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Planned Special Event Travel Demand Model Development

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P A P E R I N F O

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A B S T R A C T

When a planned special event (PSE) is mentioned, large and international organizations are considered. These organizations attract so many people all around the world to local points. However, relatively small scale PSEs such as ordinary league games that are organized once every two weeks that impact the daily traffic of the cities especially metropolitans, are neglected. This paper focuses on the travel demand modelling of the ordinary super league games in Istanbul. As a purpose of this paper, in order to obtain a customizable and standalone PSE model, survey design and data collection procedures, a new methodology for trip generation, trip distribution, and modal split steps of the traditional 4-step demand modelling are considered. With the opportunity provided by the newly proposed methodology, unlike most previous studies in literature, all trips and activities in the same day with the PSE are taken into the modelling process. Because of the nature of the PSEs, participants prefer to perform additional (derived) activities in the time between leaving the origin and joining the PSE. Accordingly, 1, 2, and 3-step groups are defined, and the shape of trip length distributions are different not only from the peak hours but also from each other. At the end, the model estimation and development of the PSE travel demand model are presented with conclusions and suggestions.

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NOMENCLATURE

U	Utility of an alternative
X	Vector of attributes
S	Vector that specifies the characteristics of the individual
C	Choice set
V	Deterministic component of the equation (deterministic part)
Pr	Probability of a chosen alternative
e	Exponential form of formula
T_{ij}	Future trips made from zone i to zone j
t_{ij}	Current trips made from zone i to zone j
P_{ij}	Future trip production of zone i
O_{ij}	Current trip production of zone i
A_{ij}	Future trip attraction of zone j
D_{ij}	Current trip attraction of zone j
k	Number of zones
A_i	Balance factor
B_j	Balance factor
f(cij)	Deterrence function of the trips between zone i and zone j.
cij	Travel costs from zone i and zone j

Greek Symbols

ε	Stochastic component of the equation (stochastic part)
Β, n	Unknown parameters
∑	Sum operator
θ	Constraint function

Subscripts

i,j	Alternatives, zones
t,	Individual

1. INTRODUCTION

Rapid increase in the world's population has contributed to a huge need for new transport demand strategies [1] and one of the current transportation demands is the planned special event travel demand. A planned special event (PSE) is a public activity with a predetermined date, venue, and duration that may affect the regular service of the surface transport network due to enhanced traffic demand and/or decreased capability related to event planning [2]. PSE impacts transportation network with its known location and scheduled time as a result of increases in travel demand or decreases in the

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capacity of road segments [3]. Even though PSEs are planned occurrences, they raise the travel demand abnormally and temporarily while their impact on traffic could be significant [4]. For example in a study by Kwon et al. [5] PSEs effect on total daily travel delay is found to be 4.5% in San Francisco Bay Area (USA). Furthermore, according to Federal Highway Administration Office (FHWA) report [6], an estimated 5 percent of congestion is caused by special events.

Special events can be classified in different ways in terms of their size (number of participants), form, content, location and impact area [7]. While the peak hour demand found by reducing from daily travel demand is used in traditional models, temporary and short period of time travel demand is modelled by event based modelling. Kuppam et al. [8] claims that travel demand models were designed to understand traveling to unique special events. Generally, the literature on PSE studies is dominated by large-scale events such as Olympic Games, World Cup Tournaments, Winter Games, etc. [9-11]. Kuppam et al. [8] try for defining special events in the area that have an effect on travel demand, especially transit riding, gathering travel relevant data associated with the PSEs, and creating an exclusive model for special events (SEM) which is also the aim of this study as well.

In the literature, PSE models generally consider the travel demand for the main activity by directly focusing on the trips between origin of the individual and the activity venue. Travel demand from other zones to the event venues is solely forecasted [8, 11-13]. The main activity approach leads to various analyses considering traffic management [2, 3, 9, 10, 14] or spectator (customer) satisfaction [15] while the interim trips (and derived activities) are disregarded. However, due to the nature of the PSEs, most of the time, participants prefer to perform additional (derived) activities in the time between leaving the origin and joining the PSE. While some studies in the literature consider the origin of the special event trips as only home or hotel with some assumptions [16], some others, such as Florez et al. [17] stated that especially the guest travelers in the area may choose walking mode in order to perform some activity in the surrounding area before the game. Moreover, Yan et al. [16] grouped the spectators with regard to their origins, and stated the possibility of the performing other type of activities before or after the main activity which is PSE. Bowman and Ben-Akiva [18] defined activities into groups and named the most important activity of the day as the primary activity, and the other activities defined as secondary activities.

The aim of this study is to establish a custom PSE model for Istanbul (Turkey). For this aim a number of soccer games in three different stadiums in the city is considered. By using the data collected from attendees to these games, conventional 4-step model is retrofitted to PSEs with various modifications in the first three steps of the model. These modifications account for the constraints (such as stadium capacity) arise from the event itself while new additions (such as the derived activities/trips) are also integrated. The paper is structured as follows: firstly survey methodology will be explained, and then data results will be given afterward. Following part, the modelling methodology is presented briefly with the detailed case study and the custom PSE model for soccer games in Istanbul and then the results of the model are presented. At the end, the paper is finished by the discussion and conclusion part by giving recommendations for future studies and new policy decisions.

