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Modelling of Stress in Public Transport

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Abstract: The quality of the public transport system is an important factor in determining passenger travel satisfaction and it leads to a better quality of life. Quality of life depends on the quality of services provided in the city. Satisfaction is strongly related to the perception of the users. Many people use public transport on their everyday trips and this paper investigates how road users perceive the public transportation system and the place of the stress factor in this perception. Furthermore, willingness to pay analysis was also carried out, and the amount of additional charge for a less stressful trip was included as a new variable in the model. The binomial logit model is used as a method in this study. As a result, the trip time and the home-based work trips increase the stress level in travel rises. Stress level affects the perception of public transport users, and therefore, users tend to stay away from the stress.

Keywords: User Perception, Public Transport Quality, Willingness to Pay, Binomial Logit Model.

1. Introduction

Many people use public transport on their routine trips and as a result public transport can be seen as one of the indispensable parts of daily life. The quality of the public transport service not only attracts the private car user, but also increases the loyalty of the public transport user. As a result, passenger happiness with public transportation is influenced by its quality [1]. In the end, travel satisfaction is strongly related to how the user perceives the system. The perception of the public transport system is linked with the system performance. [2] found that in order to improve total travel pleasure, an improvement in comfort, functionality/reliability, and affordability is necessary. This suggests that in this situation, comfort is both a required and sufficient criterion, whereas functionality/reliability and cost are both adequate but not necessary. Stress is one of the most critical comfort criteria.

The performance of the public transport system is generally determined by measurable values such as travel time, travel cost, trip distance, and stop/station distance. However, user satisfaction is also evaluated within the scope of criteria that cannot be easily detected, for instance driver behavior, crowding, route, stress and tension or annoyance, and fatigue. For example, [3] reached the conclusion that commuting is discovered to be a significant difficulty for several pregnant women. It is frequently a cause of stress and anxiety, and it had negative consequences for women's health and well-being, especially when they already had medical concerns.

Traffic management is a necessity for metropolitan cities and if the traffic is not managed well, traffic jams occur and this situation effects on quality of life of the city. Congestion can be classified into two groups which are recurrent and non-recurrent congestion according to [4]. Unpredictable circumstances that generate a temporary rise in travel demand or decrease in road segment capacity are referred to as non-recurrent congestion [5]. On the other hand, recurrent congestion is described as predictable occurrences that generate an increase in travel demand and cause a road's capacity to be exceeded at a certain place and for a specific period of time as a result of regular traffic. It's worth remembering that drivers get a sense of regular traffic patterns and plan their travels appropriately. Non-recurrent congestion, on the other hand, is closely linked to random events, and as a result of the unpredictability of the events, it produces more discontent among road users than recurrent congestion [6]. Well-managed traffic results a high performance of the public transportation system, especially in big cities, and this high performance increases user satisfaction.

In this paper, it is investigated how road users perceive the public transportation system and the place of the stress factor in this perception. Variables such as the travel behavior of individuals, their socio-economic characteristics, and the quality of the public transportation system are included in this research study. Furthermore, willingness to pay analysis was also carried out, and the amount of additional charge for a less stressful trip was included as a new variable in the model. This paper is organized as follows: the literature review is presented in the next section and previous

studies on the subject are included in this section. Afterward, the methodology used in the study is given in general. The information about the study area and why this area was chosen are discussed in the following section, and the data obtained from the face-to-face survey study in the field is explained in the "Data" section. In the following section, the model results are given and the results are assessed, and then the study is concluded with the conclusion section.

2. Literature

The quality of a public transportation system may be evaluated by rating service variables including timeliness, network size of the transport system, connectivity of lines, and frequency of services, and this ranking can also be requested of customers in general [7]. Some of these variables are measurable (quantitative) (trip time, trip cost, waiting time at the stop, frequency of buses/trains, etc.), and some are unmeasurable (qualitative) (crowding, stress or nervousness, fatigue, etc.).

A survey study conducted in 13 regions of Sweden tried to measure users' perceptions of the public transport system. The surveys are in two stages, before the improvements and after the improvements. In the study, the perceptions of these two situations by the users were compared and the following conclusion was reached: increasing the quality of the public transportation system has an effect on people's perception only with certain restrictions. There has not been a great perceptual change as the previous experiences of the users are imprinted in their memories. Another reason for this situation is that adequate information may not have been provided [8].

Stress factor is not the same for all kinds of users. Where private vehicle users are more stressful than users of other modes, and as urbanization spreads towards the city periphery, stress and noise and air pollution increase due to the increase in the duration of home-business trips.

