Transportation Research Record

Transportation Network Company Service Usage in the University Community: Service Adoption, Usage Frequency and Service Type Choice

--Manuscript Draft--

Full Title:	Transportation Network Company Service Usage in the University Community: Service Adoption, Usage Frequency and Service Type Choice
Abstract:	Transportation Network Company (TNC) services have grown exponentially in recent years in terms of both, ridership, and business models. The TNC growth has outpaced the capacity of cities to oversee their operations, with many unprepared to deal with the consequences of this growth in terms of increase in congestion, and impact on other transportation services (e.g. transit). Though many studies performed surveys to understand TNC service usage behavior and their impacts on other modes for general population, very few studies focused on TNC usage of the university community. This paper presents a web-based survey study on the university community TNC usage behavior, including TNC service adoption, usage frequency and choice of TNC service types. The behavior was explored using both descriptive and cluster analysis techniques. The descriptive analysis on service adoption and frequency highlights the importance of income, car and bike ownership, age and status. Analysis regarding selection of TNC service type also indicates the importance of socio-demographic factors including age, status, regular commuting mode, membership in car or bike sharing, car ownership, and income. Trip attributes such as distance and cost per person, as well as destination type also influence people's selection of different TNC service types. Cluster analysis based on users' sociodemographic characteristics is used to characterize the different TNC usage behaviors. Groups with higher income, age, bike and car ownership, tend to adopt TNC services less frequently. They also adopt pool service less. Lower income, age and bike/car ownership groups as well as groups with higher membership in shared mobility services adopted TNC services more and also preferred pool services more.
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ABSTRACT

Transportation Network Company (TNC) services have grown exponentially in recent years in terms of both, ridership, and business models. The TNC growth has outpaced the capacity of cities to oversee their operations, with many unprepared to deal with the consequences of this growth in terms of increase in congestion, and impact on other transportation services (e.g. transit). Though many studies performed surveys to understand TNC service usage behavior and their impacts on other modes for general population, very few studies focused on TNC usage of the university community. This paper presents a web-based survey study on the university community TNC usage behavior, including TNC service adoption, usage frequency and choice of TNC service types. The behavior was explored using both descriptive and cluster analysis techniques. The descriptive analysis on service adoption and frequency highlights the importance of income, car and bike ownership, age and status. Analysis regarding selection of TNC service type also indicates the importance of socio-demographic factors including age, status, regular commuting mode, membership in car or bike sharing, car ownership, and income. Trip attributes such as distance and cost per person, as well as destination type also influence people's selection of different TNC service types. Cluster analysis based on users' sociodemographic characteristics is used to characterize the different TNC usage behaviors. Groups with higher income, age, bike and car ownership, tend to adopt TNC services less frequently. They also adopt pool service less. Lower income, age and bike/car ownership groups as well as groups with higher membership in shared mobility services adopted TNC services more and also preferred pool services more.

Key words: Transportation network company (TNC) service, university community, service adoption, usage frequency, choice of service types, clustering analysis

INTRODUCTION

TNCs have grown exponentially in recent years, in terms of ridership, and business models. It took Uber almost 6 years to reach its first 1 billion rides, but only 6 months for the next billion. In 2018, 42,201,375 TNC rides started in Boston municipality, with 68.33 rides per person. Rides increased by 21% from 2017, according to the Department of Public Utilities (DPU) of Massachusetts (1). SFCTA reports that TNCs are responsible for half of the increase in congestion in San Francisco from 2010 to 2016 (while employment and population growth contributed the other half). It also finds that TNCs account for an estimated 25% of the total congestion in the city and 36% of the delay in the downtown area. On a typical day they add 170,000 vehicle trips and more than 570,000 VMT. They contribute to congestion at all times of day, especially in the evenings.