2. SURVEY METHODOLOGY

The data used in this study were collected from three venues that belong to the three biggest soccer clubs in Istanbul and Turkey which are Besiktas, Fenerbahce and Galatasaray through face-to-face surveys. For each team, seven game days were selected. Seven games were included in the survey study for Besiktas and Fenerbahce, and six games were included for Galatasaray. At each game day, the surveys started about three hours before the games and completed before the game started because the road segments were started to be closed three hours before the game. Also, according to the study of Chang and Lu [19], around 30% of attendees reached to the immediate vicinity of the venue three hours before the PSE. The surveys were conducted to the fans waiting in the area that is closed to traffic and fully secured by police while only the fans who were going to enter the stadium were inquired. All the participants were home team fans. The key obstacles encountered by the survey team and the steps taken to mitigate the related issues are described below:

- Permission (Having permits to execute surveys from the stadium managers): The clubs were contacted to get permission to perform the surveys inside the stadiums. Due to having no permission, surveys were conducted in the immediate vicinity of the stadiums. Also, Kuppam et al. [8] tried the same way in their study.
- Different profiles (Conflicts in attendance profiles): Every game draws essentially the same socio-demographic profile but the profile varies with respect to the various ticket prices that makes it very difficult to get a representative sample. Thus, broad enough surveys were designed to obtain the required statistical meaning at a relatively small marginal error.

The surveys were conducted only for ordinary league games. In order to avoid any difference in the fan profiles, local derbies and European cup games were omitted. The socio-economic structures and seniority of the fans who participated in the surveyed games are similar and it does not change from game to game. In Table 1, information about stadiums as well the surveys are provided.

3. DATA DESCRIPTION

The number of the valid surveys in Besiktas Vodafone Park, Fenerbahce Ulker and Galatasaray Turk Telekom venues is 1168. The general descriptive statistics of the data are presented in Table 2. According to Table 2, the average age of the fans is 30 and only 6% are women. At most, the 25 - 34 age group of fans follow the game in the stadium (38%). Generally, fans not only come from any districts of Istanbul, but also from out of Istanbul and even abroad. According to the data, 24% (n=277) of the respondents are from out of the city and 3% (n = 39) from abroad. 26% of the participants stated that they have a monthly income of 3,501-5,000 Turkish Liras (TL) while the average monthly income is around 3.200 TL. People attend to soccer games mostly with a friend (n = 704; 60%). Moreover, 35% and above of Fenerbahce and Galatasaray fans follow all home games inside the stadium during one season.

TABLE 1. Information about the venues and the surveys

Teams	Name of the Venues	Venue Capacity	Average Number of Attendance	Survey		
				Sample Size	Confidence Level	Sample Size/Average Number of Attendance
Besiktas	Vodafone Park	41,903	31,245	386	95%	0.01
Fenerbahce	Ulker	50,530	36,677	399	95%	0.01
Galatasaray	Turk Telekom	52,280	34,481	383	95%	0.01

TABLE 2. Descriptive statistics (N=1168)

Criteria	Classification	N	Percentage	Criteria	Classification	N	Percentage
Age Groups	15-24	361	31%	Private Car Ownership	No	648	55%
	25-34	446	38%		Yes	520	45%
	35-44	265	23%	Who Does the Activity with?	Alone	259	22%
	45-54	79	7%		Friends	704	60%
	55 +	17	1%		Older Family Member	71	6%
Gender	Woman	68	6%		Adult Family Member	100	9%
	Man	1100	94%		Young Family Member	34	3%
Residential Status	Out-of-town	277	24%	Ticket Types	Gift Match Ticket	113	9.7%
	Abroad	39	3%		Gift Seasonal Ticket	18	1.5%
	Istanbul	852	73%		Match Ticket	620	53.1%
Income Groups	< 1.800	289	25%		Seasonal Ticket	417	35.7%
	1.800 - 3.500	249	21%	Seasonal Ticket	No	733	63%
	3.501 - 5.000	307	26%		Yes	435	37%
	5.001 - 6.500	140	12%	How Often Do You Participate in Matches?	0 - 4	382	33%
	6.501 - 8.000	58	5%		5 - 8	248	21%
	8.000 +	125	11%		9 - 13	139	12%
Top 5 Job/Task	Student	285	24%		14 +	399	34%
	Tradesman	117	10%	How Do You Watch the Matches outside the Venue?	Do Not Watch	79	7%
	Engineer	58	5%		Paid Channel	664	57%
	Civil Servant	42	4%		Cafe	223	19%
	Teacher	39	3%		Internet	202	17%
	Others	627	54%				

4. PLANNED SPECIAL EVENTS MODELS

In this section, the proposed PSE model is presented. The structure of this model is strongly linked to traditional 4-step model which is well-known and widely used for the aggregate trip-based modelling [20]. However, based on various properties of PSEs a number of modifications are introduced where necessary. The proposed methodology presented in this paper covers the first three steps of the 4-step model while traffic assignment is left out. It should be noted that regardless of the modelling purpose, the assignment procedure is well known, widely applied and straightforward. In addition, the inherent nature of PSEs does not bring in any constraints or necessitates any changes in the assignment procedure.

Eventually, the proposed model will extend to the mode choice step (3rd step) and it should be assumed that a standard traffic assignment calculation will complete the model.

