIFFERENT USER GROUPS

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Abstract: This study investigates the effects of Transit Information Systems (TIS). TIS are wide range of systems that provide travelers information about travel options such as; travel times, delays and/or incidents. In this study, the important transit information types and their service levels are investigated in Izmir City, Turkey. The study focused on the transit users; considered information types for different transit mode segments were identified. In addition, accepted information types for non-transit users to consider transit as an alternative commute mode was investigated. For these purposes, a stated preference scenario was prepared which included the considered important information types of respondents and a function of their actual travel time. In this study, static pre-transit information systems were considered. Results indicated that considered TIS between transit and non-transit users are not much different from each other. However, considered TIS among different transit mode segments is significantly different.

Key Words: *Public transit, Transit information systems, Stated preference scenario.*

1. INTRODUCTION

Transit services are one of the essential parts of city life which provides mobility to its users usually with low prices. The history of public transportation is intimately connected to industrialization, urbanization, and the separation of residence from workplace. The patronage of public transit grew steadily from 1900s in the world and since then industrialized (developed) countries improved service level of transit and developing countries introduced transit into their major cities. Nowadays, there is a growing effort to introduce new public transit systems and improving the service quality of available services.

Population of the world is growing very fast and with industrialization, there is a migration from rural areas to urban areas. Thus, traffic and parking problems rise in big cities. One of the solutions of this common problem is introducing new infrastructure to provide mobility to the residents. This consumes much time and money. Another solution is mostly used by developed countries, which have already solved the infrastructure problems, is increasing the attractiveness of public transit by improving its service quality to use them more effectively. Transit Information Systems (TIS) is one of the most common tools for this purpose, since information became an indispensable part of our lives. TIS are wide range of systems that provide travelers information about travel options such as; travel times, delays and/or incidents, etc. Increasing value of time in city life impel us to make informed decisions in all stages of our daily activities. TIS can be used as a powerful instrument to make informed decisions for trips, if it can be provided to users.

This study is conducted in Izmir City, which is the third biggest city in Turkey. Turkey is a country which can be defined as a developing country. The city is located around a bay along the Aegean Sea. The population of the metropolitan city is around 2,235,000. The metropolitan area includes nine municipalities. Being one of the biggest and developed cities in Turkey, population of the city is growing very fast with immigration from rural areas. The young population of the city needs mobility. Still, there is lack of transit infrastructure and the ongoing projects try to solve this problem.

In the city, five different transit modes are in service. The biggest service capacity belongs to buses with 1545 buses in 277 different routes. Subway is totally 11.7 km and it has 10 stations. Local train line has 21 stations inside the metropolitan area, but, the service is slow and frequency is low. Sea transportation is done with 21 commuter boats and ferries between eight harbors and two ferry harbors. Another transit mode is available which is called "dolmus" in Turkey. This service is provided by minibuses, which can carry 14 passengers. This service has its own routes and stops. Usually, they do not have custom schedules, but, they are very popular especially in the areas which have a lack of other public transit activities. In recent years, many significant improvements were done in public transit services. However, introducing new infrastructure or transit services are costly. Improvements in transit do not only depend on introducing new services but also improving the service quality. One of the most effective methods to provide better service is to investigate what travelers consider and to improve service in the light of these considerations.

This study investigates the important transit information types and its service levels to improve the satisfaction level of travelers in Izmir City. This will help to keep actual users with public transit and provide better comfort level. In addition, the effects of TIS to attract non-transit users to consider transit as an alternative commute mode are investigated. For these purposes, a stated preference scenario was prepared which included the considered important information types by the respondent with its different service levels and a function of actual travel time of respondent. Survey was conducted as face-to-face interviews in four different areas in metropolitan city.

Discrete choice modeling was used to evaluate the responses of individuals. To investigate the important service levels, satisfaction levels of the respondents were asked for the given scenario. Responses for the satisfaction level has a natural ordering, thus, ordered probit model was used for the modeling approach. This study focused on four main objectives:

- To determine which types of transit information are considered as important by users;
    - For transit users, to increase the satisfaction level from the current transit service.
    - For non-transit users, to attract more users to increase the likelihood of using transit as an alternative commute mode with available TIS.
- To investigate the considered TIS among transit users depending on the different transit mode segments.
- To identify the effects of significant transit information types and their service levels for the satisfaction of the transit users by the transit service.
- To determine the socioeconomic characteristics of the transit and non-transit users.

1.1 Transit Information Systems

TIS provide passengers information on one or more modes of transportation service to assist decision maker. This assistance can be before the trip (pre-trip) or while already traveling (en-route). En-route transit information can help the users to make their decisions about their trips on the way or at the stops/stations (wayside) or while they are traveling on the train, bus etc. (in-vehicle). Basically, information can be provided to the trip maker anywhere starting from his/her decision process at home to reaching the final destination. Implementation of TIS necessitates gathering, processing and distributing information on transit routes and schedules. Generally, three types of TIS are considered in the literature; pre-trip, wayside and in-vehicle transit information.