At the same time, many transit systems experience reduction in ridership in recent years, especially for buses. This decline is partially attributed to direct competition from TNCs. CTA for example, is reporting that the decline in ridership is partly caused by competition from ride hailing companies like Uber and Lyft (2). Equally alarming is the decline in student ridership. MTA reported a 12.7% decline in student ridership in buses in 2018 (3).

A number of studies in the literature have used surveys to explore the impact of TNCs on traditional transportation modes (e.g. transit) and the transportation system as a whole. Feigon et al. (4) explored the usage of TNC services and TNC's relationship with public transportation and concluded that the more people use shared modes, the more likely they are to use public transportation, own fewer cars, and spend less on transportation overall. Hall et al. (5) studied Uber's effect on public transportation and pointed out that Uber can contribute to increase in congestion due to increased trip numbers and by putting more drivers onto streets.

Many studies explored the factors affecting people's usage of TNC services. Alemi et al. (6) investigated factors affecting people's adoption and frequency of TNC services by analyzing data from surveys conducted in California. Alemi et al. (7) also indicated that sociodemographic variables could only be used to predict adoption rate for TNC on-demand services, but not frequency of TNC services usage because of their coarse description of frequency questions in their surveys. The survey presented subjects with only three options in TNC usage, 'never used', 'use less than once a month' and 'use at least once a month'.

They also emphasized the significance of car ownership on adoption of TNC services. In another study, Alemi et al. (8), further confirmed that land use characteristics and activity density could be used for frequency prediction. Chu et al. (9) proposed a multinomial logit model to study the factors affecting people's adoption of TNC services. Age, income and car ownership were significant factors behind adoption.

Unlike studies investigated the factors explaning the adoption of TNC services or frequency, not much has been reported on the specific TNC service types that are used. For example, Uber provides standard, pool and other services for passengers. With the standard service, passengers will not share a ride with other passengers (unless they come in a group). With Uber's pool service, passengers may share the ride tiwh other passengers at the benefit of a lower fare (10). Pooling services most likely increase travel time. Because of the nature of the standard and pool services, it is important to differentiate them when exploring TNC services usage and adoption behavior.

For many U.S. cities, the campus population is an important component of the city. For example, there are 138,180 students enrolled in colleges or universities (11) in the Boston area therefore important to better understand their TNC usage behaviors in order to design effective strategies. A relevant study by Tarabay et al. (12) looked at factors affecting university students' choice of Uber or other TNC services for social and recreational trips. The results showed that fare is a significant facotr. However, the research did not explore much on people's demographic information and its impact on ride-sourcing adoption.

This study focuses on the university population's TNC usage behavior, including service adoption, frequency, and the type of TNC service they use. A web-based survey was designed and conducted at Northeastern University Boston. 1985 valid responses were collected and analyzed. The rest of the paper is organized as follows: Section 2 introduces the survey. Section 3 discusses results for people's TNC service adoption, frequency and specific type of services being used. Section 4 concludes the paper.

SURVEY DESIGN AND IMPLEMENTATION

To explore the TNC usage behavior in terms of service adoption, frequency, and choice of service types, the survey has 4 major parts, commute to school or work, TNC preferences, TNC experience, and demographic information.

- **Commute to school or work**. In this part respondents were asked about their daily commuting to school or work, transportation modes used, frequency, parking availability and means of payment if they used public transportation.
- **TNC preferences**. Respondents were asked about their TNC service preferences, frequency, attitude towards TNC services, service type preference, willingness for sharing ride with others, and willingness to walk to a pick-up/drop-off location.
- **TNC experience.** Respondents were asked about their most recent TNC trip. Type of service they used, number of people in their party, number of sharing passengers in the car in addition to their party, wait time, origin location characteristics, destination location characteristics, time of day, mileage, trip length, and other modes they would consider.
- **Demographic information**. Respondents status and standard sociodemographic information was collected.

The survey was developed on the Qualtrics online survey platform. The survey was distributed to undergraduate and graduate students, staff, and faculty in the College of Engineering and College of Computer Science of Northeastern University. The survey was administered in the Spring 2019.

