8-1-2019

Effects Associated with the Deployment of Autonomous and Connected Vehicles: Insights from Las Vegas, NV

Sarah Dennis
sarahhh51@yahoo.com

EFFECTS ASSOCIATED WITH THE DEPLOYMENT OF AUTONOMOUS AND CONNECTED VEHICLES: INSIGHTS FROM LAS VEGAS, NV

By

Sarah Robin Dennis

Bachelor of Science in Public Health
University of Nevada, Las Vegas
2016

A thesis submitted in partial fulfillment
of the requirements for the

Master of Science in Engineering – Civil and Environmental Engineering

Department of Civil and Environmental Engineering and Construction
Howard R. Hughes College of Engineering
The Graduate College

University of Nevada, Las Vegas
August 2019

UNLV | GRADUATE COLLEGE

Thesis Approval

The Graduate College
The University of Nevada, Las Vegas

August 15, 2019

This thesis prepared by

Sarah Robin Dennis

entitled

Effects Associated with the Deployment of Autonomous and Connected Vehicles: Insights from Las Vegas, NV

is approved in partial fulfillment of the requirements for the degree of

Master of Science in Engineering – Civil and Environmental Engineering
Department of Civil and Environmental Engineering and Construction

Alexander Paz-Cruz, Ph.D.
Examination Committee Chair

Courtney Coughenour, Ph.D.
Examination Committee Co-Chair

Pramen Shrestha, Ph.D.
Examination Committee Member

Moses Karakouzian, Ph.D.
Examination Committee Member

Timothy Bungum, Ph.D.
Graduate College Faculty Representative

Kathryn Hausbeck Korgan, Ph.D.
Graduate College Dean

ABSTRACT

Autonomous and connected vehicles (ACVs) are quickly evolving and becoming part of our transportation systems. Adoption of this technology is largely dependent on public perceptions and comfort. The objective of this study was to evaluate public perceptions of ACVs and gain knowledge regarding potential use and important aspects towards acceptance of ACVs. Specifically, the differences in perceptions of people who have ridden an ACV are compared to those who have not. A stated preference approach was utilized, as this is an emerging technology. Two different survey questionnaires were distributed. The first survey was distributed to participants considered to be members of the general public. The second survey was distributed to participants who had ridden an autonomous and connected shuttle bus operating in downtown Las Vegas. Data were analyzed using penalized logistic regression. Results suggest that people from the general public who have had exposure to or have ridden an ACV feel more positively about them becoming more widespread. From the shuttle-rider survey, participants expressed positive sentiments with a higher portion than those from the general survey. This may suggest that a public exposure period to ACVs would benefit those interested in implementing ACVs. Younger people, middle to low income households and males also felt more positively about ACVs than their older, high income and female counterparts, respectively. However, from the shuttle-rider survey, lower income people favored ACVs more than higher income people. In addition, commuting distances and amount of vehicle travel may increase. This could potentially result in sprawling which certainly has public health and planning implications.

ACKNOWLEDGMENT

First and foremost, I would like to thank Dr. Alexander Paz for his professional, technical, and personal support. His mentorship has helped me accomplish more than I had ever planned for myself — I am ever grateful. I would also like to thank Dr. Courtney Coughenour for her guidance and encouragement. Thank you to Sawyer Bauer, Sydney Dennis and Cristian Arteaga for their hours of help in data collection. Thank you to my committee members – Dr. Shrestha, Dr. Karakouzian and Dr. Bungum for taking the time to review my work and for their dedication to academic excellence. Last, but certainly not least, I would like to thank Cristian Arteaga for his patience, assistance, and friendship.

This study was funded and supported by the City of Las Vegas and the University of Nevada Las Vegas through a Teaching Assistantship. Thank you to the City of Las Vegas and a special thanks to Joanna Wadsworth.

DEDICATION

To my friends who have kept me balanced. To my family whose love, support, and constant reminders of how proud they are, make for the best motivation a person could ask for. To Sawyer, for brewing midnight coffees when I had more hours of work than there were hours in a day, for hugging me when it felt like too much, and for filling even my most stressful times with smiles.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

The development, production and deployment of partially and fully autonomous vehicles are paving the way for significant changes in many ways, some of which are difficult to anticipate (Faisal et al., 2019; Yigitcanlar et al., 2019). From November 2017 to October 2018, the city Las Vegas deployed an autonomous and connected shuttle bus within the Fremont Entertainment District of downtown Las Vegas in partnership with Keolis North America, AAA, and Regional Transportation Commission of Southern Nevada. This was one of the few completely driverless vehicles in the world operating on public roads in mixed traffic. The free-service shuttle bus allowed the public to experience the autonomous driving technology first-hand.

The operation of this autonomous and connected vehicle (ACV) in downtown Las Vegas, which was open to the public, is representative of how rapidly ACVs are developing and improving. Hence, it is important to study the feasibility of widespread use to plan accordingly. The use of these vehicles is largely subject to public perception, attitudes and preferences, as they could dictate how, where, when and if ACVs are widely adopted.

Attitudes and preferences toward the autonomous and connected shuttle bus can be used to investigate future adoption. If the public does not trust or is not comfortable with the technology, it is unlikely to be used. This study seeks to gain knowledge about perceptions and attitudes regarding ACVs, comparing people with and without experience with the technology. In addition, knowledge was gained about how people anticipate using ACVs and important contributors to their acceptance. To accomplish these objectives, the general population was surveyed from various community centers within the city of Las Vegas and via university communication channels. Similarly, people who were riding or had just finished riding the ACV in downtown Las Vegas were surveyed. Considering that the shuttle was an early representation of the type of vehicle that is expected to become more widespread within the next several decades, it provided an opportunity for reliably capturing opinions and attitudes from people who have some experience with the technology.

CHAPTER 2: LITERATURE REVIEW

The Society of Automotive Engineers have developed a scale for distinguishing different levels of automation. The scale starts at zero (no automation) and goes to five (full automation). Levels one through three have some automated or assistive capabilities but human control is still largely required. At a level four of automation, the vehicle is capable of handling all driving responsibilities in most situations, however, drivers are still capable of taking over driving responsibilities (SAE, 2018).

ACVs are largely debated and studied because of their difficult-to-predict implications. A study by Fagnant and Kockelman (2015) explored several possibilities through an extensive literature review and conceptual exploration. They highlight that ACVs obey traffic laws, do not make driving errors, and can optimize driving behaviors, including smoothing traffic flows and driving more environmentally efficient. It was speculated that the benefits of ACVs will include safety improvements, fuel savings, decreased congestion and improvements in all associated externalities. In addition, they supported the motivation for this current study by emphasizing the importance of users' perception and attitudes. Liu et al. (2019) stated that perception issues have often been known to drive policy and that poor perception could result in near-impossible adoption. That is, in order for ACVs to be a viable option for future transportation modes, people must feel positively or minimally open to their widespread deployment. Even more, how people feel about ACVs can be more predictive of future adoption than what people think about ACVs (Liu et al., 2019).

Theoretically, ACVs could be safer than vehicles with no automation. Kalra and Paddock (2016) found that it would take unreasonable amounts of mileage to verify that ACVs are safer than non-autonomous vehicles using traditional measures. For example, it would take 5 million miles to verify that ACVs have a fatality rate 20% lower than humans (Kalra and Paddock, 2016).

Many authors use different conceptual approaches to measure acceptability of ACVs. One selected method included identifying the reasons that ACVs would be most attractive. Payre et al. (2014) found that 67.2% of the time participants would use autonomous technology to park their vehicles. For about 62.3% of the time people would use autonomous capabilities on highways and 60% of the time they would use them during traffic congestion. More generally, it appears that participants preferred ACVs for traffic or driving situations considered to be monotonous or stressful (Payre et al., 2014) or for trips that are a short distance/travel time (Nielsen and Haustein, 2018).

There appears to be gender differences in perceptions and acceptance of ACVs. Men tend to be more likely to adopt, pay to use or own, and use ACVs (Payre et al., 2014; Schoettle and Sivak, 2014; König and Neumayr, 2017; Kyriakidis et al., 2015; Hulse et al., 2018; Liljamo et al., 2018). Sensation-seeking drivers were also more likely to be interested in using ACVs (Payre et al., 2014). Females tended to be more concerned than their male counterparts and less likely to believe that the anticipated benefits from widespread use of ACVs would occur (Schoettle and Sivak, 2014).

Males were more likely than their female counterparts to be interested in using ACVs while impaired, although 71% of all participants in the study conveyed interest in using the technology while impaired (Payre et al., 2014). This could be a particularly important item to note for Las Vegas, specifically for any ACV projects being contemplated near the Las Vegas Resort Corridor. Perhaps interest in riding while impaired is an indication that drivers may be tempted to release all driving tasks and duties once ACVs are being widely used. In 2018, over

42 million people visited Las Vegas (LVCVA, 2019) and the use of ACVs while impaired could certainly have important implications when discussing deployment of vehicles with lower levels of autonomy. In addition, if this technology is deemed safe and viable for widespread use, improved safety and reductions in impaired driving are just a few potential benefits.

Younger respondents were another demographic that tended to lean more favorably toward ACVs. They were more likely than older participants to have faith that the anticipated benefits of ACVs would be met (Schoettle and Sivak, 2014; König and Neumayr, 2017; Shabanpour et al., 2018; Hulse et al., 2018). Older people tend to prefer non-automated vehicles (Haboucha et al., 2017).

Educational attainment seems to play a role in perceptions. More educated individuals were more likely to indicate signs of acceptance for ACVs (Haboucha et al., 2017; Liljamo et al., 2018). This includes participants showing more interest in having autonomous technology in their own vehicles, as well as anticipation of many benefits (Schoettle and Sivak, 2014). Highly educated participants also tend to have declining interest in adoption of ACVs with high emission levels (Shabanpour et al., 2018).

Some other factors that appeared to contribute to participants willingness-to-accept ACVs included knowledge about ACVs (Schoettle and Sivak, 2014), access to higher levels of autonomous capabilities, lack of a personal vehicle (Schoettle and Sivak, 2014; König and Neumayr, 2017; Kyriakidis et al., 2015), and living in urban settings in comparison to rural locales (König and Neumayr, 2017). Pro-ACV sentiments and interest in technology were indicators that a person would likely choose to use an ACV compared to a non-automated vehicle (Haboucha et al., 2017). People with more vehicle miles traveled tended to have less-positive attitudes, especially in terms of the safety of ACVs (König and Neumayr, 2017;

Shabanpour et al., 2018; Kyriakidis et al., 2015). This finding is contradicted by Haboucha et al. (2017) who found that people who travel more kilometers per year were more likely to favor ACVs. However, this finding includes the caveat that people who drive more days per week did not respond positively to the use of a shared-ACV (Haboucha et al., 2017). Participants with a previous crash-experience (Shabanpour et al., 2018) and people with knowledge of ACVs (König and Neumayr, 2017) tend to have more positive views of their safety capabilities. People with disabilities are less sensitive to higher ACV purchase prices (Shabanpour et al., 2018). Higher income appears to be related to someone's willingness-to-adopt (Shabanpour et al., 2018) and the amount they are willing to pay (Kyriakidis et al., 2015).

In addition, people who share work-trips with others (carpool) (Shabanpour et al., 2018) tend to be willing to pay more while, conversely, Bansal et al. (2016) reported that people who commute to work alone tend to be willing to pay more for automated technologies. When a person had direct experience with an ACV, they reported higher levels of perceived use and ease of use of ACVs (Xu et al., 2018). In addition, people who felt safer while riding an ACV tended to show more willingness to use ACVs (Xu et al., 2018). A study by Nielsen and Haustein (2018) revealed that only 25% of people felt that ACVs would improve safety. Although there are certainly some issues to be addressed in terms of widespread adoption, public acceptance and comfort with ACVs, approximately two-thirds of participants in one study would be willing to use ACVs (Payre et al., 2014).

In terms of ownership, the most frequent response when asked how interested participants would be in owning or leasing an ACV, was "Not at all interested" with 33.7% of participants selecting this choice (Schoettle and Sivak, 2014). In a study by König and Neumayr (2017) 30% of participants would not pay any additional amount of money for ACVs compared to their current vehicle cost. Comparatively Kyriakidis et al. (2015) found that 22% of participants were not willing to pay for fully automated vehicles. However, study participants still seemed to be more interested in owning their own ACV rather than shared-use ACVs (such as ride-sharing or car-sharing) (Nielsen and Haustein, 2018). When comparing a willingness-to-pay for fully versus partially automated or connected vehicles, participants were willing to pay more for full automation, with 4.9% of them even willing to pay more than $30,000 (Kyriakidis et al., 2015). Wadud et al. (2016) suggested that vehicle ownership will decline and potentially disappear if ACVs become more widespread. Chen et al. (2016) found that each shared ACV (non-electric) can replace 7.3 personally owned vehicles. Shared electric ACVs with an 80-mile range and four-hour charge time could replace 3.7 personal vehicles (Chen et al., 2016). This could result in lower rates of vehicle-ownership and improved environmental outcomes, such as decreased emissions per capita.

Some studies have discussed the improved mobility granted by ACVs to previously non-mobile community members such as the younger and older populations (Truong et al., 2017; Fagnant and Kockelman, 2015; Chan, 2017). Truong et al. (2017) also used household vehicle ownership as an indicator of if or how frequently people may replace transit with ACVs. They estimated that the widespread adoption of ACVs could lead to about a 4.18% decrease in transit use (Truong et al., 2017). The underlying idea is that ACVs will lead to changes in mode decisions and will likely even induce new trips. Thus, we can anticipate unpredicted and widespread social and economic implications.

The anticipated benefits from ACVs have also been used to measure people's perceptions toward these vehicles. Participants with higher levels of autonomy in their current vehicles were more likely to cite crash-reductions, less traffic congestion, decreases in travel times, improved emission levels, and improved fuel economy as benefits of ACVs (Schoettle and Sivak, 2014). Nielsen and Haustein (2018) highlighted that participants were attracted to the idea of arriving at their destination more relaxed, not having to park their vehicle and the ability to use their travel time to perform various activities. ACVs would free occupants from the stress and attention that driving demands, allowing people to use that time for more favorable activities (Wadud et al., 2016). In addition, assuming that people feel no or reduced stress while riding in an ACV, improvements in health outcomes are likely. This can include mental and physical health implications resulting from less driving-induced stress.

Few studies have been able to predict potential behavioral changes as ACVs become more accessible. Wadud et al. (2016) stated that ACVs could create more travel demand for cars or they could lead to a modal shift from mass transportation to ACVs. Another study identified shared ACVs as a potential route to strengthen existing public transit systems by improving first- and last-mile connectivity (Gruel and Standford, 2016). People tend to favor ACVs for long-distance leisure trips but not for short-distance commutes (Ashkrof et al., 2019).

Although the overall results in most cases appeared to show that most participants felt positively about ACVs, there were also many important and common concerns identified. Approximately 36% of people interviewed in the U.S. were "very concerned" about riding in a vehicle with a high level of automation, which was the most severe negative category (Schoettle and Sivak, 2014). Although 36% is not the majority, it was the most frequent choice from the four given options (Schoettle and Sivak, 2014). U.S. participants specifically identified some key concerns including legal liability (Schoettle and Sivak, 2014; König and Neumayr, 2017), inability to safely interact with non-autonomous vehicles on the roadway, technological performance under poor weather circumstances, the potential for ACVs to drive more poorly than people, overall road safety of ACVs (Hulse et al., 2018), and data privacy/hacking (Schoettle and Sivak, 2014; König and Neumayr, 2017; Hulse et al., 2018).

People were also concerned about traffic safety with ACVs and moral issues associated with automated driving technology (Liljamo et al., 2018). For example, in the case of an imminent crash with a group of pedestrians, should the ACV passenger or pedestrian be saved? All ACVs are considered targets for electronic threats from hackers, disgruntled employees, terrorists or other hostile entities (Fagnant and Kockelman, 2015). Failure of the system or the equipment are also cited as a major concern (Bansal et al., 2016; Liljamo et al., 2018). Drivers appeared to be very concerned about riding in a vehicle with no controls available for riders to take over the vehicle (Schoettle and Sivak, 2014; König and Neumayr, 2017). Liljamo et al. (2018) found that about 90% of participants needed ACVs to have a manual takeover option in case they needed to override the automated system. They also reported that 70% of respondents were stressed about a computer having the driver responsibility (Liljamo et al., 2018). Some authors have also suggested that improper use of ACVs is a major concern until full automation is achieved (Chan, 2017). Misuse and overreliance of semi-automated technologies has already been witnessed (Chan, 2017). Chan (2017) specifically gives the example of the drivers of vehicles with a level two of automation relying too heavily on the limited capabilities of their vehicle.

Schoettle and Sivak (2014) identified that only 16.4% of participants in their study indicated negative feelings toward ACVs while Hulse et al. (2018) recorded 7% of participants being conditionally negative, and 3% being negative.

Liu et al. (2019) reported that experience with ACVs resulted in positive feelings. Schoettle and Sivak (2014) disclosed that 56.3% of participants in the U.S. have positive feelings toward ACVs. This finding is very comparable to Liljamo et al. (2018) who found that over 60% of participants felt positive about the development of ACVs. They also reported only about 7% of participants expressing *very* negative feelings toward ACVs (Liljamo et al., 2018). Zhang et al. (2019) reported that participants tended to feel that ACVs were moderately trustworthy, had a positive attitude about them and conveyed an intention to use ACVs. They also found that initial trust toward ACVs largely predicted if people would accept and use ACVs (Zhang et al., 2019; Ashkrof et al., 2019). Identifying the proportions of people who are accepting and rejecting ACVs is important as it has been estimated that fully automated vehicles will take up a significant portion of the market space by the year 2030 (Kyriakidis et al., 2015; Nielsen and Haustein, 2018).

Public acceptance and use are based largely around trust. A study with similar aims and design to the one proposed in this paper was completed by Eden et al. (2017). Preliminary discussions showed that all participants who had stated safety concerns before riding a driverless shuttle no longer expressed those concerns after their ride. Passengers also expressed a general feeling of safety due to the low speed of the shuttle. However, they expressed greatly reduced convenience due to associated long travel times.

Perceptions, preferences and attitudes of people toward ACVs, varies largely by group and scenario. Given that the adoption of ACVs is quickly approaching, it is critical for policy makers to better understand some of the changes that they might expect to see, both beneficial and not, to help compensate and appropriately prepare their infrastructure and communities. With proper preparedness better efficiency, public health and safety outcomes can likely be achieved.

CHAPTER 3: METHODOLOGY

Study Objectives

This study contributes to the existing body of knowledge regarding ACVs and their effects by comparing the experiences and attitudes from people who have and have not ridden on an ACV. The ACV in this study was available to the public, operated on public roads, and was a great instrument to illustrate the potential of the technology. The ACV in this study can be seen as an advanced system that over time will be widespread.

The primary objectives of this study are to evaluate public perceptions, preferences and attitudes toward ACVs. It is important to understand characteristics of ACVs that are important to the public as well as factors that could limit early adoption of ACVs by particular segments of the population. The focus of this study includes the purposes for which people would use ACVs, opinions about ACVs, potential travel behavior changes and important factors affecting the acceptance of ACVs.

This paper is organized as follows. The next section describes the survey questionnaires used for data collection followed by a detailed description of the analysis methodology. Then, a comprehensive layout of results is provided, including descriptive statistics and statistical models. The subsequent section contains a discussion of results, limitations and concluding comments.