Transit information available before the trip is called pre-trip TIS. Pre-trip TIS help people to make decisions about the choice of transportation mode, route, and departure time before they start their trip. Surveys conducted in four different regions of USA showed that pre-trip transit information is very important for the travelers (Cluet, *et al.*, 2003). Most common pre-trip TIS are transit route maps, schedules, park and ride information, transit trip itineraries, stop and station locations, weather etc. Pre-trip TIS is the first chain in the information series and the most important one. Especially, for the non-transit users, travelers' decision between driving and transit must be changed before they start their trip. Most important factors that non-transit users choose driving are the convenience and travel timesavings. Thus, providing detailed information about transit, such as, waiting times at the stop or seat availability, can ignore them to choose transit as an alternative. Providing reliable transit information to travelers before they choose their trip mode enable them to make informed decisions thus, they can consider alternatives in a more realistic way. Mostly considered TIS in this study are pre-trip information.

2. PREVIOUS STUDIES

Many studies were conducted about the Advanced Transit Information Systems (ATIS) and its effects. However, few studies investigated the effect of TIS on transit and non-transit users' choice decision. Nevertheless, these kinds of studies have started to be popular especially in advanced countries to improve the service quality and satisfaction of the travelers and to attract non-transit users to consider transit as an alternative commute mode.

Polak and Jones (1992) investigated travelers' preferences for different types of travel information and the effects of such information on travel behavior. The study was conducted as a stated preference design for whom uses personal computers at home. Respondents were informed about the car and transit (bus) travel times from home to the city. Result of this study indicated that there is a significant demand for such information, even among car users. Hall *et al.* (1994) investigated the effectiveness of Southern California Rapid Transit District telephone information service. Schweiger (1995), Hickman and Day (1996) reviewed some of the transit information systems.

Kitamura *et al.* (1995) investigated the effect of pre-trip information systems by conducting in-laboratory interviews. Their finding showed that age is an important variable that defines market segments for pre-trip information systems. Shank and Roberts (1996) reviewed the benefits of TIS and found that traveler information technologies could result in shifts from the car alternative to transit alternative. They informed that in the areas; Seattle, Washington and Boston, MA, which they conducted the surveys, 5-10 % of the car users could shift from car to transit if they were informed. Khattak *et al.* (1996) and Adler & McNally (1994) conducted experiments to study the effects of information on traveler behavior.

Mehndiratta *et al.* (2000) investigated the user characteristics of Travel Advisory Telephone System (TATS) in San Francisco Bay Area and also investigated from what elements of ATIS information, provided by this system, do the users derive value. Abdel-Aty (2001) conducted another comprehensive study to investigate the transit information service mostly desired by non-transit users. They conducted a telephone interview survey in Sacramento and San Jose areas of California. The likelihood of commuter choice was investigated under given information. They got promising results, which showed 38% of the non-transit users would like to consider transit as an alternative commute mode if transit information was available. He found that frequency of service, number of transfers, seat availability, fare, and walking times to the stops were considered information types by non-transit users.

Cluet et al. (2003) indicates the results of customer preference for transit ATIS in Seattle, Salt Lake City, Columbus and Providence/Kingston in USA. These results show that timetables are the most preferred pre-trip information. Traditional (static) information is preferred to real time information for pre-trip planning. These surveys showed that transit users want to obtain pre-trip information in printed form and via computer. In this survey, the overall level of preference for information while at the wayside is substantially less than for pre-trip planning.

3. SURVEY DESIGN AND MODELING METHODOLOGY

A questionnaire survey was conducted in Izmir City, Turkey. Survey was conducted in four different locations in the metropolitan area of the city to collect samples from different socioeconomic groups and different respondents whose transit choices are different. Data was collected by in-person interviews from May 22 to Jun 17, 2005. Totally 645 interviews were conducted during this time period.

Prepared survey has two parts, first part covers the questions to identify the socioeconomic characteristics of the respondent and some other significant factors that could effect the trip decision. Main part of the questionnaires was prepared in two different forms. First one is for transit users and second one is for non-transit users who want to consider transit as an alternative commute mode at least once in a week. The main structure of the questions was same for transit and non-transit users with slight differences and investigates the considered significant information types and their service levels. Questions for transit users include extra questions about the actual transit mode and satisfaction level from the current service conditions.