ANALYSIS

A. TNC Service adoption and usage frequency

Figure 1 shows the distribution of TNC service adoption and usage frequency of all respondents. 90% of respondents adopted the TNC service. Most people use 1-3 times per month (~ 60%), while around 5% of the respondents use more than 4 times a week. This may reflect that the respondents may not use TNC as the main mode for commuting purpose, but mainly used for other activities, such as recreation.

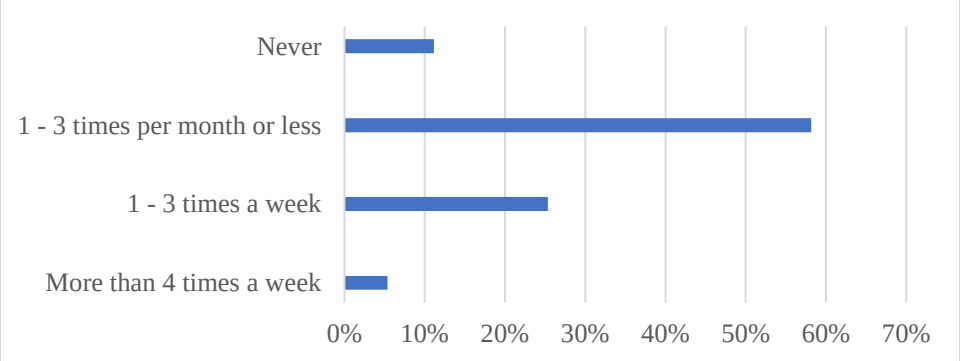

Figure 1 Distribution of respondents' TNC service adoption and frequency

For discussion convenience, we define the group of users as High (> 4 times a week), Medium (1-3 times per week), Low frequent (1-3 times per month or less) and Non-users based on their service usage frequency. Table 1 lists significant variables impacting users' TNC service adoption and usage frequency.

- Age has a significant impact on TNC service adoption and usage frequency. The percentage of service adoption decreases with the increase of the age, for example, around 89% of people with age between 22 and 34 use TNC services, while the figure drops to 52.8% for the group with age >45. It also highlights that the respondents with age between 18 and 34 have very similar TNC service usage patterns with 58% are low frequency users, 24-28% are medium frequency users, and 4.8-6.0% are high frequency users.
- Similar patterns are observed for different occupation groups, since the occupation is highly correlated with ages for University community respondents. Faculty and staff have the highest percentage of non-user, and the lowest percentage of medium and high frequency users. Interestingly, the part-time graduate students, who are also mostly below age of 34, have high percentage of non-user and also the highest percentage of high frequency TNC service usage (10.2%). Some other personal characteristics such as income could be contributing factors.
- For membership and car ownership, people with private cars have the highest non-user rate (18.7%), while people with car-sharing or bike sharing membership expressing the lowest non-user percentage and the highest medium and high frequency usage ratio. Transit subscription membership could also slightly lower the service adoption and usage frequency rate.
- The impact of income on service adoption fluctuates, though generally the higher income leads to less use of TNC services when the income is above $60, 000 per year. And user group with income 60, 000 – 75, 000 per year has the highest percentage of non-users (23.2%). Medium and high frequency usage percentage decreases for higher income groups compared to those with lower or no income.
- Interestingly, users' daily commuting behavior also impacts their adoption and usage frequency of TNC services. Walking commuters have the lowest non-user percentage (6.8%), and they also have large high (5.5%) and medium frequency users (29.6%). Driving commuters tend to not use TNC services. Female users are prone to use TNC services than male users, and also they use the TNC more frequently than male users.