Study Approach

Stated Preferences Approach

ACVs are emerging across the world under experimental conditions. Hence, the general public have little-to-no personal experience with them. In addition, although vehicles with semi-automated features such as adaptive cruise control and lane correction are increasingly more common, fully autonomous vehicles are not yet commercially available. For this reason, a revealed preference approach is not feasible to study these emerging technologies. Rather, a stratified stated preference (SP) approach is proposed to gain insights about people's attitudes and preferences toward ACVs. The SP approach is a well-known technique used to gain similar insights, typically associated with emerging technologies (Peeta et al., 2008; Nordland et al., 2013).

The SP approach potentially suffers from a hypothetical bias that results from participants responding differently to the hypothesized circumstance than they would to the real-world version. With emerging technologies there is a potential that participants are learning about the technology through the survey questionnaire and therefore their responses are based on limited information. However, this study design utilizes those participants who have ridden on the ACV to evaluate stated preferences with and without the experience. This allows for comparison between how stated preferences change based on experience with ACVs. Comparing responses between those who did and did not ride the shuttle helps account for some bias by allowing interpretation of the change rather than just the opinion.

Survey Design and Implementation

Data collection for this study included two survey questionnaires. Both surveys include a brief word-bank to clearly define any terms used within the surveys that may be unclear or ambiguous. Included were terms such as autonomous vehicle/transportation, mode, ride-hailing (Contreras and Paz, 2018) and business trips versus personal trips. All participants were 18 years or older.

The first survey, referred to as "the general survey," was intended for the general public and is presented in Appendix A. This survey included 30 questions and was conducted at publicly owned community centers within the city of Las Vegas to try to capture opinions representing the entire community. Surveys were conducted in at least one community center in each of the six wards within the city of Las Vegas. An identical online version of the survey was shared via outlets provided by the University of Nevada Las Vegas. There were 73 survey responses collected in-person and 162 collected via the online survey. This survey collected the following information: (1) demographic information, (2) current transportation modes and practices (including if/how much exposure participants had to ACVs), (3) participant's criteria for the use of ACVs as well as the circumstances and situations in which they would choose autonomous transportation in some form, and (4) perceptions and opinions toward ACVs.

The second survey, referred to as "the shuttle-rider survey," was intended only for participants who had ridden the autonomous shuttle in downtown Las Vegas and is presented in Appendix B. These surveys were conducted in-person and on-site at the shuttle location. A map of the shuttle route is depicted in Figure 1; it included four stoplights and two stop signs. The shuttle ride took approximately 6-8 minutes from start to finish and the shuttle interacted with other vehicles and pedestrians. It is worth noting that this route is located in a high-tourist area and being a tourist was not considered exclusion criteria. Participants completed the survey either during or immediately after their ride. This version of the survey included 17 questions, all of which fell into the following categories: (1) demographic information, (2) perceptions and opinions towards ACVs, and (3) if/how the autonomous shuttle impacted their perceptions or opinions.

Figure 1. Map of ACV route

Methodology

Discrete Choice Models

Participants were asked to choose between several alternatives. A common assumption is to expect that people are naturally inclined to choose the alternative that maximizes their satisfaction. Utility functions seek to capture the satisfaction with each alternative and are typically given by (Equation 1):

$$u_{i,j} = v_{i,j} + \varepsilon_{i,j} = \boldsymbol{x}'_{i,j}\boldsymbol{\beta} + \varepsilon_{i,j} \tag{1}$$

where,

i = individual 1, 2,…, N

j = alternative choice 1, 2,…, J

$v_{i,j}$ = a varying utility function

$\varepsilon_{i,j}$ = unknown error

Maximization of these utilities is the basis of discrete choice modelling. For this study, responses were binary-coded. Hence, binary choice models were created to analyze acceptance of ACVs. The probability of a participant *i* choosing alternative *j* is (Equation 2):

$$P_i(j) = \Phi\left(\frac{\beta_j x_{i,j} - \beta_{j+1} x_{i,j+1}}{\sigma}\right) \tag{2}$$

where $\Phi(\cdot)$ is the standardized cumulative normal distribution.

Data Considerations

Some of the categorical independent variables have very few samples associated with some levels of the domain. For example, for the general survey there were 236 survey responses collected, out of which nine participants were over 65 years old, four participants drove a work vehicle, and six felt that ACVs would have only downfalls. Similar observations were made for the shuttle-rider survey. Due to these small samples for select responses, estimated models using standard approaches, such as logit and probit models, resulted in perfect separation errors.

Perfect separation can occur with small data sets or when a specific exposure is "rare" within the data (Albert and Anderson, 1984; Puhr et al., 2017). Rarity in the statistical sense is not strictly defined, however, where possible and appropriate for this study, an exposure was considered rare if it obtained less than 10% of the given sample space. Penalized Logistic Regression (PLR) is one of the more subjectively complicated ways of addressing the bias resulting from perfect separation (Firth, 1993). PLR is only slightly more complex than MLE (Heinze, 2006) although often more basic solutions such as increasing sample size, combining similar categories of variables or omitting a category (Heinze and Schemper, 2002; Allison, 2004) are first attempted.

For this study, increasing sample size was not a viable option, the "transgender" category was the only one that could be omitted, but several categories were combined. For example, in the general survey the 65 and older age group was combined with the 55 to 64 years old category. The result was an age category of 55 years or older appearing within the estimated model (AGE55M.). Similarly, the shuttle-rider survey also included the 45 to 54 age group (AGE45M.). This resulted in the highest age group being 45 years or older for the shuttle-rider survey. The same approach was used for "current mode of transportation". For both surveys, "walking" and "biking" were combined into WALKBIKE, "riding a bus" and "rail" were combined into BUSRAIL. Similarly, "Ride-hailing," "work vehicles," and "other" were combined into RHWVO. Finally, the general survey included two questions asking how much exposure participants had to ACVs. The first asked participants if they had ever ridden an ACV; RDN_ACV is equal to one if the participant answered "yes". The second question asked participants to rank their level of exposure with five being the highest level. However, only a small sample (9%) had an experience level of four or five so these two categories were combined into MORE_EXP. Levels two and three were combined into SOME_EXP. Finally, level one ranking was labelled EXP_LVL1.

Unfortunately, this combination of categories still sometimes resulted in perfect separation errors. Hence, exact logistic regression and PLR were tested using the same model variables. Exact logistic regression is highly sensitive to a large number of independent variables within the model (Corcoran et al., 2001). After testing several specifications, exact logistic regression was deemed inappropriate for this study.

Penalized Logistic Regression

Although PLR was originally developed to create reliable models for rare events, it has also been shown to reduce bias in models experiencing separation (Heinze and Schemper, 2002). In outlining the penalization that takes place in PLR, a description of the binary logit model is a helpful starting point. The binary logit model is represented by the following (Equation 3) (Wooldridge, 2016):

$$P(Y_i = 1|x_i) = \Lambda\left(\beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i} + \ \dots + \beta_N x_{N,i}\right) = \Lambda(\beta_0 + \boldsymbol{x\beta}) \qquad (3)$$

where,

i = index for a given decision maker

Y_i = choice of decision maker i; it can take values 0 or 1

P_i = the probability of decision maker i choosing alternative 1

$X_{n,i}$ = characteristic n for decision maker i (n = 1, 2, …, N and N = the total number of independent variables)

β_0 = model constant or intercept

β_n = coefficient which defines how much a one-unit change in $X_{i,n}$ will change P_i

$\boldsymbol{x}$ = vector of variables to be included within the model

$\boldsymbol{\beta}$ = vector of estimated or estimable parameters

$\Lambda(z) = \exp(x_i\beta)/[1 + \exp(x_i\beta)]$ = the logistic cumulative distribution function that takes values strictly between 0 and 1, $0 < \Lambda(z) < 1$ for all real numbers z

The coefficients β for logistic regression are estimated using maximum likelihood (ML). To facilitate the calculation of the maximum likelihood and estimation of the coefficients, the likelihood function is (Equation 4):

$$\mathcal{L}(\beta) = \prod_i^N p(x_i)^{y_i}(1 - p(x_i)^{1-y_i}) \qquad (4)$$

A convenient starting point to derive the coefficient estimates using Firth's PLR method is the likelihood function for PLR (Equation 5) (Firth, 1993):

$$\mathcal{L}_{PLR}(\beta) = \mathcal{L}(\beta) \times |i(\beta)|^{0.5} \quad (5)$$

where,

$i(\beta)$ = the Fisher information matrix

$|i(\beta)|^{0.5}$ = Jeffrey's invariant prior

Jeffrey's invariant prior is the penalization applied to the binary logistic regression likelihood function to formulate the PLR likelihood function. As in the logistic regression model, the resulting coefficients β from PLR can be interpreted as the change in the log-odds of the output given a one-unit change in the dependent variable.

As previously mentioned, both surveys sought various types of information from participants. For this study, the selected variables to include in the model are intended to relate the use, acceptability and openness toward ACVs (dependent variables) to demographics, socioeconomic indicators, ACV exposure (general survey), mode of transportation and acceptability of ACVs (independent variables). Models are described in detail in the following section.

CHAPTER 4: MODEL ANALYSIS AND INSIGHTS

Descriptive statistics and PLR model results are presented in this section. The following presentation of results includes descriptions of model coefficients statistically significant at the 10% level. Sample sizes associated with each figure and table are not always equal to the total number of samples per survey due to blank responses. In addition, a comprehensive list of variable definitions is provided in Appendix C; Appendix D includes all tables with full model outputs.

Survey Sample Characteristics

The demographics associated with each survey are presented in Table 1.

Table 1. Demographics for general survey respondents (n=236) and shuttle-riders (n=153).

Demographics:		Variable Names	General Survey	Shuttle-rider Survey
			(percentage of participants)	
Gender	*Male*	-	42	44
	Female	FEMALE	57	56
	Transgender	-	1	-
Age	*Less than 25*	AGE25L.	30	37
	25-34	AGE2534.	30	29
	35-44	AGE3544.	19	18
	45-54	AGE4554.	11	6
	55-64	AGE5564.	7	5
	65 or higher	AGE65M.	4	5
Income	*Under $30,000*	INC30L.	24	31
	$30,000 - $59,999	INC3059.	29	22
	$60,000 - $99,999	INC6099.	20	21
	$100,000 - $150,000	INC100150.	16	13
	Over $150,000	INC150M.	8	9
Education	*High school or less*	EDUCHS	8	10
	Some college	EDUCSC	38	45
	College graduate	EDUCCG	27	33
	Postgraduate	EDUCPG	27	10

Important Contributors to Acceptance

Descriptive Statistics

Three questions from the general survey asked participants how they feel about specific transportation factors that may be affected by ACVs. These include safety, accessibility, schedule flexibility, reliability and familiarity. Participants were asked to rank these factors in order of importance, most (rank = 1) to least (rank = 5). The names of the variables associated with this question begin with the word "RANK", followed by the ranking place selected by the participant (i.e. 1-5) and a two-letter abbreviation for the factor being discussed. For example, RANK2RE is the variable name for those who ranked reliability (RE) second. Safety, accessibility, schedule flexibility and familiarity have abbreviations, SA, AC, SF, FA, respectively. It was apparent that this question may have been confusing to participants because approximately 14% did not answer or misunderstood this question. A summary of the rankings are provided in Table 2 and the statistical model outputs related to this question are outlined in Table 6 in Appendix D.

Table 2. Summary of factor rankings.

	Ranked:					**n**
	First	*Second*	*Third*	*Fourth*	*Fifth*	
Accessibility	15%	14%	31%	25%	10%	226
Safety	58%	17%	10%	6%	5%	225
Flexibility	13%	14%	22%	29%	19%	226
Familiarity	3%	6%	8%	18%	61%	226
Reliability	20%	42%	18%	10%	6%	226

The second question, outlined in Appendix D Table 7, asked participants to indicate if they felt safety, accessibility, schedule flexibility, familiarity and reliability will get better, worse or will not change with a switch to ACVs. The corresponding variable names are summarized in Appendix C. The results of this question are briefly discussed below and comprehensively outlined in Figure 2.

The third question extended this list of factors to include privacy (SAB_PR), duration/travel time (SAB_DT) and cost (SAB_CO). The previously mentioned factors are also included in this question so that SAB_SA is the variable name for safety, SAB_AC for accessibility, SAB_SF for schedule flexibility and SAB_FA for familiarity. This question asked participants to select which factors must be the same as or better than their current mode of transportation before they would consider switching to ACVs. These model outputs are included in Appendix D Table 8.

The participant responses to these questions are summarized below. Privacy, cost and duration/travel time are not included here, but rather outlined in Figure 3. This is because they were included only in one of the three previously mentioned survey questions.

> *Safety* – Traffic safety was most often ranked as the first most important factor. Approximately 60% of participants ranked safety first with the next closest factor being reliability at 16%. Additionally, only three participants out of the 202, ranked safety fifth. About 58% of participants felt that safety would get better with a switch from their current mode to autonomous transportation while 13% anticipated that safety would not change. However, still over a quarter of participants (28%) felt that safety would get worse. This is an especially important finding because safety was extremely important for participants and many feel negatively about the potential of ACVs in this context. Around

87% of participants indicated that the safety of an ACV would need to be the same as or better than their current mode before they would consider using it.

Accessibility – Only 12% of participants ranked accessibility as the number one most important aspect. The most frequent rank value given to accessibility was three. Just over 48% of participants felt that accessibility will get better with autonomous transportation although only 12% of participants indicated accessibility as one of the factors that they need to be better than their current mode before adopting ACVs. Accessibility had the lowest proportion of participants indicating that it needed to be improved for them to switch to ACVs.

Schedule Flexibility – When participants were asked to rank these factors, about 33% of participants ranked flexibility as the fourth most important. Over 41% of participants did not think that schedule flexibility would change with a switch from their current mode to ACVs but almost 38% of participants also indicated that they felt it would get better. Approximately 41% of participants indicated that flexibility of ACVs would need to be the same as or better than their current mode of transportation before they would consider switching.

Familiarity – The majority (68%) of participants rated familiarity fifth, or least important. Only one participant rated familiarity as the first most important factor. Approximately 30% of participants felt that it would get better, 37% felt that it would get worse and 31% felt that it would not change. The remaining 2% of participants failed to complete this question. In terms of factors that need to be better for people to consider switching from their current mode to ACVs, only 14% of participants indicated familiarity as being one of these factors.

Reliability – Around 48% of participants ranked reliability as their second most important factor which was also the largest for the second rank position. Reliability of ACVs was indicated by 73% of the participants as needing to be better than their current mode of transportation for them to consider adopting ACVs. Just over 44% of participants indicated that reliability would get better with ACVs while about 20% think that it will get worse. Approximately 34% of participants did not think that there would be a change in reliability when switching from their current mode to ACVs.

The overall ordered ranking of these characteristics was: safety, reliability, accessibility, flexibility, and familiarity.

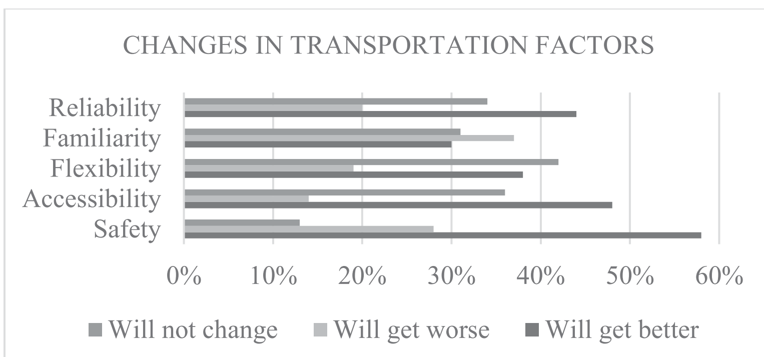


Figure 2. Perceptions of changes in key transportation related factors with the deployment of ACVs (n=232).

A question was asked about which entities would make the participant feel most comfortable if they conducted safety testing including the state and federal governments, the AAA Foundation, JD Power, and the ACV manufacturer. This question was only included on the survey for members of the general public, not the shuttle-riders. Variable names related to safety testing are provided in Appendix C. A summary of results are provided in Table 3 and model outputs are included in Table 9 in Appendix D.

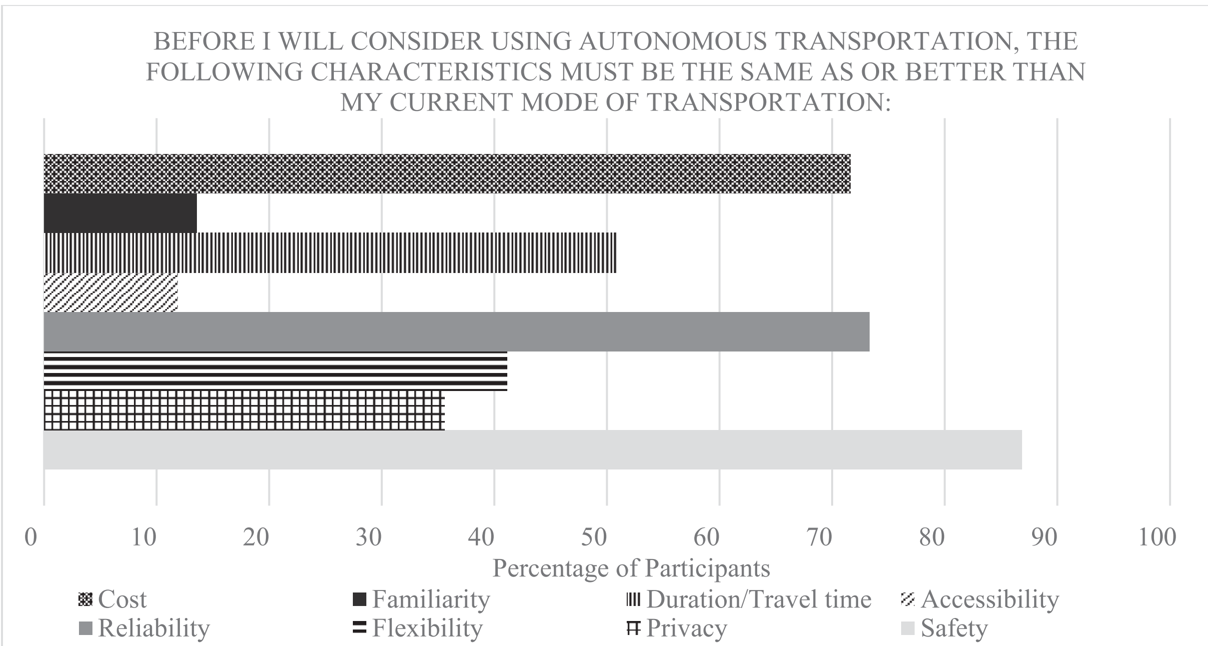


Figure 3. Perceptions of factors that need to be the same as or better in ACVs in order to change from current mode of transportation to use of ACVs (n=231).

Table 3. Perceptions about safety testing.

	Yes, I would feel much safer	I would feel somewhat safer	No impact	n
Autonomous vehicle manufacturer	38%	28%	32%	230
Federal government	48%	31%	20%	232
State government	42%	33%	22%	259
AAA	42%	28%	27%	258
JD Power	32%	28%	37%	259

Nearly half (48%) of participants would feel much safer if the federal government conducted safety testing. Around 42% of the participants would feel safer if safety testing was conducted by the state government or AAA. JD Power had the lowest portion of participants indicating they would feel much safer if they conducted safety testing and predictably, they also had the highest portion of participants selecting it would have no impact on their perception.

Shuttle-riders were also asked if they felt safer knowing that the shuttle was sponsored by AAA. The participants could select "yes," "no," and "uncertain." Approximately 58% of participants felt safer knowing that the shuttle was sponsored by AAA and about one-fifth of participants were uncertain. The model outputs for this question are presented in Table 10 in Appendix D.