3.1 Questionnaire

3.1.1 First part: socioeconomic characteristics and some other important factors
This part of the questionnaire mainly investigates the general socioeconomic characteristics of the respondents. Considered personal and socioeconomic characteristics are; gender, age, income, education level and occupation. In addition, some questions were asked to clarify the other significant factors that could effect the trip decision. These additional questions are; car ownership, flexibility of work starting time, car-pooling and if the respondent travels to multiple locations from work/school. Finally, all respondents were asked actual work/school trip time. Sample characteristics of the survey are indicated in Table 1. The sample group

represents the city population; the amount of young population (<39 years old) and male population are not different from the 2000 population statistics of Izmir City, 68.1% and 50.4%, respectively. Different from transit users the main characteristics of non-transit users are; old age (40 years old<=), high income (1,000 YTL (833 $)<=) and high car ownership rates. In addition, car-pooling is very popular among non-transit users.

Table 1 Sample characteristics

Socioeconomic characteristics		Total	Transit users	Non-transit Users
Gender	Male	54%	49%	69%
	Female	46%	51%	31%
Age	Young (<39 years old)	71%	74%	22%
	Old (40 years old<=)	29%	26%	88%
Income	Low (<1,000 YTL)	75%	73%	19%
	High (1,000 YTL <=)	25%	27%	81%
Education	Low (high school and lower)	29%	30%	27%
	High(higher than high school)	71%	70%	73%
Car ownership	Yes	54%	46%	82%
	No	46%	54%	18%
Commute to multiple locations	Yes	65%	68%	57%
	No	35%	32%	43%
Carpool	Yes	32%	25%	55%
	No	68%	75%	45%
Flexibility of work starting time	No flexibility	63%	65%	58%
	There is flexibility	37%	35%	42%

YTL is Turkish money unit (1.2 YTL ≃ 1 $)

3.1.2 Main part

The main part of the questionnaires was prepared in two different forms for transit and non-transit users. Before starting the main part, respondents were asked, *"Have you used transit at least once in last seven days as a commute/school trip?"* to identify if he/she is a transit user or not. Then the respondents were asked two types of questionnaire sheets depending on their answers. The structure and questions in both sheets are almost same. The only difference was the way how the questions were asked, because one of them was prepared for transit users to identify their satisfaction level from the available transit service with TIS and the other one was for non-transit users to identify the likelihood of using transit service under available TIS.

According to the answers, 493 (76%) of the respondents were classified as transit users and 152 (24%) of them as non-transit users. Transit users were asked the questions, which were prepared for them. Non-transit users were asked one more question before the main part of questionnaire, to separate the non-transit users who would not want to consider transit as an alternative commute mode under available information. Thus, non-transit users were asked, *"If you have more information, might you consider transit as an alternative commute mode at least once in a week?"*. Respondents who had answered "*yes*" were asked the main part of the questionnaires and the ones who answered "*no*" were not asked any more questions. 107 (70.4%) of the non-transit users answered "*no*" and their interviews were finished and 45 (29.6%) of the non-transit users told they would consider transit as an alternative commute mode if they had more information available.

3.2 Hypothetical Stated Preference Scenario

The main structure of the questionnaires includes a stated preference scenario, which depends on the chosen transit information types and actual commute time of the respondents. As discussed, main objective of this survey was to investigate the important information types, which are considered as significant by the transit users. In addition, important information types for the non-transit users to increase the likelihood of using transit as an alternative commute mode were investigated. Design of the hypothetical scenario both for transit and non-transit users were the same.

Before the hypothetical scenario, each respondent was asked to pick three information types from the list, which are significant for him to increase his satisfaction from the current transit service or to consider transit as an alternative commute mode. Respondents were also asked to rank these information types as first, second and third important information types. Ten transit information types were shown to the respondents (Abdel-Aty, 2001):

- Park & Ride information.
- Information about frequency of service.
- Fare information.
- Information about walking time to/from the station.
- Information about transfers, and transfer locations.
- Transit route map.
- Information about operating hours.
- Information about waiting times at the stop/station.
- Information about seat availability.
- Information about station locations.

A hypothetical scenario was prepared by using these chosen information types and actual commute/school trip time of the respondent. The chosen information types were presented in the scenario with their randomly chosen service levels. These service levels were prepared before the experiment to use in the hypothetical scenarios and only information types were shown to the respondents not the service levels. Generally four service levels were decided for each information type. In the preparation of the service levels, three points were considered; the current transit service conditions during peak hours, the current transit service conditions during normal hours (not peak hours), and the improved transit service conditions. The actual commute time was presented in the scenario by multiplying it randomly by one of these parameters; 0.75, 1.00, 1.25, and 1.50. These multiplications were prepared to present the worse or better travel timesaving. This can be understood longer or shorter travel time for non-transit user when he/she changes the mode or a change in the service conditions for the transit user.

In the scenario, a function of actual travel time and randomly selected service levels of each chosen important information types were presented. Then, respondents were asked for their satisfaction level under the given conditions. For transit users, satisfaction level of the given service level was asked and for non-transit users, they were asked if they would be satisfied with the given scenario to consider transit as an alternative commute mode. Satisfaction level was asked in a five-ranked scale where one means very dissatisfied and five very satisfied.

