

1 **CARPOOLING BETWEEN CAMPUSES: CASE STUDY OF BOGAZICI**
2 **UNIVERSITY**

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20 Word count: 3379 + 7 Figures + 7 Tables = 6879 words

21 Abstract: 185 words

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Paper Submitted for Presentation and Publication at the
Transportation Research Board's 96th Annual Meeting, Washington, D.C., 2017
Submission Date: August 1st, 2016

1 ABSTRACT

2 Carpooling strategies have become important for sustainable transportation and environment.
3 There have been numerous studies about carpooling for commuting to universities. In this paper,
4 a new possible carpooling scheme was proposed for the trips between four campuses of Bogazici
5 University in Istanbul, Turkey, and responses were collected. The four campuses are within
6 walking distance to each other and have shuttle services between them. However, the shuttle
7 services can become very crowded at certain times of the day. Hence, to solve this problem,
8 vehicles belonging to the university administration are suggested to be carpool for the individuals
9 in the university, as the administrative personnel make trips between the campuses. An internet-
10 based survey was conducted with the individuals in the university. The individuals were grouped
11 as academic personnel, administrative personnel and students. The responses indicated a positive
12 response from all individual groups in the university, and especially from the students. It was also
13 found that each individual group had different inter-campus trip characteristics than each other.
14 The recommendation is that this service should be implemented at certain times of the day between
15 two of the four campuses.

16 *Keywords:* Carpooling, University, Campus Trips, Students.

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1 INTRODUCTION AND BACKGROUND

2 Creating a sustainable transportation system for university campuses is one of the main goals for
3 a better and more accessible campus environment for all students and employees of a university.
4 With the increasing number of private vehicles in cities, carpooling is a choice that can be
5 beneficial for the students by creating a new mode of transportation that is both sustainable and
6 economic.

7 Carpooling and carsharing terms are different from each other and should not be confused
8 (1). Carsharing is a service to carpool with others for a certain fee while carpooling is simply
9 sharing rides with others in personally-owned vehicles (2). Casual carpooling is defined by Chan
10 and Shaheen (3) as a user-run, informal type of ad-hoc ridesharing. It can be formed by three or
11 more travelers per vehicle, including both the driver and the passengers. It is also highlighted that
12 ridesharing is non-profit; therefore, taxis and jitneys are excluded.

13 General carpooling initiatives are popular in United States (4). For example, there are about
14 638 ride-matching services in USA and Canada, characterized by merging of internet, mobile
15 phones and social networking into these services (5). Having the advantages of time and cost
16 benefits for participants with having access to high-occupancy vehicle (HOV) lanes with often
17 tolling discounts, decreasing number of automobiles travelling during peak periods causing
18 reduced congestion, greenhouse gas emission and vehicle delays, carpooling is becoming a more
19 preferred transportation mode for the travelers. Similarly, flexible carpooling is the most cost
20 competitive mode for travelers. Its key factor is the quality of existing mode choices. Should the
21 traveler use public transport and this mode has poor connectivity, then flexible carpooling becomes
22 much more attractive to the travelers. With the availability of HOV lanes in cities where high
23 levels of congestion is present, single occupant vehicle (SOV) drivers would be much more
24 attracted to flexible carpooling (6). This need to reduce the SOV usage was also stressed by
25 Vanoutrive et al. (7). Furthermore, in that study which was made in Belgium, it was found that
26 carpooling was a popular option for trips to workplaces, especially from locations where the
27 accessibility is lower. In addition, sociodemographic and household auto ownership play an
28 important role in carpooling (8). It should also be noted that through the reduction of the SOV
29 trips, carpooling would be beneficial to the environment. Erdogan et al. (9) stressed that
30 establishments need to have alternative transportation options such as carpooling in order to lower
31 the greenhouse gas emissions.

32 On the other hand, campuses are different than other communities because the daily
33 activities are not the same as that of residential and commercial areas (10); and they can be
34 considered as special trip generators (11). Thus, trips to universities are different from general
35 transportation patterns, because students have significantly different travel behaviors and
36 sociodemographic characteristics from the general population (12). This situation can be turned
37 into a great advantage but in the last decade, campus planners in the United States have been
38 struggling to provide access and mobility without destroying campus qualities as distinct
39 communities. While converting the general use of personal vehicles into bicycle use or wayfaring,
40 the carpooling system can aid the goal of creating a sustainable campus and transportation system
41 (10). It was found out by Tezcan (13) that the respondents are generally willing to consider
42 passenger car pooling for commuting to campus. Also, Akar (14) has found with their survey made
43 in Ohio campus that 40% of the participants would be interested in a carpooling program both as
44 a passenger or as a driver. Interestingly, Erdogan et al. (9) investigated the characteristics of the

1 individuals who would carpool to and from the university campus, and found that the
2 characteristics and willingness to carpooling were different between passengers and drivers.
3 Furthermore, Deakin et al. (4) studied the potential of dynamic carsharing in UC Berkeley Campus
4 in California, and found that employers of UC Berkeley had a higher preference rate of carsharing
5 than UC Berkeley graduate students. Similarly, Miralles-Guasch and Domene (15) revealed that
6 students and personnel had different trip patterns in campuses. Hence, it can be inferred that
7 different individual profiles might have different carsharing preferences and patterns in a campus.
8 The carsharing preferences might also be different between on-campus and off-campus residents
9 as well because their trip rates are not the same (11).