In another study conducted by [9], they examined the stress experienced by private vehicle users and rail system users during their trips. As a result of the analysis, it was revealed that people who make home-business trips with a private vehicle are in a more negative mood and have a more stressful travel.

In addition to people's perceptions of a whole transportation system, whether they choose the public transportation or not is related to the users' satisfaction and perception of the public transportation system. In another study, [10] evaluate the function of satisfaction in relation to certain service quality criteria before and after a significant change in the service provision. According to their findings, travel satisfaction is complicated phenomena and service quality attributes interacts jointly to the high level of total travel satisfaction. [11] try to use stress physiology to measure active traveler comfort which means the users those walk and drive bicycle as active transport modes.

3. Methodology

Demand models are a very important issue, especially for bulky sectors such as transportation. According to the results of demand models, a new investment decision can be made. Models are an effective tool used by decision makers. In general, it is the basis for decisions such as which type of transportation should serve at which starting and ending points. At the same time, the effect of a change in the transportation system on passenger behavior can be tested through the model. In this context, users' reactions to a price rise in public transportation vehicles, how users would behave if bus frequency is increased or decreased, and if private car owners' behavior will alter as a result of improved public transportation may all be addressed using mode choice models. The flexibility technique is unable to depict the precise effects of adjustments in the transportation system, including increase in price, public transit frequency, and route modifications [12]. On one hand, collective derivative discrete models are inadequately responsive since they look at a group of passengers or people of an area as a whole. Discrete demand models, on the other hand, are concerned with the specific preferences of travelers. Until the 1980s, collective demand models were the norm; after that, discrete demand models became the norm [13].

Users pick the mode that will benefit them the most in discrete choice models, which is one of the key assumptions of the Random Utility Theory. The utility function is a function that defines the advantages of users and as demonstrated in Equation **[1]**, the utility function is generally expressed by a linear form.

$$U_i = V_i + \varepsilon_1 \quad (1)$$

The person's utility is represented by the letter U in the calculation. In the right part of the formula, the variable V shows the quantities that may be measured by observation in the equation (for example age, travel time, travel cost, income, etc.). Right part of the equation contains the model's determining components and is the part that the model can explain. The ε is, on the other hand, defined as an alternative-specific error phrase. This section discusses characteristics that are difficult to quantify or observe yet have an influence on mode or alternative choice. This section of the model is known as the random or stochastic piece. It takes into account factors such as a person's perspective, comfort, and convenience which are cannot easily be measured. Nonetheless, because of the error term, it is understood that these elections are held with a reasonable chance of being chosen, rather than with certainty. Thus,

probabilities of alternatives are calculated by using Equation **[2]**:

$$P_r(1) = \frac{e^{V_1}}{e^{V_1}+e^{V_2}} \quad (2)$$

The P value is set to a number between 0 and 1 in this case and $P_r(1)$ represents probability of being choosen of alternative 1. In this study the logit model is considered. The two most common types of binomial choice models used in practice are the logit and probit models. The probit model implies that errors are distributed normally, whereas the logit model posits that they are distributed logistically.

4. Study Area and Data Analysis

According to the data of the Turkish Statistical Institute [14], which has a population of approximately 16 million (15.6 million) in 2020, with the inclusion of domestic and foreign tourists, home-business trips from the surrounding cities, approximately 20 million people live and intense urbanization is experienced. In big cities like Istanbul, providing new services is not only easy but also costly.

Data

This study was conducted in Istanbul in 2015 and consists of 175 survey data in total. A face-to-face survey was conducted with randomly selected participants in the 4 centers with the highest traffic attracted districts of the city. The surveys were generally carried out during rush hour and the day/time distinction was not considered. The survey consists of stated preferences (SP) and revealed preferences (RP) parts. Within the scope of the study, the variable of "stress, tension and loss of motivation", which is defined as one of the public transportation system characteristics, was examined. Moreover, private vehicle and public transport users's perception about the public transport system in the context of stress was measured using a 5-point likert scale and this information was added to the model as a dummy variable.

The binary logit modeling technique was used to model the survey data. The model included a total of 9 variables. These variables were divided into four categories (Figure 1). Passenger behavior, travel profile, willingness to pay, and average score are all some the variables. The "home based work trips" variable indicates the objective of the trip, whereas a fictitious variable is created which is named as the "AVG" variable that takes 1 if the user picks a score greater than the middle value of 3, and 0 otherwise. The fourth group variable is referred to as "Additional Payment." The extra payment was intended to indicate how much people are ready to pay for less stress, tension, and motivation-losing situations, or for a more comfortable public transit system.