As an example, consider that a transit user had chosen seat availability as an important information type in the first place, transit route map and information about frequency of service second and third, respectively. If he told his normal travel time is 30 minutes, then the scenario was created as shown in Table 2 and worded as follows:

Table 2 Example hypothetical scenario

Actual travel time	*(30 min.)*	*30 *1.5 = 45 min*
1. choice	*(seat availability)*	*50% chance*
2. choice	*(transit route map)*	*Available*
3. choice	*(frequency of service)*	*10 min.*

*"Please think that if your travel time is 45 minutes (30*1.5), the chance of seat availability is 50%, a transit route map is available with you and frequency of the transit service is 10 minutes. Under listed service conditions above, please rank your satisfaction level to keep on using transit from the listed satisfaction levels below."*

Very dissatisfied *Dissatisfied* *Neutral* *Satisfied* *Very satisfied*

This scenario was asked to the respondents for two times. Respondents chose important information types once. In the second scenario, random number, which is multiplied by the travel time and service levels of chosen information types were changed randomly. Second scenario helps to collect two data sets from a respondent.

3.3 Modeling Methodology

An ordered probit approach was used to model the satisfaction levels from the given hypothetical scenarios, which represent different information types provided by TIS. In some cases, multinomial choice variables are naturally ordered. In these cases, if the dependent variable takes more than two values, ordered probit model is appropriate to solve the discrete choice problem. The ordered probit model is a fairly straightforward extension of the binary probit model which can be used in cases where there are multiple and ranked discrete dependent variables. The multinomial logit or probit model would fail to account for the ordinal nature of the dependent variable. In addition, the regression model cannot be used to solve the problem, because if the responses are coded from zero to five, the regression model will assume the differences between the responses two and three same as the differences between four and five, however, they are only ordinal ranking.

In the survey design, as discussed, the satisfaction levels of the respondents were investigated for the given hypothetical scenarios, which depend on the chosen information types with its service levels. The unobserved dependent variable, y^*, is described as follows;

$$y_i^* = x_i\beta + s_i\gamma + \varepsilon \tag{1}$$

Explanatory variables are formed of two parts; vector of explanatory variables describing the service levels of information types, x_i, and the socioeconomic characteristics of respondent and actual travel time, s_i. β and γ are the vector of coefficients for service levels of information types and socioeconomic characters with travel time, respectively. The error term, ε, is normally distributed with mean zero and variance one, N[0,1]. The observed ordinal value y_i, takes on values zero through m according to the following scheme:

$$y_i = j \Leftrightarrow \mu_{j-1} < y_i^* \leq \mu_j \tag{2}$$

Where $j = 0,\ldots\ldots,m$. In the equation (2) the threshold parameters μs are unknown parameters to be estimated with coefficients vector β. In ordered probit modeling, it is not possible to estimate the coefficients of a constant term and four cut points (thresholds) in five-category case. The distribution curve can be shifted on the X-axis, the value of cut point's changes, but, probabilities are kept constant. For that reason, in this study three thresholds are estimated in five-category case (Greene, 2000). Thus, in the estimation some threshold values are set as shown; $\mu_{-1} = -\infty$, $\mu_0 = 0$ and $\mu_m = +\infty$. In the study, dependent variable was collected as the satisfaction level for the scenario. Satisfaction levels from very dissatisfied to very satisfied, were converted to a five scale ranking to use in the estimation. Then the probabilities of each satisfaction level can be written as follows:

$$
\begin{aligned}
P[y_i = 0] &= \Phi(-x_i\beta) && \text{(very dissatisfied)} \\
P[y_i = 1] &= \Phi(\mu_1 - x_i\beta) - \Phi(-x_i\beta) && \text{(dissatisfied)} \\
P[y_i = 2] &= \Phi(\mu_2 - x_i\beta) - \Phi(\mu_1 - x_i\beta) && \text{(neutral)} \\
P[y_i = 3] &= \Phi(\mu_3 - x_i\beta) - \Phi(\mu_2 - x_i\beta) && \text{(satisfied)} \\
P[y_i = 4] &= 1 - \Phi(\mu_3 - x_i\beta) && \text{(very satisfied)}
\end{aligned} \tag{3}
$$

Where, $\Phi(......)$ represents the areas under normal distribution curve.

4. MODELING RESULTS

In this section estimated models are discussed under two subsections. In the first approach significant information types are identified for transit and non-transit users, separately. Depending on the low car ownership rate related with low economic welfare and expensive gas prices in Turkey, most of the users are using public transit for commute trips. As a second approach the differences between the transit modes by means of significant information types and their service levels are investigated.

