State of Ride Sharing in America: Implications for the Shared Autonomous Vehicle Future

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BACKGROUND

Autonomous electric vehicles (AEV) has been regarded to be the most disruptive technologies of the modern era comparable to the invention of the automobile in the eighteenth century (Sprei 2018). Transportation planners and policy makers have been contemplating the consequences of the wide scale operation of the AEV. Among other things the transport professionals are trying to infer the mode of operation of AEV since this will directly impact the travel pattern of the individuals. Two most prominent models of operation for AEV are (i) personal ownership of autonomous vehicles (AV) and (ii) shared autonomous electric vehicles (SAEV) (Litman 2017). It can be noted that these two modes of operations are not necessarily mutually exclusive; however, dominance of any one mode over another will likely create two distinct scenarios for future mobility.

Due to the lack of revealed preference data AEV researchers are relying on stated preference data to make predictions about the autonomous vehicle future which requires forecasting of current mobility trends (e.g. household vehicle transaction and ownership decisions) as well as extrapolation of the technological advances (Bansal and Kockelman 2017, Bansal and Kockelman 2018). This line of research needs to be augmented with the investigation of the emerging mobility trends (such as the adoption of the ride hailing and ride sharing services) so that the transportation researchers become better equipped to effectively guide the future mobility.

The objective of the current research is to investigate the state of the ride sharing services[1] in America using data from 2017 National Household Travel Survey (NHTS). This research has been partly motivated by the need to elucidate the future mobility scenario under mass adoption of AEV. Specifically, the research aims at highlighting the differences in the mobility that are likely to be encountered under two operational models of AV adoption, namely (i) predominant ownership of AV and (ii) wide range availability of shared autonomous electric vehicles. The research queries explored in the current work can be broadly grouped into following three categories (1) Identify the users of the ride sharing services and compare their characteristics with the US population, (2) Compare the household characteristics of the people using ride sharing services with the overall household characteristics in US, (3) Identify the characteristics of the ride sharing trips and compare those with the overall trip characteristics in terms of purpose, miles traveled, time of travel and so on. The next three sections of the report respectively present the results on the above three queries. The last section provides a summary of the findings and highlight their implications for the shared autonomous vehicle future.

USERS OF RIDE SHARING SERVICES

This section compares the individual characteristics of the people using ride sharing services (RSS) with those of the US population. The comparisons are drawn on the following demographic characteristics – age, gender, holding of driving license, education status and the primary activity conducted during the last week. Table 1 presents the *weighted* proportions of different demographic groups in the RSS sample and in the US population respectively in columns 2 and 3. It can be noted that the differences in proportions across all the demographic groups are statistically significant at more than 99.99% level of confidence.

The table alludes to some interesting observations – individuals belonging to 20 to 49 years age group are the predominant users of the ride sharing services with 20 to 29 years age group leading the tally. There is a 7 to 12 percent point difference between the proportion of these age groups using ride sharing services and their proportion in the US population. On the other hand, the old age people do not seem to be at per with the young age population in terms of using RSS. This is an important observation that requires further attention. Often providing mobility to old user group is identified as one of the advantages of shared AEV system – however, the low penetration of the RSS among the old age community cast doubt on the effectiveness of SAEV in providing mobility to this age group. The low penetration of RSS among the old age people might be due to this age groups' disinclination to adopt novel technology (Wang et al. 2009).

[1] In NHTS 2017 dataset the ride sharing services such as Uber, Lyft are grouped together with taxi services. Hence any reference to ride sharing services include the traditional taxi services as well.

However, it might also be due to the misalignment of the concentration of RSS and the distribution of old age people in different geographic region of USA.

Next, in terms of gender distribution comparatively low proportions of female riders are using RSS compared to male. One plausible reason for this disparity might be the female riders' discomfort to share rides with unknown riders/chauffeurs.

Another debate that pervades the transportation community is whether the SAEV services can provide mobility to the user groups who do not have alternative mobility options at their disposal. The significantly low proportion of driving license holders among the ride sharing service users (compared to the proportion of driving license holders among the US population) provides affirmation to this argument.

Interesting distribution is noted in terms of education as well – more than 50% of the RSS users belong to high education group – meaning they have completed bachelor's degree or higher. This proportion of educated riders is markedly higher compared to the same in the overall US population which is around 30%. Multiple cofounding factors might be responsible for this disparity – the high educated population might be better informed about the availability of the RSS. Similarly, they might be quicker or more inclined to make use of new technologies such as RSS compared to the less educated user group. The uneven concentration of the RSS among different geographic areas of US might also be attributing to this non-uniform distribution of adoption across different level of education.