10 Considering the fact that carpooling is a popular mode of transportation and the issues
11 given above, carpooling is aimed to be introduced to the individuals in Bogazici University for the
12 trips between the campuses. This mode of transportation is the carpooling of vehicles which are
13 owned by the university administration and used by some of the administrative personnel for work
14 purposes such as food delivery to security personnel. The number of those vehicles are 20, which
15 would significantly contribute to the mobility of the individuals in the university as well as the
16 sustainability of the campus. When those properties are taken into account, this service contributes
17 to the literature by differing itself from the other initiatives taken for campuses so far. It should be
18 noted that these vehicles often make trips within and among campuses when personnel needs, and
19 would offer a seat to other individuals. Carpooling of personnel vehicles will enhance the fast
20 movement of individuals when needed, and make them HOVs. Furthermore, this service would
21 help reducing the number of trips that regular shuttles, and personal vehicles if possible, make. In
22 other words, by reducing the gas emissions, this service might bring about positive effects in terms
23 of the environment as well. Also, in accordance with the findings of Deakin et al. (4), Zhou (16)
24 stated that the carsharing and carpooling characteristics of different individual groups should be
25 investigated and understood so that different promotion strategies can be developed for each group.
26 Thus, in this study, the opinions and attitudes of the individual groups for this proposed service
27 were investigated.

28 **DATA DESCRIPTION**

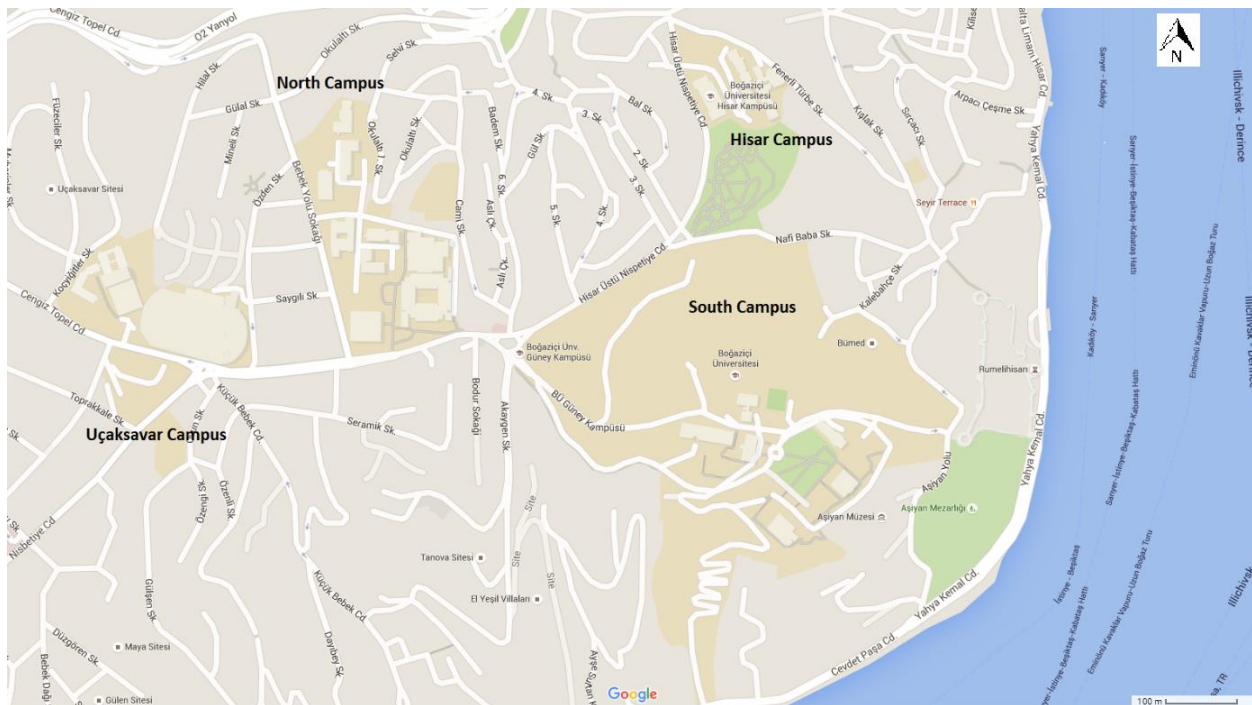
29 Bogazici University has six campuses, namely Kandilli, Kilyos, South, North, Hisar and
30 Uçaksavar Campuses. While South, North, Hisar and Uçaksavar Campuses are located in Etiler
31 district of Istanbul (Figure 1), Kandilli and Kilyos Campuses are located in Kandilli and Kilyos,
32 respectively. While there are classrooms and departmental offices in five of the six campuses,
33 Uçaksavar Campus is only used for dormitories. The campuses in Etiler district are within walking
34 distance, which can be viewed in Figure 1. Despite being very close to each other, shuttle services
35 are provided between them. They run as the vehicles fill up completely. This situation creates an
36 in-vehicle waiting time for the users. Also, there is a less-frequent shuttle service between South
37 and Kandilli Campuses (one service in every 60 minutes) because the distance between the two is
38 12 km and one has to cross the Bosphorus to access from one campus to the other. Similarly, the
39 distances between other campuses are shown in Table 1. As it can be observed, Kandilli and Kilyos
40 Campuses are beyond walking distance, thus only the campuses in Etiler district are the subjects
41 in this study.