As discussed, ordered probit model was used for the modeling and the responses for the hypothetical scenarios were used as the dependent variable. In the ordered probit model, two sets of parameters were estimated. First one is, the threshold parameters which indicate the cut points on the normal distribution curve, associated with specific values of the defined explanatory variables. In five categories four thresholds are needed; first threshold was set to zero ($\mu_0 = 0$) and, other three of them were estimated. Second one is, explanatory variables, which were considered in two groups; service levels of each information types and socioeconomic variables with actual travel time of the respondent. In the model, explanatory variables were defined as dummy variables. Information types were presented with their service levels as dummy variables. Socioeconomic variables were also defined as dummy variables after combining some characteristics into significant and appropriate groups. Travel times of the respondents were used as they were presented in the scenario (not dummy variable). Many modeling attempts were done and most significant models are presented in this paper.

4.1 Considered Information Types for Transit and Non-transit Users

Totally, 645 data was collected and 493 of them were classified as transit users. Among the non-transit users, 45 of them agreed to consider transit as an alternative commute mode if transit information is available. Thus, 45 data was collected from non-transit users. Survey was designed with two scenarios to obtain more data. The number of non-transit users who considers using transit under available information is quite small. However, since two observations were collected from one respondent to use, using two responses from same respondent can widen data set. On the other hand, using two data sets from one respondent in the model without any correction causes some biases, because the data sets are correlated (unobserved heterogeneity). Some studies have accounted for the correlation between repeated observations, a brief review can be found in Abdel-Aty and Abdalla (2004). Alternatively, Bunch *et al.* (1993) ignored the effect of heterogeneity by indicating that in small numbers of repeated observations from each individual the properties of parameter estimates themselves do not rely on the strict independence assumption and the benefits of using a much larger pooled data is more important than this concern. The effect of unobserved heterogeneity on the estimated results could be corrected by dividing the t-statistics to the square root of the number of repeated observations (Louviere & Woodworth, 1983; Mannering, 1987). However, it is indicated by the same references that, this method is conservative and over corrects the t-statistics. Thus, in the estimation of significant information types for transit and non-transit users, since two hypothetical scenarios were used from one respondent, the t-statistics are a little inflated and are not corrected to account for the unobserved heterogeneity effects. Dividing the t-statistic by $\sqrt{2}$ can do it in a conservative way.

Estimated models for transit users and non-transit users who would consider transit as an alternative commute mode are presented in Table 3. For transit users, income and having a car are significant (95%) socioeconomic factors, which affect the satisfaction level from the current transit service under information. If the respondent is in low-income group and does not have a car, his satisfaction level is higher. Probably, he does not have any other alternative and cannot compare the transit service with car. For non-transit users, flexibility of work starting time is the most significant factor with 95% significance level and also gender is significant with 90% significance level. If the respondent has no flexibility on work starting time, he is most likely to use his car. Male drivers consider transit as alternative more than female drivers do. Travel time is significant only for non-transit users. Probably for long trips, non-transit users are more likely to use transit because of high travel costs and uncomfortable driving for a long time under congested conditions.

Frequency of service is significant with one service level for both transit and non-transit users; 30 minutes waiting time affects significance level in a negative way for transit users and 15 minutes in a positive way for non-transit users. 0.5 YTL (0.42 $) is considered as cheap transit fare and increase the satisfaction level for both transit and non-transit users and the effect is higher for transit users. Operating hours is considered as a significant information type with three service levels for transit users and with one service level for non-transit users. Waiting times at the stop is considered as significant with two service levels for transit users and with one service level for non-transit users, all decrease the satisfaction levels from transit service. Also, far distances between the station and house of the respondent effect the satisfaction in a negative way. Number of transfers was considered as significant information with two service levels and both decrease the satisfaction level for transit users. In addition, walking time to/from the station was considered as an important information type with two levels for non-transit users and decreases the likelihood of using transit service. Usually convenience is considered more by non-transit users thus, walking distance is significant for them.