Finally, people who are working use the RSS in significantly higher proportion compared to the people who are not working with a percent point difference of more than 22% (when compared with the US population). On the other hand, the penetration of RSS users is considerably low among the homemakers and the retired population. In both cases the proportion of ride sharing service users is almost half of that in the US population.

To summarize, this section highlights the demographic characteristics of the persons using ride sharing services. It can be noted that the RSS users have some distinctive characteristics that isolate them from the average US population. RSS users in the US are the working age males who are highly educated, and the possession of driving license among this group of people is also low compared to the average US population.

HOUSEHOLD CHARACTERISTICS OF THE USERS OF RIDE SHARING SERVICES

In this section we compare the household characteristics of the RSS users with those of the US population. Any household that made at least one RSS trip during the travel day has been characterized as RSS household. Comparisons are made on the following characteristics - household size, family income, household vehicle count and household trip count. The comparisons on the household characteristics are presented in Table 2. Like the personal characteristics all the differences in the household characteristics are statistically significant at more than 99.99% level of confidence.

The proportion of 1- and 2-person household seem to be slightly higher among the RSS users compared to the proportion in the US population. The distribution of the family income among the RSS users seem to be interesting when compared with the US population. In general, a high proportion of households with family income less than $10,000 are using ride sharing services where the percent point difference is about 3.71% when compared with the US population. What is interesting to note is that, there is high proportion of households with family income above $125,000 among the RSS users. The biggest difference is noted for the income level $200,000 and more – the proportion of households with family income $200,000 and more is about 13.5 percent point higher compared to that in the US population. This indicates that, the RSS users are not necessarily captive users of the service at least not based on their financial conditions. However, there might be a group of households who want to complement the use of other transport modes with RSS.

In terms of household vehicle count the most prominent difference in the proportion is noted for the zero-vehicle household category. The proportion of households owning zero vehicle is remarkably high among the RSS users – the difference in the proportion when compared with the US population is more than 25%. This finding supports the argument of RSS providing mobility to the households who do not own personal motorized vehicles.

Finally, it is interesting to note that, the proportion of households making 1 to 5 trips during the travel day among the RSS users is slightly lower compared to the proportion among the US population. On the other hand, the proportion of households making 6 to 25 trips are slightly high among the RSS users compared to the US population. Although household trip making can be influenced by a multitude of factors including household size, number of adult/workers – still this observation deserves further investigation as to whether availability of RSS is generating extra trips that otherwise would not have been made.

CHARACTERISTICS OF THE TRIPS USING RIDE SHARING SERVICES

In this section we will compare the trip characteristics of the trips made by RSS with those of the overall trip file. Specifically, this section compares the trip characteristics such as trip purpose, mode used, trip distance and trip start time.

Trip Purpose

Table 3 presents the proportions of different trip purposes and their associated ranks for the RSS trips and overall trips, respectively. Some interesting observations can be noted in terms of trip purpose distribution among the RSS users and the overall US passengers. In general, return home purpose assumes the highest rank among both the RSS trips and the overall trips. However, proportion of return home journeys served by RSS is quite high compared to its proportion while considering all modes. This observation indicates that, RSS is a popular mode for the last leg of the journey while returning home.

Although no noticeable difference is found between RSS and other modes in terms of serving work trips. However, RSS are considerably less likely to be used by students to attend school indicated by a difference of proportion of almost 3%.

It is interesting to note that buy goods purpose assumes second rank while considering all modes. However, this purpose has quite low rank (8) while considering only the RSS trips. A similar trend (though slightly less skewed) is observed for buy meals purpose as well (a rank of 6 while considering only RSS mode versus a rank of 4 considering all modes). However, the rank of the buy service is not significantly different. This observation might be indicative of people's inclination to use own vehicle while carrying goods/meals compared to hired vehicles. Like buying goods, meals people seem to be averse to use hired vehicles for picking or dropping up somebody indicated by a rank difference of 10 versus 5 among the RSS trips and overall trips, respectively.

On the other hand, RSS serves considerably high proportions of recreational trips when compared with trips served all modes – the rank of the recreational activity purpose is 3 among the RSS trips while the rank this purpose is only 9 while considering all modes. This rank difference of recreational activity purpose is resulted from a percent point difference of about 6%.

Another significant difference in ranking/proportion is noted for the work-related meeting/trip purpose. Among different purposes served by the RSS, work related meeting/trip purpose assumes 4^{th} rank while the rank of this purpose considering all modes is only 14^{th} – this is associated with a proportion difference of slightly less than 6%.

