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Effect of different passenger characteristics and bus types on boarding times at bus-stops

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Abstract
Development of the public transport systems has a significant importance for a sustainable transportation. Especially, the importance of the busses are increasing day by day because of the ease of accessibility, comfort, etc. Comfortable, eco and user friendly busses should be preferred to increase the utilization of busses for the disabled and elder passengers and families with child of 0-6 ages. The aim of this study is calculate the boarding time of the elderly passengers, passengers with child (0-6 ages), passengers with strollers and other (typical) passengers in five different cities (İstanbul, Ankara, İzmir, Antalya and Gümüşhane) of Turkey; then examine and suggest solutions for encountered problems of those passengers. According to analyze results, the longest and shortest boarding times were obtained respectively, passengers with strollers and typical passengers. It was also determined from the results that midibuses, multiple stepped and stepless articulated were less effective for boarding operations with respect to stepless single unit and articulated busses. Results showed that passenger characteristics have great importance on boarding time as well as bus types.

Keywords: Waiting time at bus-stop; boarding/alighting problems; elderly passengers; public transport

1. Introduction

Public transportation by using busses, with its many advantages such as ease of accessibility, is one of the most popular transportation system in Turkey and its utilization is expected to be increased in the near future. In recent years, academicians, researchers, decision makers and transportation planners were involved in studies for improving the efficiency of the transportation modes including buses. Especially for highly populated cities and metropolitan areas, these studies are also cover the optimization studies involving the bus types, trip times, trip frequencies and route selection to change the behaviors of the private car owners so that, they tend to select the public transportation systems more frequently [1-6]. For making the bus transportation systems more desirable for the passengers, more environment friendly vehicles must be provided equipped with accessibility equipment to aid the boarding of the disabled and or elder passengers. Additionally, the needs of pregnant passengers and the passenger with small children must be taken into consideration. Beside the characteristics of the vehicles, it is also an important issue to establish a reliable, safe, fast and economic bus transportation substructure in which the passengers will be able to access easily. Based on these aforementioned issues, this study aimed to investigate the problems encountered by the typical and elder passengers, passengers with small children and with strollers during the boarding of a bus at a bus-stop and tried to suggest plausible solutions to the problems they encountered.

2. Literature review

In the recent literature, there exist several studies which aim to investigate the performances of the bus transport systems and to increase their efficiency. Chen and Liu [7] investigated the effects of the passenger activities on the dwell times (waiting times of the bus at bus-stop) of the buses at the bus-stops

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and trip times between bus-stops. In these analyses, the numbers of the boarding passenger were investigated. The relationship between the operational characteristics of the buses (dwell time, trip time between two bus-stops) and the passenger activities were analyzed by implementing the artificial neural network (ANN) models. Results showed that, the principal factors affecting the dwell times are found to be passenger activities and number of boarding passengers with respect to other variables. In another study, Shen and Lie [8] considered a three-phased dwell time approach for proposing a macroscopic model to consider the dwell times. Their study not only investigated a singular bus-stop but also all the bus-stops in the route of the buses. According to this study, the first phase of the dwell time was the approaching of the bus to a bus-stop which is called "inverse acceleration delay". Second phase was consisted of the elapsed time of boarding and alighting of the passengers. This boarding phase can also be considered as the time passed between the opening and closing of the vehicle's doors. Third and the last phase was called the "acceleration delay" and it corresponded to the elapsed time in which the bus reached its normal speed. Shen and Lie [8] indicated that this three-phased dwell time methodology can results more extensive and detailed representation of the dwell time.