42

1 **TABLE 1 Distances between Campuses (km)**

South						
North	0.78					
Hisar	1.21	0.88				
Uçaksavar	1.26	0.48	1.36			
Kandilli	12.04	11.26	12.14	11.43		
Kilyos	31.30	30.52	31.40	30.04	38.50	
	South	North	Hisar	Uçaksavar	Kandilli	Kilyos

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3

4 **FIGURE 1 The map of Bogazici University Campuses in Etiler district.**

5 South Campus has a hilly topography, while the remaining three campuses in Etiler district
 6 have level terrain. This is especially visible along the way between the gate and the buildings of
 7 South Campus, which have a distance of 0.5 km. Therefore, it can be said that the hilly topography
 8 affects the walks to and from South Campus.

9 There is a limited parking space available in South and North Campuses. In South Campus,
 10 the capacity of student carpark is 120 passenger cars, and the campus has a total parking capacity
 11 (for students, administrative and academic personnel) of 306 passenger cars. These parking
 12 capacities in North Campus are 122 and 224 passenger cars, respectively. However, the number
 13 of parking permits is 942 for academic and administrative personnel and 350 for students. Hence,
 14 total parking capacity in both campuses is not sufficient (17).

15 All individuals in Bogazici University were categorized into three groups: Students,
 16 academic personnel and administrative personnel. As of 2014, there are 15,684 students (88.6 %),
 17 860 academic personnel (4.9 %) and 984 (5.5 %) administrative personnel (18). Teaching and
 18 research assistants were included in the academic personnel group. A web-based survey was sent

1 to all of the students and personnel via e-mail, and a total of 1,587 completed surveys were
 2 collected. Stratified sampling was used with respect to individual groups in Bogazici University;
 3 data was collected such that the sizes of the drawn samples for each stratum were parallel to the
 4 population sizes of each group. In fact, the percentages of the stratum sizes in sample were close
 5 to that of the population: 12.0 % for academic personnel, 11.5 % administrative personnel and 76.6
 6 % for students. It should also be noted that for each stratum, simple random sampling was used.

7 The questions were about the demographics such as gender and income, role of the
 8 individual in Bogazici University (student or personnel), the campus where they study or work the
 9 most, their opinions about shuttle services, attitudes toward a possible carpooling service using
 10 personnel vehicles, ownership about parking permit, frequency of usage of the proposed carpool
 11 service between campuses and their hourly distributions.

12 Of the respondents, 52.6 % were male, 43.2 % female and 4.2 % declined to respond the
 13 gender.

14 Breakdown of the individual groups in Bogazici University over the campuses in Etiler
 15 district with respect to where they work or study mostly is shown in Table 2. It should be noted
 16 that Uçaksavar Campus was omitted from Table 2 since it is only used for dormitories, as explained
 17 before. It can be seen that most of the classes are in North campus, followed by South Campus;
 18 60.6 % and 29.3 %, respectively. On the other hand, most of the personnel work in South Campus
 19 (44.7 % of academic and 60.1 % of administrative personnel) and this is followed by North
 20 Campus (35.2 % of academic and 25.3 % of administrative personnel). Therefore, most of the trips
 21 are made between the South and North Campuses.