TABLE 1 TNC service adoption and usage frequency

Variable Name	Low frequency	Medium frequency	High frequency	Non-User
Age Groups				
Age > 45	44.4%	6.9%	1.4%	47.2%
Age > 35 and < 44	60.9%	12.5%	1.6%	25.0%
Age > 22 and < 34	58.8%	24.2%	6.0%	11.0%
Age > 18 and < 21	58.4%	28.2%	4.8%	8.7%
Status				
Faculty and staff	56.3%	13.0%	3.1%	27.6%
Undergraduate Students	57.5%	28.4%	5.3%	8.8%
Part-time Graduate Students	42.9%	26.5%	10.2%	20.4%
Graduate Students	60.1%	23.5%	5.1%	11.4%
Membership or Ownership				
MBTA_PASS	59.7%	23.1%	4.6%	12.6%
Car Ownership	59.5%	19.0%	2.8%	18.7%
Sharing Mode Membership	56.2%	28.7%	7.9%	7.2%

Annual Income				
Low Income	58.7%	26.5%	5.3%	9.4%
income > $30000 and < $44999	54.8%	26.6%	6.5%	12.1%
income > $45000 and < $59999	55.3%	22.4%	10.6%	11.8%
income > $60000 and < $74999	47.8%	24.6%	4.3%	23.2%
income > $75000	61.1%	18.5%	1.9%	18.5%
Regular commute type				
commute to school: bike	66.2%	19.1%	1.5%	13.2%
commute to school: PT	60.3%	21.4%	3.1%	15.3%
commute to school: walk	58.1%	29.6%	5.5%	6.8%
commute to school: drive	59.0%	14.0%	3.9%	23.0%
commute to school: PT combination	57.5%	17.9%	7.5%	17.0%
commute to school: Carpool	67.5%	15.0%	5.0%	12.5%
Gender				
Male	60.5%	21.6%	4.4%	13.5%
Female	55.2%	29.9%	6.3%	8.6%
Other gender	56.3%	12.5%	12.5%	18.8%

B. Users' Choice of TNC Service Types

TNCs, like Uber and Lyft, provides alternative services with different level of service and cost, such as Standard (taxi-type), Uber Pool (sharing rides), Express Pool (sharing rides with walking), and XL, etc. By analyzing the last trip information on the service types that the respondents used, users' choice of TNC service types are identified.

Figure 2 shows the distribution of user choice of TNC service types for all respondents in the survey. It shows that most of the respondents (58%) used the standard service (taxi type of service with no trip sharing). The sharing trip users, including pool/shared or walk for a ride, is around 37%, which can be regarded as users' willingness to share. Considering the operation constraints in practice, the actual percentage of sharing trips could be even lower.

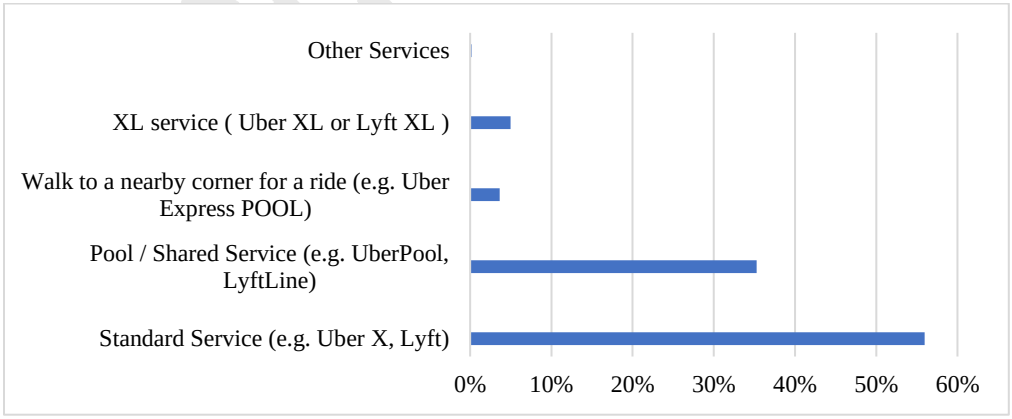

Figure 2 Distribution of users' choice of TNC service types

Table 2 shows users' choice of TNC service types with respect to impacting variables. Three types of services are analyzed, including pool service, standard service and other services. The main findings are summarized as follows:

- Pool services adoption rate is very low for respondents with age above 45 (7.7%). The younger the respondents are, the higher rate that they will use pool service. Most of the age groups use standard service more than the pooling services, except the group with age between 22 and 34. In that group, the ratio of pooling (41.4%) and standard service usage (50.4%) is close.
- Most users in faculty and staff group use standard service (76.1%). Undergraduate students and part-time graduate students have similar service type preference. Interestingly to see is that the full-time graduate students used the pool services (47.6%) as many as using the standard services (45.1%).
- Daily commuting modes also contribute to users' choice of TNC service types. People using bike, public transportation (PT), Uber or Lyft and walking for commuting tend to have a higher rate of choosing pool service for their last trip. People who usually drive to work or school are less likely to choose pool service.
- For membership and ownership, people with private car are less likely to adopt pool service compared to people with sharing mobility membership or public transportation pass.
- Annual income is another important factor for people choice of TNC services. For respondent with income higher than $ 30, 000 per year, the possibility that they will choose to use pool service in the last trip decreases with the increase of annual income increases. The percentage users choosing standard service increases dramatically with increasing incomes. No significant impact was found for income lower than $30, 000 per year, since many of them in the group are full-time and part-time students who are depending on family support.

Apart from the individual characteristics, the trip performance and cost could also impact the users' choice of TNC service types. Table 2 shows that the percentage of pool service adoption increase with the decrease of trip costs and distance. Interestingly, the trip time does not seem to have much impact on people's last trip's TNC service types choice, partly because the estimated arrival time in TNC services app is optimistic or travelers are more concerned about the access time than the trip time. The trip destination type suggests that the pool service usage is low for recreational, medical appointment, major transportation facility trips.

TABLE 2 Users' choice of TNC service types

Variable Name	Pool Services	Standard Services	Other
Age Groups			
Age > 45	7.7%	87.2%	5.1%
Age > 35 and < 44	25.0%	68.8%	6.3%
Age > 22and < 34	41.4%	50.4%	8.1%
Age > 18 and < 21	29.0%	60.9%	10.1%
Status			
Faculty and staff	18.8%	76.1%	5.1%
Undergraduate Students	29.1%	60.4%	10.4%
Part-time Graduate Students	32.5%	55.0%	12.5%
Graduate Students	47.6%	45.1%	7.3%
Regular commute type			
commute to school: bike	46.2%	46.2%	7.7%
commute to school: PT	43.4%	50.2%	6.5%
commute to school: Uber / Lyft	45.5%	38.6%	15.9%
commute to school: walk	33.2%	57.8%	8.9%
commute to school: drive	25.0%	62.1%	12.9%
commute to school: PT combination	27.3%	62.2%	10.5%
commute to school: Carpool	31.4%	57.1%	11.4%

Membership or Ownership			
MBTA_PASS	37.8%	54.3%	7.9%
Car Ownership	23.4%	69.0%	7.6%
Sharing Mode Membership	39.3%	51.8%	9.0%
Annual Income			
Low Income	37.6%	52.6%	9.8%
income > $15000and < $30000	35.8%	53.6%	10.7%
income > $30000 and < $44999	44.3%	48.9%	6.9%
income > $45000 and < $59999	36.0%	54.7%	9.3%
income > $60000 and < $74999	28.3%	66.0%	5.7%
income > $75000	18.2%	75.0%	6.8%
Cost per person			
Price per person < $5	60.6%	26.9%	12.5%
Price per person > $5 and < $10	46.1%	48.2%	5.7%
Price per person > $10 and <$20	21.6%	69.5%	8.9%
Price per person > $20 and < $30	15.4%	72.5%	12.1%
Price per person > $30 and < $40	8.8%	76.5%	14.7%
Price per person > $40	9.1%	81.8%	9.1%
Trip distance			
Mileage < 2 mi	41.9%	50.6%	7.5%
Mileage < 5 mi and > 2 mi	36.2%	55.0%	8.8%
Mileage < 10 mi and > 6 mi	31.7%	56.9%	11.4%
Mileage > 10 mi	22.3%	70.7%	7.0%
Trip length			
Trip length < 10 mins	36.1%	56.2%	7.7%
Trip length < 20 mins and > 11 mins	33.6%	58.0%	8.5%
Trip length < 30 mins and > 21 mins	38.3%	50.4%	11.3%
Trip length > 30 mins	37.8%	54.3%	7.9%
Destination type			
Destination: major transportation facility	34.4%	46.9%	18.8%
Destination: recreational	24.1%	62.6%	13.3%
Destination: medical	33.3%	59.3%	7.4%