Model Outputs

Tables 6-10 in Appendix D contain the statistically significant model outputs for the previously discussed models. Each black horizontal line separates the results of one model from the next. The coefficient estimate, standard error and chi-squared statistic are reported. The likelihood ratio test (LRT) statistic is reported as well as the respective p-value. These results are reported for all independent variables that were statistically significant for each model, even if the LRT statistic was not significant. Finally, for ease-of-interpretation, the odds ratio and calculated probabilities are also reported.

Females were more likely than males to select accessibility as a factor that must be the same as or better than their current mode in order to consider using ACVs. This may be the result of women being less comfortable in unknown situations than their male counterparts and placing importance on minimizing discomfort. From Table 9 in Appendix D, females had nearly a 63%

probability of feeling that testing by the state government would change their perception of ACVs. In addition, females had a 73% probability of indicating that the AAA sponsorship made them feel safer.

Participants between the age of 25 and 34 had a high probability (67%) of saying they would not switch to ACVs unless the privacy was the same as or better than their current mode. They also were not very likely to change their perceptions of ACVs given safety testing was done by the federal or state governments. Participants between 35 and 44 had approximately a 75% probability of feeling safer knowing that the shuttle was sponsored by AAA. In addition, from Table 8 Appendix D, participants 25 years to 54 years wanted accessibility to be the same as or better than their current mode before they would consider switching. This could be due to this age group consisting of parents, early to mid-career employees and generally busy schedules.

From Appendix D Table 7, when a participant indicated that they earned between $30,000 to $99,999 per year they had high inclination for thinking that safety would not change with the mode switch to ACVs. This group also indicated that reliability would need to be the same as or better than their current mode before they would consider switching. When participants had an income between $30,000 and $59,999, compared to those making $30,000 or less, they placed more importance on travel time being the same or better than their current mode. Those who made between $100,000 and $150,000 per year felt that schedule flexibility would get worse with a switch from their current mode to ACVs. Participants who made more than $150,000 per year had over a 90% probability of feeling that AAA's sponsorship did not make them feel safer.

College graduates had a high probability (81%) of saying that safety testing by the state would make them feel somewhat safer with the technology. Table 9 in Appendix D also shows that some college education leads to a high probability (81%) of feeling somewhat safer when safety testing was performed by JD Power.

Those who use a bus or rail had over a 95% probability of indicating that they felt accessibility would get worse with ACVs. From Table 6 Appendix D, using a bus, rail, ride-hail, work vehicle or other, as their regular mode of transportation was a strong predictor for a person ranking schedule flexibility as one of the least important aspects of their transportation. This makes sense because these modes typically depend on different schedules, such as a work, transit, and/or ride-hail availability. These participants exercise patience with their current mode which means they are likely willing to be more flexible with their future mode as well.

Participants were classified as feeling negatively about ACVs if they did not want to see ACVs more available or if they felt ACVs would have downfalls. Then, participants who did want to see ACVs more available and felt they would be beneficial were classified as feeling positively about ACVs. In Table 7 Appendix D, we observe that participants who felt negatively about ACVs felt safety, schedule flexibility and reliability would get worse. It was also important to this group of people that safety was the same as or better than their current mode before they would consider switching. Participants with positive feelings about ACVs indicated that they would change their perception of ACVs if safety testing was conducted by the manufacturer and state government. Interestingly, from Appendix D Table 9, participants who anticipated positive ACV outcomes, negative ACV outcomes or both (AV_BEN_BD), all agreed that they would feel safer if AAA conducted safety tests and that they would not feel more comfortable if JD Power conducted safety tests. Those who wanted to see ACVs more available favored safety testing by JD Power, while those who felt that ACVs would have benefits felt that safety testing by JD Power would not change their perception. Interestingly, participants who did not want to see ACVs more widely available had a 95% probability of selecting that they felt safer knowing the shuttle is sponsored by AAA. Participants who had more exposure to ACVs had higher probabilities of preferring safety testing done by the manufacturer, the federal government, and the state government (82%, 83% and 72%, respectively).

Exposure to ACVs indicates that people's safety perceptions improve (Appendix D Table 7). Exposure is also associated with positive feelings about schedule flexibility improvements. When a person had ridden an ACV, there was a very high probability they felt accessibility (91%) and familiarity (80%) would get worse.

Perceptions/Opinions

Descriptive Statistics

There are two perception-related questions shared by both surveys. The first question was framed as follows: "In general, I think autonomous transportation will have." Then, participants were asked to select one of the following responses: "vast benefits" (AV_BEN_VB), "many benefits and some downfalls" (AV_BEN_MB), "just as many downfalls as benefits" (AV_BEN_BD), "many downfalls and some benefits" (AV_BEN_MD), "only downfalls" (AV_BEN_OD) or "I'm not sure" (AV_BEN_NS). Two variables combining responses were created. AVBENS includes AV_BEN_VB and AV_BEN_MB while DWNFL includes AV_BEN_MD and AV_BEN_OD. The model outputs associated with this question are presented in Appendix D Table 11.

The second question asks: "Would you like to see autonomous transportation more widely available in the future?" Participants are asked to respond with "yes" (MA_Y), "no" (MA_N), or "no opinion" (MA_X). The results for each survey are summarized in Table 4 and model outputs are provided in Appendix D Table 12. The findings related to these questions are critical given Liu et al. (2019) reported that perceived benefits predict adoption of ACVs more strongly than perceived risks do. Meaning, if participants perceive ACVs as beneficial they may be more likely to adopt ACVs even if they still perceive some risks. In comparison to the general public, shuttle-riders tend to have more positive perceptions of autonomous vehicles and autonomous transportation than their counterparts.

Table 4. If participants from the general survey (n=236) and the shuttle-rider survey (n=150) would like to see ACVs more available.

	General Survey	Shuttle-Rider Survey
Yes	69%	81%
No	19%	4%
No opinion	12%	13%

In both surveys, an obvious majority responded positively in terms of the benefits they anticipate from ACVs. This can be seen in Figure 4, which provides a side-by-side summary of the responses from each group (general public and shuttle-riders) to an identical question. For the general public, only 3% of participants expected only downfalls while nearly 20% expected vast benefits. Even more, only 12% of participants responded with a negative answer, "only downfalls" or "many downfalls, some benefits", while 62% responded with a positive answer, “vast benefits” or “many benefits, some downfalls”. A similar pattern was observed from shuttle-riders but with greater severity. About 1% of the participants anticipated only downfalls and 3% anticipated many downfalls and only some benefits, resulting in only 4% indicating negative responses. On the positive end, 32% of participants selected “vast benefits” and another 51% anticipated many benefits and some downfalls as ACVs become more widespread. This results in a towering 83% of shuttle-riders who felt positively about the benefits of ACVs.

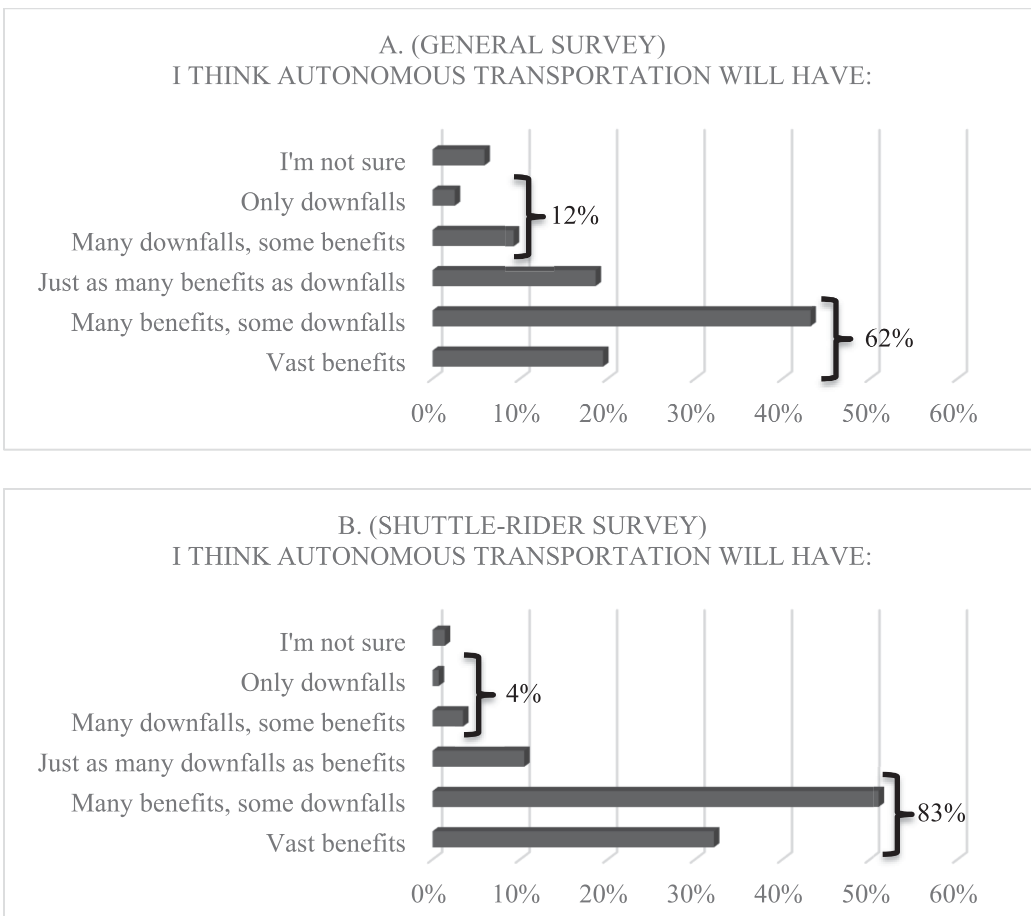


Figure 4. Comparison of responses from the general public (n=234) and shuttle-riders (n=152).

There were a few perception/opinion related questions included only on the shuttle-rider survey. First, participants were asked to rate how they felt about ACVs becoming more widespread and were given the option of “extremely happy” (FEEL_EH), “fairly happy” (FEEL_FH), “no opinion” (FEEL_NO), “somewhat happy and somewhat unhappy” (FEEL_HU), “mildly unhappy” (FEEL_MU), and “extremely unhappy” (FEEL_EU). Approximately 33% of participants said that they were extremely happy with autonomous transportation becoming more widespread. Following that, 34% indicated they were fairly happy, while only 3% were mildly unhappy and no participants stated that they were “extremely unhappy”. The responses “extremely happy” and “fairly happy” were combined into one category for people who felt happy about ACVs becoming more widespread (FEEL_H). For the sake of consistency, the same was done for participants who were mildly or extremely unhappy. These variables were combined into an “unhappy” variable called FEEL_U although it is worth clarifying that there were no participants who selected “extremely unhappy”. Overall, 67% of participants answered that they were happy, while only 3% indicated they were unhappy. The model results related to this question are presented in Table 13 in Appendix D.

Another question used to evaluate participant perceptions of ACVs was to indicate to what extent they agree with the following statement: “Overall, I believe autonomous transportation will improve my life.” They could “agree” (IMPV_A), “mostly agree” (IMPV_MA), have “no opinion” (IMPV_NO), “mostly disagree” (IMPV_MD) or “disagree” (IMPV_D). A summary of the results associated with this question are given in Figure 5.

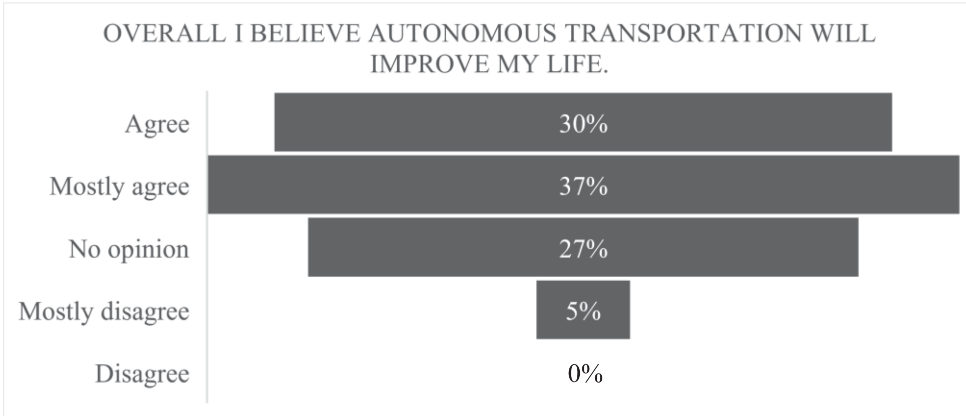


Figure 5. If participants feel ACVs will improve their life (n=150).

Overall, the portion of participants who showed some level of agreeance was 67% and less than 5% showed some level of disagreement. Combination variables were created for this question as well. “Agree” and “mostly agree” were combined into the variable IMPV_AGREE, while “mostly disagree” and “disagree” were combined into IMPV_DIS, although again, no participants disagreed completely. The model outputs are provided in Table 14 in Appendix D.

The shuttle-rider survey contained an additional question asking if the participant would recommend the shuttle experience to a friend (RCMD_Y for the “yes” response, RCMD_N for the “no” response, or RCMD_U for “unsure”). A vast majority (82%) would have recommended the experience to a friend while only 2% said they would not. The remainder of participants were uncertain or did not answer. Model results from this question can be found in Appendix D Table 15.

Finally, shuttle-riders were asked how much the shuttle enhanced their understanding of self-driving technology, capabilities, safety or benefits (variable names summarized in Appendix

C). The responses are summarized in Table 5 and model outputs for this question are presented in Appendix D Table 16.

Table 5. Perceptions about if/how much the ACV enhanced understanding.

	Yes, a lot	Yes, somewhat	A little	Not at all	n
Technology	58%	30%	6%	2%	147
Capabilities	59%	28%	6%	2%	146
Safety	54%	27%	12%	2%	146
Benefits	47%	31%	14%	3%	145

Model Outputs

Supporting the results of other studies (Payre et al., 2014; Schoettle and Sivak, 2014; König and Neumayr, 2017; Kyriakidis et al., 2015; Hulse et al., 2018; Liljamo et al., 2018), females had lower odds of expressing positive sentiments toward ACVs than males. For this section, "positive sentiments" can be understood to include, anticipating ACVs to have benefits, wanting to see them more available, feeling they would improve lives and feeling happy about ACVs becoming more widespread. Predictably, females also had a higher probability than their male counterparts to express negative feelings toward ACVs and their eventual outcomes. Female shuttle-riders were less likely than males to feel that ACVs would have vast benefits, however, they were over two times more likely to feel that they would have many benefits and some downfalls (Appendix D Table 11). Perhaps this is suggestive that female participants are maintaining more uncertainty than males, but still expect to see positive outcomes.

Participants between the ages of 25 and 44 years old had high probabilities of indicating that riding on the shuttle enhanced their understanding of the self-driving technology. They also were less likely to feel positively about ACVs than those younger than 25. Participants between 35 and 44 years old had respective probabilities of 77% and 72% for feeling the shuttle enhanced their understanding of the capabilities and benefits of the technology “a lot”. Those 45 and older had a high probability (over 90%) of anticipating downfalls from ACVs becoming more widespread. Older people who had participated in the shuttle-rider survey had a very high probability (92%) of indicting that they had no opinion on whether they would like to see ACVs more available. Older shuttle-riders indicated more uncertainty than negativity toward ACVs.

The general public participants who identified as being within the highest income bracket ($150,000 a year or more) were more likely to indicate negative feelings toward ACVs than those who reported an income of $30,000 or less. They had a 90% probability of not wanting to see ACVs more available, which is interesting given that they had an 88% probability of believing ACVs would be beneficial. This is contrary to the findings of previous studies (Shabanpour et al., 2018). They also largely indicated that riding on the shuttle enhanced their understanding of self-driving vehicle benefits just a little bit. From Table 11 in Appendix D, all shuttle-riders with an annual income of $30,000 or more had a high probability of indicating that they felt ACVs would have some benefits and some downfalls. Shuttle-riders who had an income of $60,000 to $99,999 and those who make over $150,000 per year had high probabilities (94% and 99%, respectively) of wanting to see ACVs more widely available. Participants with incomes $60,000 or higher had at least a 79% probability of saying that the shuttle somewhat enhanced their understanding of self-driving technology. Those who made between $100,000 and $150,000 per year also had a 79% probability of saying the shuttle somewhat enhanced their understanding of the capabilities of ACVs.

For shuttle-riders, having some college education or being a college graduate led to high probabilities (83% and 80%, respectively) of the person indicating that they mostly agree with the statement that ACVs would improve their lives.

Shuttle-riders who used ride-hail, a work vehicle or other were highly likely to feel that ACVs would improve their lives (Appendix D Table 14) and feel extremely happy about ACVs becoming more widespread (Appendix D Table 13). Shuttle-riders who drive themselves had a high probability (86%) to feel happy about ACVs becoming more widespread. They also had a 96% probability of feeling that that riding the shuttle somewhat enhanced their understanding of the benefits associated with ACVs.

As would be expected, when a participant felt that ACVs would have benefits they also had a high probability of wanting to see them more available (98% for the general public and 99% for shuttle-riders). It is not surprising that generally indicating that they were happy with ACVs being more widespread, anticipated benefits or wanted to see ACVs more widely available, the participant had a high probability of selecting positive responses for all other perception questions. When a participant felt that ACVs would improve their life, they also wanted to see ACVs more widely available and they felt happy about ACVs becoming more widespread. When general public participants felt ACVs would have downfalls, they were highly likely (97%) to not want ACVs to be more available. Predictably, when participants felt negatively about ACVs, they had a low probability (11%) of wanting to see ACVs more widely available. From the general public we can see that higher levels of exposure or having ridden on an ACV strongly predict positive sentiments toward ACVs. When a participant felt positively about ACVs, they had a high probability of feeling that the shuttle enhanced their understanding of safety and benefits of ACVs. Interestingly, those who did not want to see ACVs more widely available also had a 99% probability of saying that the shuttle somewhat enhanced their understanding of the benefits associated with ACVs.

Purpose

Descriptive Statistics

In terms of gaining knowledge on the impact that ACVs could have and how they will be received by the public, it is helpful to explore for what purposes people would want or feel comfortable using them.

One survey question asked if participants would be most comfortable using ACVs for business reasons only (AV_PURP_B), personal reasons only (AV_PURP_P), both business and personal reasons (AV_PURP_BP) or neither (AV_PURP_N). This question was included in both the general survey and the shuttle-rider survey and the model outputs can be found in Table 17 in Appendix D. Another question asked participants if they would prefer to use a shared ACV for business reasons only (USE_B), personal reasons only (USE_P), both business and personal reasons (USE_PB) or neither of these reasons (USE_N). This question appeared only on the general survey and model outputs are presented in Table 18 in Appendix D.

For the general survey, the largest portion of participants would be willing to use ACVs for both reasons. However, just over half of participants indicated that this was true for autonomous transportation as a whole, while only about 42% of participants indicated that this was true for a shared ACV. For autonomous transportation, less than 20% of participants selected that they would use ACVs for neither personal nor business reasons. For a shared ACV, nearly a quarter of participants claimed they would not use it for either purpose.

Half of the shuttle-riders said they would use ACVs for both reasons. The next most-selected option was "personal reasons" with only 35% of participants selecting this response.

Model Outputs

Female shuttle-riders had a high probability (71%) of selecting that they would use ACVs for personal reasons only. They were also less likely than their male counterparts to want to use ACVs for both business and personal reasons.

General public participants who were 55 years or older were nearly five times more likely than those 25 years or younger to state that they would use ACVs for personal reasons only. This is intuitive as this age range includes participants who are likely retired and do not have "business purposes." Compared to participants 25 years or younger, participants between the ages of 45 and 54 years old were over 5.5 times more likely to indicate that they would not use ACVs for business or personal reasons.