In his study, Khoo [9] proposed a statistical approach to model the dwell times for a bus transportation system by evaluating the video recordings of the 20 bus-stops located in Klang Valley/Malesia. The selection criterion for these bus-stops were based on the vehicle types, routes and estimated passenger demands. The results of the study indicated that, the dwell time was deviated with respect to the hours of the day, payment method and the crowdedness of the bus-stop. Regression analysis also showed that, the most effective factor which increased the dwell time was the payment method. One other factor was considered as the boarding and alighting activities of passengers. Another outcome of this study was that, the boarding and alighting schemes were deviated at peak and regular hours of the day and they were among the principal factors influencing the dwell times. Apart from the aforementioned studies, Kieu et al. [10], carried out a study for clarifying the benefits of estimating the trip times and finding out the problems related with the trip time. Their study was based on two different approaches for short and long time trips. A travel corridor inside the urbanized area of the Brisbane city was investigated for the relationships between the trip times of buses and cars. This study also demonstrated that, the vehicle tracking systems and GPS data can be successfully used to estimate the trip times confidently. Yoon et al. [11] investigated the relationship between the weather condition (rainy or dry) on the trip times of the buses for different hours of the day (peak and regular hours). In their study, they considered the trip time as the addition of the dwell time and elapsed time while the bus was moving. According to their analysis, trip time was differentiated for the dry days compared with the rainy days, and dwell time was differentiated for the rainy days compared with the dry days. The variation of coefficient of the dwell times data for 32 cases were considered and for 28 of 32 cases it was found that the trip time could be influenced by the weather conditions.

El-Geneidy and Vijayakumar [12] used the automatic vehicle location (AVL) and automatic passenger counter (APC) data for investigating the influences of the articulated and down-step buses on the dwell and trip times at the bus transportation systems. Results indicated that, the articulated buses had complex influences on the dwell time and by using these kind of buses, transportation planners may decreases the time for alighting of the passengers and buses with a complex affect decreasing the dwell time. However, utilization of the articulated buses was found to be important for increasing the total trip time such that, approximately two minutes of delay was discovered on the bus schedules at the bus-stops. Tirachini [13] proposed multiple regression models (MRM) for explaining the relationship between the waiting, boarding and alighting times of the passengers with various factors such as ticket payment methods, availability of door steps in buses and age of the passengers. For this aim, bus routes were examined in Sydney city of Australia and gathered data were classified according to the payment methods and its technologies. It was found that, dwell time was directly influenced by many variables such as age of the passengers, availability of the door steps in buses and the interaction of the passengers during boarding and alighting. The following outcomes of the study were proposed as follows:

- All the investigated variables have unique influences over the dwell times.
- Implementation of the new payment methods (such as prepaid cards) significantly decreases the dwell time.
- Availability of double steps at the boarding door increase the elapsed time for the boarding of the passengers and so the dwell time.

- Single door for boarding trigger a secondary queue due to the interactions between the passengers and due to this secondary queue, boarding time significantly increases with respect to a single queue.
- If the bus is crowded, the boarding time significantly increases due to the interactions between the passengers in the bus and translation of the passengers to the backs of the bus.

3. Materials and methods

In the scope of the study, five different cities (İstanbul, Ankara, İzmir, Gümüşhane and Antalya) in Turkey were chosen for investigating the problems associated with the passengers with small children, with stroller, elder passengers and typical passengers while boarding the buses (Figure 1). The data for the corresponding boarding and alighting of the passengers was gathered by video recordings for İstanbul, Ankara, İzmir and Antalya cities. For the Gümüşhane city, video recording were collected from the three different surveillance cameras mounted inside the buses.