Table 3 Estimated ordered probit models for transit and non-transit users

Thresholds		Transit users Estimate (t-statistics)	Non-transit users Estimate (t-statistics)
T1	(μ_1)	0.4654 (27.91) **	0.6507 (8.46) **
T2	(μ_2)	0.8598 (25.76) **	0.9869 (5.98) **
T3	(μ_3)	2.2386 (22.27) **	2.3210 (3.67) **
	Service level of transit information		
X_2	Frequency of service (1 if frequency is 15 min, 0 otherwise)		0.7513 (2.39) **
X_4	Frequency of service (1 if frequency is 30 min, 0 otherwise)	-0.4052 (-3.43) **	
X_5	Fare information (1 if fare is 0.5 YTL.(0.42 $), 0 otherwise)	0.4295 (3.71) **	1.1093 (1.88) **
X_8	Walking time to/from the station (1 if walking time is 5 min., 0 otherwise)		-1.4901 (-2.67) **
X_9	Walking time to/from the station (1 if walking time is 10 min. , 0 otherwise)		-0.8684 (-1.91) **
X_{12}	Transfer information (1 if 2 transfer is needed, 0 otherwise)	-0.5895 (-4.20) **	
X_{13}	Transfer information (1 if 3 transfer is needed, 0 otherwise)	-0.7441 (-3.32) **	
X_{15}	Operating hours (1 if operating hours is between 6.00am-midnight, 0 otherwise)	0.4170 (3.38) **	1.0132 (2.03) **
X_{16}	Operating hours (1 if operating hours is between 6.00am- 2.00 am, 0 otherwise)	0.3761 (3.03) **	
X_{17}	Operating hours (1 if operating hours is 24 hours, 0 otherwise)	0.8895 (6.47) **	
X_{19}	Waiting times at the stops (1 if waiting time is 20 min., 0 otherwise)	-0.3099 (-2.92) **	
X_{20}	Waiting times at the stops (1 if waiting time is 30 min., 0 otherwise)	-1.1625 (-6.81) **	-1.9782 (-2.43) **
X_{25}	Distance of the stop to the resident of the respondent (1 if 750m, 0 otherwise)		-1.2083 (-3.02) **
X_{26}	Distance between the station and respondents home (1 if 1000m, 0 otherwise)	-1.3697 (-5.95) **	
	Socioeconomic characteristics and some other significant factors		
S_1	Actual travel time of the respondent	-0.0016 (-1.15)	0.0116 (1.80) **
S_2	Gender (1 if male, 0 otherwise)		0.5774 (1.68) *
S_4	Income (1 if lower than 1,000 YTL.(833 $), 0 otherwise)	0.5641 (8.54) **	
S_7	Having a car (1 if respondent has no car, 0 otherwise)	0.2819 (4.19) **	
S_8	Flexibility of work starting time (1 if there is no flexibility, 0 otherwise)		-0.7527 (-2.04) **
	Number of samples	975	90
	Log likelihood at zero	-2402.73	-189.08
	Log likelihood at convergence	-1348.81	-101.02

* 0.10 significant ** 0.05 significant

Both transit and non-transit users considered six information types as significant. Five information types are same among transit and non-transit users. However, there are differences on the considered service levels for same information types. In addition, walking distance to/from the station is considered as significant among non-transit users different from transit users and only transit users consider number of transfers as significant information.

4.2 Considered Information Types Depending on Transit Mode Segments

As a result of the survey 76% of the commute/school trips are done by transit service in Izmir City. One of the main reasons of this high transit usage percentage is low car ownership rate and the other one is the high gasoline prices (1.95 $/lt.) in Turkey. TIS can be used for two important purposes for transit users. First one is to provide a more comfortable service to the current transit users, second one is also related with the further, to keep actual users as a transit user in the future. As indicated in the survey design, most of the non-transit users are in old age (40 years old<=) and high-income (1,000 YTL(833 $)<=) group. It is the reality that most of the young population cannot afford a car today in Turkey, however they would convert to use their car when they will afford it. For the listed reasons above, the applicability of TIS must be investigated more deeply especially for transit users. Increasing economic welfare will cause increasing traffic problems in near future, if the investments for infrastructure fall behind. Successful TIS applications can help to solve such problems.

The transit service in Izmir City has five different modes as discussed. The quality of these modes is not similar. Local train service is not a common transit mode for intra-city commuting. Only two respondents answered that they use this mode in daily commute or school trips. Thus, this mode was eliminated. Subway and commuter boats have more comfortable service than bus and dolmus modes. In addition, subway and boat have reliable and fast service. These similarities between transit modes gave us an idea to consider two segments of transit modes and to investigate the effects of TIS separately for these mode segments. Comparing ridership attraction for subway/boat and bus/dolmus modes, what kind of transit information considered as urgent is important. Subway/boat services tend to have the advantage of having more information over bus/dolmus services. Subway/boat services operate on an easily identifiable right-of-way and have higher frequency rates than bus/dolmus service. In some advanced countries there is reliable bus frequency information but still the off-hand information in Turkey for subway/boats are considered to be better than bus/dolmus modes due to mentioned reasons. The available TIS in Izmir City for these considered four modes are indicated in Table 4, but all these information are not easily accessible. Usually, most of the transit information for subway and boat modes available via internet and most of the users are not aware of this information. Available TIS is similar among the mode segments and it can be seen that it is totally different between the mode segments. At waiting time, level of comfort at subway stations and commuter boat harbors are usually higher than bus/dolmus stops. Also comfort level in subway and boat are higher than bus/dolmus modes, former can provide better ventilation and more seats. On the contrary of the poor service and lack of information bus/dolmus stops are generally be within walking distance of a greater number of people acting as their own feeders and serves in larger areas.

Table 4 Available information for transit modes

Subway	Commuter boat	Bus	Dolmus
Fare information	Fare information	Fare information	Fare information
Information about operating hours	Information about operating hours	Information about operating hours	
Frequency information	Frequency information		
Transit route map	Transit route map		
Information about station locations	Information about station locations		

Depending on these differences in the quality of service, responses to hypothetical scenarios vary among transit users. From this point, we thought that significant information types for both segments could be different from each other. Thus, two additional models were estimated separately for subway/boat and bus/dolmus modes.