C. Clustering Analysis

From the above discussion, we can see that the sociodemographic information has significant impacts on people's TNC adoption, usage frequency and what service types they used for the last TNC trip. To get a better understanding of the relationship of users' characteristics and TNC usage behavior, the respondents were segmented into different groups. Different segments have different preferences and behaviors. Such segmentation can help researchers and planners to further explore their travel patterns, and thus compose different strategies to better manage/nudge their behavior.

The clustering analysis was based on respondents' socio-demographic characteristics, including: 1. Age; 2. Occupation; 3. Gender; 4. Race; 5. Income; 6. Vehicle ownership; 7. Bike ownership 8. Driver's license; 9. Car sharing membership; 10. Bike sharing ownership. 11. MBTA pass (transit pass). K-means clustering was utilized to cluster passengers. Clusters of size of 4 were concluded from the clustering analysis. Clusters 1, 2, 3 and 4 have a group size of 431, 419, 504 and 631 respectively.

Using these 4 clusters, TNC services usage and choice patterns are investigated regarding people's TNC service adoption, frequency, service type choice and people's second choice when TNC services was hypothesized as not available. Table 3 summarizes the clustering results and also the TNC services usage and choice patterns.

- *Cluster 1:* Cluster 1 is mostly made up of faculty/staff and full-time graduate student, both taking up more than 40% of the population in this cluster. The age within this cluster was the oldest among the four clusters. The respondents are more likely to be financially independent. More than 63% of the respondents claimed to have annual income of more than $30,000. Car ownership and driver license ownership are high, reaching approximately 80% and 95% respectively. In fact, the car and bike ownership and MBTA pass ownership are the highest in cluster 1 compared to other groups. This group of respondents are more accustomed to traditional transportation modes including driving and public transportation. Thus, it is not surprising that a highest non-TNC service user percentage in this groups is observed, reaching more than 22%. It also has the lowest percentage of high and medium frequency for TNC services among all four clusters. Regarding what type of TNC services they adopted, people in cluster 1 adopted standard service over pool service more. And when TNC services was not available, they prefer public transportation and taxi over walking and other options.
- Cluster 2: More than 97% of respondents in this group belong to undergraduate students. Most of them are under age of 21, having low annual income, indicating higher possibility of family support or student loans. Car and bike ownership are low for cluster 2. Within this cluster, people have very high adoption of TNC services. And more than 40% of them are medium and high frequency users. The pool service percentage is high, with more than 30% choosing such an option. If TNC services was not available, they prefer public transportation and walking.
- *Cluster 3:* Cluster 3 is similar to cluster 2, where respondents are mostly young undergraduate students. But some of the other characteristics and behaviors are quite different between cluster 2 and 3. Compared to cluster 2, cluster 3 has a significantly higher car and bike ownership percentage. And cluster 3 has more respondents with a high annual income. Compared to cluster 2, respondents in cluster 3 have a lower adoption of TNC service, usage frequency and also pool service choice. Considering these two clusters are mostly undergraduate students, the main factors causing the TNC usage and choice are car or bike ownership and personal finance.
- *Cluster 4:* Cluster 4 is mostly graduate students aging between 22 to 34. 44.53% of them have annual income lower than $15, 000. Car and bike ownership percentage are surprisingly low for this group (3.65% and 7.61%). They also have relatively low possession rate of driver license. However, the car sharing membership percentage is relatively high compared to other clusters, indicating that they may have preference over sharing concept. Low TNC non-user rate is observed in this cluster. It also has a very high pool service percentage for the last trip. More than 43.9% respondents used pool services, even higher than the standard service.