General public participants within the income brackets of $60,000 per year to $150,000 were more likely than those with an annual salary below $30,000 to select that they would use ACVs for personal reasons.

General public post-graduates had respective probabilities of 78% and 83% for using ACVs and shared ACVs for both personal and business reasons. Conversely, when participants had some college education or were college graduates, they had 87% and 89% probabilities of not using shared ACVs for either purpose.

If a person selected that they felt ACVs would result in benefits, they had a high probability (82%) of indicating that they would use both personal and shared ACVs for personal and business reasons. This was also true for shuttle-riders who agreed that they felt ACVs would improve their lives. As would be expected, participants from the general public who felt that ACVs would result in downfalls had a 92% probability of not wanting to use them for either reason.

Behavioral Changes

Descriptive Statistics

General public participants were asked several questions aimed at understanding potential travel changes that could arise with ACVs becoming more prevalent. They were first asked if they would consider replacing their current vehicle with a personal ACV (REP_PERS), autonomous transit (REP_TRANS), autonomous ride-hailing (REP_RH) or none of those options (REP_NONE) given price was excluded as a factor. As seen in Figure 6, over half of the participants said that they would be willing to replace their current vehicle with a personal autonomous vehicle. However, nearly a third of the sample also said that they would not consider replacing their current vehicle with any of the suggested options. Model outputs associated with this question are presented in Appendix D Table 19.

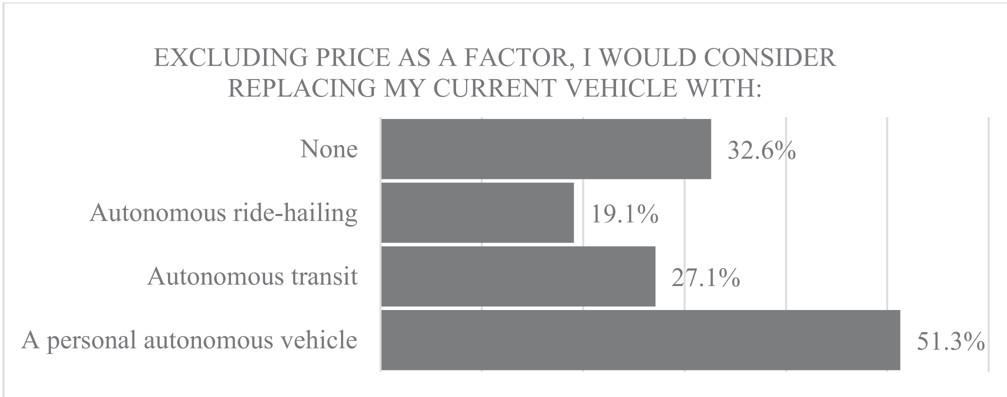


Figure 6. Percentage of participants choosing alternative forms of ACV as replacement for their current vehicle (n=235). More than one option could be elected so totals will not sum to 100%.

Another survey question asked participants if they would consider getting rid of a household vehicle (RID), and if so, how many? Most participants (nearly 60%) indicated that they would consider getting rid of their personal vehicles if ACVs became more widespread. Among participants who indicated that they would consider getting rid of a vehicle, the average response was that they would get rid of 1.35 vehicles. The model outputs for this question are also presented in Table 19 Appendix D.

Participants in the general public were asked to select which forms of ACVs they would feel comfortable using from a safety standpoint. Their options included a personal/household ACV (COMF_PH), bus transit (COMF_BT) and/or ride-hailing (COMF_RH). Approximately 61% of participants were comfortable with a personal/household ACV, 53% for bus/transit and 34% for autonomous ride-hailing. There were no statistically significant outputs related to this question.

Participants were then asked if they would make more daily trips if ACVs became more widespread, to which participants could respond with "yes," "no," "no change," and "unsure" (DTR_Y, DTR_N, DTR_X, DTR_U, respectively). The minority of participants (17%) responded yes to this question while nearly 60% indicated that they would not take more trips or that there would be no change in their number of daily trips. The same question was also asked about taking longer trips (LTR_Y, LTR_N, LTR_X, LTR_U). For this question, nearly a third of participants said that they would take longer trips, however, just under half (46%) still indicated that they would not take longer trips or there would be no change in their length of trips. Model outputs associated with these questions are in Table 20 in Appendix D.

Participants were also asked if they would consider increasing their commuting distance. They could respond "yes" or "no" to the distance ranges of 0 to 5 miles (COMDST05.), 5 to 10 miles (COMDST510.), 10 to 20 miles (COMDST1020.), 20 to 30 miles (COMDST2030.), and 30 or more miles (COMDST30M.). The results from this question are summarized in Figure 7. For a commuting distance increase from 0 and 10 miles approximately half of participants were willing to increase their commuting distance. This proportion then decreased as the commuting distance increased. This could imply that with ACVs becoming more widespread, some sprawling could result. This is an important side-effect of ACVs that should be appropriately acknowledged and addressed. Table 21 presents the model outputs associated with this question.

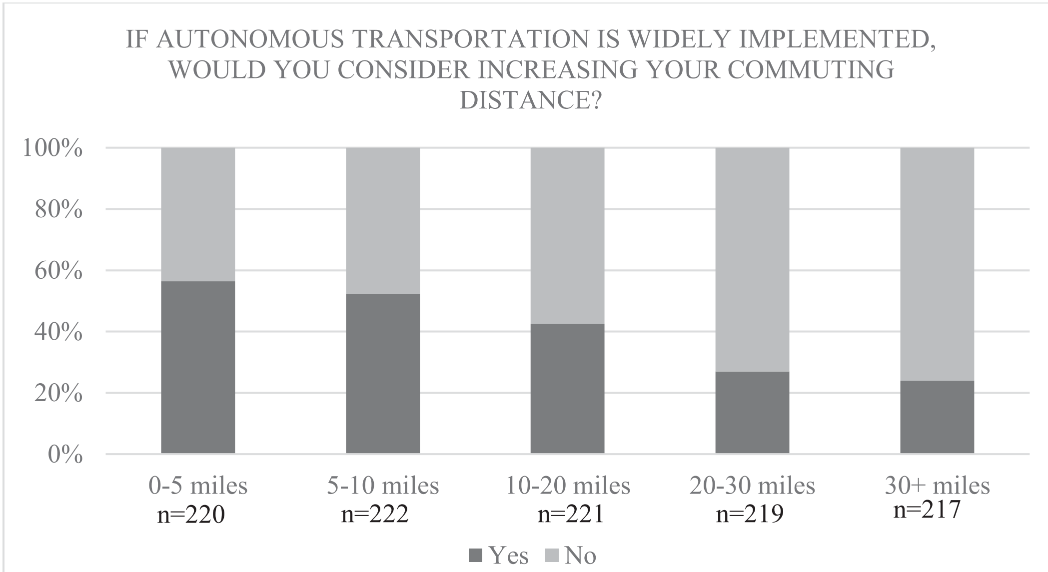


Figure 7. Percentage who would increase their commuting distance.

Another question asked if participants would consider switching from air travel to vehicle travel for a given vehicle travel time. The ranges provided were 5 to 6 hours (AIR56.), 6 to 8 hours (AIR68.), 8 to 10 hours (AIR810.) and 12 or more hours (AIR12M.). From Figure 8, over 60% of participants would elect to drive rather than fly for 5 to 6 hours of vehicle travel time if they could use an ACV. In addition, nearly a fifth of participants would still choose to use an ACV rather than air travel for 10 hours or more of vehicle travel. Model outputs can be found in Table 22 in Appendix D.

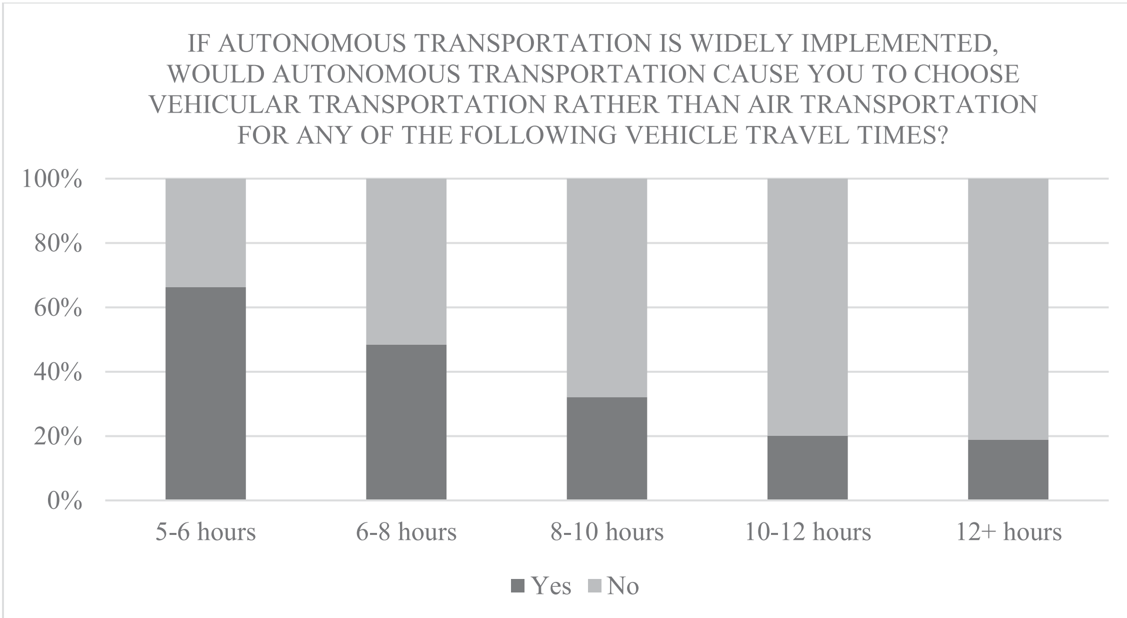


Figure 8. Percentage of participants who would drive rather than fly for specific travel times (n=228).

Finally, participants were asked how they would spend their time in the vehicle if they did not have to drive. They were provided the options of social media (SPND_TM_SM), talk on the phone (SPND_TM_TP), sleep (SPND_TM_SL), socializing with other passengers (SPND_TM_SP), working (SPND_TM_WO), or other (SPND_TM_OT). The responses to this question are summarized in Figure 9. Notably, about half of participants indicated that they would sleep or work. The model outputs for this question can be found in Table 23 Appendix D.

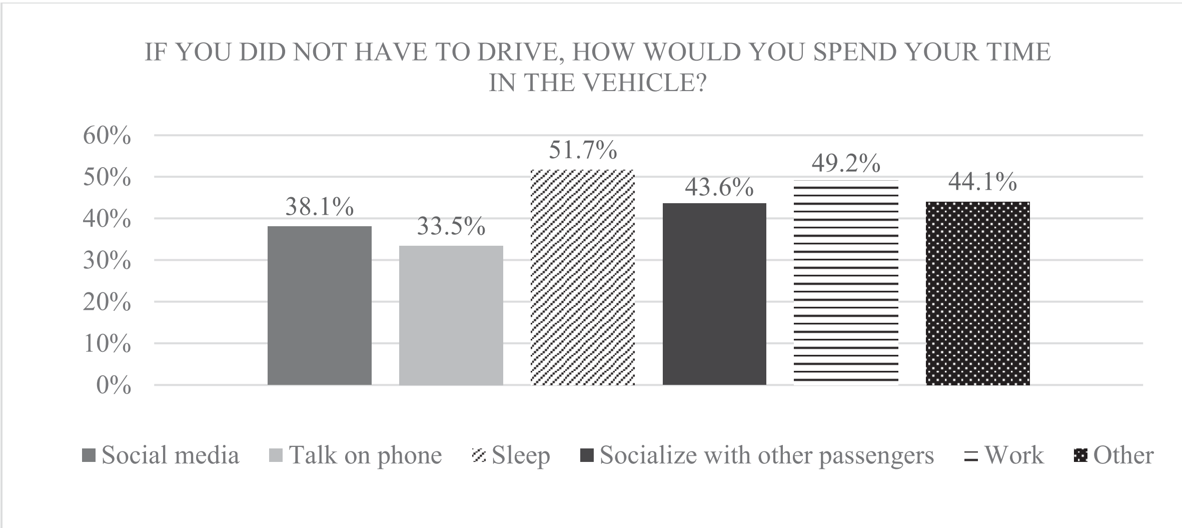


Figure 9. Activities respondents would participate in while riding an ACV if they did not have to drive (n=233). More than one option could be selected.

The last questions on this topic asks participants if they would be more willing to take a shared ACV that would pick them up from their neighborhood and take them to the nearest transit stop (TRNS_STP). The same question was asked for an express transit stop (EXP_STP). Participants could answer "yes" (where the value assigned to that variable was set equal to one) or "no" (assigned the value zero). To these questions, 63% would use a shared ACV to get to the nearest transit stop and express transit stop. The associated outputs are located in Appendix D Table 24.

Model Outputs

Female participants had lower odds of taking longer trips than males if ACVs were more widely implemented and they were over two and a half times more likely to be unsure if they would take longer trips.

Younger participants (those 25 years or younger) were more likely than participants over 25 to consider replacing their current vehicle with an autonomous vehicle. Participants between 45 and 54 years old had an 80% probability of selecting that they would not replace their current vehicle with any of the suggested ACV options. Those between 35 and 44 and 55 years or older had a high probability of not anticipating more daily trips than they currently take. Participants between 45 and 54 years old had much lower odds than younger participants to increase their commuting distance to 30 miles or more. They were also more likely to switch to driving rather than flying at the 5 to 6-hour travel time range.

Earning between \$100,000 and \$150,000 per year led to an 85% probability that the participant would not replace their current vehicle with any of the suggested ACVs. Participants with an income greater than \$150,000 per year had an 81% probability of stating that they would not change their number or length of trips. They also had a high probability of selecting that they would be interested in being picked up in their neighborhood by a shared ACV and taken to the nearest transit stop. Those who earn more than \$100,000 per year had high probabilities of selecting that they would increase their commuting distance up to 30 miles or more.

Having some college education resulted in a high probability (88%) that someone would not consider replacing their current vehicle with any form of ACV. Compared to those with a high school education, those who have some college education, graduates, and post-graduates had higher odds of increasing their commuting distance up to 20 to 30, 0 to 5 and 10 to 20 miles, respectively. College graduates also indicated that if they did not have to drive, they would spend their time looking at social media, talking on the phone and working. Post-graduates had a high probability (82%) of working while riding an ACV.

Participants who currently drive themselves have a high probability (83%) of using their travel time working, while those who walk or bike have a high probability (69%) of saying they would like to use their travel time to sleep. People who drive themselves also had a 91% probability of saying that they would be willing to take a shared ACV from their neighborhood to the nearest express transit stop. Additionally, those who ride a bus or rail had a high probability of increasing their commuting distance by 20 to 30 miles. This may make sense because these people are already used to not having to be engaged in the driving task, meaning that their travel time is already of more use to them. They can spend their travel time on important or relaxing tasks so it may not bother them to increase this travel time. Interestingly, those who use ride-hail, a work vehicle, or other had only a 25% probability of increasing their commute by 20-30 miles. Not surprisingly, they also had a 76% probability of replacing their current vehicle for autonomous ride-hail.

Having ridden an ACV, participants had a high probability (77%) of being comfortable replacing 12 or more hours of travel with vehicular transportation rather than air transport. They also had a high probability (79%) of increasing their commuting distance by 20 to 30 miles. They had a 78% probability of willing to take a shared ACV from their neighborhood to the nearest transit stop. Compared to those who had not ridden an ACV, they had much lower odds of willing to replace their current vehicle with autonomous transit. The same was true for participants who had higher levels of exposure. They had only a 12% probability of selecting that they would replace their current vehicle with autonomous transit. People who had ridden an ACV also had only a 25% probability of indicating they would make more daily trips.

Participants who felt positively about ACVs had a high probability of willing to replace their current vehicle with a personal ACV (79%) or autonomous ride hail (83%) and of getting rid of their personal vehicle (76%). Interestingly, participants who did not want to see ACVs more widely available had a high probability of increasing their commuting distance by 5 to 10 miles.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

This study held the distinct objectives of contributing to the knowledge base on public perceptions and opinions of ACVs, reasons people may choose to use ACVs, potential travel behavior changes and important contributors to the acceptance of ACVs.

In terms of public opinions many of the relationships seen in this study are comparable to what previous studies have identified. For example, females were more resistant to ACVs than males, more highly educated people were more open to ACVs and younger people tend to be more accepting than older people. From the general survey, higher income participants favored ACVs more than those with a lower income. However, differing from previous studies, from the shuttle-rider survey those with a lower income tended to favor ACVs more than higher income participants. This relationship is worth future research to better understand if this is indicative of lower income people making a larger “leap” to positive sentiments in the shuttle-rider survey. It could also be indicative of shuttle-riders with higher incomes not following the general trend of feeling more positively about ACVs.

Current mode of transportation was also included as an independent variable which, to the knowledge of these authors, has not previously been done. Although the mode of transportation was rarely a statistically significant variable, there were a few statistically significant relationships. Mainly, participants who already use modes of transportation that require some schedule flexibility (bus, rail, ride-hail, etc.) are likely to not be as concerned as other travellers if ACVs require some flexibility. This is likely because their current mode of transportation requires more patience and so they are more willing to exercise patience with their future mode as well.

The shuttle-rider survey provided interesting insights that are largely unmatched in the literature because of the unprecedented opportunity provided to this research team. Having access to a fully autonomous vehicle carrying members of the public provides an environment ripe with unrecorded opinions and perceptions. Through statistical analysis, and even summary statistics, there was a distinctive positive trend. Remarkably few participants who had ridden the autonomous shuttle expressed any negative sentiments toward ACVs, suggesting that experiencing the ACV first-hand is largely related to positive feelings about this technology. This is also supported by largely positive sentiments expressed by people who participated in the general survey but indicated having experience with ACVs. This is important for several reasons. First, entities interested in deploying ACVs should consider a trial period with ACVs prior to larger deployment – like the City of Las Vegas has done. Second, and perhaps more importantly, this could suggest that negative and uncertain feelings about ACVs are alleviated once people have the opportunity to experience the capabilities of this type of technology. Even further, this trial period might give wary or curious members of the public an opportunity to trust ACVs resulting in more widespread adoption and use of them.

As part of the motivation for this study, ACVs will likely encounter some barriers to adoption or will not meet some criteria that people require in order to use them. Not surprisingly, safety was generally the number one priority followed by reliability and accessibility. This was the anticipated result since generally people need to feel comfortable but ACVs would not get much use if they are too inconvenient for users. Additionally, it seems that the general public has distinctive ideas of what is important to them in terms of their transportation but not all requirements are currently satisfied by ACVs. Specifically, although many participants needed safety and reliability to be better than their current mode of transportation before they would consider switching modes, a sizable portion still indicated some uncertainty that these would improve with ACVs. This study can help manufacturers and industry parties understand what uncertainties people have about ACVs so that appropriate marketing or design actions can be taken.

It appears that travel behaviors may indeed change as ACVs begin to take up more of the market share. For example, commuting distances will likely increase for some groups more so than others. People may elect to take a vehicle rather than air travel and people may take more and longer trips. This could have serious implications in terms of public health, planning and design. Specifically, we might expect to see sprawling occur. This will likely lead to poorer health and environmental outcomes. Planning and design will also certainly need to compensate for this change in community layouts and travel behaviors.

It is difficult to predict which version of ACVs will take up much of the market share. From this study it appears that personal ACVs are the currently preferred mode, but autonomous ride-hail also appeared to be an attractive option to participants. If a breakthrough or design leads to one option being more commercially attractive, then the public preference could quickly switch. This topic is worth further research to help identify what changes will occur dependent on which form of ACVs becomes favored. Regardless, many changes should be expected, given ACVs become more widespread. It is critical to identify what changes will occur so that proper measures can be taken to accommodate future communities and fuel further research. Mainly, many changes that have the potential to occur have been identified and now the magnitude of these changes is deserving of further study.