22
 23 **TABLE 2 Categorization of Individuals over Campuses**

	South		Hisar		North		Kandilli		Kilyos	
	Count	%	Count	%	Count	%	Count	%	Count	%
Academic Personnel	71	44.7	17	10.7	56	35.2	7	4.4	8	5.0
Administrative Personnel	95	60.1	4	2.5	40	25.3	15	9.5	4	2.5
Student	372	29.3	101	8.0	770	60.6	4	0.3	23	1.8

24
 25 **RESULTS**

26 It can be seen that on Mondays and Tuesdays, the shuttle queues have peaks at every two hours
 27 from 11:00 AM until 5:00 PM, except the peaks are longer at noon due to lunch time (Figure 2).
 28 This pattern is also similar on Thursdays but on Wednesdays, the shuttle service has the widest
 29 peak from around 12:00 PM to 3:00 PM. On Fridays, the peaks are more frequent but few people
 30 use the shuttle service until 12:00 PM. These differences can be due to the different weekly
 31 distributions of classes.

32 Table 3 shows the percentages of the respondents' opinions about the sufficiency of the shuttle
 33 services in campuses. As it can be observed, only 31.6 % of the respondents thought that the
 34 aforementioned services were sufficient. When these percentages are investigated for each
 35 individual group, students are the least satisfied group with only 27.2 % positive responses, while
 36 administrative personnel are the most satisfied with 51.3 % positive responses. It can be assumed

1 that this could be due to less frequent travel needs of the administrative personnel between
2 campuses. Nevertheless, the lack of satisfaction among the students may suggest that additional
3 means of transport may be needed between campuses; in this case, the personnel vehicles. This
4 suggestion is also supported by the fact that the queue lengths in South Campus shuttle stop are
5 significantly long (Figure 2).

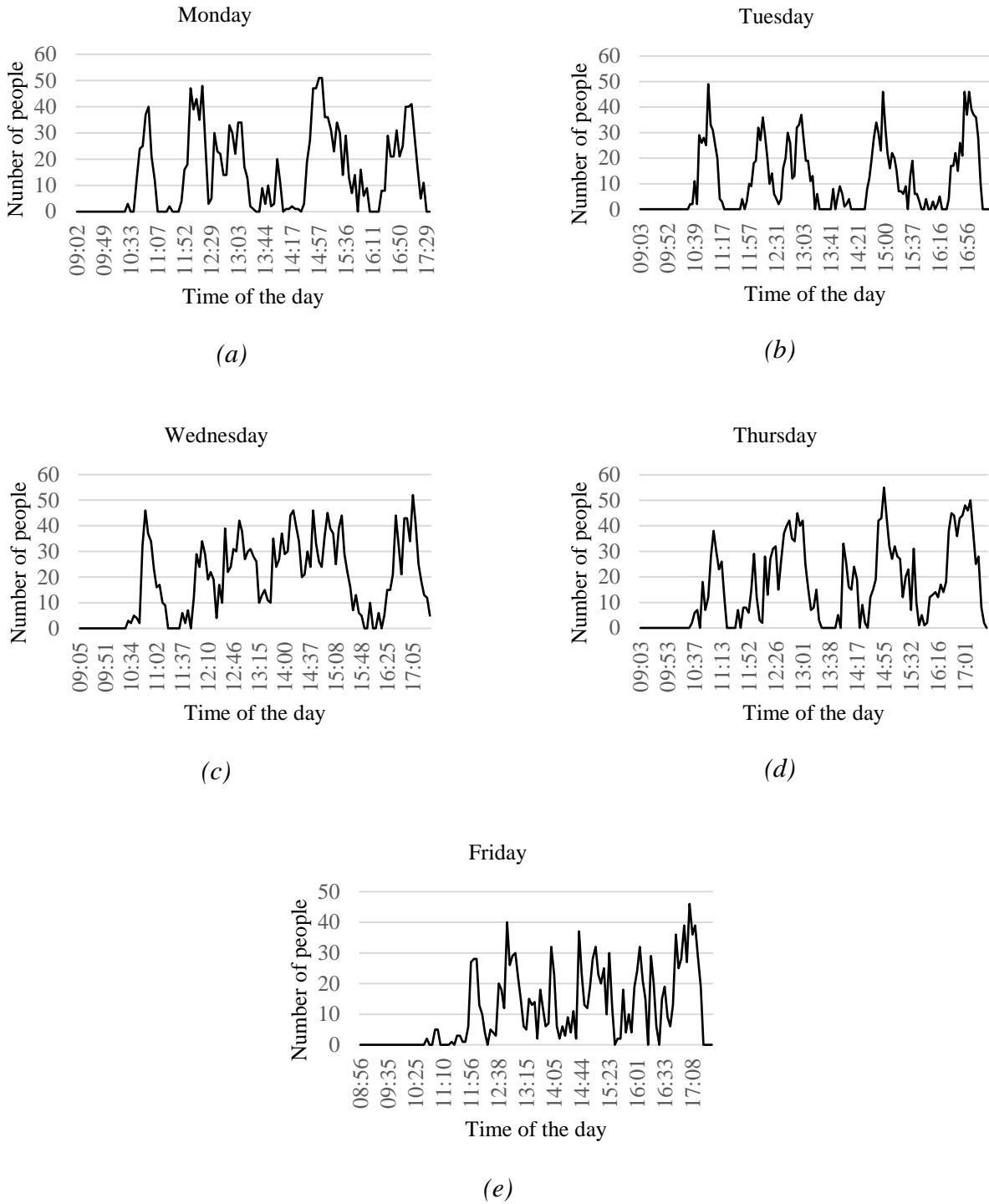


FIGURE 2 Hourly distributions of shuttle queues for each weekday in South Campus (17).