Descriptive statistics

The average age of those surveyed is 29.7 years old. Furthermore, 67% of those surveyed are men, and also 33% are married. The average household size is 3.09 according to the data. Likely, the average household size in Istanbul is 3.53, according to the Istanbul Transportation Master Plan (IUAP) 2006 Report. According to the results, 31% of participants are unemployed, 50% having their own houses, and 45% possess a personal automobile.

The average monthly household income is 5,300 TL. When trips are categorized by their purpose, it is discovered that home-work trips account for 41% of all trips. According to the study's findings, the average trip time in one direction is 48.8 minutes, and the average travel cost in one direction is 6.25 TL. Despite the fact that 45 percent of participants have a private automobile, just 20% of those who go only by private vehicle and only 6% of those who utilize park and ride systems do so.

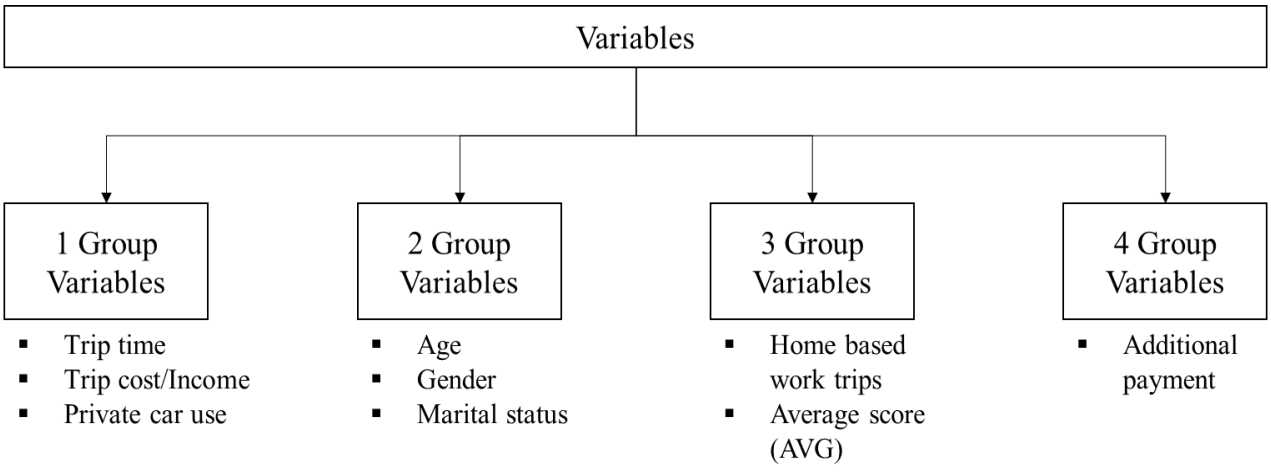

Figure 1. Groups of variables

Willingness to pay analysis

According to the survey results, the majority of respondents claimed that 32% of them would not be willing to pay more for a more pleasant transportation service. There is a density of 1 TL, 2 TL, and 5 TL when considering the payments that may be made. The distributed percentages of these values are 14%, 13%, and 10%, respectively. The remaining quarter of a percent is spread among intermediate values. As a consequence, the dummy variables' monetary values are set to 1 TL, 2 TL, and 5 TL that means customers can contribute in addition to the present transit cost in order to improve the public transportation system's service conditions.

Determination of the alternative

During the collection of model data, it was determined if each individual would like to remain in the old mode or switch to the new mode based on the price they designate in terms of the accepted additional payment amounts. The purpose of this model is to see if individuals remained in the OLD mode and, if so, under what circumstances they choose the NEW mode In addition, the models below show which independent factors play a more active role in discrete travel mode selection.

5. Model Results

In the model, a single utility function is defined, and this function is solely calculated for the newly created mode. As a result, the predicted coefficients represent the relative influence in comparison to the present mode which can be named as OLD one. The estimation was made three times for the overall sample, private vehicle users and public transport users.

Utility function:

$U(NEW)=Constant + \beta_1*TripTime + \beta_2*TripCost/Income + \beta_3*AdditionalPayment + \beta_4*Age+ \beta_5*Gender+ \beta_6*MartialStatus+ \beta_7*PCOuse + \beta_8*HBWtrips + \beta_9*AverageScore$

As can be seen, since a single model is created, the coefficients will be alternative-specific, not general.

Table 1. Binary Logit Model Results of Stress, Tension and Loss of Motivation.