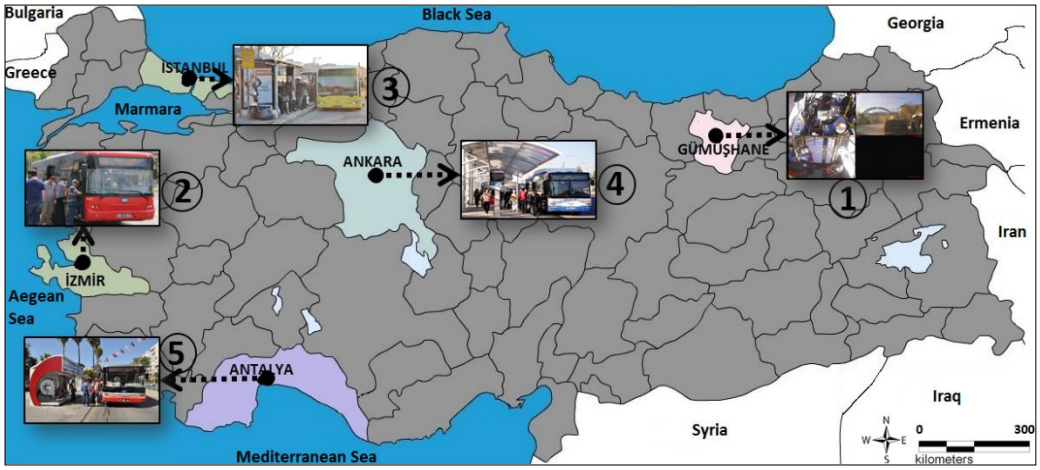
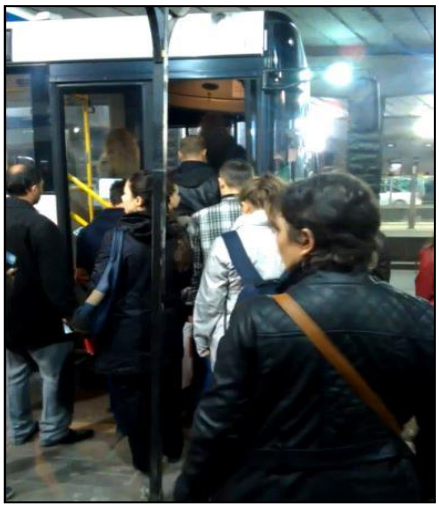


Figure 1. Chosen five different pilot cities for the study.

The video recording for the Ankara, İzmir, Ankara and İstanbul cities gathered by using a regular video camera recorder between the 07:00 and 09:00 hours and 17:00 and 19:00 hours for the weekdays. The bus-stops were selected randomly which are located on the main arterials of the urban road networks. The camera recordings were taken at appropriate distances to the bus-stops in which the passengers could not notice the recording operations as shown in Figure 2a-d [2]. For Gümüşhane city, the vehicle surveillance camera recordings were investigated and counted for composing the corresponding data. (Figure 2e).

(a) İstanbul

(b) İzmir



(c) Ankara

(d)Antalya

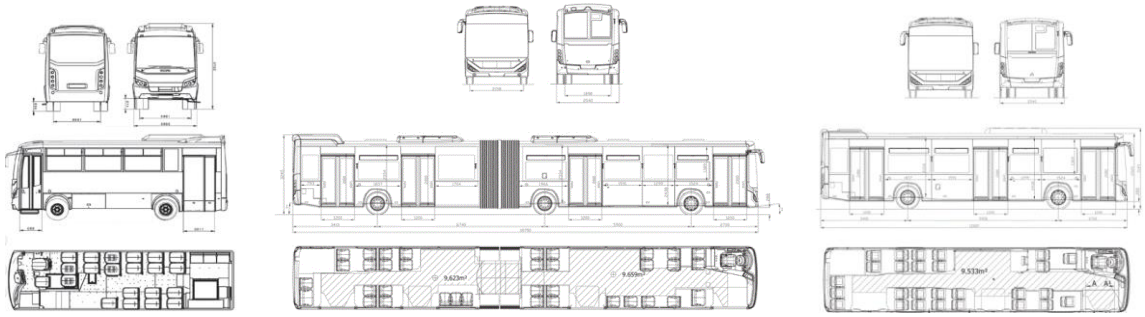
(e) Gümüşhane

Figure 2. Five sample frames from the video recordings taken in different cities.

The following characteristics of the data were distinguished by using the composed video recordings:

- Type of the bus (midibus, single or articulated bus) (Figure 3),
- Number of steps at boarding door (none, 2 steps, 3 steps),
- Total number of doors at the buses,
- Number of doors opened while boarding,
- Payment type (prepaid card, cash),
- Passenger density (fully loaded, partially loaded, few passenger, no passenger),
- Number of passengers waiting at the bus-stop,
- Gender of the boarding and alighting passengers (male or female),
- Type of the bus-stop (closed or open),
- Availability of a bus bay at the bus-stop,
- Age ranges of the passengers (children, youth, middle age, elder, very old),
- Total waiting time (dwell time) of a bus at the bus-stop,

Boarding and alighting times of the passengers.