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TABLE 3 Responses Regarding Sufficiency of the Shuttle Services

		Frequency	Percent (%)
Academic Personnel	Positive	35	29.6
	Neutral	52	44.1
	Negative	31	26.2
	Total	118	100
Administrative Personnel	Positive	58	51.3
	Neutral	33	29.2
	Negative	22	19.5
	Total	113	100
Student	Positive	205	27.2
	Neutral	218	28.9
	Negative	332	44
	Total	755	100
Overall	Positive	615	38.7
	Neutral	471	29.7
	Negative	501	31.6
	Total	1,587	100

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Opinions about the introduction of the carpooling of the personnel vehicles are shown in Table 4. It can easily be inferred that most of the respondents are interested in carpooling between campus trips, and students are the mostly interested, as expected. One interesting fact is that administrative personnel are the least supportive on the carpooling idea, with 26.6 % positive responses. It can be assumed that some of the personnel who uses the vehicles subject to carpooling could be unwilling to share them, and this could be the reason behind the higher rate of negative answers. Total number of negative responses out of 1,587 observations for carpooling is 180, just 11.3 %.

1

TABLE 4 Opinions about the Introduction of Carpooling

		Frequency	Percent (%)
Academic Personnel	Positive	119	74.9
	I have no idea	14	8.8
	Negative	26	16.3
	Total	159	100.0
Administrative Personnel	Positive	102	64.6
	I have no idea	14	8.9
	Negative	42	26.6
	Total	158	100.0
Student	Positive	1,108	87.2
	I have no idea	50	3.9
	Negative	112	8.8
	Total	1,270	100.0

2

3 Parking permit status of the respondents was tested against the opinions about carpooling
4 of personnel vehicles. This was done using chi-squared test, and the test statistic of 6.003 the
5 significance of 0.014 implies that parking permit ownership did affect the opinion on carpooling
6 with 5 % level of significance. As it can be seen in Table 5, rate of accepting carpooling is lower
7 (72.3 % compared to 87.2 %) for the respondents who has parking permit. This can be expected
8 because these respondents may opt to use their own vehicles between campuses. It should be noted
9 that there are many individuals who do not own a car, hence, they are omitted in Table 5. Similarly,
10 individuals who have responded for carpool opinion as “Neutral” were not used in Table 5. So, the
11 sum of row percentages may not be equal to 100 %.

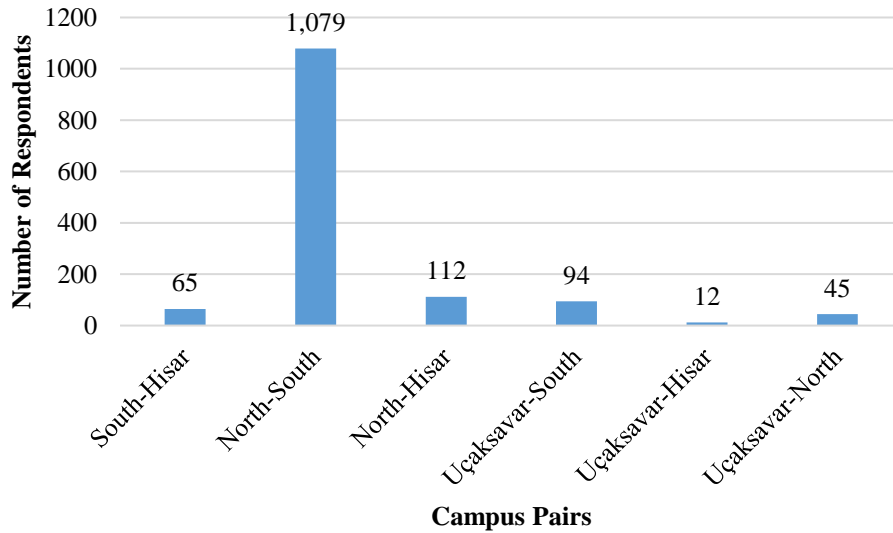
12 When the effect of parking permits on carpooling opinions is investigated for each
13 individual type, it can be observed in Table 5 that students have the highest positive opinion. Out
14 of 147 students who have a car, 100 of the students do not have a parking permit whom have the
15 highest demand for carpooling of personnel vehicles. The same demand can be said for the students
16 who have a parking permit as well, 82.4 % of them are thinking positively about the proposed
17 carpooling service.