	Overall		Private Car Users		Public Transport Users	
Variables	**Coef.**	**t- statistics**	**Coef.**	**t- statistics**	**Coef.**	**t-statistics**
Travel Time	**0,021**	**4,842(a)**	**0,019**	**2,279(a)**	**0,023**	**4,169(a)**
Travel cost/Income	5,405	0,934	-11,327	-1,136	**12,709**	**1,645(b)**
Additional payment	**-0,637**	**-9,018(a)**	**-0,351**	**-2,980(a)**	**-0,850**	**-8,414(a)**
Age	0,015	1,080	0,006	0,261	0,026	1,300
Gender	-0,154	-0,675	**-1,023**	**-1,825(b)**	0,112	0,410
Marriage status	0,299	0,987	-0,081	-0,145	0,351	0,875
Private car usage	**0,593**	**2,182(a)**	-	-	-	-
Home – Work trips	**-0,437**	**-1,820(b)**	**0,865**	**1,733(b)**	**-0,965**	**-3,071(a)**
Average score	**-0,827**	**-2,923(a)**	**-1,605**	**-3,134(a)**	**-0,664**	**-1,826(b)**
Constant	-0,157	-0,339	0,637	0,591	-0,307	-0,534
No. of observations	525		138		387	
LL ()	282,706		77,678		187,602	
LL (M)	358,526		95,639		260,536	
- 2LL	151,640		35,922		145,868	
ρ^2	0,211		0,188		0,280	

(a), and (b) are significant at 95% (1,960), 90% (1,645), respectively and written in **bold.**

According to the Table 1, interpretation of the coefficients are described as follows.

Travel time

The travel time variable is statistically significant in the 95% confidence interval for all classified users. A positive sign of the coefficient means that if the journey time increases, the probability of users switching to the new mode will increase. This indicates that travel time has a significant impact on stress. It is seen that the increase in travel time causes an increase in stress.

Travel cost/income

As the travel cost/income ratio increases, users tend to shift to the newly created mode. Statistically, it is possible to state that this rate has a meaning for stress on users only for public transport users.

Additional payment

Since the Additional Payment coefficient is negative, users are found to prefer to stay in the present mode as the monetary value sacrificed increases.

Gender

Users who are male are more inclined to stick with the old style. For reduced stress and strain, female private automobile users are more inclined to convert to the new mode.

Private car usage

As the use of private vehicles increases, the probability of the be chosen of new mode increases. In this case, users of private vehicles can be considered as having experience in stress, tension and loss of motivation in current traffic conditions, even if they are traveling with their private vehicle.

Home-Work trips

While the variable Home-Work trips is statistically significant in the 95% confidence interval for public transport users, it is also statistically significant for the overall sample and private vehicle users (90% confidence interval). It can be seen that private vehicle users are more inclined to shift to the newly created mode during their home-work trips, while the likelihood of remaining in the old mode rises as the stress state of public transport users' increases. Thus, it is thought that private vehicle owners need a new mode for their home - work trips, public transportation users have no other choice and tend to stay in the old mode inevitably.

Average Score

In the 90% confidence interval for public transportation passengers, the variable is statistically significant, and the 95% confidence interval for the overall sample and private vehicle users.

6. Conclusion

The urban transportation system is frequently rated as "moderate," "poor," or "extremely terrible" by participants. It can be said that the reason for the low level of stress is due to the habitual desperation as stated by the survey participants. Only in accordance with this knowledge it can be concluded that investment decisions in the urban transportation system should be made within this framework in order to enhance customer satisfaction. According to the results obtained from the model, the probability of switching to a new mode increases as the travel time of the users increases. With the improvements to be made, it might be argued that private car owners can be motivated to utilize public transportation by providing public transportation modes that can serve without being trapped in traffic owing to the potential of shorter travels. As consumers' ages grow, they have a greater need for a more comfortable and safe travel. Moreover, female commuters demand better public transit more than male commuters. The mode of travel that is most affected by stress and tension is home-work trips. This is due to the fact that travelers experience more stress in order to reach a place on time.

Public transportation services can be provided on different routes and in numbers, especially during work and off-work hours. For example, trips between continents should be encouraged to be made mostly by sea ways. The service quality of the pedestrian paths of the sections that are continued on foot in home-work trips should be increased. It is observed that pedestrians continue their trips on foot on vehicle roads in areas where population density is high during commuting and rush hour. Such situations should be prevented and improvements to be made in the transportation system should be considered as a one unit.

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Conflict of interest

The Author has no conflicts of interest to declare that they are relevant to the content of this article.

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