IMPACT OF RIDE-SOURCING SERVICES ON TRAVEL HABITS AND TRANSPORTATION PLANNING

by

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University of Pittsburgh, 2015

The use of app-based, on-demand ride-sourcing services has spread rapidly and become more and more important in urban transport. Companies such as Uber and Lyft may provide better service with less waiting time and higher vehicle occupancy when compared to traditional transportation services such as private auto, public transit and taxis. This new type of transportation service is defined as ride-sourcing. This increase in the ride-sourcing availability, due to the introduction of Uber and Lyft, may impact travel habits and change the local, regional and national travel demand. The research compared the users' differences in travel characteristics between traditional transportation services and new ride-sourcing services. This comparison was be done by conducting a survey in the Pittsburgh region to determine users' attitude and travel habits when using ride-sourcing services. The results of the survey were used to compare to the travel characteristics of ride-source users to established travel behavior data and then determine how the impact of ride-sourcing on travel habits may be incorporated into the transportation planning process.

The findings indicate that ride-sourcing users are generally younger than the typical traveler, the service is used by a higher percentage of males and females. Social and recreational trips are the predominant type of trips used for ride-sourcing followed by work trips, trip lengths are shorter for all types of trips when compared to typical trip makers and vehicle occupancy rates are generally higher for ride-sourcing trips. Ride sourcing users generate more trips than typical

traveler's in the Pittsburgh region and the use of taxis and private autos are most impacted by ride sourcing where users' shift away from these modes.

Currently, ride-sourcing is still a relatively small number of daily trips in an urban area. However as populations increase in urban areas and the demand for transportation facilities increases the new type of travel could increase to significant levels. It could be considered as a new transportation mode or categorized in as an auto mode in travel demand models.

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1.0 INTRODUCTION

As ride-sourcing service has spread rapidly in Pittsburgh, this increase in the use of ride-sourcing availability may impact travel habits and change the local, regional and national travel demand. The research aims to compare the users' differences in travel characteristics between traditional transportation services and new ride-sourcing services. This comparison was be done by conducting a survey in the Pittsburgh region to determine users' attitude and travel habits when using ride-sourcing services. The results of the survey were used to compare to the travel characteristics of ride-sourcing users to established travel behavior data and then determine how the impact of ride-sourcing on travel habits may be incorporated into the transportation planning process.

1.1 HYPOTHESIS

The app-based, on-demand ride-sourcing services has spread rapidly and become more and more important in urban transport. Ride service companies such as Uber and Lyft may provide better service with less waiting time and higher vehicle occupancy when compared to traditional transportation services such as private auto, public transit and taxis. This increase in the use of ride-sourcing availability may impact travel habits and change the local, regional and national travel demand. Are these positive impacts that would be more efficient and reduce environmental

impacts of travel? If these changes are significant, how would this be incorporated into a travel demand model? This is the hypothesis that is investigated for this thesis.

1.2 OVERVIEW OF THE OBJECTIVE

As the importance of trip efficiency and convenience has become more important to transportation users, the ride-sourcing apps such as Uber and Lyft rapidly spread in transportation users' daily life and may play more important roles in future. This research project aimed to:

- Compare the differences between traditional transportation service users and new ride-sourcing service users.
- This comparison was be done by conducting a survey in Pittsburgh, Pennsylvania of ride-sourcing users in the Pittsburgh area to determine users' attitudes and travel habits when using ride-sourcing services.
- The results of the survey were then compared to documented local and national travel behavior data and then the potential impact of ride-sourcing to the transportation planning process was evaluated

1.3 RESEARCH APPROACH

In order to accomplish the objectives set forth by this study, a detailed research approach was followed. The first step in the research approach was to perform a literature and policy review.

This review documented the definition and development of Ride-sourcing services, and provided the background information for the analysis of impacts of ride-sharing and other services to travel characteristics and potentially travel demand modeling in order to analyze the potential influence of Ride-sourcing service.

The second step in the research approach was to develop a survey to distribute to ride-sourcing users in the Pittsburgh area, where ride-sourcing was recently introduced and made available. This survey included questions on basic background information, travel habits of ride-sourcing users and how ride-sourcing changes users' travel attitudes.

The third step in the research approach was analyzing the completed surveys. Once the surveys were collected, the responses were analyzed and summarized. The survey results were compared to travel characteristics data of Pittsburgh area from National Household Travel Survey (NHTS) data and well as national travel survey data.

Finally, the fourth step in the research approach was hypothesizing the potential impact of ride-sourcing on the urban transportation planning process including travel demand modeling. This part of the research evaluated whether ride-sourcing service impacted travel behavior significantly enough to consider this change in transportation planning methods and models. Travel characteristics of ride-sourcing users were compared to the traditional methods of predicting mode choice and trip generation in travel demand models.

2.0 LITERATURE REVIEW

Ride-sourcing have some common characteristics with ridesharing and taxis, sometimes it was defined as “real-time ridesharing” or “app-based taxis” (1). However, are the new services provided by ride-sourcing companies a new mode of transportation? Or are they a combining tradition taxis or ridesharing service with mobile information science (1)? If they are different are they a new mode of travel with new travel characteristics that should be considered by transportation planners?

Little published literature on the travel characteristics of ride-sourcing users was found. Because this type of transportation has only been in operation for 5 years (2) and still not operated everywhere, transportation planners have not yet considered their impact on how systems may be impacted.

Therefore, the literature review focused on the development history of ride-sourcing, the relationship of ride-sourcing and Ridesharing, Car sharing and Taxis, how these modes operate as part of the options available to transportation users and the impact of them to travel demand models.

2.1 DEFINATION OF RIDE-SOURCING

Ride-sourcing was firstly defined as a new type of ridesharing which can provide services that use Geographic Information Systems (GIS) and global positioning systems (GPS) technologies on Internet-enabled “smartphones” to organize ridesharing in real time, just minutes before the trip takes place (3). Drivers post their trip as they drive, and potential riders request rides right before their desired departure time. Ride matching software automatically matches riders to drivers with similar trips and notifies each party’s smartphone (3). Although companies like Uber (UberX is the most popular service and defined as ride-sourcing service in this paper, Uberpool is a service that works similar to Carpools) and Lyft used to dub their services as ‘ridesharing’, they are still doing it as a for profit business. If you use such a service, you're not sharing someone's car; you're paying them to give you a ride (4). On the other hand, ride-sourcing companies not only work similar to taxicab companies, in essence, they work exactly like them, and the main distinction is technology. Unlike companies like Yellow cab, rides of ride-sourcing do not start with the hailing of a cab or by speaking over the phone to a dispatcher; rather rides are enabled through smartphones with the help of app. The other major difference is to use GIS and GPS technologies to reduce waiting time. When a ride is needed, customers use an app to make the arrangement. Shortly thereafter a paid driver pulls up and takes the passenger to their destination. The transaction is paid via credit card stored electronically (5).

2.2 RELATED LITERATURE REVIEW

The literature research revealed that no significant research has been done on ride-sourcing users' travel characteristics. Thereupon, the research approach focused on the usages of ridesharing and to evaluate the role in transportation planning. And then the research evaluated this new type of transportation mode, Car sharing, which provide new features in consideration of transportation characteristics of users may be similar to ride-sourcing, and then explore the influence of them to travel demand models.

Traditional ridesharing services (such as carpools and vanpools) is promoted as a way to increase auto occupancy and better utilize the empty seats in most passenger cars of higher capacity smaller vehicles such as vans, thus lowering fuel usage and transport costs per passenger (3). Research has also shown an analysis method of carpooling can be developed for short-range travel demand predictions (6).

Taxis have historically accounted for a very small share of urban travel and are much less extensively studied than other transport modes. In the National Household Travel survey (NHTS) report from 2009 (13), taxis were categorized in 'other modes'. In the regional taxi user survey (7) in San Francisco in 2013, more than 70 percent respondents said they would like to use taxi occasionally and only 15% said they use at least weekly. Despite their small modal share, taxis fill a critical gap by providing transportation when driving or other public transit modes are not available (8).

Car sharing is a service that allows individuals to share vehicles rather than each household owning its own car. Most privately owned cars spend a great deal of time sitting idle. With Car sharing, fewer cars can serve more people, resulting in less traffic and parking congestion. The research shows two years after the introduction of City Car sharing in San

Francisco, CA, nearly 30% of members have gotten rid of one or more cars and two-thirds of them opted not to purchase another car. Per capita gasoline consumption and greenhouse gas emissions among the members also appeared to be reduced (9). While not specific to ridesharing alone, one report estimated that using information and communication technology to optimize logistics of individual road transport could save 70 to 190 million metric tons of carbon dioxide emissions by 2020 in the U.S.(10).

Car sharing can substantially reduce the number of vehicles owned by member households, despite the fact that 60 percent of all households joining Car sharing are carless. A research conducted in 2011 shown households joining Car sharing owned an average of 0.47 vehicles per household before joining Car sharing, but that average dropped to 0.24 after membership (11). Car sharing households exhibited a dramatic shift towards a carless lifestyle. The vehicles shed are often older, and the Car sharing fleet is an average of 10 mpg more efficient than the vehicles shed.

Based upon this review of both ridesharing and Car sharing it was concluded that ride-sourcing is a new and unique method of transportation and warrants further research into its users' travel characteristics.

2.3 THE REGULATION OF RIDE-SOURCING IN PENNSYLVANIA

Uber first launched in Pittsburgh on April 1st, 2014. In August, 2014 the Pennsylvania Public Utility Commission issued a certificate of public convenience to Lyft Inc. Lyft can operate legally in Allegheny County for 60 calendar days. It is seeking permanent authority to operate in Allegheny County and statewide.

In January, 2015 Uber has received a two-year experimental license from the Pennsylvania Public Utility Commission that allows it to operate in most of the state. Uber also must inform drivers of the specifics of its own insurance policy, conduct background checks on drivers, and ensure any vehicles used to give rides meet annual inspection standards of the Pennsylvania Department of Transportation (12).

Since these ride-sourcing services have been established in the Pittsburgh regions it was concluded that valuable information could be received from their users' to conduct this research that could be applicable to other urban regions.

3.0 PROPOSED METHODOLOGY

This section introduce what was the purpose of the survey, how the questions were structured and how relative to data it will be compared to.

3.1 SURVEY METHODOLOGY

3.1.1 Development of survey tool

The survey, to test the hypothesis, was conducted online and hosted by Qualtrics Survey System of University of Pittsburgh. The survey link was emailed to potential respondents. Potential respondents were identified through contacts maintained by the Center for Sustainable Transportation Infrastructure at the University of Pittsburgh. These contacts included public agencies, engineering consulting firms and other transportation related entities or individuals. The survey was structured to identify ride-sourcing users by first asking them if they have a smart phone, which is required to use the app, and have used Uber or Lyft. If they responded positive to both questions they could then complete the survey. These were questions 1 and 2. The survey was activated on May. 10th 2015 and closed on May. 25th 2015.

3.1.2 Survey flow chart

The survey was divided by several parts. The first part gathered demographics data about the user, including age, gender, and vehicle ownership. The survey questions were structured to obtain the same data on travel characteristics of the general population as documented in the NHTS survey (13).