Lastly, it appears that riding in an ACV helped enhance the understanding of many aspects of ACVs and could have been the reason these participants overall felt more positively about ACVs. This is likely why participants who have ridden on an autonomous vehicle (in the general survey) would feel safer if the vehicle manufacturer conducted safety testing. Importantly, it seems that all entities proposed to perform safety testing were favored by some group, however, the government entities tended to have the majority of parties in favor of their safety testing. This is good information to have as cities and states contemplate allowing ACVs to flourish in their cities and ensuring that deployment of these vehicles is comfortable and favorable to their constituents. These findings are important to note since people's trust in responsible parties are determinants of how accepting people may be of the technology being introduced (Liu et al., 2019).

Although this study resulted in important and highly useful information, there are some important limitations to address in future research. For one, survey data can be lacking due to instrument bias and people's inaccuracy in reporting or uncertainty on specific topics. In addition, the scope of questions resulted in some groups perfectly predicting some outcomes and others being exceedingly close to doing so. PLR was used to account for the resulting perfect separation, but it is still a limitation of this study that a penalized model needed to be used to account for some uncertainty. Puhr et al. (2017) was able to show that the predicted probabilities using PLR can be biased toward 0.5 so this is certainly a limitation resulting from the use of this method. Finally, there may be some resulting bias due to shuttle-riding participants electing to ride the shuttle. If people felt a certain level of negativity about ACVs, they likely would have never selected into riding on the autonomous shuttle. Then, per the study design, shuttle-riders were identified based on the fact that they had ridden this shuttle. Therefore, there is likely some level of resulting selection bias here from participants who were already open-minded, or even enthusiastic, about ACVs making up the vast majority of shuttle-riders. Finally, this study is limited by data collected only in Las Vegas as described in the survey design and implementation section.

APPENDIX A: THE GENERAL SURVEY

Survey 1

Autonomous vehicles are expected to arrive soon and will not require drivers. Throughout this survey, the use of multiple modes of autonomous vehicles are referred as *autonomous vehicular transportation*. Please answer the following questions to the best of your abilities.

Definitions to keep in mind:

<u>Autonomous vehicle/transportation:</u> Driverless or self-driving vehicle/transportation

<u>Personal autonomous vehicles:</u> A household or otherwise personal vehicle belonging to you that does not require a driver

<u>Mode:</u> Method/vehicle of transportation; includes but is not limited to: walking, bicycling/biking, public transit, personal vehicle, etc.

<u>Ride-hailing:</u> Mode of transportation which involves hailing a vehicle whether it be physically (taxi) or via a ride-hailing phone application such as Uber or Lyft.

<u>Trips:</u> Any use of a vehicle to move from one location to another (vehicles include bicycles, automobiles, bus, train, etc.); Walking trips should not be included; Please consider roundtrip to be one trip

<u>Business trip:</u> Any trip made that is associated with work, even if you are not compensated for your travel time to get to work and to get home from work, for the purpose of this survey please consider these business trips

<u>Personal trip:</u> Made for any reason not related to your paid work/business

1. Please mark which gender you identify as (Please circle only one):

Male Female Transgender Prefer to self-describe ____________________

2. What is your age group?

Less than 25 25-34 35-44 45-54 55-64 65 or higher

3. With which ethnicity do you identify? (Please circle all that apply)

Black/African American Hispanic/ Latino White/ Caucasian Native American/ American Indian Asian/ Pacific Islander Other

4. What is your highest completed level of education?

High school or less Some college College graduate Postgraduate

5. What is your approximate annual household income?

Under $30,000 $30,000-$59,999 $60,000-$99,999

$100,000-$150,000 Over $150,000

6. What is the zip code of your household? __________________

7. Including yourself, how many people live in your household? Under 18 years old: ____ Over 18: _______

8. What is/are your current mode(s) of daily transportation? (Please circle all that apply)

Walk Bike Drive self Ride-hailing

Bus Rail/Train Work/Company Vehicle Other _______________

9. What is the approximate value of each vehicle at your household? (Please fill in each blank only for cars that your household has and uses)

Vehicle 1____________________ Vehicle 3 ____________________ Vehicle 5____________________

Vehicle 2____________________ Vehicle 4 ____________________ Vehicle 6 ____________________

10. On average, how many total trips do you make in a week? (Round trip)

For personal reasons? ______________________ For business reasons?______________________

11. If autonomous transportation is widely implemented, for what purpose are you more likely to it (circle one):

Business Personal Both Neither

12. In general, I think autonomous transportation will have (Please circle only one):

Vast benefits	Many benefits, some downfalls	Just as many downfalls as benefits	Many downfalls, some benefits	Only downfalls	I'm not sure

13. Would you like to see autonomous transportation more widely available in the future?

YES NO No opinion

14. Excluding price as a factor, I would consider replacing my current vehicle with: (Please circle all that apply)

A personal autonomous vehicle Autonomous transit Autonomous ride-hailing None

15. If autonomous transportation is widely implemented, would your household consider getting rid of any of its vehicles? If yes, how many? (Please consider time of day each household member needs transportation, duration of trips and other relevant household factors)

NO YES, __________ eliminated vehicles

16. Please rank the aspects of your transportation mode that are most important to you on a scale of 1 to 5, with 1 being the most important.

Accessibility	Safety	Schedule Flexibility	Familiarity	Reliability
________	________	________	________	________

17. Please indicate if you think autonomous vehicular transportation will make the following factors better, worse or no different than they currently are with the mode you use now. (Please mark one option in each row)

	Will get better	Will get worse	Will not change
Safety	☐	☐	☐
Accessibility	☐	☐	☐
Schedule Flexibility	☐	☐	☐
Familiarity	☐	☐	☐
Reliability	☐	☐	☐

18. Before I will consider using autonomous transportation, the following characteristics must be the same as/better than my current mode of transportation: (Please circle all that apply)

Safety Privacy Flexibility Reliability Accessibility Duration/travel time Familiarity Cost

19. If autonomous transportation is widely implemented, would you make more daily trips than you currently do today?

YES NO NO CHANGE UNSURE

20. If autonomous transportation is widely implemented, would you take longer trips than you do today?

YES NO NO CHANGE UNSURE

21. If autonomous transportation is widely implemented, would autonomous transportation cause you to choose vehicular transportation rather than air transportation for any of the following vehicle travel times: (Mark all that apply)

	Yes	No
5-6 hours	☐	☐
6-8 hours	☐	☐
8-10 hours	☐	☐
10-12 hours	☐	☐
12 or more hours	☐	☐

22. From a safety standpoint, I am comfortable riding in an autonomous ________ .

(Please circle all that apply, if none apply do not circle any):

Personal/Household vehicle   Bus/Transit mode   Ride-hailing

23. Please indicate if safety testing by the following entities would change your perception of autonomous transportation:

Safety tested by:	Yes, I would feel much a safer	I would feel somewhat safer	No impact
The autonomous vehicle manufacturer	☐	☐	☐
Federal government	☐	☐	☐
State government	☐	☐	☐
AAA	☐	☐	☐
JD Power	☐	☐	☐

24. If autonomous transportation is widely implemented, would you consider increasing your commuting distance?:

(mark all that apply)

	YES	NO		YES	NO
0-5 miles	☐	☐	20-30 miles	☐	☐
5-10 miles	☐	☐	30 or more miles	☐	☐
10-20 miles	☐	☐		☐	☐

25. If you did not have to drive, how would you spend your time in the vehicle?

Social media   Talk on phone   Sleep   Socialize with other passengers   Work   Other

26. Rate your level of exposure to driverless vehicles on a scale of 1 to 5 with 5 being a very high level of exposure.________

27. Have you ridden in a driverless vehicle?   YES   NO

28. If autonomous transportation is widely implemented, I would use a shared driverless vehicle for the following purposes (Please circle only one):

Personal   Business   Both   Neither

29. Would you be more willing to take transit if there was a shared form of transportation such as autonomous shuttle that would pick you up from your neighborhood and take you to the nearest express transit stop?

YES   NO

30. Would you be willing to take a shared autonomous shuttle that would pick you up from your neighborhood and take you to the nearest transit stop?   YES   NO

APPENDIX B: THE SHUTTLE-RIDER SURVEY

Survey 2

Autonomous vehicles are expected to arrive soon and will not require drivers. Throughout this survey, the use of multiple modes of autonomous vehicles are referred as *autonomous vehicular transportation*. Please answer the following questions to the best of your abilities.

Definitions to keep in mind:

Autonomous vehicle/transportation: Driverless or self-driving vehicle/transportation

Personal autonomous vehicles: A household or otherwise personal vehicle belonging to you that does not require a driver

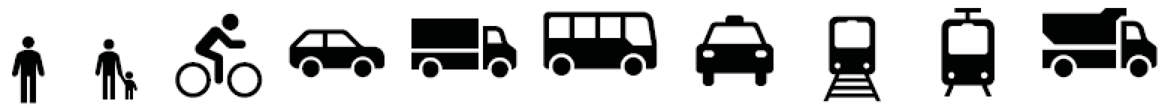
Mode: Method/vehicle of transportation; includes but is not limited to: walking, bicycling/biking, public transit, personal vehicle, etc.

Ride-hailing: Mode of transportation which involves hailing a vehicle whether it be physically or via a ride-hailing phone application such as Uber or Lyft.

Trips: Any use of a vehicle to move from one location to another (vehicles include bicycles, automobiles, bus, train, etc.); Walking trips should not be included; Please consider roundtrip to be one trip

Business trip: Any trip made that is associated with work, even if you are not compensated for your travel time to get to work and to get home from work, for the purpose of this survey please consider these business trips

Personal trip: Made for any reason not related to your paid work/business



1. Please mark which gender you identify as (Please circle only one):

Male   Female   Transgender   Prefer to self-describe ____________________

2. What is your age group?

Less than 25   25-34   35-44   45-54   55-64   65 or higher

3. With which ethnicity do you identify? (Please circle all that apply)

Black/African American   Hispanic/ Latino   White/ Caucasian   Native American/ American Indian   Asian/ Pacific Islander   Other

4. What is your highest completed level of education?

High school or less   Some college   College graduate   Postgraduate

5. What is your approximate annual household income?

Under $30,000 $30,000-$59,999 $60,000-$99,999

$100,000-$150,000   Over $150,000

6. Including yourself, how many people live in your household? Under 18 years old: ________ Over 18: ________

7. What is/are your current mode(s) of daily transportation? (Please circle all that apply)

Walk   Bike   Drive self   Ride-hailing

Bus   Rail/Train   Work/Company Vehicle   Other ________________

8. If autonomous transportation is widely implemented, for what purpose are you more likely to use it (Circle one):

Business Personal Both Neither

9. Please rate how you feel about autonomous vehicular transportation becoming more widespread? (Circle one)

Extremely happy Fairly happy No opinion Somewhat happy and somewhat unhappy Mildly unhappy Extremely unhappy

10. In general, I think autonomous transportation will have (Please circle only one):

Vast benefits Many benefits, some downfalls Just as many downfalls as benefits Many downfalls, some benefits Only downfalls I'm not sure

11. Overall, I believe autonomous transportation will improve my life. (Please circle only one)

Agree Mostly agree No opinion Mostly disagree Disagree

12. Would you like to see autonomous transportation more widely available in the future?

YES NO No opinion

13. Would you recommend the AAA Self-Driving Shuttle experience to a friend? YES NO UNCERTAIN

14. Did the AAA Self-Driving Shuttle experience enhance your understanding of (Please mark one answer in each row):

	Yes, a lot	Yes, somewhat	A little	Not at all
Self-driving technology	☐	☐	☐	☐
Self-driving vehicle capabilities	☐	☐	☐	☐
Self-driving vehicle safety	☐	☐	☐	☐
Self-driving vehicle benefits	☐	☐	☐	☐

15. Did you feel safer in the shuttle knowing it was sponsored by AAA? YES NO UNCERTAIN

16. How would you improve the experience of a self-driving shuttle?

____
____
____
____

17. What features would you want on this self-driving shuttle?

____
____
____
____

APPENDIX C: VARIABLE DEFINITIONS

BINARY VARIABLES	
FEMALE	indicates whether the participant is male or female
AGE25L.	participants 25 years or younger
AGE2534.	participants between 25 and 34 years old
AGE3544.	participants between 35 and 44 years old
AGE4554.	participants between 45 and 54 years old
AGE55M.	participants 55 years or older (for the general survey only)
AGE45M.	participants 45 years of older (for the shuttle-rider survey only)
EDUCHS	high school education or less
EDUCSC	some college education
EDUCCG	college graduate
EDUCPG	post-graduate education
INC30L.	annual income of $30,000 or less
INC3059.	annual income of $30,000 to $59,999
INC6099.	annual income of $60,000 to $99,999
INC100150.	annual income of $100,000 to $150,000
INC150M.	annual income of $150,000 or more
NH_U	number of people living in the household under 18
NH_O	number of people living in the household over 18
WALKBIKE	current mode of transportation walking or biking
DRIVESELF	current mode of transportation driving themselves
BUSRAIL	current mode of transportation riding a bus or rail
RHWVO	current mode of transportation ride-hail, work vehicle or other
VEH_COST1.	cost of vehicle 1
VEH_COST2.	cost of vehicle 2
VEH_COST3.	cost of vehicle 3
VEH_COST4.	cost of vehicle 4
VEH_COST5.	cost of vehicle 5
VEH_COST6.	cost of vehicle 6
NT_P	number of personal trips per week
NT_B	number of business trips per week
AV_PURP_B	use ACVs for business reasons only
AV_PURP_P	use ACVs for personal reasons only
AV_PURP_BP	use ACVs for both business and personal reasons
AV_PURP_N	use ACVs for neither business nor personal reasons
AV_BEN_V	ACVs will have vast benefits
AV_BEN_MB	ACVs will have many benefits, some downfalls
BENS	ACVs will have benefits (a combination of AV_BEN_V and AV_BEN_MB)
AV_BEN_BD	ACVs will have just as many benefits as downfalls
AV_BEN_MD	ACVs will have many downfalls, some benefits
AV_BEN_OD	ACVs will have only downfalls
DWNFL	ACVs will have downfalls (a combination of AV_BEN_MD and AV_BEN_OD)
AV_BEN_NS	Not sure what level of benefits ACVs will have
MA_Y	would like to ACVs more widely available

MA_N	would not like to see ACVs more widely available
MA_X	no opinion on if they would like to see ACVs more widely available
REP_PERS	would replace their current vehicle with a personal ACV
REP_TRANS	would replace their current vehicle with autonomous transit
REP_RH	would replace their current vehicle with autonomous ride-hail
REP_NONE	would no replace their current vehicle with an autonomous personal vehicle, transit or ride-hail
RID	if a participant would consider getting rid of a personal vehicle if ACVs became more widespread
RIDNUM	if yes to the previous question (RID), how many vehicles would they get rid of?
RANK1AC	if the participant ranked accessibility first
RANK1SA	if the participant ranked safety first
RANK1SF	if the participant ranked schedule flexibility first
RANK1FA	if the participant ranked familiarity first
RANK1RE	if the participant ranked reliability first
RANK2AC	if the participant ranked accessibility second
RANK2SA	if the participant ranked safety second
RANK2SF	if the participant ranked schedule flexibility second
RANK2FA	if the participant ranked familiarity second
RANK2RE	if the participant ranked reliability second
RANK3AC	if the participant ranked accessibility third
RANK3SA	if the participant ranked safety third
RANK3SF	if the participant ranked schedule flexibility third
RANK3FA	if the participant ranked familiarity second
RANK3RE	if the participant ranked reliability second
RANK4AC	if the participant ranked accessibility fourth
RANK4SA	if the participant ranked safety fourth
RANK4SF	if the participant ranked schedule flexibility fourth
RANK4FA	if the participant ranked familiarity second
RANK4RE	if the participant ranked reliability second
RANK5AC	if the participant ranked accessibility fifth
RANK5SA	if the participant ranked safety fifth
RANK5SF	if the participant ranked schedule flexibility fifth
RANK5FA	if the participant ranked familiarity second
RANK5RE	if the participant ranked reliability second
BTR_SA_B	safety will get better
BTR_SA_W	safety will get worse
BTR_SA_NC	safety will not change
BTR_AC_B	accessibility will get better
BTR_AC_W	accessibility will get worse
BTR_AC_NC	accessibility will not change
BTR_SF_B	schedule flexibility will get better
BTR_SF_W	schedule flexibility will get worse
BTR_SF_NC	schedule flexibility will not change
BTR_FA_B	familiarity will get better
BTR_FA_W	familiarity will get worse

BTR_FA_NC	familiarity will not change
BTR_RE_B	reliability will get better
BTR_RE_W	reliability will get worse
BTR_RE_NC	reliability will not change
SA_BET_SA	safety must be the same as or better than the current mode of transportation
SA_BET_PR	privacy must be the same as or better than the current mode of transportation
SA_BET_FL	flexibility must be the same as or better than the current mode of transportation
SA_BET_RE	reliability must be the same as or better than the current mode of transportation
SA_BET_AC	accessibility must be the same as or better than the current mode of transportation
SA_BET_DT	duration/travel time must be the same as or better than the current mode of transportation
SA_BET_FA	familiarity must be the same as or better than the current mode of transportation
SA_BET_CO	cost must be the same as or better than the current mode of transportation
DTR_Y	the participant would take more daily trips if autonomous transportation was widely implemented
DTR_N	the participant would not take more daily trips if autonomous transportation was widely implemented
DTR_X	the participant would not change their number of daily trips if autonomous transportation was widely implemented
DTR_U	the participant was not sure if their number of daily trips would change if autonomous transportation was widely implemented
LTR_Y	the participant would take longer daily trips if autonomous transportation was widely implemented
LTR_N	the participant would not take longer daily trips if autonomous transportation was widely implemented
LTR_X	the participant would not change the length of their daily trips if autonomous transportation was widely implemented
LTR_U	the participant was not sure if the length of their daily trips would change if autonomous transportation was widely implemented
AIR56.	widespread ACVs would lead to the participant choosing autonomous transportation over air travel for 5-6 hours of vehicle travel time
AIR68.	widespread ACVs would lead to the participant choosing autonomous transportation over air travel for 6-8 hours of vehicle travel time
AIR810.	widespread ACVs would lead to the participant choosing autonomous transportation over air travel for 8-10 hours of vehicle travel time
AIR1012.	widespread ACVs would lead to the participant choosing autonomous transportation over air travel for 10-12 hours of vehicle travel time
AIR12M.	widespread ACVs would lead to the participant choosing autonomous transportation over air travel for 12 or more hours of vehicle travel time
COMF_PH	from a safety standpoint, the participant is comfortable riding in an autonomous personal household vehicle
COMF_BT	from a safety standpoint, the participant is comfortable riding in autonomous buses/transit
COMF_RH	from a safety standpoint, the participant is comfortable riding in an autonomous ride-hail vehicle
SA_TST_MAN_Y	safety testing by the manufacturer would change the participants perception of ACVs