(a) (b) (c)

Figure 3. Bus types: (a) midibus, (b) articulated bus and (c) single unit bus [14]

In the scope of the study, the flow diagram (Figure 4) was used for gathering the required data about the type of the bus, number of the steps, the passengers characteristics (passengers with children, passengers with strollers, elder passengers and typical passengers), boarding times of the passengers. Before the counting phase for the analysis, the passengers were categorized as below:

- Typical passengers: Passengers without any obstacles for boarding and completes the boarding without any problems.
- Elder passengers: Passengers who acts more slowly compared with the typical passengers and generally handling anything for assistance.
- Passengers with strollers: Passengers traveling with their strollers.
- Passengers with 0-6 years old children: Passengers with or holding the 0-6 years old children.

Boarding of the handicapped passengers was not identified as a category in the scope of this study as this phenomenon is a specific case.

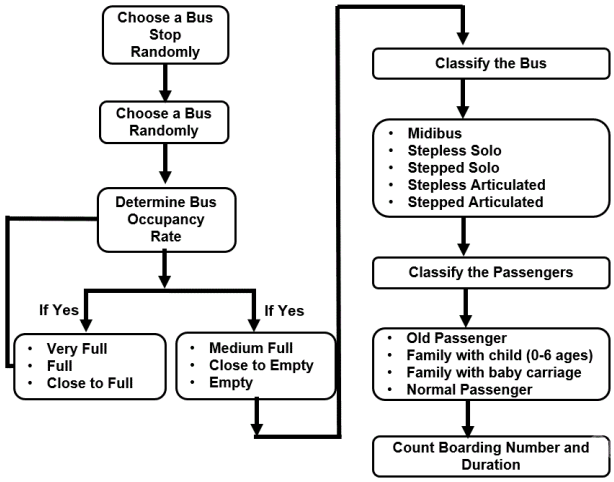


Figure 4. Flowchart for the gathering and analyses of the data.

Types and characteristics of the buses are shown in Table 1 for each city based on the gathered data.

Table 1. Types and characteristics of the buses for all cities

City	Payment method		Type of the bus		Number of steps at boarding door	
	Prepaid card	**Midibus**	**Single**	**Articulated**	**None**	**Two steps**
Gümüşhane	✓	✓	—	—	—	✓
İzmir	✓	—	✓	✓	✓	✓
İstanbul	✓	—	✓	✓	✓	✓
Ankara	✓	—	✓	✓	✓	✓
Antalya	✓	✓	✓	—	✓	✓

By evaluating the data for all cities, it was found that, prepaid card method was used for all of the cities. Apart from Gümüşhane city, more than two different types of the buses are used in other cities.

A total number of 3232 passengers were investigated for the boarding behaviors in which the detailed numbers of these passengers and characteristics are given for each city in Table 2.

Table 2. The characteristics and number of passengers for all cities

Passenger Characteristics	Number of the Boarding Passengers					
	Antalya	**Gümüşhane**	**İzmir**	**İstanbul**	**Ankara**	**Total (∑)**
Typical passenger	593	247	788	753	523	2901
Elder passenger	20	15	36	51	38	160
Passengers with 0-6 years old children	23	14	20	39	28	124
Passengers with strollers	10	6	11	8	12	47
Total (∑)	646	282	855	851	601	3232

4. Analysis and Findings

4.1. Descriptive Statistics

The summary of the boarding data which is composed from three bus types in Antalya, four different bus types in İstanbul, İzmir and Ankara and midibus for Gümüşhane is shown in Table 3 according to the cities, bus types and passenger characteristics.