The second part of the survey gathered information of travel habits include trip purpose, trip length and vehicle occupancy.

The third part of the survey related to how ride-sourcing changes participants' travel attitude.

3.2 SURVEY DESCRIPTION

This section presents the specific questions of the survey and the reason why these questions were set. A blank copy of the survey, with the multiple choice responses, can be found in Appendix A. The survey was developed with four sections, including:

3.2.1 Screen questions

1) Do you own a smart phone?
2) Have you use Uber or Lyft (ride-sourcing) before?

Survey questions 1 and 2 were designed to screen out the respondents who own the smart phone and have used ride-sourcing before, then continue showing the remaining questions to ride-sourcing users.

3.2.2 Demographics information

3) What's your age?
4) What's your gender?
5) Do you own a vehicle?

Survey questions 2, 3, 4 were designed to collect trip makers' characteristics including age, gender and car ownership. Finding out if there were any differences between ride-sourcing users and Pittsburgh or national traveler demographics can help to recognize each individual's choice of mode for each trip, based upon demographic information, instead of combining the trips in one homogeneous group.

3.2.3 Travel habits

6) How many trips do you make per weekday for all of your purposes combined (leaving and return for a purpose are two trips)?
7) For the last trip you made using a ride-sourcing service what was your trip purpose?
8) Currently when you use ride-sourcing how many trips per week do you make?
9) What's the average distance of your trips when use ride-sourcing service?
10) What's the vehicle occupancy of your ride-sourcing trip?

The third part of the survey was designed to collect the information on the characteristics of trip making of ride-sourcing users which could then be compared to typical travel habits of traveler's in the Pittsburgh region and national characteristics.

3.2.4 Change of Ride-sourcing users' attitudes

The fourth part of the survey was designed to analyze how ride-sourcing usage changes travelers attitude. A change in traveler's attitudes to items such as previous modes used and number of trips could impact how travel is impacted and how this future trend could be predicted in a region.

11) When you used ride-sourcing recently what mode of travel did you use previously for that trip?
12) What type of trip have you considering using ride-sourcing for in lieu of the mode in previous question?
13) Does ride-sourcing service change the number of trip you make for all purposes?
14) Does availability of ride-sourcing impact your need to own a vehicle?

Finally, this part of the survey aimed to assess the impact of the ride-sourcing services on trip generation in a traditional travel demand model. Question 13 asked directly if ride-sourcing will change users' tendency of making a trip and could help to make a future determination on the impact this mode could have on the assumptions used in transportation planning. Question 14 asked the potential impact of ride-sourcing to vehicle ownership that may also have an influence on number of vehicles per household and therefor trip generation and VMT (Vehicle Miles Travelled)/VKT (Vehicle Kilometers Travelled) in future by the users.

3.3 CONCLUSION

The survey was developed and structured to obtain the necessary data to compare with national data and Pittsburgh Regional data on travel characteristics. The survey results were also structured to obtain data on the characteristics of ride-sourcing and determine if it's a new transportation mode. The determination of if this is a new mode or how it impact's the traditional mode selection process could impact the transportation planning process.

4.0 SURVEY RESULT AND ANALYSIS OF DATA

In this section, Pittsburgh data was compared to national data to demonstrate how the national survey results match with the population travel characteristics currently in the Pittsburgh region.

Then the researcher discussed the results from the survey including user demographics, travel habits and the travel habit change of using ride-sourcing and compared the results to the Pittsburgh data. The comparison, used to evaluate potential impacts on transportation planning, was between the ride-sourcing survey data and Pittsburgh regional data in NHTS 2009. This comparison was used to test the hypothesis.

4.1 NHTS 2009 DATA ANALYSIS

The National Household Travel Survey (NHTS) is the flagship survey of the U.S. Department of Transportation (DOT) and is conducted periodically to assess the mobility of the American public (13). The survey gathers trip-related data such as mode of transportation, duration, distance and purpose, and then links the travel related information to demographic, geographic, and economic data for analysis. Policy makers, individual state DOTs, metropolitan planning organizations, industry professionals, and academic researchers use the data to gauge the extent and patterns of travel, to plan new investments, and for innumerable applications of data on trends in travel for policy and planning.

This section discusses key findings from the NHTS 2009 including user demographics, trip characteristics, and transportation system characteristics. The researcher compared the ride-sourcing survey data results with the NHTS 2009 survey results in order to analyze the potential changes to travel characteristics of ride-sourcing users and current travel characteristics as report by the NHTS survey.

The data used for comparison to the survey was based upon NHTS survey results from the Pittsburgh region. The data was obtained from the CBSA (Core-Based Statistical Area) codes which were also included in NHTS 2009 database. The CBSA code of Pittsburgh Metropolitan area (the green part in the figure 1 defined the metropolitan statistical area) is 38300(14).The data of Pittsburgh area was found from NHTS 2009 data set with the variable HH_CBSA (House Hold Core-Based Statistical Area), which consisted of 171 household survey samples.

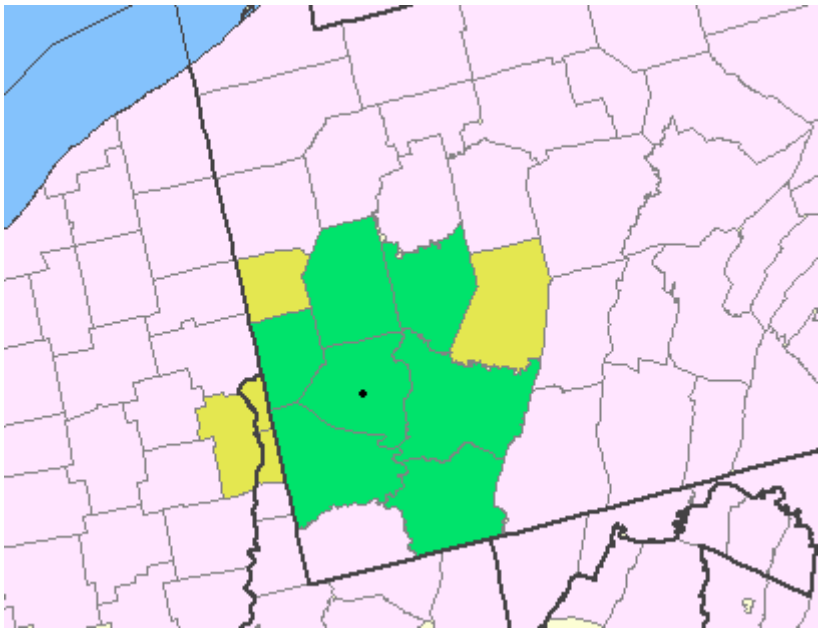

Figure 1. Pittsburgh Metropolitan Region Map for NHTS 2009

The analysis work was divided into 3 parts, the first part gathered the demographics data about travelers in the Pittsburgh metropolitan area from the NHTS survey, including the gender,

age and vehicle ownership information of respondents and then compared that data to the NHTS survey results for the United States as a whole. The second part gathered and compared the Pittsburgh regional trip characteristics data with the national survey data. The third part compared the Pittsburgh regional trip characteristics information for characteristics such as trip purposes and trip length of different kinds of modes to the national survey results. The purpose of this comparison was to identify the differences from Pittsburgh regional travel characteristics from US national travel characteristics to provide a regional context when comparing the survey results.

4.1.1 US national and Pittsburgh regional demographic data of NHTS 2009

Gender of respondents Comparison

The NHTS 2009 data shows that there were 283,054 respondents in total; include 139,257 males and 143,797 females as shown in Figure 2. In Pittsburgh area there are 349 respondents in the 171 households which included 153 males and 196 females. The Pittsburgh regional data has a higher proportion of females.

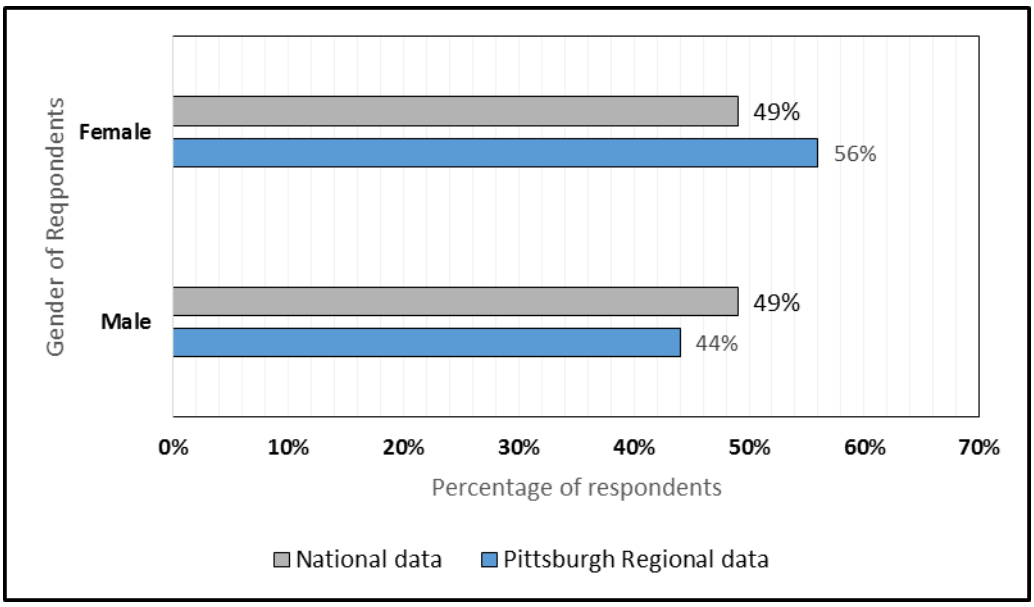

Figure 2. National and Pittsburgh Regional Respondents Gender Data Comparison

Age of respondents

The NHTS 2009 data shows that there are 283,054 respondents in total; include 64,138 Under 20, 50,844 from 20 to 34 males, 129,202 from 35 to 64 and 38,870 over 65. In Pittsburgh area there are 346 respondents include 47 under 20, 32 from 20 to 34, 160 from 35 to 64 and 107 over 65 as shown in Figure 3. This comparison reveals an older population in the Pittsburgh region responding to the survey.