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4. 1. Trip Generation

Trip generation is used for prediction of the number of trips produced from a particular zone and trips attracted to a particular zone. Factors affecting trip production and attraction can be specified as household size, household income, residential density, employment, retail floor space area, hospital capacity, school capacity, etc. Different modelling methods are used for trip generation step such as category analysis, trip rates based on activity participation, and regression analysis. The regression analysis is the mostly used method of the trip generation step.

Due to the characteristics of selected PSE, in this study, the trip generation step carried out by only considering the trip attractions. Consequently, in trip matrices, venues are considered only attraction zones. In this study, the districts of the Istanbul were determined as production zones.

Especially in metropolitan cities such as Istanbul, PSE should be considered together with all activities and trips on the event day. Therefore, in this study, daily activities and trips starting from leaving home and up to the PSE are considered. As a result, the trips made on the days of PSE were divided into three groups. These are:

- 1-Step Group (n=742): who reach the stadium directly and without extra activity,
- 2-Step Group (n=376): who reach the stadium after performing one interim activity and makes two trips,
- 3-Step Group (n=50): who reach the stadium after performing two interim activities and makes three trips.

As a well-known fact, transportation demand is derived from activity demand. Consequently, for each individual, all the activities occurring at different locations in a day generate trips by different transport means. Therefore, the individuals in 1-step group make a single trip to reach PSE while each additional step generate an additional trip.

4. 1. 1. Trip Production Methodology for PSEs in Trip Generation

According to Kuppam et al. [8], the capacity of the stadium constraints the generation of trips for special events. Yan et al. [16] used the 2005 HITS data where the group-specific activity chain probability is specified, in order to obtain the total number of trips generated by traffic analysis zone (TAZ) by multiplying the activity chain probability with the number of group population in trip generation step of the modelling.

No matter how much the population of the analysis area increases, the number of people entering the stadium will not change unless the stadium capacity is increased. For this reason, the following procedure has been applied to each stadium separately. First of all, trips to the stadium are divided into trip groups as above and the number of people in each travel group is determined. Depending on the capacity of the stadium, those who came by 1 trip, those who came by two trips and those who came by 3 trips were enlarged according to the number of people in the group. In this approach, additional trip matrices are generated. The total number of the generated trip matrices is 6 (one trip matrix is for 1-step group, 2 trip matrices are for 2-step group and 3 trip matrices are for 3-step group). For example, those who came by 2 trips must have a travel matrix for their first trip, and the growth constraint for this trip matrix should not exceed the total capacity of those who arrived by 2 trips in total. Moreover, those who come with 3 trips must have trip matrices of their first and second trips, and so on. For this group, the growth constraint of their second trip is the capacity of the last trip, and the growth constraint of their first trip is the capacity of the second trip. The constraints are illustrated in Figure 1. These constraints are not only for the total number of trips, especially for the first step of 2-step group and the first and the second step of the 3-

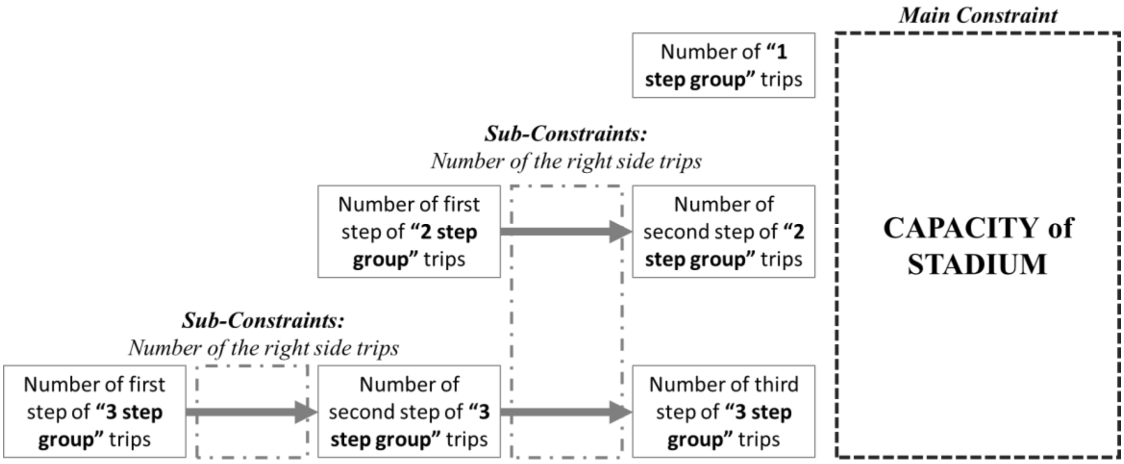

Figure 1. Illustration of the constraints of the growth of the trips

step group. If these constraints does not apply, there may be inconsistency with the number of the trips and some of the trips may be lost in the model. At the end, the trips are enlarged by the origin and destination accordingly.

Istanbul has 39 districts and all of them are included into the model as separate zones. Moreover, out-of-town arrivals are represented by an independent zone. In addition to this, the three venues are defined as different zones. In the 1-step group and the last steps of 2-step and 3-step trip group matrices, the venue zones are defined as only the attraction zones.