Table 3. Summary table for the boarding data

City	Type of the bus	The Characteristics and Number of Boarding Passengers for All Cities.				
		Typical P. (%)	**Elder P. (%)**	**Passengers with 0-6 years old children**	**With strollers (%)**	**Total (∑) (%)**
Antalya	Single unit bus with step	331 (51.2)	9 (1.4)	9 (1.4)	4 (0.6)	353 (54.6)
	Single unit bus without step	176 (27.2)	8 (1.2)	11 (1.7)	2 (0.3)	197 (30.5)
	Midibus	86 (13.3)	3 (0.5)	3 (0.5)	4 (0.6)	96 (14.9)
	Total (∑)	593 (91.8)	20 (3.1)	23 (3.6)	10 (1.5)	646 (100.0)
Gümüşhane	Midibus	247 (87.6)	15 (5.3)	14 (5.0)	6 (2.1)	282 (100.0)
İzmir	Single unit bus with step	187 (21.9)	7 (0.8)	4 (0.5)	2 (0.2)	200 (23.4)
	Single unit bus without step	186 (21.8)	9 (1.1)	7 (0.8)	1 (0.1)	203 (23.7)
	Articulated bus with step	209 (24.4)	15 (1.8)	7 (0.8)	6 (0.7)	237 (27.7)
	Articulated bus without step	206 (24.1)	5 (0.6)	2 (0.2)	2 (0.2)	215 (25.1)
	Total (∑)	788 (92.2)	36 (4.2)	20 (2.3)	11 (1.3)	855 (100)
İstanbul	Single unit bus with step	238 (28)	14 (1.6)	8 (0.9)	0 (0.0)	260 (30.6)
	Single unit bus without step	332 (39)	16 (1.9)	9 (1.1)	1 (0.1)	358 (42.1)
	Articulated bus with step	89 (10.5)	12 (1.4)	12 (1.4)	5 (0.6)	118 (13.9)
	Articulated bus without step	94 (11.0)	9 (1.1)	10 (1.2)	2 (0.2)	115 (13.5)
	Total (∑)	753 (88.5)	51 (6.0)	39 (4.6)	8 (0.9)	851 (100)
Ankara	Single unit bus with step	398 (66.2)	13 (2.2)	10 (1.7)	5 (0.8)	426 (70.9)
	Single unit bus without step	37 (6.2)	10 (1.7)	10 (1.7)	3 (0.5)	60 (10.0)
	Articulated bus with step	58 (9.7)	9 (1.5)	3 (0.5)	2 (0.3)	72 (12.0)
	Articulated bus without step	30 (5.0)	6 (1.0)	5 (0.8)	2 (0.3)	43 (7.2)
	Total (∑)	523 (87.0)	38 (6.3)	28 (4.7)	12 (2.0)	601 (100)

Based on the descriptive statistics and analyses of the data as seen in Table 3. The following results were obtained as follows:

- *Typical passengers :* The maximum average boarding time was 3 seconds for the vehicle type of midibuses and Gümüşhane city. Additionally, the data showed less homogeneity and more scattered for Gümüşhane city with a standard deviation of 1.4 seconds.
- *Elder Passengers:* The maximum average boarding time was 8.7 seconds for the vehicle type of articulated bus with door steps and İzmir city. The data showed less homogeneity also for the same bus type and İzmir city with a standard deviation of 3.2 seconds.
- *Passengers with 0-6 years old children:* The maximum average boarding time for the midibuses was seen in Gümüşhane and for articulated buses with door steps the maximum average boarding time was 9 seconds for İstanbul data. The data showed less homogeneity for articulated buses with door steps and İzmir city with standard deviation of 2.4 seconds.