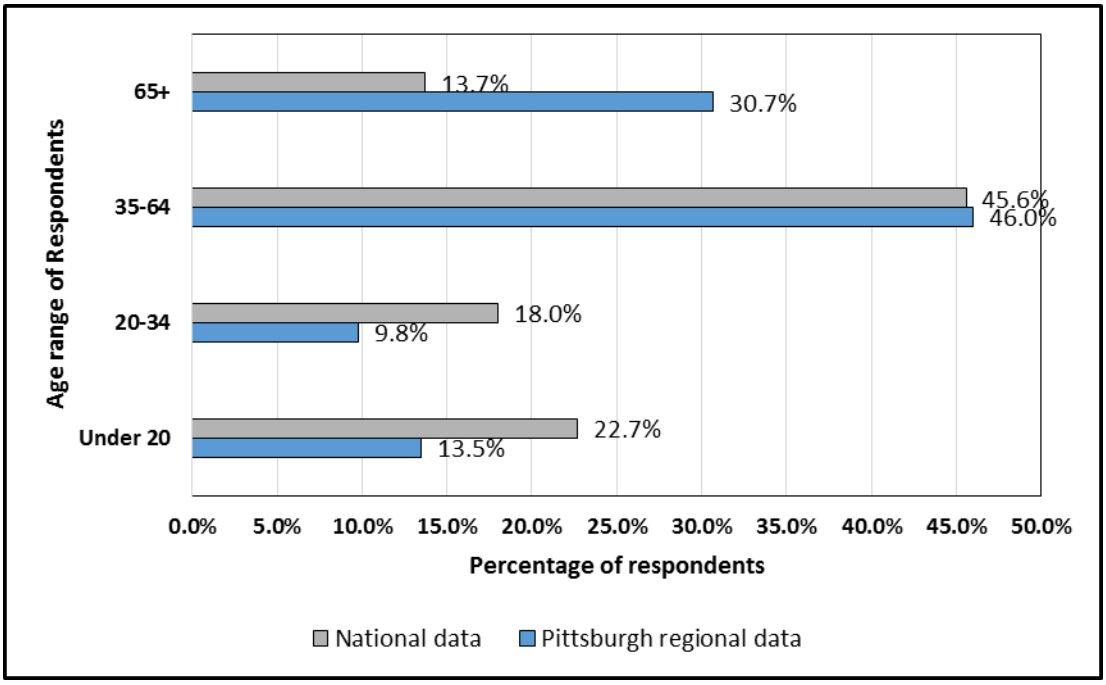

Figure 3. National and Pittsburgh Regional Respondents Age Data Comparison

Vehicle Ownership of respondents

The NHTS 2009 data shows that there are 283,054 respondents in total; include 210,778 respondents that own vehicles and 72,276 respondents that don't own vehicles. In Pittsburgh area there are 387 respondents of vehicle ownership include 316 respondents that own vehicles and 71 respondents don't own vehicles as shown in Figure 4. This comparison revealed that auto ownership rates in the Pittsburgh region are almost identical to the national rates.

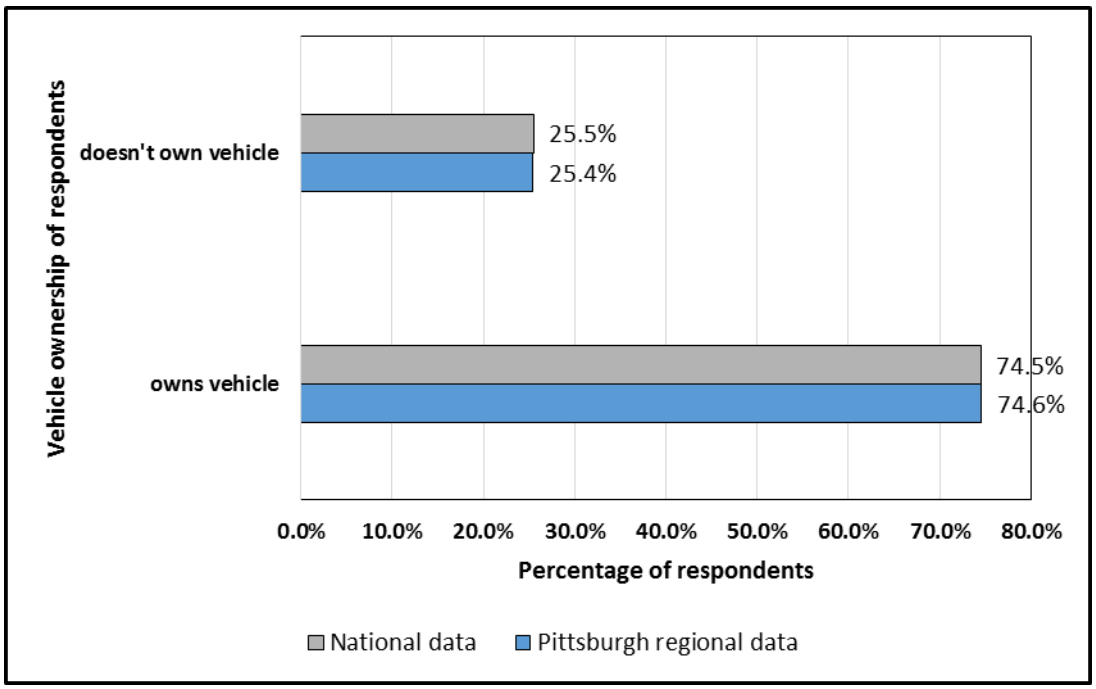

Figure 4. National and Pittsburgh Regional Respondents' Vehicle Ownership Data Comparison

In summary, this section obviously shows that demographically the Pittsburgh region has an older population and the auto ownership rate is similar to National data. This comparison will help to analyze if the demographic information of ride-sourcing data was influenced by Pittsburgh regional demographic characteristics.

4.1.2 US national and Pittsburgh regional travel habits data of NHTS 2009

Daily trip purpose distribution per household comparison

The NHTS 2009 data shows that the average number of daily trips per household (2.50 persons per household in average) is 5.94 in total, include 1.31 trips commute to/from work, 1.25 trips for shopping, 1.47 trips for other family/personal errands and 1.21 trips for social and recreational. In Pittsburgh area the number of daily trips per household (2.26 persons per

household in average) is 3.86 in total, include 0.80 trips commute to/from work, 1.09 trips for shopping, 1.49 trips for other family/personal errands and 0.46 trips for social and recreational as shown in Figure 5.

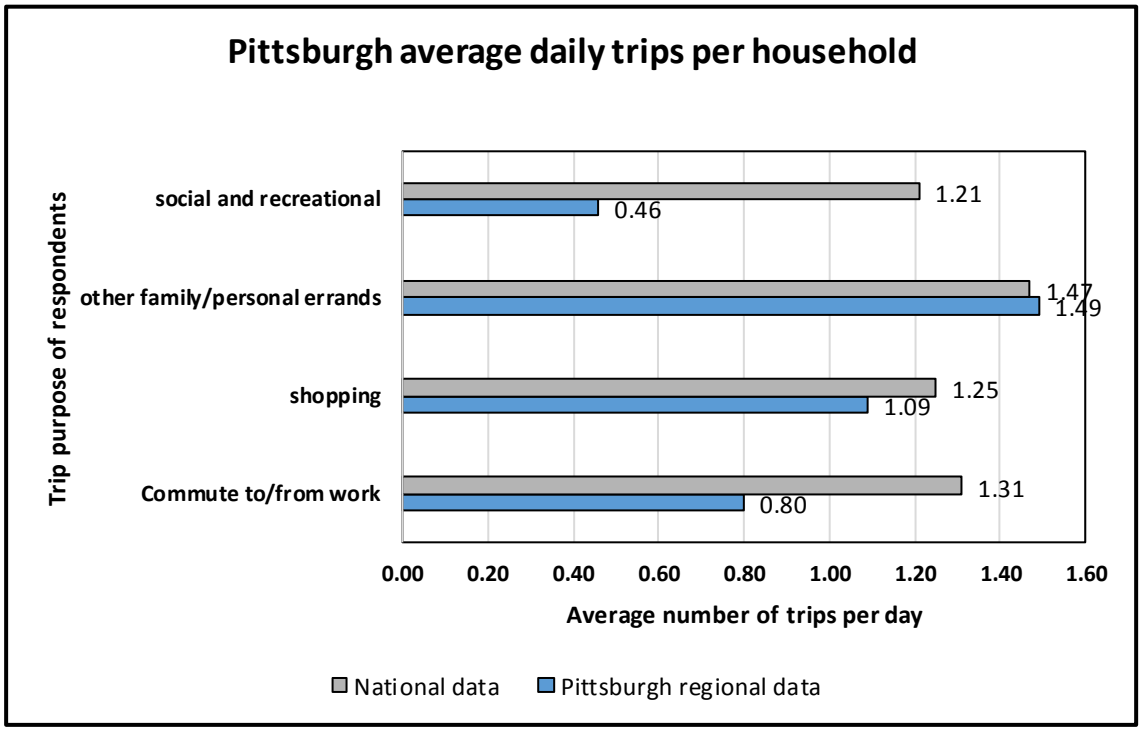

Figure 5. National and Pittsburgh Regional Respondents' Average Number of Daily Trip Purpose

Trip modes distribution of respondents

The NHTS 2009 data shows that in travel day trips there were 88% private vehicle trips, 2.22% transit trips and 9.72% other type of trips. In Pittsburgh area the travel day trips included 85% private vehicle trips, 2.57 transit trips and 12.22% other type of trips as shown in Figure 6.

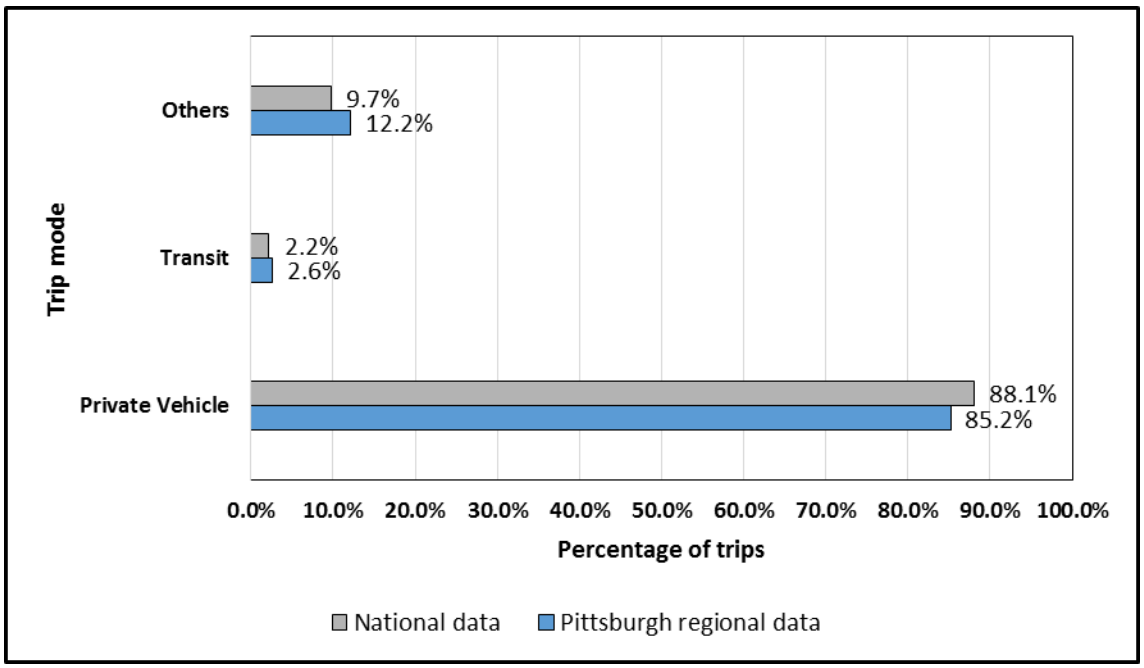

Figure 6. National and Pittsburgh Regional Respondents' Travel Day Trip Modes

Trip length for different purpose

The Pittsburgh regional respondents' trip length is less than the trip length shown in national data. The average trip length of Pittsburgh regional respondents combined all purposes is 8.0 miles and the average trip length of nation respondents is 9.9 miles as shown in Figure 7.