4. 2. Trip Distribution Trip productions and attractions is not adequate for modelling and decision making. In order to get a better idea for decision making trip distribution step uses the trips obtained from previous step. Trip distribution presents the distribution of trips from/to particular zones. Generally, a trip matrix is used which shows the origin and destination of the trips between particular zones and this matrix is called origin-destination (O-D) trip matrix. Ortuzar and Willumsen [21] stated that this representation is needed for all assignment models. After having the last version of the O-D trip matrix, the total number of the generated trips should be equal to the number of the attracted trips. If it is not, the balancing process should be performed.

In the study of Kuppam et al. [8] only the last trips were taken into consideration and trips were classified as home-based, work-based, hotel-based, and other-based trips. Moreover, as it was emphasized before, other trips and activities on the PSE day were considered as activities unrelated to PSE. However, derived activities and trips on the day of PSE mostly related with the PSE as it is stated in the Bowman and Ben-Akiva [18] study. It is not only this connection but also the location of the derived activity may affect the chosen transportation mode to reach the venue of PSE. Therefore, in this study, the trips before PSE are also included in the model. By this way, it is aimed to account for all trips from the starting time of the day to the starting time of the PSE.

Trip distribution step was implemented for each 6 different trip matrices which were created in the previous step, separately. However, it is clear that the characteristics of the matrices are very different from each other. In this regard, two types of distribution modelling was used: The growth factor model and the gravity model. Shortly, Figure 2 shows the specific place of which model is used.

Different models were used at this step due to the fact that the gravity model distributes the trips to the places where there is no trip demand. In this case, due to the calculation procedure, even when there are no trips between two observed zones, a certain number of trips are distributed between these zones. This approach can be accepted to be valid in classical 4-step model approach context for daily home-based travel demand. Because in these models, the production of the trips are related with household size, number of student, and number of workers. On the other hand, the attraction of the trips are related with socio-economic indicators such as school capacity, hospital capacity, and employment.

However, this does not apply to the special events travel demand model, due to the fact that all zones do not contain venues which are the main attraction points. For example, in this study, we could lose some of the trips between specific zones to venues in our last trip matrices if we would use the gravity model instead of the growth factor, because, the gravity model distributes the trips with regards to their population and distance. So, the traveler would be stunned by the purpose and lost in the model. For this reason, the Fratar method from the growth factor family was used in the first leg

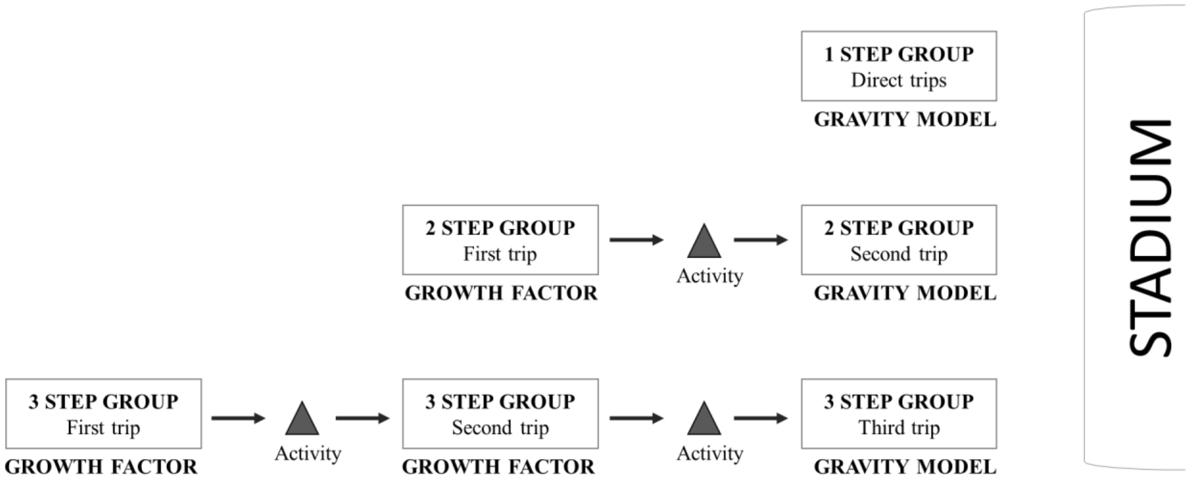

Figure 2. Distribution methodology of the trip groups

of the 2-step group matrix and the first two legs of the 3-step group matrix. Moreover, the gravity model is used in the 1-step group matrix, the last steps of the 2 and 3-step groups' matrices.

Estimation of the number of future trips in each of them matrix cells, the base data is used by various methods such as the growth factor method and the gravity model.

4. 2. 1. The Growth-Factor Method Where the data is only available with regards to the future trip rates of factors which are defined as growth factor, the growth factor methods can be used. The uniform growth factor, single constrained growth factor, the doubly constrained growth factor, the Fratar method are members of the growth factor family.