4.2.1 Subway and boat modes

Due to the discussed reasons above subway/boat modes are gathered in a segment. Especially, differences in the service quality and high travel timesavings of this segment attract different socioeconomic groups. Considered TIS and satisfaction levels from available information types for subway/bus users have some differences from those of other transit segment users. Thus, it is important to consider the significant information types separately for two transit segments. Understanding the characteristics and needs of different types of users is one of the main cornerstones in providing and deciding successful applications of TIS. For this purpose significant information types are investigated for these two mode segments separately. The final and significant model for subway/boat segment is indicated in Table 5.

Table 5 Results of the estimated model for subway/boat and bus/dolmus segments.

		Subway/boat	Bus/dolmus
Thresholds		Estimate (t-statistics)	Estimate (t-statistics)
T1	(μ_1)	0.6106 (10.06)**	0.5330 (16.61)**
T2	(μ_2)	1.2841 (10.73)**	0.8726 (13.50)**
T3	(μ_3)	2.7213 (5.57)**	2.0027 (9.00)**
Service level of transit information			
X_4	Frequency of service (1 if frequency is 30 min, 0 otherwise.)	-0.8103 (-1.99)**	-0.6069 (-3.13)**
X_5	Fare information (1 if fare is 0.5 YTL (0.42 $), 0 otherwise)	0.8279 (2.50)**	
X_6	Fare information (1 if fare is 0.75 YTL (0.63 $), 0 otherwise)	0.6739 (1.90)**	
X_8	Walking time to/from the station (1 if walking time is 5 min., 0 otherwise)		0.4713 (1.65)*
X_{11}	Transfer information (1 if 1 transfer is needed, 0 otherwise)		-0.7839 (-2.38)**
X_{13}	Transfer information (1 if 3 transfer is needed, 0 otherwise)	-1.7420 (-1.01)	-1.0025 (-2.20)**
X_{15}	Operating hours (1 if operating hours is between 6.00 am - midnight, 0 otherwise)	0.8254 (2.17)**	
X_{16}	Operating hours (1 if operating hours is between 6.00 am- 2.00 am, 0 otherwise)		0.3159 (1.51)*
X_{17}	Operating hours (1 if operating hours is 24 hours, 0 otherwise)	2.0874 (1.90)**	0.5446 (2.27)**
X_{19}	Waiting times at the stops (1 if waiting time is 20 min., 0 otherwise)	-0.4924 (-1.56)*	
X_{20}	Waiting times at the stops (1 if waiting time is 30 min., 0 otherwise)		-1.0708 (-3.51)**
X_{21}	Seat availability (1 if 50% seat is available in the coming transit, 0 otherwise)	-0.4751 (-1.30)	
X_{22}	Seat availability (1 if 75% seat is available in the coming transit, 0 otherwise)	-0.9251 (-1.51)*	
X_{24}	Distance between the station and respondents house (1 if 500m, 0 otherwise)	-0.4347 (-1.30)	
X_{26}	Distance between the station and respondents house (1 if 1000m, 0 otherwise)		-1.1930 (-2.46)**
Socioeconomic characteristics and some other significant factors			
S_1	Actual travel time of the respondent	0.0164 (2.50)**	-0.0043 (-1.55)*
S_4	Income (1 if lower than 1,000 YTL.(833 $), 0 otherwise)		0.3727 (2.78)**
S_5	Education level (1 if less than high school, 0 otherwise)	0.4408 (2.10)**	0.1963 (1.45)*
S_6	Having a car (1 if respondent has no car, 0 otherwise)		0.4684 (3.70)**
Number of samples		113	308
Log likelihood at zero		-278.399	- 796.024
Log likelihood at convergence		-149.997	-442.058
		* 0.10 significant	** 0.05 significant

Travel time and education are the only two significant variables among the socioeconomic characteristics and other trip attributes. Generally, subway/boat modes are fast transit modes and users of both modes consider travel time more than other mode users. Subway and boat users consider three transit information types significant (95%) with five service levels.

4.2.2 Bus and dolmus modes

Bus/dolmus users were considered in another group among transit users. The biggest share of the transit users belong to this group. Depending on our survey, 73% of transit passengers use even bus/dolmus as their commute mode. Nevertheless, they do not have enough transit information available. Finally, most significant estimated model for bus/dolmus users is indicated in Table 5.

In the estimation, travel time and education level are 90% significant. Income and having car dummy variables are 95% significant. Having a car dummy variable is very significant in this estimation, however, it was not in the previous model (subway/boat segment). The car ownership rate is high among the subway and boat users. Users who have car available for their commute/school trips prefer subway and boat modes because they are as fast as car mode (sometimes faster) and also comfortable. However, this is not the case for bus and dolmus users. Usually they have no choice except using these modes because they do not have car. In the model five information types were considered as significant (95%) with six service levels. Significant information types for two mode segments are indicated in Table 6 with number of significant service levels in parenthesis.