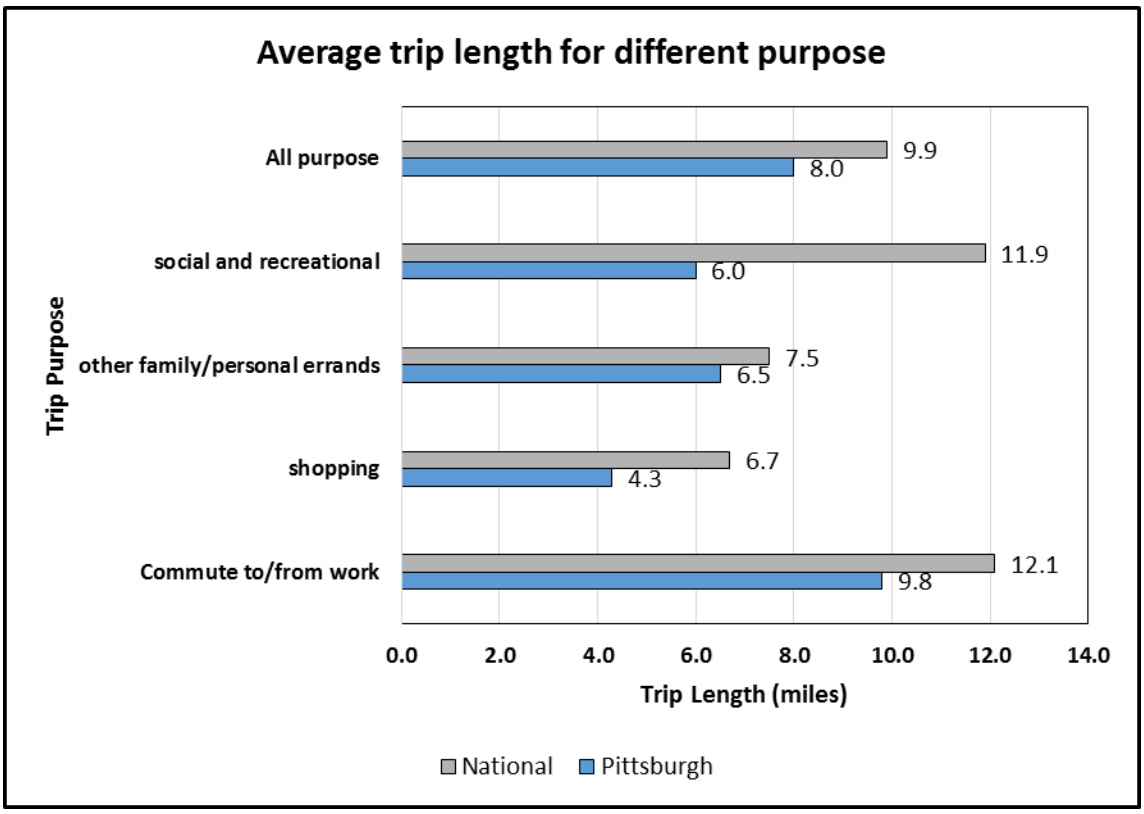

Figure 7. National and Pittsburgh Regional Respondents' Average Trip Length

Vehicle occupancy

For NHTS data, vehicle occupancy is generally computed in two ways: mile-based method or trip-based method. The mile-based method calculates person miles of travel per vehicle mile. The trip-based method is calculated from the number of persons per vehicle trip (referred to as the number on trip)

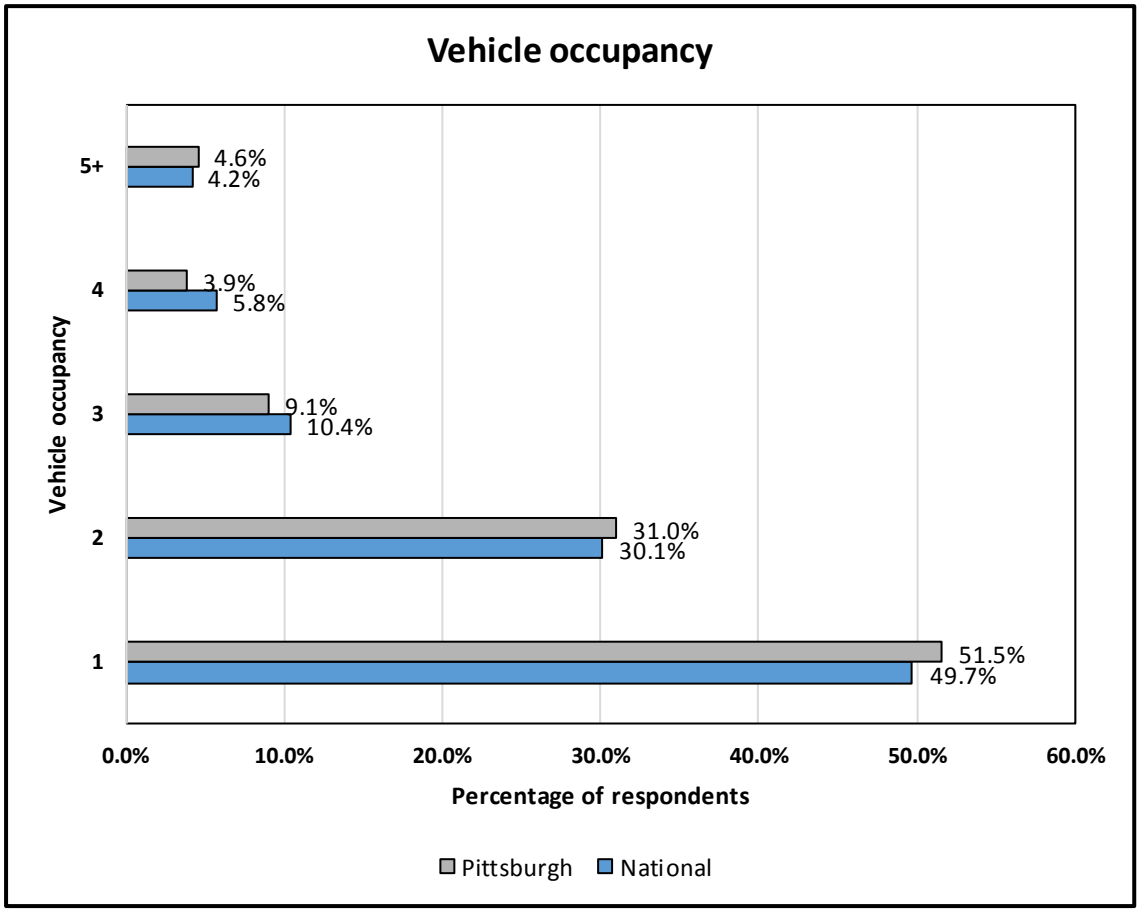

Figure 8. National and Pittsburgh Regional Trips' Vehicle Occupancy

In summary, the Pittsburgh data was compared to national data to demonstrate how the survey matches with the population travel characteristics currently in the Pittsburgh region. As shown in figure 8, the comparison revealed that the vehicle occupancy rate of Pittsburgh area is similar to national data in NHTS 2009 and can represent the typical data.

The national data could be compared to the survey however it would not be as a direct comparison as the Pittsburgh data. When interrupting the survey results a comparison with national data could be performed but would require adjustment for local conditions.

4.2 RIDE-SOURCING SURVEY RESULTS

The survey was conducted online and hosted by Qualtrics Survey System of University of Pittsburgh in Pittsburgh Pennsylvania. The number of responses received was 89 in total, the raw data of the survey is provided in appendix C. The data is being presented as percentages of responses for comparison purposes however the actual number of responses to each question is provided in appendix C.

4.2.1 Respondent demographic information comparison

As the result as shown in Figure 9, respondents to the research survey were generally younger than the average population in Pittsburgh area as reported in the NHTS survey.

Ride-sourcing Respondents were 70% male and 30% female, these results is differ significantly from the results from the NHTS survey (56% female and 44% male) as shown in Figure 10.

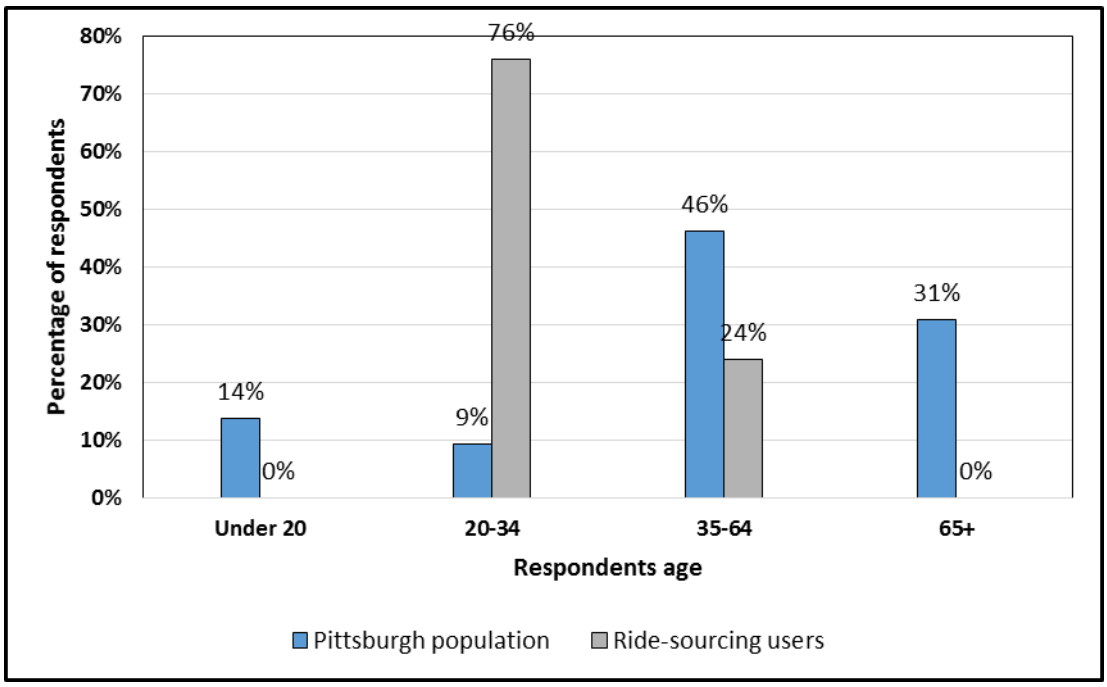

Figure 9. Age (Respondents under 13 were eliminated) Distribution of Ride-sourcing Survey Respondents Compared with Pittsburgh Regional Data in NHTS 2009