4. 2. 2. The Fratar Model This method was introduced by Fratar and this modelling approach makes the assumptions that the existing trips *tij* would increase proportionally to (P_i/O_i) and proportionally to (A_j/D_j). The multiplication by two growth factors of the current flow would result in projected trips occurring in zone i being greater than the future forecasts. Therefore, a normalizing expression is presented which is proportion of the total of all the existing trips out of zone i, and multiplication of the total of all the existing trips out of zone i and the growth factor at the end of the trip. The Fratar model is given by Salter and Hounsell [22]:

$$T_{ij} = t_{ij} \times \frac{P_i}{O_i} \times \frac{A_j}{D_j} \times \frac{\sum^k t_{ik}}{\sum^k \left[\frac{A_i}{\alpha_i}\right] \times t_{ik}} \quad (1)$$

With this approach, the distribution of future trips is made by defining a separate coefficient for each zone. In the Fratar model, the trip distribution rate of each zone within all zones and the future production and attraction rates are included, and is calculated separately for each zone. This calculation model has some disadvantages like other growth factor models. For example, as Salter and Hounsell [22] stated that the growth factor methods are strongly dependent on the growth factor itself and the growth factor should be calculated precisely, and this can be defined as the source of error. Since the Fratar method is a member of the growth factor family, no calibration is required.

In the context of the proposed methodology, this method is used for the trips of people who attended a certain activity (eating, drinking, meeting, sightseeing, shopping, etc.) which are their previous trip/trips before coming to the venue. Moreover, within the scope of this study, the possible maximum number of trips are defined by the limitations of the known capacities of the stadiums.

The reasons for applying the Fratar method can be listed as follows:

- The trips whose only purposes are to participate in the planned special event, are made to different zones with different purposes by using the gravity model,
- Because of the nature of the gravity model, as the size of the zones increases the number of trips increases. As a result, mostly attracted zones obtain high number of trips and it increases during the calibration of the gravity model. Even, at the end of the second iteration, some of the zones which produced low rate of trips are seemed almost zero travel demand,
- As in the traditional four-step model, the capacity of the hospital, school, or the number of employment is very important however, it can be deducted that the travel demand for planned special events are not related to them.

4. 2. 3. The Gravity Model As it is known, in the two restricted gravity models, the whole trips are separated to all zones by weighting according to the number of trip productions and attractions.

$$T_{ij} = A_i \times B_j \times O_i \times D_j \times f(c_{ij}) \quad (2)$$

The given *f(cij)* function generally is chosen among following forms. The sum of the trips made to a region in the below forms is distributed to all zones that are linked to the origin zone.

1) $f(c_{ij}) = e^{(-\beta \times c_{ij})}$

2) $f(c_{ij}) = c_{ij}^{-n}$ (3)

3) $f(c_{ij}) = c_{ij}^{n} \times \exp(-\beta c_{ij})$

The calibration of the unknown parameters in Equation 3 (β and/or n) is performed by an iterative procedure that looks for convergence to the actual trip length distribution (TLD) at each iteration. In the general practice, for trips during morning or evening peak hours the TLD follows a right-skewed distribution that represents less numbers of short and long trips. However, for PSEs the distributional shape of the TLDs should be expected to be very much different than the TLDs for peak hours.

In the proposed methodology, the gravity model was used for the last steps of the trip groups. The last step of each group only contains trips between various districts and the venues while no trips exist between other zones.

In the traditional 4-step model, in order to obtain the trip distribution matrix, Equation (2) is generally used and the third form of the $f(c_{ij})$ is preferred. In this calculation, when there are no trips between zones, the c_{ij} values are equal to zero. However, based on the selected deterrence function these zero values could be converted into a non-zero deterrence value (*since* $e^0=1$) and in turn, these non-zero deterrence values would lead to the distribution of trips between zones that do not have any observed trips. Obviously, this is a quite problematic issue when modelling PSEs because the final step of the PSE trip distribution should strictly assign the trips only to the venues. In an effort to overcome this problem, a dummy variable that takes the value of 1 if the destination is the venue and 0 otherwise is incorporated into the deterrence function. By this way, it becomes possible to assure that the trips are assigned only to the venues. Equation (4) presents the new deterrence function that contains the abovementioned dummy variable. In the equation, j = 41, 42 and 43 are the zone numbers of the venues:

$$f(c_{ij}) = e^{(-\beta \times c_{ij})} \times \theta_{ij}$$

$$\text{subject to } \theta_{ij} = \begin{cases} 1; \text{if } i \leq 40 \text{ and } j = 41,42,43 \\ 1; \text{if } i > 40 \text{ and } j < 40 \\ 0; \text{otherwise} \end{cases} \quad (4)$$

Figures 3, 4 and 5 present the results of the gravity model calculations in this study. Figure 3 is for direct trips from origins to the venues while Figures 4 and 5 are for the last steps of 2-step and 3-step trips, respectively. As it can be seen from the figures the TLDs are converged after 3 iterations for all cases. Note that the shape of TLDs are different not only from the peak hours but also from each other for 1, 2 and 3-step trip groups. For the last step of 2 and 3-step trips the TLDs have a decreasing form that indicates the trips to be concentrated at short distances (or travel times) to the venues. However, for 1-step (direct) trips short distances are less frequently observed. The distribution still resembles a left skewed distribution whereas very long distances are also present.

4. 3. Modal Split The third stage of the classical 4-step travel demand model is the modal split. At this stage, the probability of selecting each transportation mode is calculated and split is made accordingly.