Table 4. Descriptive statistics obtained from analysis results

City	Type of bus	Boarding Time (Seconds)															
		Typical passenger				**Elder passenger**				**Passenger with 0-6 years old children**				**Passenger with strollers**			
		Min.	**Max.**	**μ**	**σ**	**Min.**	**Max.**	**μ**	**σ**	**Min.**	**Max.**	**μ**	**σ**	**Min.**	**Max.**	**μ**	**σ**
Antalya	Single unit bus with step	1.4	7.7	2.6	0.9	4.9	4.9	4.9	-	5.9	7.8	7.1	1.1	16.7	19.5	18.1	2.0
	Single unit bus without step	1.1	3.6	1.8	0.5	3.1	4.3	3.7	0.6	6.4	7.2	6.8	0.6	10.1	11.9	11.0	1.3
	Midibus	1.6	4.7	3.2	0.8	5.0	6.8	6.0	0.9	6.1	8.2	7.2	1.1	18.2	20.1	19.2	1.3
	Average (μ)	1.4	5.3	2.5	0.7	4.3	5.3	4.9	0.8	6.1	7.7	7.0	0.9	15.0	17.2	16.1	1.5
Gümüşhane	Midibus	1.3	10.9	3.6	1.4	5.6	10.6	7.0	1.3	6.6	13.3	9.0	2.2	11.8	20.7	16.2	3.5
İzmir	Single unit bus with step	0.7	7.5	2.7	1.0	4.3	6.6	5.2	1.0	5.9	9.9	6.9	1.5	14.2	14.2	14.2	-
	Single unit bus without step	0.8	5.7	2.1	0.9	4.3	8.4	5.6	1.4	4.9	6.9	5.8	0.8	9.2	10.8	10.0	1.1
	Articulated bus with step	0.8	9.9	2.5	1.1	4.2	14	8.7	3.2	5.6	12.4	7.7	2.4	9.2	31.2	19.1	9.3
	Articulated bus without step	1.0	7.3	2.6	0.9	5.2	11.1	6.8	2.5	7.5	8.4	8.0	0.6	12.4	14.3	13.3	1.3
	Average (μ)	0.8	7.6	2.5	1.0	4.5	10.0	6.6	2.0	6.0	9.4	7.1	1.3	11.3	17.6	14.2	3.9
İstanbul	Single unit bus with step	0.7	7.5	2.7	1.1	4.1	7.1	5.2	0.9	6.2	7.9	7.1	0.5	13.5	13.5	13.5	-
	Single unit bus without step	0.9	6.8	2.3	0.8	3.9	8.2	5.4	1.3	6.0	9.0	7.3	1.2	-	-	-	-
	Articulated bus with step	1.1	7.9	2.7	1.2	4.3	6.8	5.4	0.8	5.5	14.9	9.0	3.0	12.5	23.4	19.3	4.4
	Articulated bus without step	1.2	5.9	3.0	1.1	4.5	8.7	7.2	1.5	5.1	12.8	8.3	2.3	15.4	18.6	17.0	2.3
	Average (μ)	1.0	7.0	2.7	1.1	4.2	7.7	5.8	1.1	5.7	11.2	7.9	1.8	13.8	18.5	16.6	3.4
Ankara	Single unit bus with step	1.1	4.0	2.6	0.7	5.0	8.9	6.9	1.3	4.2	8.1	5.8	1.4	14.7	16.4	15.6	0.9
	Single unit bus without step	0.9	4.3	1.6	0.5	3.1	6.5	4.3	1.0	4.6	8.5	6.1	1.2	9.5	13.2	11.3	1.5
	Articulated bus with step	1.2	4.1	2.3	0.8	3.9	6.1	4.6	0.8	5.8	6.1	5.9	0.2	14.6	18.2	16.4	2.5
	Articulated bus without step	1.2	4.0	2.1	0.6	3.4	6.6	4.8	0.9	5.4	6.1	5.9	0.4	9.8	11.2	10.5	1.0
	Average (μ)	1.1	4.1	2.2	0.7	3.9	7.0	5.2	1.0	5.0	7.2	5.9	0.8	12.2	14.8	13.5	1.5

σ: shows the standard deviation of boarding time.

- *Passengers with stroller:* The maximum average boarding time was observed as 19.3 seconds for articulated buses with door steps in İstanbul. The data showed less homogeneity for articulated buses with door steps and İzmir city with standard deviation of 9.3 seconds

By investigating the average boarding times, it was seen that average boarding times were as followings:

- Typical passengers (2.5 sec) < *Elder Passengers* (5.7 sec) < *Passengers with 0-6 years old children* (7.1 sec) < *Passengers with strollers* (15 sec).

This also demonstrated that apart from the type of the buses the minimum boarding time observed for typical passengers and the maximum boarding times were associated with the passengers with strollers. By comparing the cities and passenger characteristics the minimum boarding times were observed for typical passengers in Ankara (2.2 sec), for elder passengers in Antalya (4.9 sec), for passengers with 0-6 years old children in Ankara (2.2 sec) and for passengers with strollers in Ankara (13.5 sec). The results indicated that the boarding times associated with Ankara is relatively shorter than remaining cities resulted from the probable outcomes of the following aspects:

- Scattering of the passengers due to the greater number of bus-stops.
- Outcomes of the greater number of bus trips and less bus delays resulted less numbers of passengers waiting at bus-stops.
- Selection of the best located bus-stops for each location resulted a safe and comfortable boarding of passengers.
- Proper approaching of the buses to the bus-stops and associated with bus bay.
- Formation of single queues for the boarding of the passengers eliminate the associated interactions and congestions during the boarding.