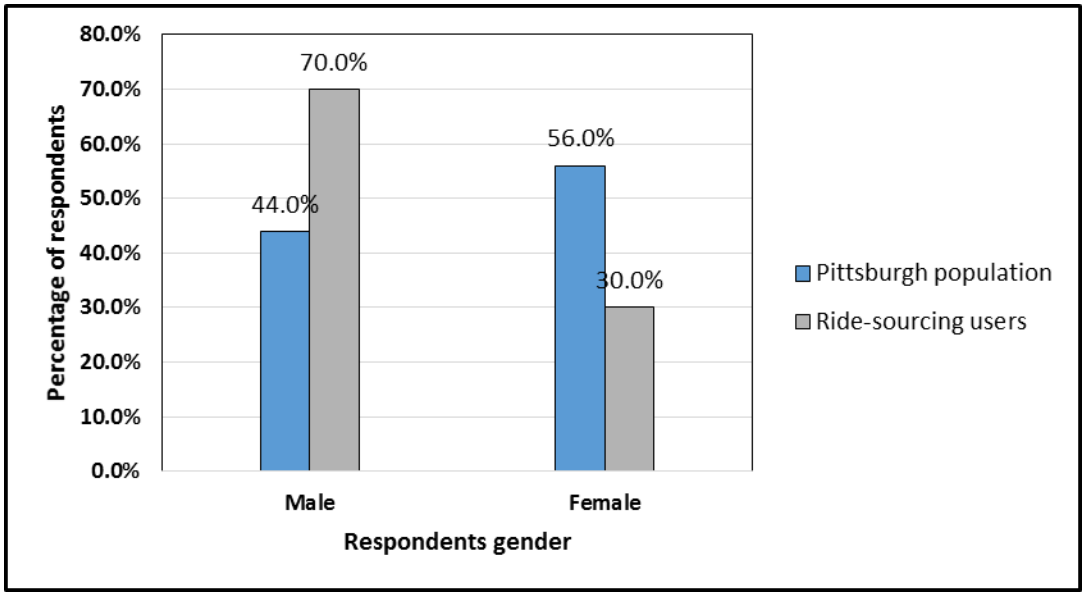

Figure 10. Gender distribution of ride-sourcing survey respondents compared with Pittsburgh regional data in NHTS 2009

This comparison shows that:

- Rider source users are generally younger than the typical traveler
- The service is used by a higher percentage of males than females

4.2.2 Respondent travel habits comparison

Trip purpose and Trip frequency

The presentation of this portion of the survey results is based upon all respondents that use ride-sourcing. The responses have not been categorized by demographic information. In comparison with Pittsburgh regional data of trip purpose, ride-sourcing trips were mainly social and leisure trips. Of all responses, 82% were social/leisure (bar, restaurant, concert, visit friends/family). Only 15% were commute to/from work, 3% were other personal/family errands. This comparison is shown in Figure 11.

Meanwhile, the trip frequency of ride-sourcing data shows that 6% of ride-sourcing survey respondents will make 1 trip per weekday, 30% respondents will make 2 trips per weekday, 18% respondents will make 3 trips per weekday, 30% respondents will make 4 trips per weekday and 15% respondents will make 5 or more trips per weekday. This information is shown in Figure 12.

This comparison shows that ride-sourcing is used primarily as a mode for social type trips and the trip frequency is greater for ride-sourcing travelers.

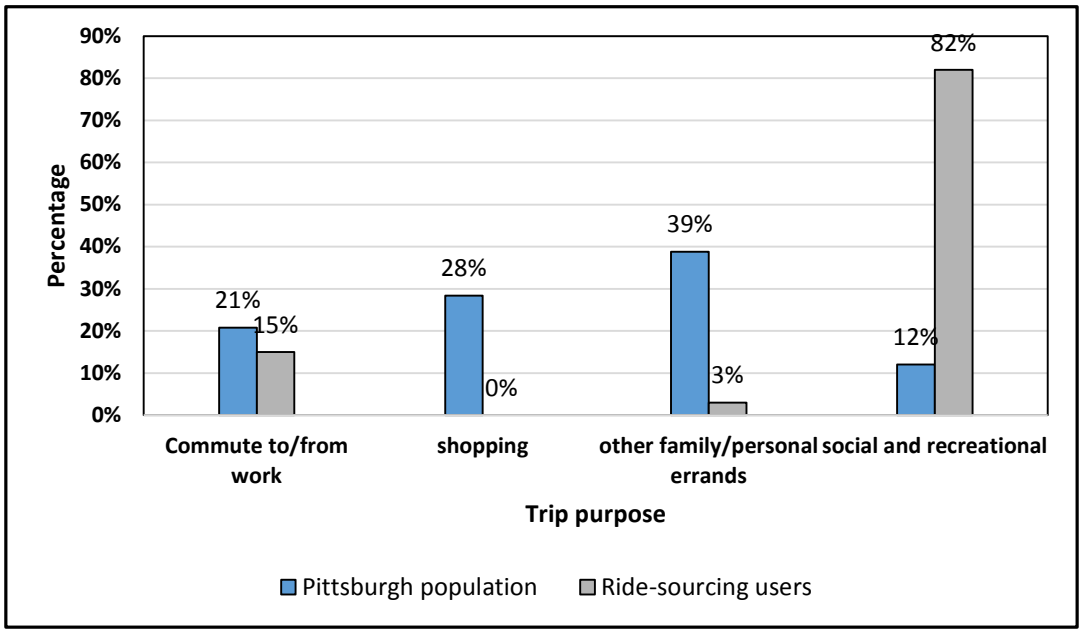

Figure 11. Trip Purpose of Ride-sourcing Respondents Compared with Pittsburgh Regional Respondents Data in NHTS 2009

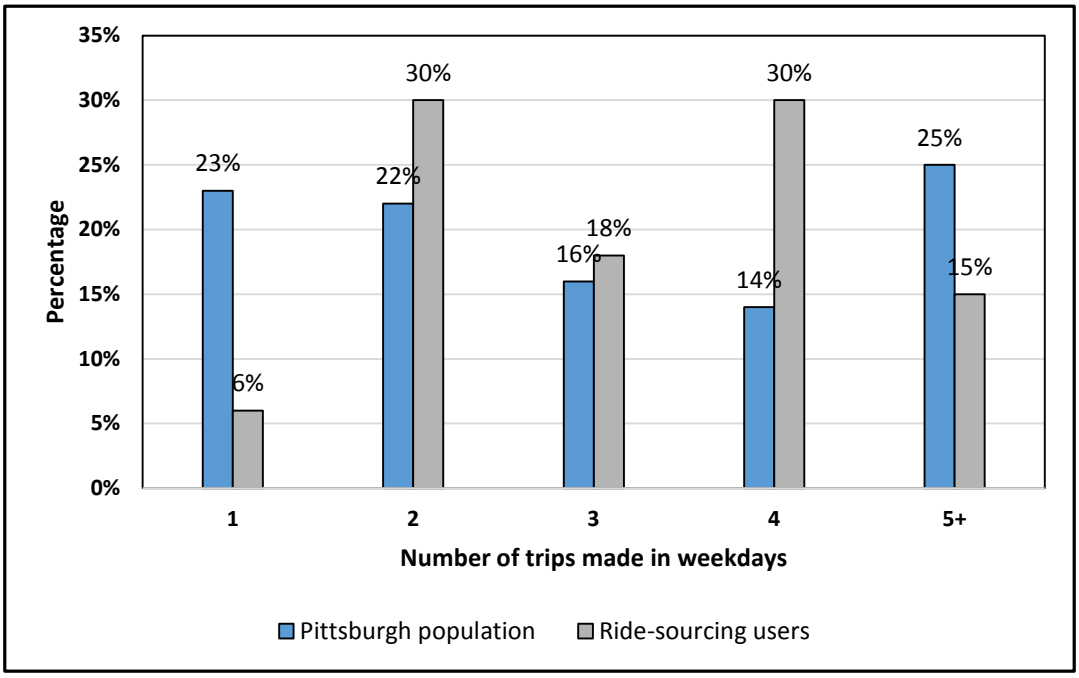

Figure 12. Trip Frequency of Ride-sourcing Respondents Compared with Pittsburgh Regional Data in NHTS 2009

Trip length

The trip length of ride-sourcing was lower than regular trips in the Pittsburgh area. The average length of the purpose commute to/from work is 3.5 miles, the average trip length of purpose other family/personal errands was 2.0 miles, the average trip length of purpose social and recreational was 4.8 miles and the average length combined all the purpose is 4.5 miles. This data comparison is shown in Figure 13. This showed that ride-sourcing trips are generally 44 percent shorter than typical travel trips using other modes. The trip length may be determined by trip makers based upon several factors including income level, trip purpose, and trip costs. It may also be a function of the availability and cost of other modes. The longest trip in the survey was 10 miles which is a long distance in Pittsburgh urban traffic. The threshold for a trip length using resourcing may be determined with more specific data.

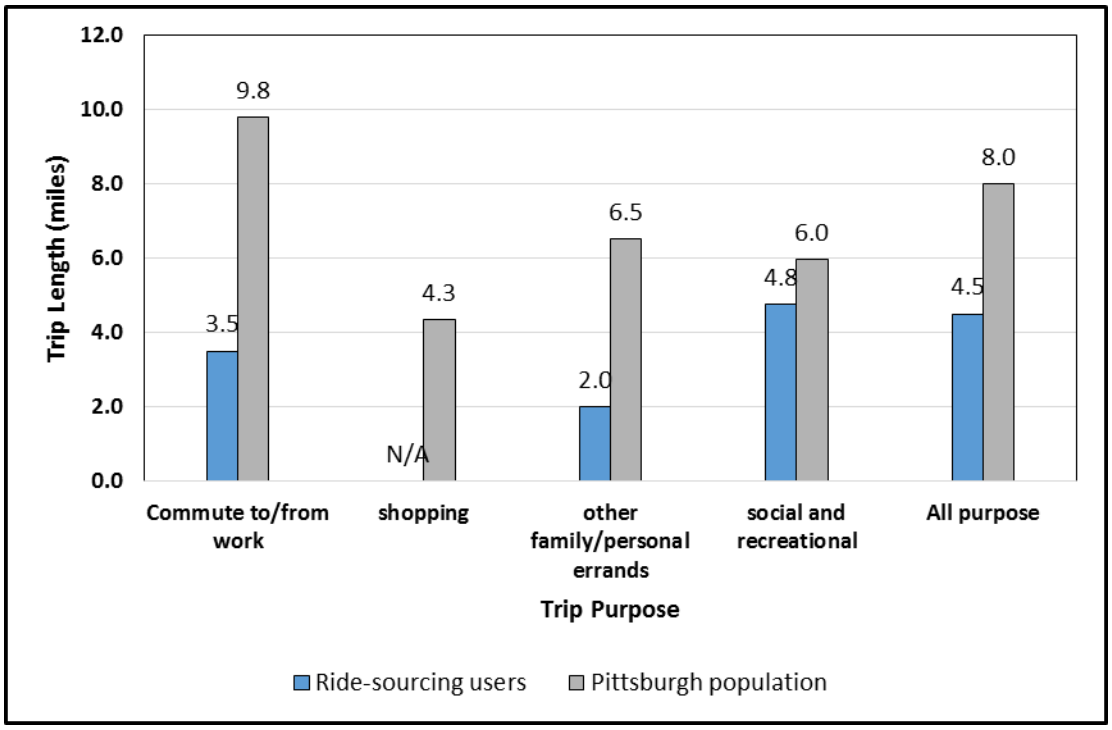

Figure 13. Trip Length of Ride-sourcing Respondents Compared with Pittsburgh Regional Respondents Data in NHTS 2009

Vehicle occupancy

Vehicle occupancy of ride-sourcing trips was higher than normal trips in Pittsburgh area. 73% of ride-sourcing trips had more than one passenger, and the average number of passengers was 2.2. According to the NHTS 2009, the average number of passengers for normal trips of Pittsburgh was 1.8. It is noted that the occupancy rate reported for ride-sourcing users did not include the driver of the ride-sourcing vehicle so therefore these occupancy rate are a direct comparison. The comparison is shown graphically in Figure 14.This reveals that ride-sourcing may make travel more efficient, in terms of auto occupancy, by carrying more travelers in fewer vehicles than current travel characteristics.