Next the observation that deserves highlighting is the rank difference of the change type of transport purpose. RSS seem to be used in significantly high proportions for changing transport modes compared to other modes. This purpose has a rank of 5 (with ~6% proportion) among the RSS trips while the purpose is ranked 15^{th} (with ~1% proportion) while considering all modes.

Finally, health care visit purpose also ranks high among the trips using RSS (9 versus 13 among the trips using all modes).

The considerably high proportions of recreational trips, work related meeting/trips (but not regular work trips), change mode trips, and health care visits served by the RSS might indicate that people prefer to use RSS for impromptu trips compared to trips that are more or less habitual with marginal variation in time and destination (such as regular work and school trips). Though this can be highlighted as the positive contribution of RSS in terms of serving health care visits and change mode trips, however this also points to RSSs' potentials to generate trips that would not otherwise have been made (such as recreational trips as well as work related trips/meetings to some extent).

Transport Mode

Next, we would like to investigate what other modes are being used by the RSS users (i.e. we consider the modal distribution of all individuals who made at least one trip by RSS on the travel day) compared to overall US population. Table 4 presents the proportion of different modes among the RSS users and the overall US population. In general, the RSS users seem to be considerably more multimodal compared to the general US population. Considerably high proportions of walk trips are reported by the RSS users compared to the overall US population – almost 1/4th trips made by the RSS users are walking trips. RSS users are also using public transportation in significantly high proportions – almost 8% of RSS users' trips are made by public or commute bus and subway/light rail/street car. While this proportion is only 2.5% among the overall US population. This high share of active modes (such as walk, bike) and public transit might also indicate that the penetration of RSS is comparatively higher in urban areas with multimodal transportation system compared to in suburban areas.

It is interesting to report that car serves ~22% of the trips made by the RSS users while 23% of their trips are served by RSS such as taxi/uber/lyft. Whereas in the US population ~42% of all trips are served by car – this indicates that RSS are not only serving the trips that would have otherwise been made by cars but are also inducing roughly 3% additional trips. In general, car, suv, van and pickup trucks are serving only 37% of all trips made by the RSS users while these four modes are serving 82% of all trips made by the US population.

Trip Distance and Trip Time

Next, we compare the distribution of trip miles served by RSS with that served by car, SUV, van and pickup trucks (Table 5). It can be noted that, we included only car, SUV, van and pickup truck, since these modes are comparable to RSS in terms of speed and are likely to be substituted by RSS if needed. While active modes such as walk and bike as well as public transit are likely to be used for trips serving inherently different radius of distance. The proportion of trips by RSS covering 2 to 10 miles are significantly high compared to the trips made by car, SUV, van and pickup trucks. In general, almost 95% of all trips served by RSS are made within 20 miles radius.

Finally, we compare the start time distribution of the trips served by RSS with those served by all modes (Table 6). Significantly high proportions of trips served by RSS start during early mornings and late evening hours. For example, the proportions of trips served by RSS starting between 12AM to 4AM in the morning and between 10PM to 12AM at night are 7.8% and 17.9% respectively. While the respective proportions are only 0.6% and 6.6% considering all modes. The significantly high proportions of trips served during early morning and late evening might be due to the unavailability of public transit during those late hours. People might also feel comparatively safer to use RSS during these early/late hours compared to using active modes such as walk and bike.

On the other hand, RSS seems to be less likely to serve trips starting during morning and extended evening peak hours starting and ending between 6AM to 8AM and 12PM to 6PM respectively. The comparatively low concentration of RSS trips during morning and evening peak hours might result from one of two reasons - the demand for RSS might be low during these hours, or the companies operating the services might deliberately want to curb their services during the peak hours due to congestion. Further research is needed to identify the appropriate factor.

SUMMARY

This investigation characterized the users of the ride sharing services (RSS) and compared those with the characteristics of the US population. Additionally, the trip characteristics of the RSS trips were compared with the overall trip patterns of USA in terms of the purposes served, distances travelled, time started and so on. This investigation was carried with the aim to draw some parallels about how shared autonomous vehicles might shape the future mobility given a mode of operation (such as personal ownership of autonomous vehicle and/or shared autonomous vehicle). Some distinguished observations and their implications for the autonomous vehicle future are noted below.

Undoubtably, young (20 to 49 years age group) and working age population are the predominant users of the RSS. Interestingly there is also a high concentration of highly educated people among the RSS riders. Unfortunately, the penetration of RSS is low among the old age people (above 50 years old) and retired people. It might be due to the low penetration of RSS in the geographic arears where the concentration of old age and retired population is comparatively high. However, it can be postulated that, proactive measures (such as educating the old age people about the availability and benefits of using RSS services) would be necessary to make the shared ride services popular among this age group. Without such measures it will not be possible to harvest the implied benefits of shared autonomous vehicle services such as providing mobility to disadvantaged user group.