Table 3 Clustering results and TNC services usage and choice patterns

Variables	Category	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Status	Full-time Graduate Student	40.56%	1.19%	0.99%	92.23%
	Faculty/Staff	40.09%	0.71%	0.40%	1.74%
	Undergraduate Student	9.79%	97.15%	97.62%	3.80%
	Part-time Graduate Student	7.46%	0.48%	0.20%	1.58%
	Other (please specify)	2.10%	0.48%	0.79%	0.63%
Age	18 - 21	1.16%	81.38%	82.54%	0.00%
	22 - 34	71.23%	17.42%	17.06%	98.57%

	34 - 44	12.30%	0.72%	0.00%	1.11%
	45 or older	15.31%	0.48%	0.40%	0.32%
Income	Prefer not to answer	14.22%	14.96%	10.52%	21.87%
	Less than $15,000	9.79%	55.34%	42.86%	44.53%
	$15,000 to $29,999	12.35%	20.43%	31.94%	14.74%
	$30,000 to $44,999	15.62%	5.70%	6.55%	11.09%
	$45,000 to $59,999	8.86%	0.48%	2.78%	4.60%
	$60,000 to $74,999	10.02%	0.95%	1.79%	2.06%
	$75,000 or more	29.14%	2.14%	3.57%	1.11%
Car ownership	Yes	80.89%	25.65%	32.54%	3.65%
	No	19.11%	74.35%	67.46%	96.35%
Bike ownership	Yes	42.19%	20.67%	35.52%	7.61%
	No	57.81%	79.33%	64.48%	92.39%
License	Yes	95.57%	84.32%	89.68%	34.23%
	No	4.43%	15.68%	10.32%	65.77%
Car sharing membership	Yes	13.52%	14.25%	15.08%	19.97%
	No	86.48%	85.75%	84.92%	80.03%
Bike Sharing membership	Yes	4.90%	2.61%	6.75%	4.28%
	No	95.10%	97.39%	93.25%	95.72%
MBTA Pass	Yes	42.66%	21.14%	22.42%	35.82%
	No	57.34%	78.86%	77.58%	64.18%
Frequency	Never	22.61%	4.51%	10.91%	9.35%
	1 - 3 times per month or less	59.91%	52.73%	61.51%	58.95%
	1 - 3 times a week	14.45%	35.87%	23.41%	25.36%
	More than 4 times a week	3.03%	6.89%	4.17%	6.34%
Service type	Never	22.61%	4.51%	10.91%	9.35%
	Pool service	21.68%	30.88%	23.61%	43.90%
	Standard service	51.52%	54.16%	57.14%	38.99%
	Other	4.20%	10.45%	8.33%	7.77%
Second Choice	Public Transportation	36.83%	51.07%	46.43%	55.94%
	Taxi	14.45%	4.28%	4.56%	5.39%
	Walk	10.02%	27.55%	22.42%	13.47%
	Ask someone for a ride	5.36%	3.56%	3.17%	3.01%
	Would not have travelled	3.96%	6.41%	6.55%	4.75%
	Other (please specify)	3.03%	1.19%	0.40%	0.63%

	Carpool	1.86%	0.95%	1.19%	5.07%
	Bike	1.86%	0.48%	4.37%	2.38%

CONCLUSION AND DISCUSSION

Better understanding the University TNC usage behavior is essential for the effective implementation of strategies contributing to sustainable campus transportation. The experiences/lessons learned could also guide the policy/regulation designs to decrease the dependence on automobile use, and yield substantial environmental benefits in the long term. This paper presents a web-based survey study on the university community TNC usage behavior, including TNC service adoption, usage frequency and choice of TNC service types. The descriptive and clustering analysis were performed to understand the relationship of TNC service usage and choice patterns with respect to a spectrum of factors, including individual characteristics, habitual commuting behavior, and alternative service performance.