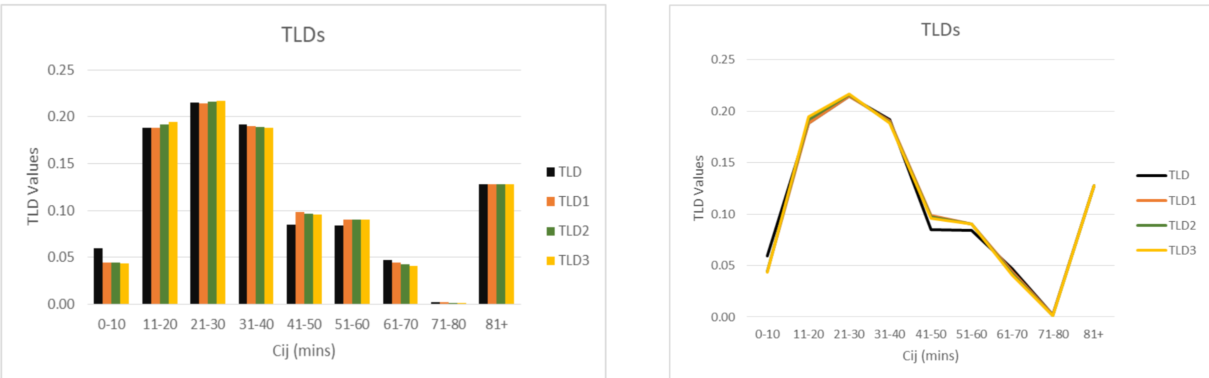

Figure 3. Trip Length Distribution Results (1-Step Trips)

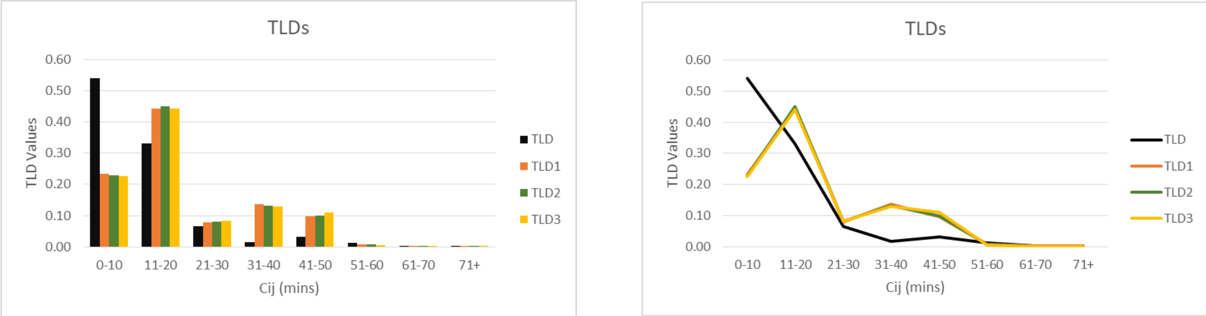

Figure 4. Trip Length Distribution Results (Last step of 2-Step Group)

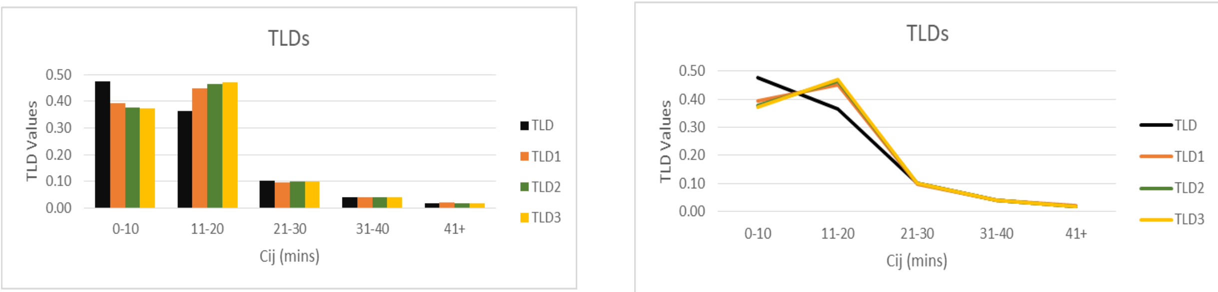

Figure 5. Trip Length Distribution Results (Last step of 3-Step Group)

First of all, the probability of selecting a transportation mode is calculated according to the assumptions within the scope of random utility theory which states that each user makes logical choices in the phase of split, has an information about each mode of transportation, and knows which one will provide the most benefit. In the 4-step model, which is generally used in home-based compulsory trips and is more effective in revealing the demand for transportation during peak hours, the benefits of the transportation modes are expressed by variables such as travel time and travel cost. In this case, the assumption is made that the user prefers the least costly and earliest mode. A widely used modelling approach for choice modelling is the multinomial logit model (MNL) which is convenient to apply and understand.

The framework of MNL is based on the utility theory. This theory assumes that an individual always selects the alternative that maximizes his/her utility from a set of alternatives. Koppelman and Bhat [23] used the utility theory general rule as:

$$U(X_i,s) > U(X_j,s) \quad (6)$$

Equation (6) specifies that when the options (alternative set includes) are only i and j, the individual will select the alternative *i* instead of *j*. To generalize the formula, it is assumed that in a case where there are *j* options, *J* will show the set of options and *J* has 2 or more elements. Thus, the probability of choosing alternative *i* is calculated by the following equation [24]:

$$P_r(i) = \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \quad (7)$$

In the literature, some of studies utilized the MNL for modelling the PSEs [8, 9, 13, 19], some others used the activity based modelling approach [16, 25] and some others tried different approaches such as the mesoscopic simulation model; an approach also containing the MNL [10], the category based modelling approach [26], etc. In this study, the MNL approach was used to calculate the probabilities of modes in the stage of modal split.