In terms of household characteristics, ~34% of the RSS users belong to households with zero vehicle whereas the overall % of zero vehicle household in the USA is only ~9%. This observation might imply that, shared ride system might not emerge as the popular mode of operation for autonomous vehicles if predominant number of US households can afford to own autonomous vehicles with the technological advances and the consequent reduction in cost. It is also noteworthy that, among the RSS riders the % of households belonging to high income group (yearly family income more than $200,000) is considerably higher compared to the overall US average. This might imply that it's not only the captive users who are leaning towards RSS, rather RSS can also be used as a complementary mode along with personally owned vehicles.

The distribution of purposes served by the RSS is very interesting. It is evident that, RSS are predominantly used to serve purposes that are not inherently fixed in time and place (such as work-related trips/meetings, recreational activities, change mode, and health care visit). It is also noted that, RSS is less likely to be used for certain trip purposes such as regular work and school trips, buy goods and meals and so on. RSS are most popular for the early morning and late-night trips. The concentration of trips served by RSS are quite low during the morning and evening peak hours. Also, the people using RSS seem to be multimodal users – a very high percentage of their trips are walking trips (~23%) – while only 10% of all trips in USA are walk trips. The purpose and the travel time distribution of the trips served by RSS indicate that RSS has the potential to induce trips that would otherwise have not been made in the absence of RSS services such as recreational trips made at late hours.

From the above discussion it can be implied that proactive policies will be needed if shared ride system is to be promoted as the ultimate mode of operation for autonomous vehicles. If there is no policy to guide the mode of operation, shared autonomous vehicles might simply be used as an additional alternative to serve certain types of trips made at certain hours (e.g. discretionary trips made during off-peaks, health care visits made at late hours). Promotion might also be necessary to nudge users to use ride sharing services for habitual trips such as regular work commute and school trips. Additionally, the riders would need to be comfortable to complement the use of shared ride system with other transport modes such as public transit, walk and bike otherwise autonomous vehicles might not be all that effective in reducing the ownership of personal automobile. Without effective policies advent of autonomous vehicles might not be all that rewarding in providing mobility to the group of riders who suffer from lack of mobility such as old people. In the absence of necessary policies to guide the mode of operation for autonomous vehicles, the transportation system might become more and more unimodal - ultimately transforming the landscape of USA in an irrevocable manner.

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Table 1 Comparison of Personal Characteristics of the RSS users with the overall US Population[a]

Characteristic	RSS User[b]	Overall US Population[b]
Age		
Not ascertained	0.1	0.2
Age group 5 to 15 years	3.3	15.0
Age group 16 to 19 years	3.6	5.9
Age group 20 to 29 years	25.5	13.8
Age group 30 to 39 years	22.5	14.8
Age group 40 to 49 years	20.6	13.0
Age group 50 to 59 years	10.3	14.4
Age group 60 to 64 years	4.9	7.1
Age above 65 years	9.2	15.8
Gender		
Not ascertained	0.7	0.1
Male	52.0	49.0
Female	47.4	50.9
Driving License		
Not ascertained	3.1	13.7
Yes	68.4	74.0
No	28.5	12.3
Education		
Not ascertained	3.1	12.4
Less than high school graduate	9.2	10.4
High school graduate	18.2	18.9
Some college or associate degree	17.9	25.0
Bachelor's degree	28.7	18.4
Graduate or professional degree	23.0	14.8
Primary activity		
Not ascertained	3.30	15.1
Work	67.10	44.9
Temporarily absent from work	4.30	2.5
Looking for work	2.20	3.5
Homemaker	3.70	6.2
School	5.10	6.5
Retired	7.70	15.3
Something else	6.60	6.0

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted

Table 2 Comparison of Household Characteristics of the RSS users with the overall US Population[a]