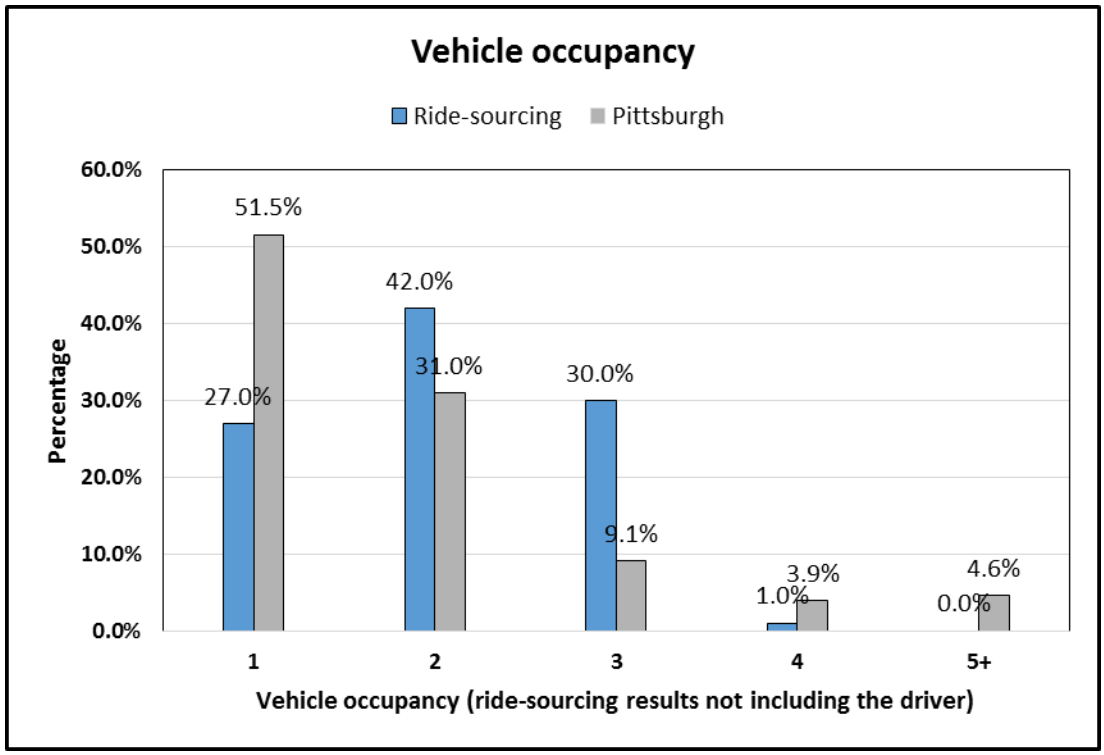

Figure 14. Vehicle Occupancy Rate of Ride-sourcing Respondents Compared with Pittsburgh Regional Respondents in NHTS 2009

In summary this comparison shows that:

- Social and recreational trips are the predominant type of trip used for ride sourcing followed by work trips.
- Ride-sourcing trips appears to be more frequent than trips for all other modes.
- Trip lengths are generally shorter when compared to typical trip makers
- Vehicle occupancy rates are generally higher for ride source trips

4.2.3 Change of respondents' trip attitudes

Change of vehicle ownership

This question was only responded to by persons that do not own a vehicle. The number of responses was very low, two, so therefore this information is not relevant and not used in the analysis of the results.

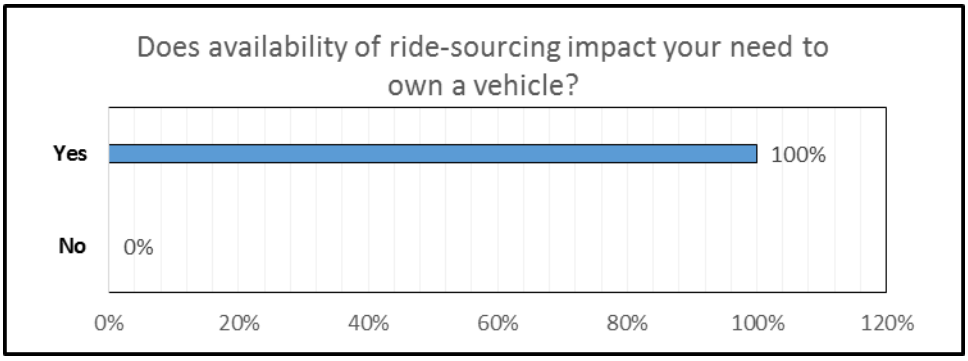

Figure 15. Vehicle Ownership Needs of Ride-sourcing Respondents

Change of trip frequency

The comparison of the frequency of trips for all purposes changed by ride-sourcing service availability shown that 27% of respondents make more trips with the help of ride-sourcing services, 67% of respondents responded that ride-sourcing has no change for the

number of trips they would make and only 6% of respondents said they would make fewer trips. The survey results are shown in Figure 16. This reveals that with ride-sourcing being available more trips could be generated by a portion of the traveling public.

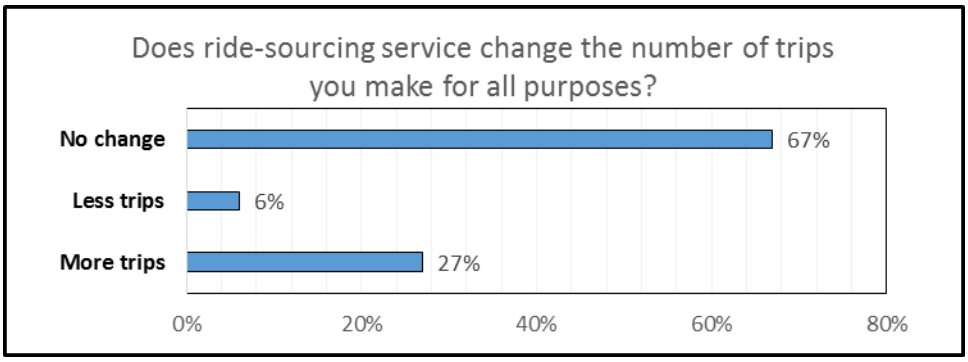

Figure 16. Travel Trends of Ride-sourcing Respondents

Mode Split

The results of the mode split shown that 9% of respondents use transit previously for the resent ride-sourcing trip, 48% respondents use private vehicle, 33% of respondents use taxis and 9% of respondents said they did not make the trips before. The responses to the question are shown in Figure 17. The results shown that if a traveler was using another mode and shifting to ride-sourcing the modes most impacted are taxi and private auto. This type of shift would have little impact on the number of vehicles on the roadway by ride-sourcing. Only a small percentage shifted from public transit which would result in more autos being generated.

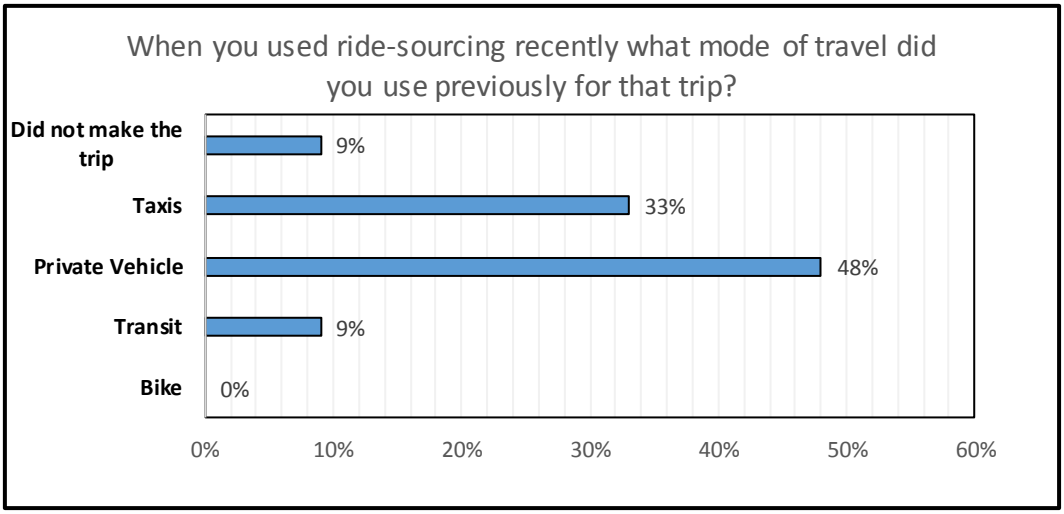

Figure 17. Mode Used Previously for the Resent Ride-sourcing Trip

These survey question results show that ride-sourcing users likely generate more trips than typical travelers in Pittsburgh region, and private vehicle trips are most impacted by ride-sourcing where a mode shift is involved.

4.3 CONCLUSION

The results from the survey including user demographics, travel habits and the change of travel habits using ride-sourcing revealed several interesting results. When the researcher compared ride-sourcing survey data with Pittsburgh population data the following was revealed.

- Rider source users are generally younger than the typical traveler
- The service is used by a higher percentage of males than females
- Social and recreational trips are the predominant type of trip used for ride sourcing followed by work trips.

- Trip lengths are generally shorter when compared to typical trip lengths
- Vehicle occupancy rates are generally higher for ride source trips.
- Ride sourcing users generate more trips than typical traveler's in the Pittsburgh region.
- The use of taxis and private autos are most impacted by ride sourcing where users' shift away from these modes.
- Transit trips are impacted by a small degree.

5.0 SURVEY RESULT AND ANALYSIS OF DATA

This section considers how the results of this research could impact the practice of transportation planning. Because regional travel demand models are the primary tool used by transportation planners to predict future travel conditions and ride-sourcing is an emerging method of travel the impact on the modeling process must be considered. All steps in traditional four step travel demand process were considered on how ride-souring could impact the current methodology. It was concluded from the research that trip generation and mode choice steps could be most impacted.

The Trip distribution step was not considered because the survey did not request information on this however based upon the information available it does not appear that ride-sourcing users are selecting destination different geographic destination from typical trips. Trip assignment was determined to be similar for ride-sourcing users since the mode of travel is auto and route selections would not change.

There are many types of travel demand models being used in the United States. Because the survey was conducted in the Pittsburgh region and compared to Pittsburgh travel characteristics, the travel demand model used for the region was examined. Data was provided by the Southwestern Pennsylvania Commission (SPC) on their current methods of trip generation and mode choice models in the regional travel demand model. This information was examined

and conclusions reached on what the survey revealed on how these methods could be impacted in the future if ridesharing was a significant number of trips in the region.