In this study, 4 transportation modes are defined: public transportation (PT), private vehicle (PV), private vehicle + public transportation (PVPT), and walking (W). The PVPT mode is used to represent the trips that are made by private vehicles at least in some part of the trip.

As it was mentioned before, the assumption is made due to the random utility theory that the user prefers the least costly and earliest mode for his/her trip. However, in this study, the choice of modes in PSEs travel demand model is thought to depend not only on travel time and travel cost but also on different variables specific to special events. For this reason, the modelling study was carried out by deriving new variables based on special events in the selection of the mode from the questionnaires.

4. 4. Variables of the Models Since the special events travel demand is different from the demand for transportation to daily home-based work trips, new variables must be defined in addition to the travel time and travel costs that are the basis for that particular type of trips. Because, the special event participants do not have the behavior to catch up with the special event as soon as possible and with the least cost based on the data obtained from the surveys. Instead, spectators tends to go to the special event area much earlier, to experience the pre-event atmosphere. Therefore, the variables to be used in the mode choice model should be defined accordingly. As a result, "Arrival time" in minutes (ARRVT) will show how much time individuals allocate coming to the venue and its surroundings before the start of the match, and ANTICI (Annual average ticket price, which shows how much of their annual earnings are reserved for a season ticket to follow their matches from the venue / Annual average income, TL) variables were defined. Unlike the traditional 4-stage model, these new variables of planned special events were defined. The rest of the variables are travel time and travel cost which are commonly used in general. Finally, "ASC" presents the alternative specific constant of the modes.

In the previous steps, trip production and trip distribution operations were carried out on 6 different travel matrices in total: 1-Step, 2_1-Step, 2_2-Step, 3_1-Step, 3_2-Step and 3_3-Step. During the modal split step of the approach, modal segregation was made for each travel matrix separately. Furthermore, PVPT mode is considered as the reference mode in the modelling process. As a result, the model estimation results are given in Table 3.

The observation modal split of each trip matrix and the model results accordingly are given in the Table 4 above.

5. DISCUSSION AND CONCLUSION

This paper offers a very detailed description of the travel demand analysis of the planned special events from the beginning to the end. This analysis consists of survey methodology and model development with the dataset obtained by travel surveys. One of the aspects of this paper that is different from other similar studies in the literature, daily activity and trips are considered as they are related to the PSE. Because, as it is shown in the results, individuals do not take any risk to miss the game, so they plan their daily activities and trips according to PSE starting time. Dai et al. [27] claimed that participants of the PSE generally arrive in a short time before the start. On the contrary, according to the survey data, the spectators arrive to the vicinity of the stadium on average 140 minutes before the start of the game, although this games are organized every two

TABLE 3. Model estimation results

Variables	1-STEP GROUP		2-STEP GROUP				3-STEP GROUP					
			2_1-STEP		2_2-STEP		3_1-STEP		3_2-STEP		3_3-STEP	
CHO	**Coefficient**	**z**	**Coefficient**	**z**	**Coefficient**	**z**	**Coefficient**	**z**	**Coefficient**	**z**	**Coefficient**	**z**
ASC_PT	3.071*	5.89	4.917*	5.69	5.175*	4.03	0.087	0.01	1.090	1.55	4.377*	1.67
Travel time	-0.004	-0.91	-.015*	-2.24	-0.005	-0.27	-.061*	-1.80	-0.003	-0.19	-0.027	-0.63
Travel cost	-0.098	-1.44	-.200*	-1.94	-.334*	-1.88	-0.122	-0.35	-153.559	-0.81	-0.491	-0.87
ANTICI_PT	0.428	0.11	-0.002	-0.01	-6.009	-0.55	11.994	0.45	1.580	0.98	-	-
ARRVT_PT	0.002	0.64	0.001	0.30	-0.000	-0.05	0.021	1.03	-	-	-0.000	-0.09
ASC_PV	2.216*	4.12	3.459*	3.91	2.336*	1.85	-0.553	-0.09	-	-	-	-
Travel time	-0.007	-0.73	-.033*	-1.78	-0.001	-0.04	-0.068	-0.70	-	-	-	-
Travel cost	-.038*	-1.83	-.064*	-2.15	-0.136	-1.38	-0.167	-1.38	-	-	-	-
ANTICI_PV	-5.671	-1.20	0.028	0.13	-21.104	-1.40	9.603	0.36	-	-	-	-
ARRVT_PV	-0.000	-0.08	0.001	0.52	0.004	0.71	0.019	0.94	-	-	-	-
ASC_W	4.171*	6.04	5.250*	4.60	8.641*	7.53	3.196	0.37	2.958*	2.15	7.488*	3.50
Travel time	-.041*	-5.67	-.048*	-3.90	-.0571*	-9.60	-0.050	-1.00	-.037*	-1.91	-.064*	-3.59
ANTICI_W	-6.320	-0.91	-1.202	-0.73	-0.983	-0.09	-259.887	-0.37	-3.178	-0.84	-	-
ARRVT_W	-0.000	-0.06	0.002	0.61	-0.006	-1.02	0.0179	0.85	-	-	-0.002	-0.22

** ==> Significance at 10% level.*

TABLE 4. Comparison of the modal split of the trip matrices of observations and model results