Characteristic	RSS User[b]	Overall US Population[b]
Household size		
One	28.5	27.9
Two	35.2	33.9
Three	15.2	15.7
Four	12.8	14.3
Five	5.4	5.4
Six	1.6	1.9
Seven	0.2	0.5
Eight	0.1	0.2
Nine	1.0	0.1
Family Income		
Not ascertained	1.1	3.0
Less than $10,000	11.0	7.3
$10,000 to $14,999	5.4	5.8
$15,000 to $24,999	6.6	9.5
$25,000 to $34,999	6.1	9.7
$35,000 to $49,999	5.3	12.0
$50,000 to $74,999	12.4	16.0
$75.000 to $99,999	9.0	11.9
$100,000 to $124,999	7.9	9.1
$125,000 to $149,999	7.5	5.2
$150,000 to $199,999	8.6	5.1
$200,000 or more	18.9	5.3
Household vehicle		
Zero	34.1	8.9
One	29.5	33.5
Two	23.3	33.1
Three	7.8	14.9
Four	3.0	6.1
Five	1.9	2.2
Six	0.2	0.7
Seven	0.1	0.3
Eight	0.1	0.1
Nine	0.0	0.1
Household Trip		
Zero	Not Applicable	8.8
1 to 5	25.8	33.6
6 to 10	40.1	32.0
11 to 15	19.6	14.7
16 to 20	9.3	6.3
21 to 25	3.1	2.6
26 to 30	1.0	1.1
31 to 35	0.2	0.5
36 to 40	0.7	0.2
40+	0.2	0.1

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted

Table 3 Comparison of Trip Purpose Made by RSS and All Modes in USA[a]

Trip Purpose	By RSS		By All Modes	
	Proportion[b]	*Rank*	*Proportion*[b]	*Rank*
Not ascertained	0.1	17	0.0	21
Home	37.4	1	34.6	1
Work from home	0.3	16	0.6	17
Work	11.5	2	11.3	3
Work Related meeting/trip	7	4	1.2	14
Volunteer activities	0.1	17	0.7	16
Drop off/pick up	2.8	10	6.8	5
Change type of transportation	6.1	5	1.1	15
Attend school as a student	0.7	14	3.4	8
Attend child care	0.1	17	0.3	18
Attend adult care	0	20	0.1	20
Buy goods	4.5	8	13.2	2
Buy services	1.5	13	2.1	12
Buy meals	5.6	6	7.3	4
Other general errands	1.8	11	2.5	10
Recreational activities	9.5	3	3.5	7
Exercise	0.4	15	3	9
Visit friends or relatives	5	7	4.2	6
Health care visit	4	9	1.5	13
Religious activities	1.6	12	2.3	11
Other	0	20	0.3	18

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted

Table 4 Comparison of Travel Modes Used by RSS Users and All Passengers in USA[a]

Travel Mode	By RSS Users	By All Passengers
Not Ascertained	0.1	0.0
Walk	23.1	10.5
Bike	1.4	1.0
Car	22.2	42.3
SUV	9.3	22.8
Van	3.9	7.5
Pickup Truck	1.5	9.5
Golf cart/Segway	0.0	0.1
Motorcycle/Moped	0.3	0.2
RV	0.0	0.1
School bus	0.9	1.9
Public or commuter bus	3.4	1.4
Paratransit	0.2	0.1
Shuttle bus	0.5	0.2
City to city bus	0.1	0
Amtrak/Commuter Rail	1.0	0.2
Subway/Light Rail/Street Car	4.3	0.9
Taxi/Limo	23.6	0.5
Rental Car	1.2	0.2
Airplane	2.7	0.2
Boat	0.1	0
Other	0.2	0.4

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted

Table 5 Distribution of Trip Distance among the RSS Users and Car, SUV, Van, Pick-up Users[a]

Trip Distance	RSS Users[b]	Car, SUV, Van, Pick-up Users[b]
Not ascertained	0.0	0.0
0 to 2 miles	28.0	29.0
> 2 to 5 miles	35.3	28.2
> 5 to 10 miles	20.5	18.9
> 10 to 20 miles	10.8	13.7
>20 to 30 miles	3.3	4.8
>30 to 40 miles	0.9	1.9
>40 to 50 miles	0.3	1.0
> 50 to 100 miles	0.3	1.6
> 100 to 200 miles	0.1	0.7
>200 to 500 miles	0.2	0.2
>500 to 1000 miles	0.0	0.0
>1000 to 2000 miles	0.0	0.0
>2000 to 5000 miles	0.1	0.0

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted

Table 6 Distribution of Trip Start Time among the RSS Users and Other Mode Users[a]

Trip Start Time (24 Hour Clock)	Trips by RSS[b]	Trips by All modes[b]
Not ascertained	0.0	0.0
0 to 4	7.8	0.6
4 to 6	1.6	2
6 to 8	5.9	11.2
8 to 10	12.1	11.9
10 to 12	12.2	12.7
12 to 14	8.9	13.7
14 to 16	9.9	15.9
16 to 18	12.9	15.6
18 to 20	10.7	9.9
20 to 22	8.5	5
22 to 24	9.4	1.6

Notes: (a) The proportion differences are statistically significant at more than 99.99% level of confidence
(b) The reported proportions are weighted