The following presents suggested modifications to the Pittsburgh regional travel demand model that could be incorporated in the future to modify these two steps in the process based upon this research.

5.1 TRIP GENERATION MODELS

Trip generation is commonly considered as the first step in the four-step modeling process. It is intended to address the question of how many trips of each type begin or end in each location. It is standard practice to aggregate trips to a specific unit of geography (e.g., a traffic analysis zone).

In the SPC model, the trip generation rates were categorized by:

- **Trip production rates:** Composed of a home-based work trip rate and home-based other trip rate.
- **Trip attraction rates:** Composed of a home-based work trip rate, a home-based other trip rate, a non-home-based work trip rate and a non-home-based other trip rate. Separate trip attraction rates are generated for trucks including light truck trip rates, medium truck trip rates and heavy truck trip rates.

5.2 TRIP GENERATION MODELS

The SPC model currently considers auto and transit modes only (17). The following is a description of how the mode choice is determined in the model.

Auto modes:

Auto modes are generally classified by automobile occupancy level (drive alone, two-person carpool and 3 or more person carpool). Sometimes autos using toll roads are modeled as separate alternatives, often also classified by auto occupancy level. Figure 18 shows how SPC classifies all types of trips including auto, fringe and transit (17).

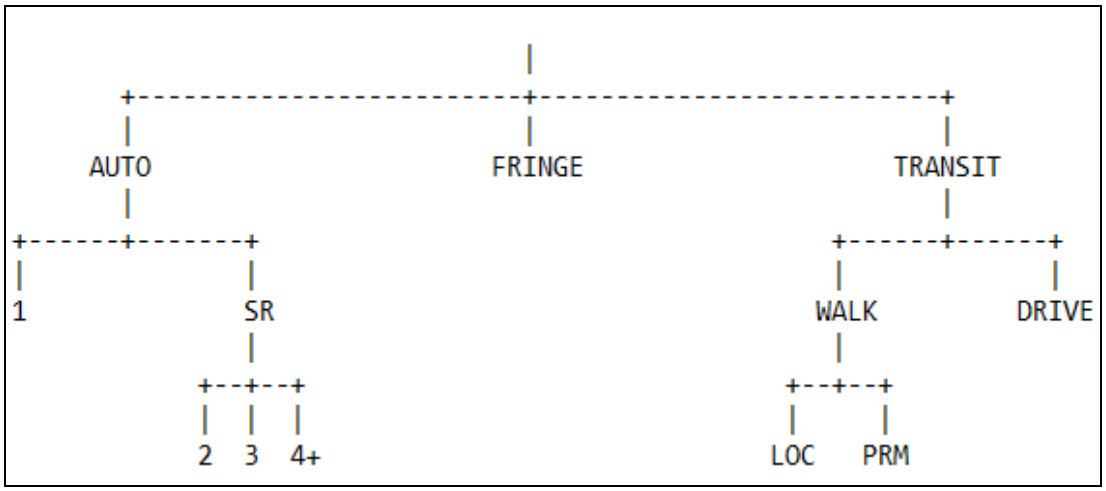

Figure 18. SPC Nested Choice Structure

The following at the definitions for each type of modes (details are provided in Appendix C):

1 = drive alone

SR = share ride

2 = 2-occupant auto

3 = 3-occupant auto

4+ = 4+occupant auto

FRINGE = park/ride to transit at a CBD fringe lot

TRANSIT = bus or rail, or both

WALK = walk access to transit

DRIVE = drive access to transit

LOC = local path (does not use rail or busway buses)

PRM = premium path (uses rail or busway buses for at least a segment)

The following utility functions are also used to determine how the mode choice is made based upon factors that determine how a traveler makes a mode choice. There are a total of 26 utility functions that impact the 11 types of mode choices shown. Each of these utility functions were reviewed to determine which may be most impacted by a ride sourcing type of trip.

Table 1. SPC Mode Choice Utility Expression (17)

	COEF	1	2	3	4	SR	AUTO	FRNG	LOC	PRM	WALK	DRIV	TRANS
CIVT/ CLSAUTO	1	X											
CIVT/(CLSAUTO*CLSOCC)	2		X	X	X								
CIVT/(CLSACC*CLSPATH)	3								X	X			
COVT/ CLSAUTO	4	X											
COVT/(CLSAUTO*CLSOCC)	5		X	X	X								
COVT/(CLSACC*CLSPATH)	6								X	X			
CPCOST/ CLSAUTO	7	X											
COCOST/ CLSAUTO	8	X											
CPCOST/(CLSAUTO*CLSOCC)	9		X	X	X								

Table 1 (continued).

COCOST/(CLSAUTO*CLSOCC)	10		X	X	X									
COCOST/(CLSACC*CLSPATH)	11								X	X				
K3	12			X										
K4	13				X									
KSR	14					X								
	15													
K1DACC/CLSACC	16							X				X		
K2DACC/CLSACC	17							X				X		
K0TRAN	18													X
K1TRAN	19													X
K2TRAN	20													X
CCBD	21											X		
COAK	22											X		
CLSOCC	23					X								
CLSAUTO	24						X							
CLSPATH	25										X	X		
CLSACC	26													X

5.3 IMPACT OF RIDE-SOURCING ON TRIP GENERATION

5.3.1 Impact to trip attraction

The type of activity that affects the number of trip attractions depends on the trip purpose. For example, home-based work trip attractions are usually estimated best by using employment as the explanatory variable. Other purposes typically use different sets of variables (school enrollment or employment for home-based school trips, retail employment for home-based shopping trips, etc.).

The impact of ride-sourcing to trip attraction cannot be directly evaluated with the survey results because the origin and type of trip productions were only considered. But trip attractions could be analyzed indirectly with data of where the origin and destination of ride-sourcing trips were if it was requested in a survey.

5.3.2 Impact to trip production

The SPC model and others estimate trip production based one a large number of utility functions which were previously presented. However the generalized trip production model is the cross-classification model. The households in each zone are classified by one or more variables, and the number of households in each category is multiplied by the appropriate "trip rate," representing the average number of trips per household for the category. Mathematically, the number of trips generated in a zone is given by (15):

$$P_i^p = \sum_k Prate_{pk} * h_{ik}$$

Where,

P_i^p=Number of trip ends produced for purpose p in zone i.

$Prate_{pk}$= The production trip rate for purpose p per household for category k

h_{ik}= The number of households in category k in zone i.

If ride-sourcing is put into consideration, the coefficient ofP_i^p, $Prate_{pk}$ may change as more trips were made and higher trip rate per household could result.

5.4 IMPACT OF RIDE-SOURCING ON MODE CHOICE

Factors that may explain a trip maker's choosing a specific mode of transportation for a trip are grouped commonly as follows (16):

Table 2. Factors may influence mode choice

Trip makers' characteristics	Income
	Car ownership
	Car availability
	Age
Trip characteristics	Trip purpose
	Trip length
	Destination Orientation- CBD vs. Non-CBD

Table 2 (continued).

Transportation Systems characteristics	Waiting time
	Speed
	Cost
	Comfort and Convenience
	Access to terminal or transfer station

Ride-sourcing may be acting a new travel mode in transportation or it may be considered an auto or transit type of trip with different characteristics. Generally mode choice can be expressed by the utility function in disaggregate model as follows:

$$\mathrm{p(k)} = \frac{e^{U_k}}{\sum_{x=1}^{n} e^{U_x}}$$

Where,

$\mathrm{p(k)}$ = probability of using mode k

e^{U_k} = utility of using mode k

e^{U_x} = utility of using any particular mode x

n = number of modes to choose from

There are two considerations of the role that ride-sourcing can have on the mode choice model.

Ride-sourcing could be included into the auto mode. Consider the survey results of vehicle occupancy of ride-sourcing, it can be consider as a type of shared ride of the auto model.

How it differs is that it is offered for a fee and the user will choose this auto mode based upon the actual trip cost to be paid at the time of the trip. While privately owned auto trips also have a cost the user when making the choice is not always considering the total cost of the trip.

The utility of ride-sourcing in Pittsburgh as an auto model could be modified and modeled with SPC method. Coefficients that could change would include the following:

- CLSOCC: the auto occupancy rate may change to a higher rate when ride-sourcing were included in Auto model.
- CPCOST: The parking cost may change and be zero since there is no need to consider the parking cost for ride-sourcing users.
- KSR: Constant of share ride will change with the influence of ride-sourcing. There would be a higher rate or ridesharing.
- CIVT/(CLSAUTO*CLSOCC): Changes with CLSOCC
- COVT/(CLSAUTO*CLSOCC): Changes with CLSOCC
- CPCOST/(CLSAUTO*CLSOCC): Changes with CPCOST and CLSOCC
- COCOST/(CLSAUTO*CLSOCC): Changes with CLSOCC

Ride-sourcing could be considered as a new mode. The survey results shown that ride-sourcing trips were shifted from the different traditional types of modes considered in the mode choice models. Since auto and transit, and to some degree pedestrian and bike, are all well-defined modes ride-souring needs a more specific definition to be considered a new mode of travel.

If ride-sourcing is considered as a new travel mode, the utility function of ride-sourcing may be taken into consideration in order to evaluate the probability of using this mode, the utility function of ride-sourcing could be:

$$p(r) = \frac{e^{U_r}}{\sum_{x=1}^{n+1} e^{U_x}}$$

$p(r)$ = probability of using ride-sourcing

e^{U_r} = utility of using mode ride-sourcing

e^{U_x} = utility of using any particular mode x

n = number of modes to choose from (not include ride-sourcing)

The key to using the function would be to define e^{U_r}. Further research would be required to determine if this function can be defined.

5.5 IMPACT OF RIDE-SOURCING ON TRAFFIC ASSIGNMENT

As two basic inputs to the assignment process are the transportation network and the zone to zone trip interchanges, the traffic assignment step be impacted directly. But changes came with ride-sourcing in trip generation and mode split also impact traffic assignment. Also we see a pattern of average trip length of ride-sourcing trips that indicate that traffic assignment could be impacted.

5.6 CONCLUSION

Ride-sourcing has both unique characteristics and has common grounds with traditional trip modes included private vehicle, ridesharing, transit and taxi. As ride-sourcing becomes more popular, it may have a greater impact on travel and therefore demand models should consider how to include this in the four step process.

Currently, ride-sourcing is still a relatively small number of daily trips in an urban area. However as populations increase in urban areas and the demand for transportation facilities increase the new type of travel could increase to significant levels.

Unlike conventional transit modes (18), ride-sourcing is an on demand service mode which doesn't operate with a schedule, and the pick-up and drop-off locations are determined by the passenger, not by the service provider. And compared with taxicab services, ride-sourcing (here means the services like UberX) also shows unique features include service technology (GIS, on demand service and a different vehicle licensing/insurance system) which differentiates it from taxicab. It could be considered as a new transportation mode or categorized in as an auto mode in travel demand models. This is an akin service provided by Taxicab Company could also be treated as ride-sourcing.