4.2. Determination of the variables and model

In this study, to understand the effective parameters on Boarding Time (BT) the Ordinary Least Square Regression (OLS) was implemented. For this purpose, effective parameters were determined and classified into two groups as dependent variables and dummy variables as shown in Table 5.

Table 5. Dependent and independent variables of OLSR model for boarding times

Dependent Variable
BT: Boarding time of passengers as dependent variable.
Dummy Variable
Passenger_Type_2 (takes the value of 1 if individual is elder passenger, 0 otherwise)
Passenger_Type_3 (takes the value of 1 if individual is passengers with child (0-6 age), 0 otherwise)
Passenger_Type_4 (takes the value of 1 if individual is passengers with strollers, 0 otherwise)
City_2 (takes the value of 1 if city is Gümüşhane, 0 otherwise)
City_3 (takes the value of 1 if city is İzmir, 0 otherwise)
City_4 (takes the value of 1 if city is İstanbul, 0 otherwise)
City_5 (takes the value of 1 if city is Ankara, 0 otherwise)
Bus_Type_2 (takes the value of 1 if bus is single unit with step, 0 otherwise)
Bus_Type_3 (takes the value of 1 if bus is single unit without step, 0 otherwise)
Bus_Type_4 (takes the value of 1 if bus is articulated with step, 0 otherwise)
Bus_Type_5 (takes the value of 1 if bus is articulated without step, 0 otherwise)

To determine the most effective parameters on the boarding times the OLSR regression model was used. The equation of OLSR model can be estimated as given below:

$$BT = \alpha_0 + \alpha_1 \text{Passenger\_Type\_2} + \alpha_2 \text{Passenger\_Type\_3} + \alpha_3 \text{Passenger\_Type\_4} + \alpha_4 \text{City\_2} + \alpha_5 \text{City\_3} + \alpha_6 \text{City\_4} + \alpha_7 \text{City\_5} + \alpha_8 \text{Bus\_Type\_2} + \alpha_9 \text{Bus\_Type\_3} + \alpha_{10} \text{Bus\_Type\_4} + \alpha_{11} \text{Bus\_Type\_5} + u \quad (1)$$

where: α_0= Constant term, α_i= Dummy variables ($i \neq 0$) and u=Disturbance term.

According to the OLRS model, multicollinearity, heteroscedasticity and model specification error problems were examined by using diagnostic tests and results are given in Table 6. After checking the

multicollinearity, heteroscedasticity and model specification error problems, it was assumed that disturbances were distributed normally because of the big sample size (3232 passengers) based on the Central Limit Theorem [15]. As seen in Table 6, the proposed model was significant for BT (F = 870.9, P = 0.000 < 0.01)

Table 6. OLSR model results for boarding times

Variables	Coefficient	St. Error	*t*	*P*
Dependent Variable.: BT				
Constant	3.335	0.119	27.91	0.000*
Passenger_Type_2	3.278	0.096	34.27	0.000*
Passenger_Type_3	4.755	0.108	44.21	0.000*
Passenger_Type_4	13.045	0.172	75.68	0.000*
City_2	0.274	0.138	1.99	0.047**
City_3	0.169	0.070	2.40	0.016**
City_4	0.340	0.066	5.11	0.000*
City_5	-0.309	0.070	-4.39	0.000*
Bus_Type_2	-0.856	0.134	-6.38	0.000*
Bus_Type_3	-1.479	0.131	-11.30	0.000*
Bus_Type_4	-0.801	0.147	-5.45	0.000*
Bus_Type_5	-0.817	0.145	-5.62	0.000*
Max. VIF	2.81 (no multicollinearity problem)			
White Test	P = 0.056 > 0.05 (no heteroscedasticity problem)			
Shapiro-Wilk W Normality Test	P = 0.021 > 0.01 (disturbances are normally distributed)			
Ramsey Reset Test	P = 0.0132 > 0.01 (no model specification error problem)			