SA_TST_MAN_S	safety testing by the manufacturer would somewhat change the participants perception of ACVs
SA_TST_MAN_N	safety testing by the manufacturer would not change the participants perceptions of ACVs
SA_TST_FED_Y	safety testing by the federal government would change the participants perception of ACVs
SA_TST_FED_S	safety testing by the federal government would somewhat change the participants perception of ACVs
SA_TST_FED_N	safety testing by the federal government would not change the participants perceptions of ACVs
SA_TST_STA_Y	safety testing by the state government would change the participants perception of ACVs
SA_TST_STA_S	safety testing by the state government would somewhat change the participants perception of ACVs
SA_TST_STA_N	safety testing by the state government would not change the participants perceptions of ACVs
SA_TST_AAA_Y	safety testing by AAA would change the participants perception of ACVs
SA_TST_AAA_S	safety testing by AAA would somewhat change the participants perception of ACVs
SA_TST_AAA_N	safety testing by AAA would not change the participants perceptions of ACVs
SA_TST_JD_Y	safety testing by JD Power would change the participants perception of ACVs
SA_TST_JD_S	safety testing by JD Power would somewhat change the participants perception of ACVs
SA_TST_JD_N	safety testing by JD Power would not change the participants perceptions of ACVs
COMDST05.	if autonomous transportation was widely implemented, the participant would consider increasing commuting distance 0-5 miles
COMDST510.	if autonomous transportation was widely implemented, the participant would consider increasing commuting distance 5-10 miles
COMDST1020.	if autonomous transportation was widely implemented, the participant would consider increasing commuting distance 10-20 miles
COMDST2030.	if autonomous transportation was widely implemented, the participant would consider increasing commuting distance 20-30 miles
COMDST30M.	if autonomous transportation was widely implemented, the participant would consider increasing commuting distance 30 or more miles
SPND_TM_SM	if they did not have to drive, the participant would spend their time in the vehicle on social media
SPND_TM_TP	if they did not have to drive, the participant would spend their time in the vehicle talking on the phone
SPND_TM_SL	if they did not have to drive, the participant would spend their time in the vehicle sleeping
SPND_TM_SP	if they did not have to drive, the participant would spend their time in the vehicle socializing with other passengers
SPND_TM_WO	if they did not have to drive, the participant would spend their time in the vehicle working
SPND_TM_OT	if they did not have to drive, the participant would spend their time in the vehicle on "other" tasks
EXP_LVL1.	the participant ranked their exposure as level 1 (lowest)
EXP_LVL2.	the participant ranked their exposure as level 2

EXP_LVL3.	the participant ranked their exposure as level 3
SOME_EXP	the participant had some exposure to autonomous vehicles (level 2 or 3)
EXP_LVL4.	the participant ranked their exposure as level 4
EXP_LVL5.	the participant ranked their exposure as level 5 (highest)
HI_EXP	the participant had some exposure to autonomous vehicles (level 4 or 5)
RDN_AV	a binary variable indicating if the participant had ridden in an ACV before
USE_P	if ACVs were widely implemented, the participant would use shared ACVs for personal reasons
USE_B	if ACVs were widely implemented, the participant would use shared ACVs for business reasons
USE_PB	if ACVs were widely implemented, the participant would use shared ACVs for both personal and business reasons
USE_N	if ACVs were widely implemented, the participant would use shared ACVs for neither personal nor business reasons
EXP_STP	a binary variable indicating if the participant would be willing to take shared ACVs that pick them up in their neighborhood and take them to the nearest express transit stop
TRNS_STP	a binary variable indicating if the participant would be willing to take shared ACVs that pick them up in their neighborhood and take them to the nearest transit stop
FEEL_EH	participants felt extremely happy about ACVs becoming more widespread
FEEL_FH	participants felt fairly happy about ACVs becoming more widespread
FEEL_H	participants felt happy about ACVs becoming more widespread (a combination variable of FEEL_EH and FEEL_FH)
FEEL_NO	participants had no opinion about ACVs becoming more widespread
FEEL_HU	participants felt somewhat happy and somewhat unhappy about ACVs becoming more widespread
FEEL_MU	participants felt mildly unhappy about ACVs becoming more widespread
FEEL_EU	participants felt extremely unhappy about ACVs becoming more widespread
FEEL_U	participants felt unhappy about ACVs becoming more widespread (a combination variable of FEEL_MU and FEEL_EU)
IMPV_A	the participant agreed that ACVs will improve their life
IMPV_MA	the participant mostly agreed that ACVs will improve their life
IMPV_NO	the participant had no opinion on if ACVs would improve their life
IMPV_MD	the participant mostly disagreed that ACVs would improve their life
IMPV_D	the participant disagreed that ACVs would improve their life
RCMD_Y	the participant would recommend the AAA shuttle to a friend
RCMD_N	the participant would not recommend the AAA shuttle to a friend
RCMD_U	the participant was unsure if they would recommend the AAA shuttle to a friend
TECH_ALOT	the shuttle enhanced the participants understanding of ACV technology a lot
TECH_SMWT	the shuttle enhanced the participants understanding of ACV technology somewhat
TECH_LTL	the shuttle enhanced the participants understanding of ACV technology a little
TECH_NO	the shuttle enhanced the participants understanding of ACV technology not at all
CPBL_ALOT	the shuttle enhanced the participants understanding of ACV capabilities a lot
CPBL_SMWT	the shuttle enhanced the participants understanding of ACV capabilities somewhat
CPBL_LTL	the shuttle enhanced the participants understanding of ACV capabilities a little
CPBL_NO	the shuttle enhanced the participants understanding of ACV capabilities not at all

SAFE_ALOT	the shuttle enhanced the participants understanding of ACV safety a lot
SAFE_SMWT	the shuttle enhanced the participants understanding of ACV safety somewhat
SAFE_LTL	the shuttle enhanced the participants understanding of ACV safety a little
SAFE_NO	the shuttle enhanced the participants understanding of ACV safety not at all
BNFT_ALOT	the shuttle enhanced the participants understanding of ACV benefits a lot
BNFT_SMWT	the shuttle enhanced the participants understanding of ACV benefits somewhat
BNFT_LTL	the shuttle enhanced the participants understanding of ACV benefits a little
BNFT_NO	the shuttle enhanced the participants understanding of ACV benefits not at all
AAA_Y	the participant did feel safer in the shuttle knowing it was sponsored by AAA
AAA_N	the participant did not feel safer in the shuttle knowing it was sponsored by AAA
AAA_U	the participant was uncertain if they felt safer in the shuttle knowing is was sponsored by AAA

APPENDIX D: MODEL SUMMARIES

Table 6. General public model outputs for ranking transportation factors.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
RANK1SF	SOME_EXP	1.3820	*	0.5555	5.9536	20.8063	0.6501	3.9829	0.7993
RANK2AC	FEMALE	-1.4270	**	0.4798	9.7640	21.6084	0.6026	0.2400	0.1936
RANK3AC	FEMALE	0.5467	~	0.3035	3.7582	18.1896	0.7937	1.7275	0.6334
	AGE4554.	1.0560	~	0.6855	2.7733			2.8748	0.7419
RANK3SA	FEMALE	-0.8769	~	0.4583	3.6221	21.7605	0.5936	0.4161	0.2938
RANK3SF	MA_Y	1.2854	~	0.8427	2.7089	13.1353	0.9638	3.6161	0.7834
RANK3FA	RDN_AV	-2.1994	*	0.9434	4.8703	22.1195	0.5721	0.1109	0.0998
RANK4AC	AGE4554.	1.1471	~	0.7104	2.9131	23.9943	0.4619	3.1490	0.7590
	AGE55M.	1.5775	*	0.8241	4.0819			4.8428	0.8289
	AVBENS	-1.3644	~	0.8768	2.9364			0.2555	0.2035
RANK4SF	AGE4554.	-1.6857	*	0.8269	5.1060	28.1877	0.2522	0.1853	0.1563
	AGE55M.	-1.5787	~	0.8858	3.7928			0.2062	0.1710
	EDUCSC	-1.6886	*	0.7590	5.8876			0.1848	0.1560
	EDUCCG	-1.3045	~	0.7757	3.3311			0.2713	0.2134
	BUSRAIL	2.1407	*	1.1394	4.4334			8.5054	0.8948
	RHWVO	-1.1560	~	0.7709	2.7993			0.3147	0.2394
	MORE_EXP	0.8965	~	0.5689	2.7673			2.4510	0.7102
RANK4FA	WALKBIKE	-0.9121	~	0.5604	2.9211	30.6158	0.1652	0.4017	0.2866
	RHWVO	1.8744	**	0.7439	7.0759			6.5169	0.8670
	MA_N	1.9186	~	1.0715	3.5921			6.8114	0.8720
	SOME_EXP	-1.0403	~	0.6009	3.3848			0.3533	0.2611
RANK4RE	INC3059.	1.2784	~	0.7013	3.2113	20.1385	0.6889	3.5909	0.7822
	INC100150.	1.8615	*	0.8549	4.4069			6.4334	0.8655
	WALKBIKE	-1.5159	~	0.8249	3.4665			0.2196	0.1801
RANK5SA	FEMALE	1.6721	*	0.6360	6.4177	13.9913	0.9468	5.3233	0.8419
RANK5SF	FEMALE	0.6024	~	0.3364	3.6970	28.8246	0.2268	1.8265	0.6462
	BUSRAIL	2.6417	~	1.6817	3.4854			14.037 0	0.9335
	SOME_EXP	0.7669	~	0.4879	2.7625			2.1531	0.6828

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 7. General public model outputs for whether factors will get better, worse or will not change.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
BET_SA_B	INC3059.	-1.3728	*	0.6063	5.4630	120.2362	<0.0001	0.2534	0.2022
	INC6099.	-1.4418	*	0.7063	4.1734			0.2365	0.1913
	INC100150.	-1.2643	~	0.7239	3.0625			0.2824	0.2202
	BUSRAIL	-1.8018	~	1.1084	2.9531			0.1650	0.1416
	AVDWNFL	-2.6141	~	1.4939	3.8210			0.0732	0.0682
	MA_Y	1.6328	*	0.7295	5.8367			5.1182	0.8366
	MORE_EXP	2.0723	~	1.2891	3.3470			7.9431	0.8882
BET_SA_W	AVDWNFL	4.4535	**	1.8451	8.8192	137.7169	<0.0001	85.9272	0.9885
	MA_Y	-2.0597	**	0.8086	7.4018			0.1275	0.1131
	SOME_EXP	-2.2844	*	1.0724	4.5159			0.1018	0.0924
BET_SA_X	INC3059.	1.8247	*	0.7795	6.4303	27.0727	0.3011	6.2009	0.8611
	INC6099.	1.9071	*	0.8459	5.5390			6.7335	0.8707
	AVDWNFL	-2.5604	~	1.5691	3.0653			0.0773	0.0717
BET_AC_B	WALKBIKE	-0.6167	~	0.3827	2.8930	32.4865	0.1154	0.5397	0.3505
	RDN_AV	-0.9335	~	0.6011	2.8297			0.3932	0.2822
BET_AC_W	AGE55M.	2.1198	*	0.9196	5.5127	47.8097	0.0027	8.3295	0.8928
	INC6099.	-1.7353	*	0.8285	4.7425			0.1763	0.1499
	BUSRAIL	3.0248	*	1.5018	3.9111			20.5899	0.9537
	AV_BEN_BD	-2.7408	*	1.3248	5.1684			0.0645	0.0606
	RDN_AV	2.2650	*	1.2962	4.1340			9.6311	0.9059
BET_AC_X	WALKBIKE	0.6565	~	0.3828	3.2152	27.3464	0.2886	1.9280	0.6585
BET_SF_B	MA_N	-1.4386	*	0.7766	3.9477	36.1185	0.0535	0.2373	0.1918
	MORE_EXP	1.3464	*	0.5860	6.3576			3.8436	0.7935
BET_SF_W	FEMALE	0.6843	~	0.3866	2.9532	48.5647	0.0021	1.9824	0.6647
	AGE55M.	1.6297	*	0.7763	4.7555			5.1023	0.8361
	INC3059.	-1.0685	~	0.5824	3.4101			0.3435	0.2557
	INC100150.	1.1378	*	0.5833	4.1044			3.1199	0.7573
	AVDWNFL	2.0337	*	0.9982	4.8514			7.6423	0.8843
BET_SF_X	INC3059.	0.7640	*	0.4053	3.9439	37.0829	0.0429	2.1468	0.6822
	AVDWNFL	-1.9359	*	0.8892	5.5364			0.1443	0.1261
	MA_N	1.2841	*	0.7084	3.8529			3.6114	0.7831
	MORE_EXP	-1.4919	*	0.6911	5.9419			0.2249	0.1836
BET_FA_B	AGE3544.	-0.9950	~	0.6088	2.8921	35.8662	0.0565	0.3697	0.2699
	INC150M.	-1.9009	*	0.9505	5.1894			0.1494	0.1300
	WALKBIKE	-0.7300	~	0.4216	3.3584			0.4819	0.3252
BET_FA_W	WALKBIKE	0.6284	~	0.3724	3.1541	25.1226	0.3991	1.8746	0.6521
	RDN_AV	1.4003	*	0.6876	5.2666			4.0564	0.8022
BET_FA_X	MORE_EXP	-1.2868	*	0.7261	4.0029	20.4725	0.6696	0.2762	0.2164
BET_RE_B	INC150M.	-1.1675	~	0.7342	2.8110	53.0341	0.0006	0.3111	0.2373
BET_RE_W	MA_Y	-1.1131	~	0.6532	3.2377	34.3418	0.0788	0.3285	0.2473
BET_RE_X	INC3059.	0.8932	*	0.4276	4.8982	30.9040	0.1566	2.4429	0.7096
	INC150M.	1.4105	*	0.6845	4.7569			4.0980	0.8038
	MA_N	1.6161	*	0.7446	5.5583			5.0334	0.8343

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 8. General public model outputs for factors that must be the same as or better with ACVs.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
SAB_SA	AV_BEN_BD	1.7730	~	0.9850	3.1615	22.4386	0.5531	5.8885	0.8548
	AVDWNFL	2.8701	~	1.5523	3.5749			17.6388	0.9463
	SOME_EXP	-1.0647	~	0.5825	3.0425			0.3448	0.2564
SAB_PR	AGE2534.	0.7229	~	0.4622	2.7242	17.2497	0.8378	2.0604	0.6732
SAB_FL	AVBENS	-1.3170	*	0.7087	4.1376	15.4126	0.9081	0.2679	0.2113
	AV_BEN_BD	-1.1592	~	0.6834	3.4094			0.3137	0.2388
SAB_RE	INC3059.	0.9375	*	0.4479	4.8156	18.2733	0.7896	2.5536	0.7186
	INC6099.	0.9250	~	0.5233	3.4942			2.5219	0.7161
SAB_AC	FEMALE	1.0763	*	0.4657	5.1838	32.6546	0.1116	2.9338	0.7458
	AGE2534.	2.3177	*	0.9100	6.4300			10.1523	0.9103
	AGE3544.	2.3053	*	0.9397	5.6585			10.0272	0.9093
	AGE4554.	2.2627	*	1.0458	4.1931			9.6090	0.9057
SAB_DT	INC3059.	1.0033	**	0.4014	7.0890	20.6022	0.6621	2.7273	0.7317
	AVBENS	-1.4835	*	0.8231	4.1152			0.2268	0.1849
	AV_BEN_BD	-1.5412	*	0.7930	4.8459			0.2141	0.1764
	AVDWNFL	-1.6780	*	0.9421	3.8704			0.1867	0.1574
SAB_FA	MA_Y	-1.3780	~	0.7979	2.8270	23.3943	0.4966	0.2521	0.2013
	MORE_EXP	1.5245	*	0.6705	4.8687			4.5928	0.8212
SAB_CO	AVBENS	-2.3922	*	1.4350	4.6213	19.5883	0.7199	0.0914	0.0838
	AV_BEN_BD	-2.5704	*	1.4135	5.8774			0.0765	0.0711

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9. General public model outputs for potential entities to conduct safety testing.

Dependent Variable	Independent Variable	Coefficient	Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
SA_TST_MAN_N	INC3059.	0.9344 *	0.4920	3.9896	61.0184	<0.0001	2.5456	0.7180
	MA_Y	-1.0782 ~	0.6095	3.5886			0.3402	0.2538
SA_TST_MAN_S	INC150M.	1.5452 *	0.6948	5.6890	22.4232	0.5540	4.6889	0.8242
	AVBENS	-1.2644 ~	0.7393	3.2698			0.2824	0.2202
	AVDWNFL	-1.5180 ~	0.9553	2.8426			0.2191	0.1798
	MORE_EXP	-0.9953 ~	0.6484	2.8311			0.3696	0.2699
SA_TST_MAN_Y	INC3059.	-0.7305 ~	0.4325	3.0973	59.0223	0.0001	0.4817	0.3251
	INC150M.	-2.2914 **	0.9716	7.5872			0.1011	0.0918
	AVBENS	2.2313 *	1.0348	6.2885			9.3118	0.9030
	MORE_EXP	1.5096 **	0.6145	7.3929			4.5249	0.8190
SA_TST_FED_N	AGE2534.	1.0990 *	0.5456	4.2917	27.6940	0.2732	3.0010	0.7501
	EDUCCG	-1.1783 ~	0.7229	2.9170			0.3078	0.2354
	EDUCPG	-1.4145 ~	0.7538	3.8351			0.2430	0.1955
SA_TST_FED_S	INC150M.	1.1603 ~	0.6721	3.3391	22.6174	0.5425	3.1910	0.7614
	MORE_EXP	-1.3953 *	0.7396	4.5807			0.2478	0.1986
SA_TST_FED_Y	INC150M.	-1.3931 *	0.7195	4.3996	41.7954	0.0136	0.2483	0.1989
	MORE_EXP	1.5733 **	0.6761	6.9348			4.8224	0.8283
SA_TST_STA_N	AGE2534.	0.8759 ~	0.5356	2.8680	31.0978	0.1510	2.4010	0.7060
	EDUCCG	-1.2619 ~	0.7208	3.3854			0.2831	0.2206
SA_TST_STA_S	EDUCCG	1.4252 *	0.7359	4.6523	20.7004	0.6563	4.1585	0.8061
	MORE_EXP	-0.9821 ~	0.6214	2.9774			0.3745	0.2725
SA_TST_STA_Y	FEMALE	0.5224 ~	0.2992	3.5396	30.4625	0.1699	1.6861	0.6277
	MA_Y	1.0350 ~	0.6361	3.0771			2.8152	0.7379
	MORE_EXP	0.9386 ~	0.5612	3.2759			2.5564	0.7188
SA_TST_AAA_S	AVBENS	-1.5383 *	0.7474	4.9796	20.9925	0.6392	0.2148	0.1768
	AV_BEN_BD	-2.1222 **	0.7504	9.8223			0.1198	0.1070
	AVDWNFL	-2.5732 **	0.9632	8.6536			0.0763	0.0709
SA_TST_AAA_Y	AVBENS	1.8339 *	0.8559	5.9062	35.9180	0.0559	6.2582	0.8622
	AV_BEN_BD	1.6426 *	0.8604	4.5934			5.1685	0.8379
	AVDWNFL	2.1219 *	1.0818	4.6107			8.3468	0.8930
SA_TST_JD_N	EDUCSC	-1.7226 **	0.7301	7.0133	35.5382	0.0608	0.1786	0.1515
	EDUCCG	-1.8443 **	0.7670	7.2540			0.1581	0.1365
	EDUCPG	-1.5891 *	0.7971	4.8365			0.2041	0.1695
	AVBENS	1.4589 ~	0.8789	3.3315			4.3013	0.8114
	AV_BEN_BD	1.2526 ~	0.8207	2.7638			3.4996	0.7778
	AVDWNFL	1.7440 ~	1.0029	3.5865			5.7203	0.8512
	MA_Y	-1.5880 **	0.6486	7.0893			0.2043	0.1697
SA_TST_JD_S	EDUCSC	1.4517 ~	0.9314	3.1782	25.9892	0.3537	4.2705	0.8103
	AVBENS	-1.6895 *	0.7876	5.3208			0.1846	0.1558
	AV_BEN_BD	-2.0947 **	0.7677	9.1072			0.1231	0.1096
	AVDWNFL	-2.1051 *	0.9726	5.5175			0.1218	0.1086
SA_TST_JD_Y	INC3059.	-0.8032 ~	0.4441	3.5291	35.8875	0.0563	0.4479	0.3093
	DRIVESELF	-1.4541 ~	0.8669	3.2335			0.2336	0.1894
	MA_Y	1.8408 **	0.7525	7.3195			6.3016	0.8630

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10. Model outputs for whether shuttle-riders felt safer with the ACV shuttle being sponsored by AAA.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
AAA_Y	FEMALE	1.0103	*	0.4468	5.9384	24.5920	0.4282	2.7463	0.7331
	AGE3544.	1.0942	~	0.6882	2.9233			2.9867	0.7492
	MA_N	2.8669	~	1.9786	3.5328			17.5817	0.9462
AAA_N	FEMALE	-0.9527	~	0.5356	3.4040	23.9408	0.4650	0.3857	0.2783
	AGE45M.	-2.5203	*	1.3271	4.1513			0.0804	0.0744
	INC150M.	2.2109	~	1.1736	3.6716			9.1237	0.9012
AAA_U	BENS	-3.4165	~	2.5245	2.7997	18.6520	0.7703	0.0328	0.0318

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11. Model outputs for if participants foresee benefits from ACVs.