6.0 CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1 CONCLUSION

As ride-sourcing is an evolving new travel option, there is little research indicating the role of ride-sourcing in current travel characteristics or urban transportation planning. In this research a survey of ride-sourcing users in Pittsburgh Pennsylvania was performed to evaluate the hypothesis that ride-sourcing travelers have different travel characteristics than other types of traveler's or modes. The survey results were compared with Pittsburgh regional data in NHTS 2009 and concluded that ride-sourcing travelers are younger users, have higher vehicle occupancy rates and replace some private vehicle trips especially when the trip purpose is social and recreational.

Although the impact of ride-sourcing still exploratory, the survey results indicates ride-sourcing may have an impact on regional travel demand models, and further work is needed to better understand its impacts.

6.2 RECOMMENDATIONS FOR FUTURE RESEARCH

6.2.1 Expanded demographic categories

Because the survey conducted was designed to be brief, additional data could be requested in an expanded survey to better understand the demographics of users. Because origins and destinations is an important issue in travel demand model this information could be requested. Ride-sourcing may be limited to urban areas with higher population densities and lower auto ownership rates however this information would be needed to make any conclusion on the geographic location of ride-sourcing users. Another important issue is the income level of the respondents, higher income populations seems to make more daily trips, an analysis focused on a screened population may help better analyze the impact of ride-sourcing.

6.2.2 Expanded trip characteristics

Because of the restriction of the length of the survey, there were no questions of the cost of ride-sourcing trips, the reason why they choose ride-sourcing and the waiting time, etc. which may help evaluate the coefficient in mode choice The future research of ride-sourcing should focus on 3 aspects of this type of travel:

Detailed Ride-sourcing trips data. More detailed data of ride-sourcing is needed and should be collected from the household survey in future. The trips data could not only achieved from the survey but also from the in-vehicle systems which can accurately record the origin, destination, trip length, cost and trip routes of the ride-sourcing trips. This information would

have to be obtained from the private companies such as Uber and Lyft. As ride-sourcing rapidly evolves, the research should also include other cities but not only in Pittsburgh.

Development of Ride-sourcing forecasts. The impact of ride-sourcing on the number of trips made by users, the vehicle ownership rates and the development of ride-sourcing needs to be researched further. There are different regulations in different states and it's still unclear if ride-sourcing can be available everywhere. The development trends of ride-sourcing is also needed in order to measure the impact of ride-sourcing to other transportation modes include taxis and ride-sharing.

Complete modeling methodology. The impact of ride-sourcing on travel demand models not only needs the complete trips data but also need a modeling methodology. The methodology should be used to determine how to use the O/D data to evaluate the ride-sourcing impact to trip generation and attraction rates, how to use the travel characteristics data to evaluate the utility of this travel mode and forecast the trip route of ride-sourcing if possible.

APPENDIX A

THE SURVEY

Default Question Block

The purpose of this research project is to evaluate the travel characteristics of ride-sourcing users to determine how this new method of travel may impact travel characteristics

Do you own a smart phone?

- Yes
- No

Have you used Uber or Lyft service (rider-sourcing) before?

- Yes
- No

The following questions relate to your demographics information

What's your age

- Under 20
- 21 to 35
- 36 to 65
- Over 65

What's your gender

- Male
- Female

Do you own a vehicle?

- Yes
- No

The following questions relate to your travel habits

When you used ride-sourcing recently what mode of travel did you use previously for that trip?

- ○ Bike
- ○ Transit
- ○ Private vehicle
- ○ Taxis
- ○ Did not make the trip

What type of trip have you considering using ride-sourcing for in lieu of the mode in previous question?

- ○ Commute to/from work
- ○ Shopping
- ○ Other Family/Personal Errands
- ○ Social and Recreational

Does ride-sourcing service change the number of trips you make for all purposes?

- ○ More trips
- ○ Less trips
- ○ No change

Does availability of ride-sourcing impact your need to own a vehicle?

- ○ yes
- ○ no

How many trips do you make per weekday for all of your purposes combined (leaving and return for a purpose are two trips) for all modes you use?

- 1
- 2
- 3
- 4
- 5+

For the last trip you made using ride-sourcing service what was your trip purpose

- Commute to/from work
- Shopping
- Other Family/Personal Errands
- Social and Recreational

Currently when you use ride-sourcing how many trips per week do you make?

- 1
- 2
- 3
- 4
- 5+

What's the average distance of your trips when use ride-sourcing service

- Less than 1 miles (less than 3 mins)
- 1-3 miles(3 to 8 mins)
- 3-5 miles(8 to 12 mins)
- 5-10 miles(12-25 mins)
- 10-20 miles(25-50 mins)
- 20+ miles(more than 50 mins)

what's the vehicle occupancy of your last ride-sourcing trip (not including the driver)

- 1 passenger
- 2 passengers
- 3 passengers

The following questions relate to how ride-sourcing changes your travel attitude

APPENDIX B

DETAILED COMPARISON OF NATIONAL AND PITTSBURGH REGIONAL DATA OF NHTS 2009

	National	Pittsburgh
Respondents Gender		
Male	139257	153
Female	143797	196
Respondents Age		
Under 20	64138	47
20-34	50844	34
35-64	129202	160
65+	38870	107
Respondents Vehicle ownership		
Own Vehicle	210778	316
Doesn't Own Vehicle	72276	107
Respondents Trip Length for different purposes		

Commute to/from the work	12.1	9.81
Shopping	6.7	4.34
Other Family/Personal Errands	7.5	6.525
Social and Recreational	11.9	5.96
All purpose	9.9	8.01
Vehicle occupancy		
1	511672	506
2	309713	304
3	106463	89
4	59182	38
5	26384	33
6	9599	10
7	3673	0
8	1190	0
9	505	1
10+	623	1
Average	1.87	1,81

APPENDIX C

RIDE-SOURCING SURVEY DATA REPORT

My Report

Last Modified: 05/12/2015

1. Do you own a smart phone?

#	Answer		Response	%
1	Yes		86	96%
4	No		4	4%
	Total		90	100%

Statistic	Value
Min Value	1
Max Value	4
Mean	1.13
Variance	0.39
Standard Deviation	0.62
Total Responses	90

2. Have you used Uber or Lyft service (ride-sourcing) before?

#	Answer		Response	%
1	Yes		38	44%
2	No		48	56%
	Total		86	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.56
Variance	0.25
Standard Deviation	0.50
Total Responses	86

3. For the last trip you made using ride-sourcing service what was your trip purpose

#	Answer		Response	%
1	Commute to/from work		5	15%
2	Shopping		0	0%
3	Other Family/Personal Errands		1	3%
4	Social and Recreational		28	82%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	4
Mean	3.53
Variance	1.17
Standard Deviation	1.08
Total Responses	34

4. Currently when you use ride-sourcing how many trips per week do you make?

#	Answer		Response	%
1	1		27	82%
2	2		3	9%
3	3		2	6%
4	4		0	0%
5	5+		1	3%
	Total		33	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	1.33
Variance	0.73
Standard Deviation	0.85
Total Responses	33

5. Does availability of ride-sourcing impact your need to own a vehicle?

#	Answer		Response	%
1	yes		2	100%
2	no		0	0%
	Total		2	100%

Statistic	Value
Min Value	1
Max Value	1
Mean	1.00
Variance	0.00
Standard Deviation	0.00
Total Responses	2

6. what's the vehicle occupancy of your last ride-sourcing trip (not including the driver)

#	Answer		Response	%
1	1 passenger		9	26%
2	2 passengers		15	44%
3	3 passengers		10	29%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	2.03
Variance	0.57
Standard Deviation	0.76
Total Responses	34

7. What's the average distance of your trips when use ride-sourcing service

#	Answer		Response	%
1	Less than 1 miles (less than 3 mins)		1	3%
2	1-3 miles(3 to 8 mins)		10	30%
3	3-5 miles(8 to 12 mins)		13	39%
4	5-10 miles(12-25 mins)		9	27%
5	10-20 miles(25-50 mins)		0	0%
6	20+ miles(more than 50 mins)		0	0%
	Total		33	100%

Statistic	Value
Min Value	1
Max Value	4
Mean	2.91
Variance	0.71
Standard Deviation	0.84
Total Responses	33

8. What's your age

#	Answer		Response	%
1	Under 20		0	0%
2	21 to 35		26	76%
3	36 to 65		8	24%
4	Over 65		0	0%
	Total		34	100%

Statistic	Value
Min Value	2
Max Value	3
Mean	2.24
Variance	0.19
Standard Deviation	0.43
Total Responses	34

9. What type of trip have you considering using ride-sourcing for in lieu of the mode in previous question?

#	Answer		Response	%
1	Commute to/from work		3	9%
2	Shopping		1	3%
3	Other Family/Personal Errands		3	9%
4	Social and Recreational		27	79%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	4
Mean	3.59
Variance	0.86
Standard Deviation	0.92
Total Responses	34

10. What's your gender

#	Answer		Response	%
1	Male		23	68%
2	Female		11	32%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.32
Variance	0.23
Standard Deviation	0.47
Total Responses	34

11. When you used ride-sourcing recently what mode of travel did you use previously for that trip?

#	Answer		Response	%
1	Bike		0	0%
2	Transit		3	9%
3	Private vehicle		16	47%
4	Taxis		12	35%
5	Did not make the trip		3	9%
	Total		34	100%

Statistic	Value
Min Value	2
Max Value	5
Mean	3.44
Variance	0.62
Standard Deviation	0.79
Total Responses	34

12. Do you own a vehicle?

#	Answer		Response	%
1	Yes		32	94%
2	No		2	6%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.06
Variance	0.06
Standard Deviation	0.24
Total Responses	34

13. How many trips do you make per weekday for all of your purposes combined (leaving and return for a purpose are two trips) for all modes you use?

#	Answer		Response	%
1	1		2	6%
2	2		10	29%
3	3		6	18%
4	4		11	32%
5	5+		5	15%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	5
Mean	3.21
Variance	1.44
Standard Deviation	1.20
Total Responses	34

14. Does ride-sourcing service change the number of trips you make for all purposes?

#	Answer		Response	%
1	More trips		9	26%
2	Less trips		2	6%
3	No change		23	68%
	Total		34	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	2.41
Variance	0.80
Standard Deviation	0.89
Total Responses	34

APPENDIX D

SPC TRAVEL DEMAND MODEL COEFFICIENT DEFINATIONS

Civt = in-vehicle time

Covt = out-of-vehicle time

Cpcost = parking cost

Cocost = other cost

Clsacc = logsum, access nest

Clspath = logsum, path nest

Clsauto = logsum, alone-vs-share nest

Clsocc = logsum, occupancy nest

K3 = 3-occupant auto

K4 = 4+occupant auto

Ksr = share ride

Kfrng = CBD-fringe park/ride

Kprem = premium transit path

Kudaccc= transit/drive to CBD

Kudacca= transit/drive to all other places

K1dacc = <not used>

K2dacc = <not used>

Kutranc = transit to CBD

Kutrano = transit to Oakland

Kutrana= transit to all other places

K1tran = <not used>

K2tran = <not used>

DCPM = Driving cost per mile (cents)

zcarshr= Fraction of 0-car trips that use transit (1.00 = 100%)

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