	1-STEP GROUP		**2-STEP GROUP**				**3-STEP GROUP**					
	1-Step Trips - Obs.	**1-Step Trips Model**	**2_1-Step Trips - Obs.**	**2_1-Step Trips Model**	**2_2-Step Trips - Obs.**	**2_2-Step Trips Model**	**3_1-Step Trips - Obs.**	**3_1-Step Trips Model**	**3_2-Step Trips - Obs.**	**3_2-Step Trips Model**	**3_3-Step Trips - Obs.**	**3_3-Step Trips Model**
PT	69%	71%	65%	65%	33%	57%	58%	58%	58%	59%	32%	34%
PV	20%	20%	27%	26%	5%	7%	32%	32%	26%	25%	8%	9%
PVPT	5%	5%	4%	4%	1%	2%	3%	3%	0%	0%	0%	0%
W	6%	4%	4%	5%	61%	33%	6%	7%	16%	16%	60%	56%

weeks. According to Chang and Lu [19], 39.5% of respondents consider about traffic congestion, 17.3% of willing to shop, some of them worry about parking space, so respondents come over the venues about three hours before the PSE. Finally, it can easily be said that the relationship between previous activities which can be defined as derived activities, and main activity (PSE) is very obvious.

As a result, the conclusions of the overall study can be emphasized as follows:

1. The new methodology of the modelling can be implied to any special event in any city,
2. The results of the modelling can be assigned easily to the current transport network. Also, the trip matrices can be added to the transportation master plan model of the metropolitan.
3. The model may be used to forecast travel demand for every potential PSE.
4. The results of the model can be used as input of the other macro planning studies such as transportation master plan, urban planning, etc.
5. In order to analyze travel behavior of the spectators, it is better to separate trips into the step groups. As it was presented in Figures 3, 4 and 5, trip length distributions of the various step groups are different from each other. Modelling PSE travel demand by combining all the trips at once decreases the resolution of the model.
6. In future studies, the traffic in the vicinity of the stadiums can be modelled at the micro-level and integrated into this macro-level PSE model in order to develop short-term, micro-scale traffic management and control policies.
7. On the other hand, the economic and fiscal feasibility of the projects may use the results of the PSE travel demand in some special cases. Generally, transportation master plan studies consider only the weekday peak hour traffic for modelling, and the projects and policies are developed according to the modelling results of the specific days and time. Due to some of the PSEs are organized on weekdays and weekend days, the effect of the travel demand for PSE can be ignored. However, it should be included travel demand forecasting process. The forecasting of travel demand brings out a very important grade which directly affects the selection of various management policies [28]. In order to follow an appropriate way to establish a policy or project to obtain a better-served transport network in the city, travel demand for PSE should be taken into consideration.
8. In this study football is considered as PSE. However, in some other countries, the PSE can be basketball, volleyball, etc. Cities of different sizes or cultures may have different orientations to a single sport, but in general sports activities are the ones that are followed with interest by everyone in all countries from east to west. For instance, in this study, no impact of age, gender, and level of income on mode choice preferences was observed. The participation patterns to these activities are similar around the world that lead to the use of models having a similar approach to the one used in this paper.
9. PSEs are extra activities that people choose for having a good time and pay for them in order to raise their happiness and satisfaction. Better transport network services support their purposes. As a result, these events have an important role for citizens to come together, to be one, and a sense of possession of the city.

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Persian Abstract

چکیده

وقتی یک رویداد ویژه برنامه ریزی شده (PSE) ذکر می شود ، سازمان های بزرگ و بین المللی در نظر گرفته می شوند. این سازمان ها افراد زیادی را در سراسر جهان به نقاط محلی جذب می کنند. با این حال ، PSE های مقیاس نسبتاً کوچک مانند بازی های لیگ معمولی که هر دو هفته یک بار برگزار می شوند و بر ترافیک روزانه شهرها به ویژه کلانشهرها تأثیر می گذارند ، نادیده گرفته می شوند. این مقاله بر مدل سازی تقاضای سفر از بازیهای سوپرلیگ معمولی در استانبول تمرکز دارد. به عنوان یک هدف از این مقاله ، به منظور دستیابی به یک مدل PSE قابل تنظیم و مستقل ، طراحی نظر سنجی و روش های جمع آوری داده ها ، روش جدیدی برای تولید سفر ، توزیع سفر و مراحل تقسیم معین مدل سنتی تقاضای ۴ مرحله ای در نظر گرفته شده است. با فرصتی که روش پیشنهادی تازه ارائه داده است ، برخلاف بیشتر مطالعات قبلی در زمینه ادبیات ، همه سفرها و فعالیت ها در همان روز با PSE به فرآیند مدل سازی اختصاص می یابد ، زیرا به دلیل ماهیت PSE ها ، شرکت کنندگان ترجیح می دهند کارهای اضافی (فعالیت های مشتق شده) در فاصله بین ترک مبدا و پیوستن بهPSE . بر این اساس ، گروه های ۱ ، ۲ و ۳ مرحله ای تعریف می شوند و شکل توزیع طول سفر نه تنها از ساعات اوج مصرف بلکه با یکدیگر متفاوت است. در پایان ، برآورد مدل و توسعه مدل تقاضای سفر PSE با نتیجه گیری و پیشنهادات ارائه شده است.