Survey	Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
General	AV_BEN_V	FEMALE	-0.9101	*	0.4006	5.5381	53.3640	0.0001	0.4025	0.2870
		MA_Y	2.2043	*	1.2958	4.6346			9.0641	0.9006
		MORE_EXP	1.1690	*	0.5837	4.4651			3.2186	0.7630
General	AV_BEN_MB	FEMALE	0.7964	**	0.3280	7.0014	69.2750	<0.0001	2.2175	0.6892
		INC150M.	2.4523	***	0.7884	11.5121			11.6154	0.9207
		WALKBIKE	0.7531	~	0.4105	3.7293			2.1237	0.6799
		RHWVO	-1.2246	~	0.6958	3.4851			0.2939	0.2271
		MA_Y	2.6319	***	0.6626	22.6740			13.8998	0.9329
		MORE_EXP	-1.0576	*	0.5779	3.8684			0.3473	0.2578
General	AV_BEN_BD	AGE2534.	-1.1039	~	0.6316	3.1691	36.7942	0.0178	0.3316	0.2490
		INC150M.	-1.5683	~	0.9116	3.3975			0.2084	0.1725
		MA_Y	-2.3984	***	0.5740	19.8127			0.0909	0.0833
		MA_N	-1.1972	*	0.6227	4.2023			0.3020	0.2320
General	AV_BEN_MD	AGE2534.	1.8909	~	0.9718	3.1151	54.0389	0.0001	6.6255	0.8689
		EDUCCG	-3.1594	*	1.2834	6.0725			0.0425	0.0407
		EDUCPG	-2.2592	~	1.2134	2.9163			0.1044	0.0946
		MA_N	3.6099	***	1.2050	12.5093			36.9614	0.9737
General	AV_BEN_OD	AGE3544.	3.3363	~	1.6038	3.1352	24.4297	0.2727	28.1154	0.9657
General	AV_BEN_NS	AGE2534.	2.6416	*	1.3018	3.9478	29.1861	0.1096	14.0351	0.9335
		AGE3544.	2.3724	~	1.3513	2.9476			10.7228	0.9147
		AGE4554.	3.2171	*	1.4390	5.0200			24.9558	0.9615
		AGE55M.	3.7157	**	1.4378	7.2175			41.0893	0.9762
		MA_Y	-2.2219	**	0.7098	9.7942			0.1084	0.0978
		MA_N	-1.7832	*	0.8675	4.4536			0.1681	0.1439
General	AVBENS	AGE4554.	-1.7485	*	0.7968	4.8657	128.1828	<0.0001	0.1740	0.1482
		AGE55M.	-2.5065	**	0.8330	9.5060			0.0816	0.0754
		INC150M.	2.0102	*	0.9193	5.2461			7.4650	0.8819
		RHWVO	-1.4704	~	0.8241	2.8510			0.2298	0.1869
		MA_Y	3.8307	***	0.7470	41.6778			46.0927	0.9788
General	DWNFL	AGE2534.	3.7267	**	1.3388	7.2907	74.9681	<0.0001	41.5398	0.9765
		AGE4554.	2.6409	~	1.4126	3.2480			14.0253	0.9334
		AGE55M.	2.7915	~	1.5156	2.9943			16.3059	0.9422
		MA_N	4.4495	***	1.3283	18.6279			85.5877	0.9885
Shuttle-rider	AVBENS	FEMALE	-2.0880	*	0.9156	5.5136	60.1014	<0.0001	0.1239	0.1103
		INC3059.	-4.1176	**	1.4821	10.3755			0.0163	0.0160
		INC6099.	-3.5294	*	1.4952	5.9628			0.0293	0.0285
		INC150M.	-4.6283	*	2.0631	4.0189			0.0098	0.0097
		RHWVO	-2.0264	*	1.0222	4.4283			0.1318	0.1165
		FEEL_H	2.2374	*	0.9464	5.3493			9.3693	0.9036
		FEEL_U	-6.4622	**	2.5198	8.5915			0.0016	0.0016
		MA_Y	3.0705	**	1.1934	8.9925			21.5519	0.9557
Shuttle-rider	AV_BEN_V	FEMALE	-0.9892	*	0.4517	5.1165	28.4277	0.1284	0.3719	0.2711
Shuttle-rider	AV_BEN_MB	INC3059.	-0.9024	~	0.5497	3.0014	22.9101	0.3488	0.4056	0.2886
		FEEL_U	-4.9468	*	3.0416	4.7253			0.0071	0.0071
		MA_Y	1.4305	*	0.7631	4.1816			4.1807	0.8070

Continued on next page

Table 11 continued										
Shuttle-rider	AV_BEN_BD	FEMALE	1.2681	~	0.7494	2.8195	31.3759	0.0676	3.5541	0.7804
		INC3059.	3.0131	**	1.1900	7.0654			20.3503	0.9532
		INC6099.	2.4029	*	1.2100	3.9727			11.0548	0.9170
		INC100150.	2.6560	*	1.2454	4.7003			14.2396	0.9344
		INC150M.	3.9223	*	1.6736	4.8403			50.5171	0.9806
		FEEL_H	-1.7294	*	0.7985	4.5513			0.1774	0.1507
		MA_Y	-1.5033	~	0.8850	3.4654			0.2224	0.1819

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12. Model outputs for if participants would like ACVs more available.

Survey	Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
General	MA_Y	FEMALE	-1.1309	*	0.4569	5.7367	134.1796	<0.0001	0.3227	0.2440
		INC150M.	-3.2726	**	1.0259	10.8221			0.0379	0.0365
		AVBENS	3.9392	***	0.8434	27.7890			51.3760	0.9809
		AVDWNFL	-2.0768	*	1.0471	4.6010			0.1253	0.1114
		MORE_EXP	2.6197	~	1.6231	3.0710			13.7310	0.9321
General	MA_N	AGE2534.	-2.5365	*	1.0455	6.0417	100.4503	<0.0001	0.0791	0.0733
		AGE3544.	-1.5408	~	0.8603	3.1182			0.2142	0.1764
		INC150M.	2.2323	~	1.1588	3.2005			9.3209	0.9031
		AVBENS	-2.8137	*	1.0671	5.9159			0.0600	0.0566
		AVDWNFL	3.6500	***	1.1118	14.9457			38.4735	0.9747
General	MA_X	AGE2534.	1.6772	*	0.8202	3.8838	60.2247	<0.0001	5.3508	0.8425
		EDUCCG	-1.9563	*	0.9634	4.0959			0.1414	0.1239
		AVBENS	-3.5594	***	0.9026	18.2190			0.0285	0.0277
		AVDWNFL	-3.2650	**	1.1345	10.3795			0.0382	0.0368
Shuttle-rider	MA_Y	AGE45M.	-2.2078	~	1.2665	2.8911	64.0270	<0.0001	0.1099	0.0991
		INC6099.	2.7536	~	1.3538	3.8305			15.6987	0.9401
		INC150M.	4.4704	~	2.3274	3.7348			87.3916	0.9887
		AVBENS	4.5137	*	2.4975	4.3789			91.2564	0.9892
		IMPV_AGREE	2.3387	**	0.8908	7.1953			10.3672	0.9120
		IMPV_DIS	-3.1498	*	1.8337	4.4937			0.0429	0.0411
Shuttle-rider	MA_X	AGE45M.	2.4050	~	1.2403	3.5269	49.4205	0.0007	11.0789	0.9172
		INC6099.	-2.5460	~	1.2572	3.5989			0.0784	0.0727
		INC150M.	-4.4646	*	2.2379	3.9904			0.0115	0.0114
		AVBENS	-5.0731	*	2.5299	5.5823			0.0063	0.0062
		IMPV_AGREE	-2.0383	*	0.8936	4.7918			0.1302	0.1152

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13. Model outputs for how shuttle-riders feel about ACVs.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
FEEL_EH	RHWVO	0.9998	~	0.6415	2.8081	32.4197	0.0705	2.7177	0.7310
FEEL_H	INC100150.	-1.5746	*	0.7919	4.2102	64.2896	<0.0001	0.2071	0.1716
	DRIVESELF	1.8103	~	1.1059	2.8236			6.1121	0.8594
	IMPV_AGREE	1.7280	**	0.6069	8.8013			5.6293	0.8492
FEEL_NO	INC100150.	2.1088	**	0.8583	6.6477	30.0091	0.1182	8.2383	0.8918
	IMPV_AGREE	-1.4414	*	0.6424	5.2704			0.2366	0.1913
FEEL_HU	AGE3544.	-4.0777	*	2.1206	5.0623	33.9992	0.0491	0.0169	0.0167
	EDUCSC	-2.7918	*	1.1813	5.2770			0.0613	0.0578
	EDUCCG	-2.4972	*	1.1838	4.2779			0.0823	0.0761
	DRIVESELF	-2.3422	~	1.3427	3.7201			0.0961	0.0877
	BUSRAIL	-2.7341	~	1.7080	2.7317			0.0650	0.0610
	AV_BEN_BD	4.5148	*	2.4728	5.5398			91.3610	0.9892
	IMPV_AGREE	-2.0093	*	0.8410	5.6596			0.1341	0.1182

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 14. Model outputs for if shuttle-riders feel ACVs will improve their lives.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
IMPV_A	EDUCSC	-1.5194	~	0.8290	3.8134	39.8928	0.0111	0.2188	0.1795
	RHWVO	1.2659	*	0.6827	3.8677			3.5462	0.7800
	FEEL_H	1.9643	*	0.8610	6.4251			7.1302	0.8770
IMPV_MA	EDUCSC	1.6015	*	0.8045	5.1054	17.9472	0.7091	4.9605	0.8322
	EDUCCG	1.4053	~	0.8197	3.6680			4.0769	0.8030
	MA_Y	1.3824	~	0.8779	3.0829			3.9843	0.7994
IMPV_AGREE	RHWVO	2.1976	*	1.1816	4.4700	60.9986	<0.0001	9.0031	0.9000
	FEEL_H	1.8182	**	0.6073	10.4236			6.1605	0.8603
	MA_Y	1.5540	~	0.8988	3.6993			4.7305	0.8255
IMPV_NO	RHWVO	-2.1790	*	1.1391	4.9804	43.8224	0.0037	0.1132	0.1017
	FEEL_H	-1.7288	**	0.5903	9.8093			0.1775	0.1507

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 15. Model outputs for if shuttle-riders would recommend the shuttle ride to a friend.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
RCMD_Y	RHWVO	-2.5479	~	1.1656	3.3282	20.4994	0.6681	0.0782	0.0726
	AVBENS	8.0772	*	3.8458	4.7228			3220.2877	0.9997
	AV_BEN_BD	7.7234	*	3.7241	4.8412			2260.6577	0.9996
	DWNFL	9.9888	~	5.3409	3.2719			21780.1249	1.0000

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 16. Model outputs for how shuttle-riders feel the shuttle enhanced their understanding of autonomous technology, capabilities, safety and benefits.

Dependent Variable	Independent Variable	Coefficient	Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
TECH_ALOT	AGE2534.	0.9588 ~	0.5917	3.0419	27.5841	0.2780	2.6086	0.7229
	AGE3544.	1.1435 ~	0.6936	3.1859			3.1377	0.7583
	INC6099.	-1.4361 *	0.6619	5.5046			0.2379	0.1922
	INC100150.	-1.4185 *	0.7137	4.5805			0.2421	0.1949
TECH_SMWT	AGE2534.	-1.1937 *	0.6340	4.0659	25.0155	0.4049	0.3031	0.2326
	INC6099.	1.3262 *	0.6869	4.1755			3.7667	0.7902
	INC10050.	1.6069 *	0.7416	5.3371			4.9873	0.8330
	INC150M.	1.7390 ~	1.0150	3.2031			5.6916	0.8506
CPBL_ALOT	AGE3544.	1.2222 ~	0.7257	3.3391	28.4562	0.2413	3.3946	0.7725
	IMPV_AGREE	1.0753 *	0.5607	4.3693			2.9309	0.7456
CPBL_SMWT	AGE3544.	-1.1598 ~	0.7551	2.7263	25.1244	0.3990	0.3135	0.2387
	INC100150.	1.3520 *	0.7308	3.8875			3.8651	0.7945
CPBL_LTL	AVBENS	-6.8883 *	3.1684	5.3763	17.3384	0.8339	0.0010	0.0010
	AV_BEN_BD	-5.2442 *	2.8587	3.9237			0.0053	0.0053
SAFE_ALOT	AGE2534.	0.8830 ~	0.5694	2.8401	24.5292	0.4317	2.4181	0.7074
	AGE3544.	1.7287 **	0.7095	7.4298			5.6333	0.8492
	IMPV_AGREE	0.9498 ~	0.5547	3.4864			2.5852	0.7211
SAFE_SMWT	MA_Y	1.4875 ~	0.9513	3.0539	18.8107	0.7620	4.4260	0.8157
SAFE_LTL	AGE2534.	-1.9075 *	0.8786	5.1688	29.4434	0.2039	0.1485	0.1293
	AGE3544.	-2.5957 *	1.2394	5.1933			0.0746	0.0694
	IMPV_AGREE	-1.2612 ~	0.7022	3.2838			0.2833	0.2208
BNFT_ALOT	AGE3544.	1.10304 ~	0.6756	3.0890	26.2372	0.3412	3.0133	0.7508
BNFT_SMWT	INC100150.	1.4187 *	0.7611	3.8973	29.9169	0.1875	4.1317	0.8051
	DRIVESELF	3.1556 *	1.8190	4.2825			23.4671	0.9591
	FEEL_U	-6.8560 *	3.7891	4.9032			0.0011	0.0011
	MA_Y	2.3324 *	1.1997	4.7262			10.3026	0.9115
	MA_N	4.6449 *	2.6337	5.3134			104.0530	0.9905
BNFT_LTL	INC150M.	2.2126 ~	1.3256	2.7152	35.1323	0.0665	9.1394	0.9014

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 17. Model outputs for how what purposes the general public and shuttle-riders will use ACVs.

Survey	Dependent Variable	Independent Variable	Coefficient	Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
General	AV_PURP_B	AGE55M.	-2.4726 *	1.4252	3.9629	19.6844	0.7146	0.0844	0.0778
General	AV_PURP_P	AGE55M.	1.6085 *	0.7653	4.7326	35.0404	0.0678	4.9954	0.8332
		EDUCCG	-1.4619 *	0.7418	4.2979			0.2318	0.1882
		EDUCPG	-2.4235 **	0.8151	10.0484			0.0886	0.0814
		INC6099.	1.4927 *	0.6203	6.4330			4.4491	0.8165
		INC100150.	1.1537 ~	0.6672	3.1281			3.1699	0.7602
		DRIVESELF	-1.6771 *	0.9105	3.9143			0.1869	0.1575
		AVBENS	-1.3235 ~	0.8006	3.0445			0.2662	0.2102
		AVDWNFL	-1.8112 ~	1.0563	3.2959			0.1635	0.1405
General	AV_PURP_BP	EDUCPG	1.2942 ~	0.7748	3.2164	68.2491	<0.0001	3.6480	0.7849
		INC6099.	-1.4122 **	0.5368	7.6754			0.2436	0.1959
		INC100150.	-0.9663 ~	0.5584	3.2894			0.3805	0.2756
		AVBENS	1.4891 *	0.7994	4.2369			4.4333	0.8159
General	AV_PURP_N	AGE4554.	1.7187 ~	0.9195	3.2560	75.3429	<0.0001	5.5772	0.8480
		AVDWNFL	2.4653 **	1.0528	6.7071			11.7671	0.9217
		MA_Y	-1.7234 *	0.8110	4.6962			0.1785	0.1514
Shuttle-rider	AV_PURP_P	FEMALE	0.8849 *	0.4384	4.6290	21.3259	0.6743	2.4227	0.7078
		MA_N	-3.9663 ~	2.6640	3.4323			0.0189	0.0186
Shuttle-rider	AV_PURP_BP	FEMALE	-0.7719 ~	0.4252	3.7282	31.2685	0.1803	0.4621	0.3161
		IMPV_AGREE	0.9067 ~	0.5533	3.1376			2.4761	0.7123

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 18. Model outputs for how what purposes the general public will use shared ACVs.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
USE_P	EDUCSC	-1.3129	*	0.6770	4.0747	20.7129	0.6556	0.2690	0.2120
	EDUCCG	-1.6020	*	0.7485	4.9134			0.2015	0.1677
	EDUCPG	-1.6118	*	0.7755	4.6317			0.1995	0.1663
	MA_Y	2.0375	*	0.9603	5.5366			7.6714	0.8847
	MA_N	1.7540	~	1.0637	2.9736			5.7779	0.8525
USE_PB	AGE55M.	-1.6002	*	0.7527	5.2750	56.3619	0.0002	0.2019	0.1680
	EDUCPG	1.5555	*	0.7553	4.9935			4.7377	0.8257
	AVBENS	1.4112	~	0.8469	3.4704			4.1010	0.8040
USE_N	EDUCSC	1.8801	~	1.0945	3.6159	62.3394	<0.0001	6.5540	0.8676
	EDUCCG	2.1395	*	1.0890	4.9248			8.4955	0.8947
	AVBENS	-1.8026	*	0.8090	5.3189			0.1649	0.1415
	SOME_EXP	1.0871	*	0.5211	4.3811			2.9657	0.7478

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 19. Model outputs for replacing or getting rid of a personal vehicle if ACVs become more widespread.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
REP_PERS	AGE2534.	-0.9246	~	0.5588	2.8925	101.2831	<0.0001	0.3967	0.2840
	AGE3544.	-1.5224	*	0.6405	6.1890			0.2182	0.1791
	AGE4554.	-2.1404	**	0.7780	8.7031			0.1176	0.1052
	AGE55M.	-1.3289	~	0.7668	3.2111			0.2648	0.2093
	INC3059.	0.9062	~	0.5131	3.2877			2.4748	0.7122
	AVBENS	1.3315	~	0.8062	3.1898			3.7869	0.7911
REP_TRANS	INC3059.	-0.7483	~	0.4505	2.9638	44.7388	0.0063	0.4732	0.3212
	INC6099.	-0.9550	~	0.5568	3.2338			0.3848	0.2779
	INC100150.	-1.1673	*	0.5972	4.2677			0.3112	0.2373
	MORE_EXP	-1.9932	**	0.8110	7.9130			0.1363	0.1199
	RDN_AV	-1.9322	**	0.6855	9.8618			0.1448	0.1265
REP_RH	RHWVO	1.1478	~	0.7090	2.7242	45.7202	0.0048	3.1514	0.7591
	MA_Y	1.6088	~	0.9541	3.1426			4.9970	0.8332
REP_NONE	AGE4554.	1.3894	~	0.8538	2.7155	117.0833	<0.0001	4.0125	0.8005
	EDUCSC	1.9722	*	0.9587	4.7371			7.1863	0.8778
	INC100150.	1.7548	*	0.7230	6.2284			5.7820	0.8526
	AVBENS	-1.7871	*	0.8292	5.1992			0.1674	0.1434
	MA_Y	-1.9481	**	0.6910	9.4006			0.1425	0.1248
RID	MA_Y	1.1658	~	0.6868	3.3320	54.0102	0.0010	3.2086	0.7624