18

1 **TABLE 5 Effect of Parking Permit on Carpooling Opinions**

			Positive	Percent	Negative	Percent
Parking Permit	No	Academic Personnel	2	50.0	2	50.0
		Administrative Personnel	1	50.0	0	0.0
		Student	92	89.3	8	7.8
		Overall	95	87.2	10	9.5
	Yes	Academic Personnel	60	74.1	13	16.0
		Administrative Personnel	31	59.6	17	32.7
		Student	42	82.4	5	9.8
		Overall	133	72.3	35	19.0

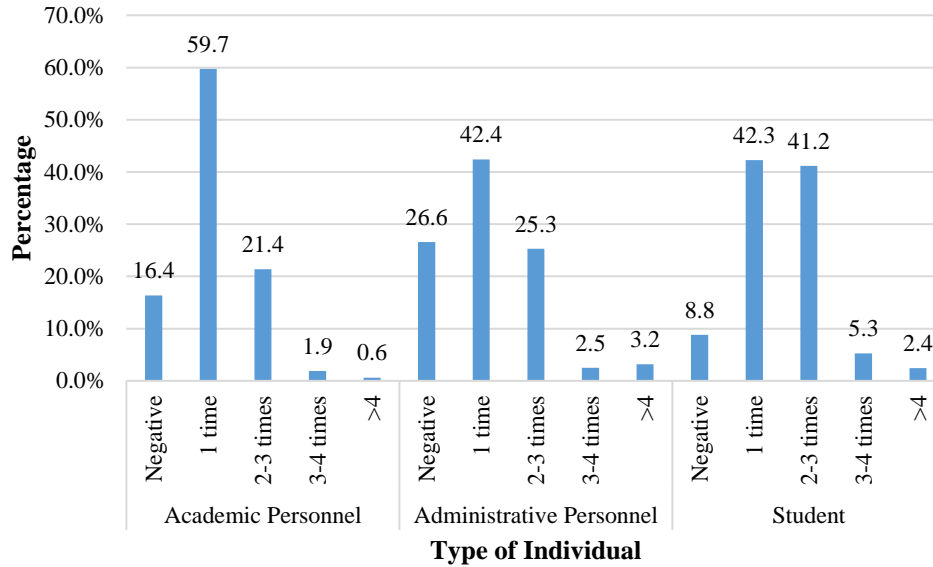
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3 Other than the 180 respondents who are against carpooling, remaining 1,407 respondents
4 who are not negative towards carpooling were asked about the preferred campus pairs between
5 which the carpooling service would be implemented. In Figure 3, it can be observed that the
6 proposed carpooling services of administration vehicles are mostly wanted between South and
7 North Campuses with 1,079 responses as they are the most populous campuses.



8
9 **FIGURE 3 Distribution of the responses for the proposed carpooling services between**
10 **campus pairs.**

11 About the frequencies of usage of the proposed carpooling services' during one day, Figure
12 4 shows that people would prefer to use the service mostly 1 time in general, but there are also
13 students who prefer to use the service between 2-3 times nearly as many as the students who would

1 use 1 time (41.2 % and 42.3 %, respectively). Thus, it can be deduced that the higher demand is
 2 from the students, which can be expected as the classes vary between campuses.



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FIGURE 4 Frequencies of carpool service usage.

5 When the frequencies of carpool service usage between the campus pairs were investigated,
 6 as shown in Table 6, it was observed that the highest frequency is between 1 and 3 times a day,
 7 from North to South Campus and vice versa. This high frequency between two campuses is
 8 understandable as the South Campus has a hilly terrain and after the North Campus it is the second
 9 most crowded one, as shown in Table 2. There is also a considerable frequency between
 10 Uçaksavar-South and North-Hisar Campuses. However, the demand between Uçaksavar and Hisar
 11 Campuses is rather low (12 trips per day).