Table 6 Significant information types among mode segments

Subway/boat	Bus/dolmus
Frequency information (1)	Frequency information (1)
Information about operating hours (2)	Information about operating hours (1)
Fare information (2)	Information about transfer and transfer locations (2)
	Information about waiting times (1)
	Information about station locations (1)

Considered information types vary among mode segments. Frequency of service and operating hours are common transit information types. Bus and dolmus users consider additional three information types as significant. Subway and boat users consider only one information type different from other mode segment. Available information about frequency and operating hours increases the satisfaction level of both mode segment users. However, providing other information types must be considered separately for different mode segments. These would increase the effectiveness of TIS. In addition, cost for TIS applications will be reduced by providing only considered information types for the transit modes. Considered information types must be investigated carefully and these kinds of investigations must be done periodically, because interests of groups can change with changing conditions.

5. CONCLUSIONS

This study depends on the data collected by in-person interviews from 645 respondents in Izmir City, Turkey. Most of the residents use transit as their commute mode in big cities because of the income level and high gas prices. Mainly, the effects of TIS on the satisfaction level of the transit users were investigated. TIS have an important role to increase the comfort level of the current users. In addition, the effects of TIS to attract non-transit users to use transit as an alternative commute mode were investigated. 29.6% of the non-transit users declared that they would consider transit if more information was available.

In the survey, ten transit information types were presented. A stated preference scenario was prepared considering the actual travel time of the respondent and chosen most important three information types. Satisfaction levels of respondents were investigated with these scenarios. By using ordered probit modeling. Finally, four models were considered. First two models were estimated for transit and non-transit users, separately. Then, two additional models were estimated by separating transit users into two segments. Survey results showed that 76% of the commute and school trips were done by public transit in Izmir City. Thus, in the second part, study focused on transit users. Transit modes have some significant differences from the viewpoint of service quality and available transit information. Thus, transit modes are divided into two segments. Subway/boat modes have more reliable, fast and comfortable service with some available transit information. On the other hand, bus/dolmus modes do not have reliable and comfortable service and available TIS is just a few. Depending on the differences in different transit modes, expectations from the available TIS and satisfaction levels of transit users from this information are different. Thus, subway/boat modes are combined in a segment and bus/dolmus modes are combined in another segment.

Results of estimated first two models showed that mostly considered significant information types are same among transit and non-transit users (5 information types). However, responses for various service levels are different among transit and non-transit users. In addition, transit and non-transit users considered one information type as significant different from each other. For transit service providers, it is important to consider the needs of different individual groups. Non-transit users’ life standard is usually high because of high income. Thus, their expectation from transit service is different from others. Additionally, the socioeconomic characteristics of the transit and non-transit users were investigated. It is found that some socioeconomic factors are significant in this decision. Gender and flexibility of work starting time are significant among non-transit users, and income and having a car are significant for transit users.

Subway/boat users considered three information types with five service levels as significant. On the other hand, bus/dolmus users considered five information types with seven service levels. Two of the considered information types are the same among the segments. Different from bus/dolmus, subway/boat users consider information on fare as significant. However, for bus/dolmus users waiting times and station locations are significant information types, because there is no available such information for bus/dolmus modes. In addition, number of transfers is another significant information type for bus/dolmus users, because transfer information is not available and transfers are uncomfortable for this group. The most significant socioeconomic factors for both subway/boat and bus/dolmus users are actual travel time and education level. In addition, income and having a car are considered as significant among bus/dolmus users.

This study shows that people would like to be informed about the service levels of transit and this information affect their satisfaction by transit service. Considered TIS does not vary much among transit and non-transit users. However, considered TIS among different mode segments is significantly different from each other. To provide more effective and comfortable service, TIS can be considered as an effective tool. However, before providing information considered information types for different groups must be investigated deeply. This will be achieved by providing more effective information with minimum cost.

TIS have a promising effect to improve the service quality of transit service. TIS provide improvements for two different groups of individuals. First one is for transit users by improving their satisfaction levels from the available public transit services. Mostly young population uses transit in Turkey. When they have economic independence and can afford a car, they can quickly change their mode. Thus, it is important to improve service quality of transit to compete with car mode. Second group is non-transit users. To solve many problems such as traffic congestion, air pollution caused by exhaust gases etc., it is important to attract non-transit users to use transit instead of car. With a little effort and with small budgets at least some of the static transit information can be provided for the users and the positive effects of this information would be more than expected. Especially, in developing countries TIS must be introduced parallel with new transit services and infrastructure investments, because the need for information is growing fast both in developing and developed countries in all stages of life.

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