** Significant at 0.05 level, *Significant at 0.01 level.

According to the model results, all examined passenger types had significant coefficients and positive effects on boarding times (coef. = 3.278, P = 0.000 for Passenger_Type_2; coef. = 4.755, P = 0.000 for Passenger_Type_3 and coef. = 13.045, P = 0.000 Passenger_Type_4). Among them, Passenger_Type_4 (passengers with strollers) variable had the highest and positive coefficient. That is, the passenger with stroller tends to boards to bus in longer duration than other passenger types.

On the other hand, the passengers who lives in İzmir finished boarding operation slower than other passengers. Also living in Ankara had a negative significant coefficient in the model (coeff.=-0.309, P=0.000). This indicated that, passengers in Ankara tend to board faster than other cities. In the model, all examined bus types had negative influences on boarding times (coef. =-0.856, P = 0.000 for Bus_Type_2; coef. =-1.479, P = 0.000 for Bus_Type_3; coef. =-0.801, P = 0.000 for Bus_Type_4; coef. =-0,817, P = 0.000 for Bus_Type_5). Among them, Bus_Type_3 (single unit without step) variable had the highest and negative coefficient. It means passengers can board this type of bus in shorter durations according to the other type of busses.

5. Conclusions and suggestions

In Turkey, bottlenecks in the traffic flow may be resulted from the delays in the boarding operations at crowded bus-stops and create intense stresses on the bus drivers because of the scheduling of the bus operations in which the bus drivers must obey. This stresses influence the behaviors of the bus drivers and force them to finish the boarding operation sooner so the frequencies of the accidents during the boarding operations may increase. The dwell times of the buses which is the time elapsed between the approach and leaving of a bus to a bus-stop is important not only for corresponding drivers but also the passengers waiting at the bus-stops. This emerging difficulties and problems in the boarding operations may result accidents at the time of boarding and alighting an even while the vehicle is in traffic flow. In the scope of this study, the lengths of the boarding times of various passenger types were investigated. The results of the field observations and corresponding analyses showed that, among the passenger types, passengers with strollers had the longest boarding time and typical passengers had the shortest boarding times. As the vehicle types were compared in manner of ease of boarding, the most advantageous vehicle types were determined as single unit bus without steps for shorter boarding durations. The outcome of the observations and analyses showed that, the authorities and decision

makers should consider the buses without door steps for the new bus purchases to decrease the problems related with boarding operations. The results also indicated that, not only the vehicle types but also the passenger characteristics were also important for the performances of the boarding operations. The cases of Gümüşhane and Antalya cities also demonstrated a good example for supporting this phenomena. With comparing the boarding times for these two cities considering a single vehicle class of midibuses, it was concluded that boarding operations were directly influenced by regional and provincial differences among the passengers characteristics because the boarding times were found to be significantly higher in Gümüşhane compared with the Antalya except the passenger class with strollers. According to obtained results, the following suggestions were recommended to decrease the boarding times and minimize its influences on the traffic flow especially at bus-stops without approach bay.

- Low statue buses without any door steps should be utilized.
- Passengers with strollers should have boarding priority and suitable spaces must be attained to them inside the buses.
- The number of the bus-stops should be optimized while considering the trip frequencies and the number of passengers waiting at the bus-stops.
- Similar to many research areas in civil engineering [16] optimization studies are involved in planning the transportation systems. A continuous optimization operation should be implemented for considering the trip times to minimize the number of passengers waiting at the bus-stops.
- Most effective bus-stop types should be evaluated by considering the climatic and environmental characteristics of the cities for assuring a safety and comfortable boarding and alighting operations.
- Approaching bays should be constructed at the road sides in which the bus-stops are located and the proper utilization of these bay should be guaranteed by the bus drivers.
- Necessary studies and awareness programs should be carried out for increasing of the awareness for boarding priorities of the passengers with strollers. Also additional awareness programs should be initialized for training the other passengers and rise the awareness among them for helping the passengers with strollers and the passengers with disabilities.

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