12

TABLE 6 Frequencies of Carpool Services between Campus Pairs

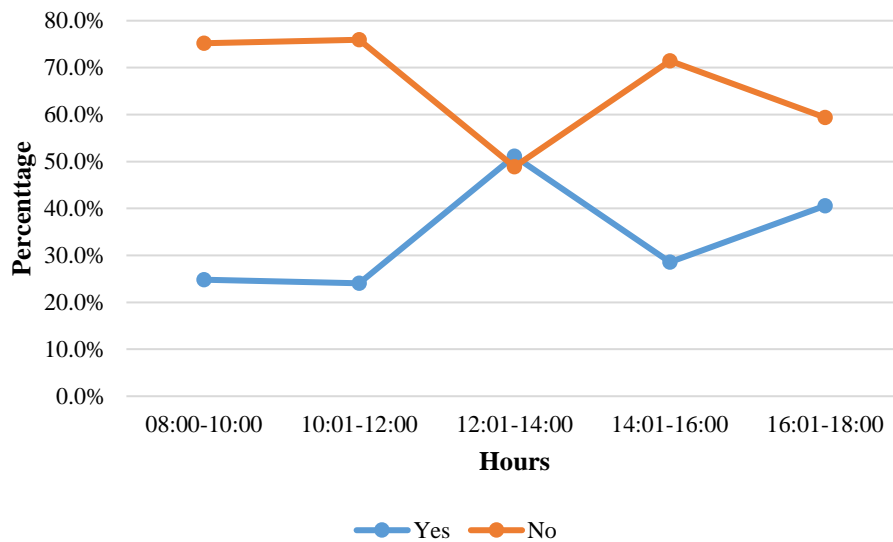
	1 time	2-3 times	3-4 times	>4 times
South-Hisar	27	32	5	1
North-South	581	433	39	26
North-Hisar	39	55	12	6
Uçaksavar-South	33	47	11	3
Uçaksavar-Hisar	5	7	0	0
Uçaksavar-North	14	23	7	1

13

14 The distribution of the demanded frequencies over the time-of-day is also considered to be
 15 important. A day was assumed to be between 08:00 AM and 6:00 PM because of the working
 16 hours. Normally, the regular working hours are between 09:00 AM and 5:00 PM, but one extra
 17 hour was added before the start and after the end of the day. This is because some of the students
 18 may opt to travel between the campuses at these extra hours.

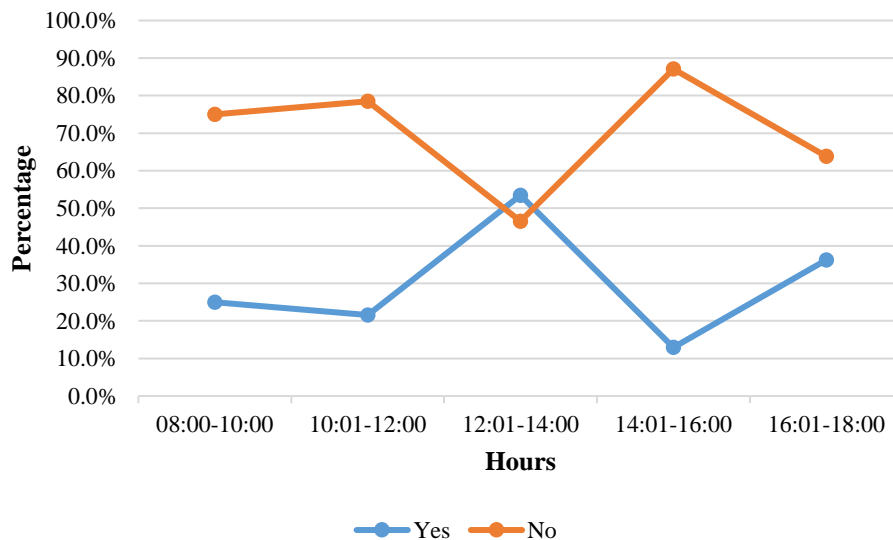
19 The demand with respect to time-of-day is different between each group in Bogazici
 20 University. From Figure 5 and Figure 6, it can be seen that for academic and administrative

1 personnel, the number of respondents replied as “Yes” for carpool usage exceeds the number of
 2 “No” answers only between 12:01 PM and 14:00 PM. This makes sense because of the lunch
 3 break, and the dining halls in the campus are located in South and North Campuses, and apparently,
 4 personnel make trips between the campuses for lunch break. Furthermore, in the afternoon,
 5 demand of the academic personnel for the carpooling service is higher than of the administrative
 6 personnel. This can be expected as the former may travel between campuses for classes. It should
 7 also be noted that, as explained before, personnel have a demand mostly for one trip between the
 8 campuses.