The results show that, among the variables, age, status, income, car and bike ownership and membership in shared mobility are playing significant part in affecting people's behavior and preferences in TNC service adoption, frequency, and TNC service type selection. People with higher income, ages, bike and car ownership tend to use TNC services less frequently, and they are less likely to use pool services. People with lower income, ages and bike/car ownership as well as higher membership in shared mobility are more likely to adopted TNC services and choose pool service for travel. Future studies will focus on collecting more data from Universities in different cities, and build advanced choice models to characterize University communities' TNC usage and choice behaviors.

AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: study conception and model design: J. Zhou, Z. Ma; data collection and implementation: J. Zhou, S. Hirschmann, Y. Lao; analysis and interpretation of results: J. Zhou, Z. Ma, S. Hirschmann, Y. Lao; draft manuscript preparation: J. Zhou, Z. Ma. All authors reviewed the results and approved the final version of the manuscript.

REFERENCE

1. Data Report on Rideshare in Massachusetts. Department of Public Utilities, Massachusetts. https://tnc.sites.digital.mass.gov/ Accessed Jul. 21, 2019.
2. Annual Ridership Report Calendar Year 2017. Chicago Transit Authority. https://www.transitchicago.com/assets/1/6/2017_CTA_Annual_Ridership_Report.pdf. Accessed Jul. 21, 2019
3. Ridership Trends, New York City Transit. 2018. http://web.mta.info/mta/news/books/docs/Ridership_Trends_FINAL_Jul2018.pdf. Accessed on Jul.21, 2019
4. Feigon, S. and Murphy, C., 2016. Shared mobility and the transformation of public transit. APTA Report, No. Project J-11, Task 21.
5. Hall, J.D., Palsson, C. and Price, J., 2018. Is Uber a substitute or complement for public transit?. *Journal of Urban Economics*, 108, pp.36-50.
6. Alemi, F., Circella, G. and Sperling, D., 2018. Adoption of Uber and Lyft, Factors Limiting and/or Encouraging Their Use and Impacts on Other Travel Modes among Millennials and Gen Xers in California. Presented in *Transportation Research Board 97th Annual Meeting*, Washington D.C., 2018.
7. Alemi, F., Circella, G., Mokhtarian, P. and Handy, S., 2018. On-demand ride services in California: Investigating the factors affecting the frequency of use of Uber/Lyft. Presented in *Transportation Research Board 97th Annual Meeting*, Washington D.C., 2018.

8. Alemi, F., Circella, G., Mokhtarian, P. and Handy, S., 2019. What drives the use of ridehailing in California? Ordered probit models of the usage frequency of Uber and Lyft. *Transportation Research Part C: Emerging Technologies*, 102, pp.233-248.
9. Chu, K.C., Hamza, K. and Laberteaux, K.P., 2018. An Analysis of Attitudinal and Socio-geographic Factors on Commute Mode Choice and Ride-Hailing Adoption, Presented in *Transportation Research Board 97th Annual Meeting*, Washington D.C., 2018.
10. Smith, N.C. and McCormick, E., 2019. Uber and the Ethics of Sharing: Exploring the Societal Promises and Responsibilities of the Sharing Economy. In *Managing Sustainable Business*. Springer, Dordrecht.
11. Boston Planning and Development Agency, 2018. Boston at a Glance – 2018. http://www.bostonplans.org/getattachment/1c004389-ed24-4f11-b2aa-78679194cb13
12. Tarabay, R. and Abou-Zeid, M., 2019. Modeling the choice to switch from traditional modes to ridesourcing services for social/recreational trips in Lebanon. *Transportation*, pp.1-31.