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 20. Model outputs for whether the general public will take longer or more daily trips.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
DTR_Y	INC100150.	-1.1667	~	0.6886	3.2035	30.9759	0.1545	0.3114	0.2374
	RDN_AV	-1.0836	~	0.6405	3.0595			0.3384	0.2528
DTR_N	AGE3544.	1.0784	~	0.6072	3.3295	18.3177	0.7873	2.9400	0.7462
	AGE55M.	1.2611	~	0.7570	2.8776			3.5293	0.7792
	INC150M.	-1.5055	~	0.8689	3.5952			0.2219	0.1816
DTR_X	INC100150.	1.1061	*	0.5128	5.2164	15.7354	0.8974	3.0227	0.7514
	INC150M.	1.2703	*	0.6561	4.2505			3.5618	0.7808
DTR_U	AGE55M.	-1.3895	~	0.8641	3.0149	17.5203	0.8256	0.2492	0.1995
	EDUCCG	1.4198	~	0.9335	2.8553			4.1362	0.8053
	AV_BEN_BD	-1.3232	~	0.7407	3.5193			0.2663	0.2103
	AVDWNFL	-1.7454	~	0.9900	3.3582			0.1746	0.1486
LTR_Y	MA_Y	1.1811	~	0.7026	3.2440	26.1400	0.3461	3.2581	0.7652
LTR_N	FEMALE	-0.7012	*	0.3656	3.9398	21.0643	0.6349	0.4960	0.3315
LTR_X	FEMALE	-0.5695	~	0.3525	2.8023	25.6177	0.3728	0.5658	0.3613
	AGE4554.	1.4176	*	0.6692	4.8932			4.1273	0.8050
	INC6099.	0.8699	~	0.5256	2.9756			2.3866	0.7047
	INC150M.	1.4414	*	0.7017	4.6852			4.2265	0.8087
	RDN_AV	1.3477	~	0.7943	3.5683			3.8484	0.7937
LTR_U	FEMALE	0.9307	**	0.3519	8.3295	21.8847	0.5862	2.5362	0.7172

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 21. Model outputs for whether the general public will commute further with ACVs.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
COMDST05.	EDUCCG	1.3293	~	0.7660	3.4917	58.1097	0.0001	3.7783	0.7907
	EDUCPG	1.5000	*	0.8126	3.9419			4.4819	0.8176
	INC6099.	-1.0505	*	0.5585	3.9108			0.3498	0.2591
	AVBENS	-1.8493	*	0.8140	6.3085			0.1573	0.1360
	AV_BEN_BD	-1.2525	~	0.8197	2.8191			0.2858	0.2223
	MA_N	1.5564	*	0.8114	4.4149			4.7416	0.8258
	MORE_EXP	-1.2209	~	0.7212	3.3421			0.2950	0.2278
COMDST510.	INC6099.	-1.0024	*	0.5362	3.8464	53.8184	0.0005	0.3670	0.2685
	AVBENS	-1.6896	*	0.8207	5.1834			0.1846	0.1558
	MA_N	1.6391	*	0.8055	4.9994			5.1505	0.8374
	MORE_EXP	-1.4812	*	0.7071	5.3215			0.2274	0.1853
COMDST1020.	EDUCSC	1.2928	*	0.7032	3.8664	62.3249	<0.0001	3.6430	0.7846
	EDUCPG	1.9356	*	0.8128	6.4399			6.9279	0.8739
	AVBENS	-1.6259	*	0.8288	4.7213			0.1967	0.1644
	MORE_EXP	-1.8156	**	0.6998	8.2170			0.1627	0.1400
COMDST2030.	EDUCSC	1.4974	*	0.6918	5.1196	35.7644	0.0578	4.4701	0.8172
	INC100150.	1.5078	*	0.6564	6.0467			4.5168	0.8187
	INC150M.	1.8316	*	0.9428	4.5628			6.2438	0.8620
	BUSRAIL	1.7675	~	1.1053	3.3785			5.8559	0.8541
	RHWVO	-1.1223	~	0.6577	3.1769			0.3255	0.2456
	RDN_AV	1.3259	*	0.6758	4.3532			3.7657	0.7902
COMDST30M.	AGE4554.	-1.5915	*	0.7464	4.8412	25.5010	0.3790	0.2036	0.1692
	INC100150.	1.5193	*	0.6751	5.8077			4.5692	0.8204
	INC150M.	1.8003	*	0.9511	4.3058			6.0513	0.8582
	RHWVO	-1.1853	~	0.6460	3.6905			0.3056	0.2341

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 22. Model outputs for whether the general public will use ACVs to replace air travel.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
AIR56.	AGE4554.	1.2403	~	0.6851	3.5276	55.2451	0.0003	3.4567	0.7756
	INC3059.	-0.9342	*	0.4610	4.5069			0.3929	0.2821
	INC6099.	-1.0171	*	0.5467	3.8540			0.3616	0.2656
	INC150M.	-1.5953	*	0.8265	4.2880			0.2028	0.1686
AIR68.	MA_Y	-1.2705	*	0.6131	5.0172	40.8170	0.0174	0.2807	0.2192
AIR810.	INC3059.	-1.0307	*	0.4301	6.4351	40.0794	0.0210	0.3567	0.2629
AIR12M.	INC150M.	3.0051	*	1.5022	6.4933	21.2331	0.6249	20.1875	0.9528
	RDN_AV	1.2344	*	0.6398	4.0345			3.4363	0.7746

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 23. Model outputs for how the general public will use their travel time in an ACV.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
SPND_TM_SM	AGE3544.	-1.2207	*	0.5489	5.6550	25.8700	0.3598	0.2950	0.2278
	AGE4554.	-1.4679	*	0.6905	5.3867			0.2304	0.1873
	EDUCCG	1.5591	*	0.7682	5.1807			4.7543	0.8262
SPND_TM_TP	EDUCCG	1.3888	*	0.7818	3.9936	27.7576	0.2704	4.0099	0.8004
	BUSRAIL	-2.5101	*	1.2028	6.1774			0.0813	0.0752
SPND_TM_SL	AGE2534.	-1.0549	*	0.4760	5.5011	37.8470	0.0359	0.3482	0.2583
	AGE3544.	-1.3654	**	0.5384	7.3174			0.2553	0.2034
	AGE4554.	-1.9833	**	0.6607	10.5876			0.1376	0.1210
	AGE55M.	-1.9604	**	0.6906	9.5064			0.1408	0.1234
	WALKBIKE	0.8044	*	0.3985	4.6619			2.2354	0.6909
SPND_TM_SP	AGE3544.	-1.0166	~	0.5687	3.5962	36.6831	0.0470	0.3618	0.2657
SPND_TM_WO	AGE4554.	-1.4835	*	0.6673	5.6622	50.9537	0.0011	0.2268	0.1849
	AGE55M.	-2.7892	***	0.8238	14.8041			0.0615	0.0579
	EDUCCG	1.2958	~	0.7697	3.3202			3.6539	0.7851
	EDUCPG	1.5000	*	0.7949	4.1830			4.4818	0.8176
	DRIVESELF	1.5797	*	0.8660	3.9824			4.8535	0.8292
	AVDWNFL	-2.3335	*	1.0372	5.5614			0.0970	0.0884
SPND_TM_OT	INC150M.	1.3818	*	0.6962	4.6562	19.3493	0.7331	3.9819	0.7993
	RHWVO	-1.0206	~	0.6605	2.9263			0.3604	0.2649

~ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 24. Model outputs for if the general public will use shared ACVs to get to transit stops.

Dependent Variable	Independent Variable	Coefficient		Std. Error	Chi-Squared	LRT	LRT p-value	Odds Ratio	Probabilities
EXP_STP	DRIVESELF	2.3528	*	1.4650	3.9478	43.5246	0.0087	10.5149	0.9132
TRNS_STP	INC150M.	1.4146	*	0.7091	4.5625	45.0469	0.0058	4.1149	0.8045
	RDN_AV	1.2706	~	0.8291	2.7838			3.5630	0.7808

~ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

REFERENCES

Albert, A. and Anderson, J. A. (1984). On the existence of maximum likelihood estiamtes in logistic regression models. *Biometrika*, 71(1), 1-10. DOI: 10.2307/2336390

Allison, P. (2004). Numerical Issues in Statistical Computing for the Social Scientist. *Convergense problems in logistic regression* (238-252). Hoboken, NJ: Wiley & Sons, Inc.

Ashkrof, P., Homem de Almeida Correia, G., Cats, O., and van Arem, B. (2019). Impact of automated vehicles on travel mode preference for different trip purposes and distances. *Transportation Research Record,* 2673(5), 607-616. DOI: 10.1177/0361198119841032

Bansal, P., Kockelman, K. M. and Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. *Transportation Research Part C: Emerging Technologies,* 67, 1–14. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.trc.2016.01.019

Chan, C. (2017). Advancements, prospects, and impacts of automated driving systems. *International Journal of Transportation Science and Technology* 6, 208-216. http://dx.doi.org/10.1016/j.ijtst.2017.07.008

Chen, T. D., Kockelman, K. M., and Hanna, J. P. (2016). Operations of a shared, autonomous, electric vehicle fleet: Implications of vehicle & charging infrastructure decisions. *Transportation Research Part A,* 94, 243-254. http://dx.doi.org/10.1016/j.tra.2016.08.020

Contreras, S. and Paz, A. (2018). The Effects of Ride-Hailing Companies on the Taxicab Industry in Las Vegas, Nevada. *Transportation Research - Part A: Policy and Practice*, 115, 63-70. DOI: 10.1016/j.tra.2017.11.008.

Corcoran, C., Mehta, C., Patel, N., and Senchaudhuri, P. (2001). Computational tools for exact conditional logistic regression. *Statistics in Medicine*, 20, 2723-2739. DOI: 10.1002/sim.739

Eden, G., Nanchen, B., Ramseyer, R., and Evequoz, F. (2017). Expectation and Experience: Passenger Acceptance of Autonomous Public Transportation Vehicles. *16th IFIP Conference on Human-Computer Interaction (INTERACT)* (Bombay, India), pp.360-363. DOI: 10.1007/978-3-319-68059-0_30

Fagnant, D. J., and Kockelman, K. (2015) Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, *Transportation Research Part A*, 77, 167-181. http://dx.doi.org/10.1016/j.tra.2015.04.003

Faisal, A., Yigitcanlar, T., Kamruzzaman, M. and Currie, G. (2019). Understanding autonomous vehicles: a systematic literature review on capability, impact, planning and policy. *Journal of Transport and Land Use,* 12(1), 45-72. http://dx.doi.org/10.5198/jtlu.2019.1405.

Firth, D. (1993) Bias Reduction of Maximum Likelihood Estimates. *Oxford Journals*, 80(1), 27–38. DOI: 10.2307/2336755

Gruel, W. and Stanford, J. M. (2016). Assessing the long-term effects of autonomous vehicles: a speculative approach. *Transportation Research Procedia,* 13, 18-29. DOI: 10.1016/j.trpro.2016.05.003

Haboucha, C. J., Ishaq, R. and Shiftan, Y. (2017) User preferences regarding autonomous vehicles. *Transportation Research Part C* 78, 37-49. http://dx.doi.org/10.1016/j.trc.2017.01.010

Heinze, G. (2006). A comparative investigation of methods for logistic regression with separated or nearly separated data. *Statistics in Medicine*, 25, 4216-4226. DOI: 10.1002/sim.2687

Heinze, G. and Schemper, M. (2002). A solution to the problem of separation in logistic regression. *Statistics in Medicine*, 21(16), 2409–2419. https://doi-org.ezproxy.library.unlv.edu/10.1002/sim.1047

Hulse, L. M., Xie, H., and Galea, E. R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science*, 102, 1–13. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.ssci.2017.10.001

Kalra, N. and Paddock, S. M. (2016). Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability? *Transportation Research Part A*, 94, 182-193, http//dx.doi.org/10.1016/j.tra.2016.09.010

König, M. and Neumayr, L. (2017). Users' resistance towards radical innovations: The case of the self-driving car, *Transportation Research Part F: Traffic Psychology and Behaviour*, 44, 42–52. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.trf.2016.10.013

Kyriakidis, M., Happee, R., and De Winter, J. C. F. (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation Research Part F: Traffic Psychology and Behaviour*, 32, 127–140. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.trf.2015.04.014

Las Vegas Convention and Visitor Authority (LVCVA) Research Center, (2019). Las Vegas Visitor Statistics: LVCVA Executive Summary of Monthly Southern Nevada Tourism Indicators, Year-End Summary for 2018, LVCVA. Retrieved from https://www.lvcva.com/stats-and-facts/visitor-statistics/

Lee, J. G., Kim, K. J., Lee, S. and Shin, D. H. (2015). Can autonomous vehicles be safe and trustworthy? Effects of appearance and autonomy of unmanned driving systems. *International Journal of Human-Computer Interaction*, 31(10), 682-691, https://doi.org/10.1080/10447318.2015.1070547.

Liljamo, T., Liimatainen, H. and Pöllänen, M. (2018) Attitudes and concerns on automated vehicles. *Transportation Research Part F,* 59, 24-44. https://doi.org/10.1016.j.trf.2018.08.010

Liu, P., Xu, Z. and Zhao, X. (2019). Road tests of self-driving vehicles: Affective and cognitive pathways in acceptance formation. *Transportation Research Part A*, 124, 354-369. http://doi.org/10.1016/j.tra.2019.04.004

Nielsen, T. A. S. and Haustein, S. (2018). On sceptics and enthusiasts: What are the expectations towards self-driving cars? *Transport Policy*, 66, 49–55. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.tranpol.2018.03.004

Nordland, A., Paz, A. and Khan, A. (2013). Public Perceptions and Preferences towards a VMT Fee System in Nevada. *Transportation Research Record*. No. 2345, 39-47.

Payre, W., Cestac, J., and Delhomme, P. (2014). Intention to use a fully automated car: Attitudes and *a priori* acceptability, *Transportation Research Part F: Traffic Psychology and Behaviour*, 27, 252-263. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.trf.2014.04.009.

Peeta, S., Paz, A., and DeLaurentis, D. (2008). Stated preference analysis of a new microjet on-demand air service. *Transportation Research Part A*, 42(4), 629-645.

Puhr, R., Heinze, G., Nold, M. and Geroldinger, A. (2017). Firth's logistic regression with rare events: accurate effect estimates and predictions? *Statistics in Medicine*, 36(14), 2302-2317. DOI: 10.1002/sim.7273

Schoettle, B. and Sivak, M. (2014) A survey of public opinion about autonomous and self-driving vehicles in the U.S., the U.K., and Australia. *University of Michigan Transportation Research Institute*. UMTRI-014-21

Shabanpour, R., Golshani, N., Shamshiripour, A. and Mohammadian, A. (Kouros). (2018). Eliciting preferences for adoption of fully automated vehicles using best-worst analysis. *Transportation Research Part C: Emerging Technologies,* 93, 463–478. https://doi-org.ezproxy.library.unlv.edu/10.1016/j.trc.2018.06.014

Society of Automotive Engineers (SAE), (2018). SAE International Releases Updated Visual Chart for its "Levels of Automation" Standard for Self-Driving Vehicles. Retrieved from https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles

Truong, L. T., De Gruyter, C., Currie, G., and Delbosc, A. (2017). Estimating the trip generation impacts of autonomous vehicles on car travel in Victoria, Australia. *Transportation*, 44(6), 1279-1292. https://doi-org.ezproxy.library.unlv.edu/10.1007/s11116-017-9802-2.

Wadud, Z., MacKenzie, D., and Leiby, P. (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A,* 86, 1-18. http://dx.doi.org/10.1016/j.tra.2015.12.001

Wooldridge, J. M. (2016). *Introductory Econometrics (Sixth)*. Boston: Cengage Learning.

Xu, Z., Zhang, K., Min, H., Wang, Z., Zhao, X., and Liu, P. (2018). What drives people to accept automated vehicles? Findings from a field experiment. *Transportation Research Part C* 95, 320-334. https://doi.org/10.1016/j.trc.2018.07.024

Yigitcanlar, T., Wilson, M., and Kamruzzaman, M. (2019). Disruptive impacts of automated driving systems on the built environment and land use: an urban planners' perspective. *Journal of Open Innovation: Technology, Market, and Complexity*, 5(1), 24, https://doi.org/10.3390/joitmc5020024.

Zhang, T., Tao, D., Qu, X., Zhang, X., Lin, R., and Zhang, W. (2019). The roles of initial trust and perceived risk in public's acceptance of automated vehicles. *Transportation Research Part C,* 98, 207-220. https://doi.org/10.1016/j.trc.2018.11.018.

CURRICULUM VITAE

SARAH DENNIS

sardennis@ucdavis.edu

EDUCATION		
University of Nevada, Las Vegas		**University of Nevada, Reno**
➢ *M.S Civil Engineering* ➢ *Post-Baccalaureate* ➢ *B.S Public Health* *(Minor in Anthropology)*	Aug. 2017 – Aug. 2019 Jan. 2016 – July 2017 Aug. 2014 – Dec. 2016	Aug. 2013 – May 2014
Thesis title: E*ffects associated with the deployment of autonomous and connected vehicles: Insights from Las Vegas, NV*		

Transportation Engineering & Statics Teaching Assistant

(August 2018-May 2019)
• Conducted 8 lectures (Transportation Engineering)
• Provided support and feedback to students on assignments, specific topics related to their class projects and verbal presentations
• Assisted in creating and grading assignments and exams

Research Assistant to Dr. Alexander Paz

(August 2017-May 2019)
• Wrote 4 research proposals for various topics
• Assisted in writing technical reports and required documentation for various projects and topics

Funded Research for the City of Las Vegas

(March 2018-August 2019)
• Collected over 400 survey-questionnaire responses both in-person and online
• Analyzed questionnaire data using discrete choice analysis
• Wrote detailed technical reports that address topics of particular interest to involved parties, including the City of Las Vegas, AAA and UNLV

Caviola-Anson Group Intern

(October 2017-May 2019)
• Attentively observed common practices and procedures used in the industry of transportation engineering
• Provided quality control assistance to PhD-level transportation engineers
• Utilized staff support and widely used transportation-related manuals and resources to assist in project-based tasks

(May 2018-August 2018)
[During these months, Caviola-Anson Group allowed me the opportunity to "tour" each department within the firm, including traffic engineering, construction management, hydrology, and software design.]

2018 Fall Transportation Conference

(October 2018)

- Verbally presented summarized results of a project titled "Perceptions and Attitudes Toward Autonomous and Connected Vehicles" to transportation professionals from Nevada and neighboring states
- Won a first-place prize in the technical paper competition

Research Assistant to Dr. Courtney Coughenour

(August 2016-December 2016)

- Assisted in developing surveying materials, writing literature reviews and following strict research guidelines to ensure integrity of research