9

10 **FIGURE 5 Change of carpool demand over the day for academic personnel.**

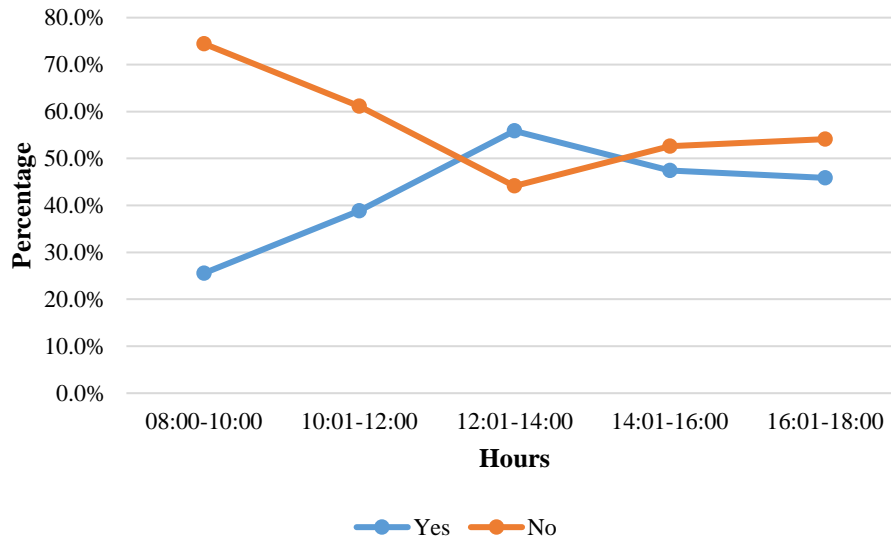


11

12 **FIGURE 6 Change of carpool demand over the day for administrative personnel.**

13 However, the situation is different for students. Even though the difference between “Yes”
 14 and “No” answers for the proposed service is similar to the personnel, the demand is higher during
 15 the rest of the day than of personnel, as it can be seen in Figure 7. This is more visible in the

1 afternoon, even though the number of “No” answers is higher, the difference between “Yes”
 2 answers is small (approximately 55 % to 45 %). This is logical because the students change
 3 campuses for classes, like the academic personnel. The only difference is that students attend more
 4 classes than academic personnel do in different campuses, and academic personnel have higher
 5 percentage of parking permit; which allows them to travel with their own cars.



6
 7 **FIGURE 7 Change of carpool demand over the day for students.**

8 Probable origin-destination (OD) table of the campus trips using the proposed carpooling
 9 service was also obtained from the study, and is shown in Table 7. The table was obtained by
 10 summing all respondents' number of trips per day between all campus pairs. As expected with the
 11 help of information from Table 6, most of the trips are between North and South campuses,
 12 whereas the lowest passenger flow is between Hisar and Uçaksavar Campuses (na = not
 13 applicable).

14 **TABLE 7 OD Table of the Campus Trips**

	North	South	Hisar	Uçaksavar
North	na	2,085	311	439
South	2,198	na	266	267
Hisar	307	258	na	73
Uçaksavar	444	258	71	na

15

16 CONCLUSIONS

17 In this study, the potential of using a carpool service for the trips between the four campuses of
 18 Bogazici University was investigated. The highlighting point of this proposed service is that the
 19 vehicles owned by university administration are to be used, and the service would be free of charge.
 20 The important result of this study is that the proposed service would introduce an innovative
 21 carpooling service which seems to be welcomed by the individual groups.

1 It was found that there is a demand for the proposed carpooling service. However, that
 2 demand is different between individual groups in the university; academic personnel,
 3 administrative personnel and students. Zhou (16) has recommended that the demand for carpooling
 4 service should be investigated between different individual groups. The demand of students is the
 5 highest, which is expected because students are likely to have classes in different campuses during
 6 the day. The administrative personnel have the lowest demand which may stem from the
 7 unwillingness of the personnel to share the vehicles which they regularly use due to work purposes.
 8 Another reason can be the fixed office location of the administrative personnel, and thus, a lower
 9 need for travel between campuses. Still, none of the individual groups had negative answers for
 10 carpooling idea more than positive responses, and the general consensus is positive.

11 Nevertheless, the service should be introduced only at certain hours of the day, potentially
 12 between 12:00 PM and 4:00 PM. Of this four-hour window, the first two hours have the most of
 13 the demand while the second two hours have the demand of the students mostly. Furthermore, the
 14 service should be introduced between South and North Campuses, where the demand is the
 15 highest. This service might reduce the queues in South Campus shuttle stop during the lunch break.

16 It should be noted that this carpooling policy will not affect the campus traffic flow
 17 negatively. This is because the personnel vehicles are already present in the campus traffic, have
 18 dedicated parking slots and will be carrying individuals of the university during their regular trips
 19 between campuses. Hence, they will not create additional traffic. In fact, it will have a positive
 20 effect, because some individuals will probably prefer carpooling between campuses instead of
 21 using their own car.

22 The next step for introduction of this service would be the development of the policy for
 23 this service with the university administration. This should be followed by the repetition of this
 24 study for other universities with a similar campus structure to Bogazici University, or with large
 25 campuses which allow intra-traffic and has departments located with large distances from each
 26 other. A further step could be the development of trip generation models once the service is
 27 introduced, and determination of the forecasts.

28 29 **ACKNOWLEDGEMENTS**

30 The authors would like to thank Bogazici University administration for granting permission to
 31 conduct this study in the campuses and all respondents.

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