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# Consumer Perception and Anticipated Adoption of Autonomous Vehicle Technology: Results from Multi-Population Surveys

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# Consumer Perception and Anticipated Adoption of Autonomous Vehicle Technology:

# Results from Multi-Population Surveys

by

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A thesis submitted in partial fulfillment
of the requirements for the degree of
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# DEDICATION

This thesis is dedicated to my father Pandalanghat Jayaprakash Manjunaath, and my mother Pushpa Jayaprakash for their unabated support and constant efforts to provide me and Vijay with lots of love, devotion, care, and joy. This is also dedicated to my mentors and friends from NIT Calicut and IST Lisbon. Their never-ending support and encouragement has gotten me to where I am today. Lastly, this thesis would not be complete if not for the spiritual guidance from the almighty.

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## ABSTRACT

Emerging automotive and transportation technologies, such as autonomous vehicles (AVs) have created revolutionary possibilities in the way we might travel in the future. Major car manufacturers and technology giants have demonstrated significant progress in advancing and testing AV technologies in real-life traffic conditions.

Results from multi-population surveys indicate that despite enjoying moderate familiarity with AVs, more than 40% of the respondents were likely to use them when they become available. Simply looking at the demographic differences without paying any regard to the perceptions might suggest that the demographic differences are the primary causal factors behind the differences observed in the intended adoption of AVs. This study investigates the role of demographics and other factors (current travel characteristics, crash history and familiarity with AVs) on consumers' perceptions and intended adoption of AVs with a view of disentangling one factor from the other. Results show that the observed demographic differences in intended adoption rates are due to demographic differences in the perceptions on the benefits and concerns of AVs.

The study outcomes suggest that it may be beneficial to first address consumers' perceptions on the benefits and concerns regarding AVs. The results from this study can be used to inform modeling decisions and policy discussions relevant to future market penetration of AV technology.

# CHAPTER 1: INTRODUCTION

## 1.1 Background

On a cold December morning in the year 1926, readers of the *Milwaukee Sentinel* came across the news of a 'Phantom Auto' that would tour the city that day. The news article, authored by Loses Husband described how the car would start its own motor, throw in its clutch, turn the steering and even "sass" the traffic policeman at the corner. It described the presence of a radio set – the "mastermind" that would guide the machine as it moved in and out of the city traffic and how commanding waves sent from a second machine would be received by the "Phantom Auto" (Husband, 1926). This was the first time members of the general public were exposed to the idea of a world with driverless (or autonomous) vehicles. Today, we stand at the verge of seeing the vision of autonomous vehicles become a reality.

Autonomous vehicles (AVs) are a category of vehicles that can drive by themselves with little to no need for a human driver. They sense their surrounding environment with the help of advanced techniques such as RADAR, LIDAR, GPS, and computer vision to navigate from origin to destination. There is a lot of discussion on the influence of AVs on the way we might travel and our transportation systems in the future. According to a report released by the National Highway Traffic Safety Administration (NHTSA), 90% of all traffic crashes are due to human error and AVs have the potential to significantly reduce these crashes (NHTSA, 2008). Preliminary research has pointed towards other benefits of AVs that include, but are not limited to (1) better use of in-vehicle travel time for productive work or leisure activities, (2) independent mobility for the elderly and other dependent members of the household, (3) increased fuel efficiency due to improved traffic flow, smoother acceleration, and deceleration characteristics, and (4) increased roadway capacity and reduced traffic congestion.

Many major automotive manufacturers such as Toyota, Nissan, and General Motors, and technology giants like Google, and Apple are actively involved in developing and testing their respective versions of autonomous vehicles (Smiechowski 2014). For instance, the Google Car (Google's version of the autonomous vehicle) has completed almost 800,000 miles of testing in California. Plans are on course to introduce the testing of these cars in Austin, TX as well (Dent, 2015). As of May 2015, four U.S. states – Nevada, Florida, California, and Michigan – and the District of Columbia have passed laws permitting the testing of autonomous vehicles (AVs) on highways.

The introduction of testing procedures has also led to a lot of speculation on forecasts predicting the market penetration of autonomous vehicles. It is worth noting that the current forecasts of AV market penetration vary considerably. While Google expects their self-driving cars to be available by 2017 (Pritchard, 2014), other manufacturers like Nissan, and General Motors expect to introduce vehicles with autonomous driving capabilities by the year 2020 (Shankland, 2013). Expert members of the IEEE estimate that 75 percent of all vehicles will be autonomous by 2040 (IEEE, 2012). Litman (2014), based on an analogy with the evolution and market penetration of previous automobile technologies (e.g., air bags) predict that while individual benefits for affluent non-drivers may begin in the 2030s, beneficial impacts of safety and congestion at a system are only likely to appear between 2040 and 2050.

## 1.2 Motivation

Not all emerging technologies that have been in the limelight are immediately welcomed into the society by the general public. Most technologies require decades of development and innovative market growth to saturate their potential markets. Some technologies get adopted much more quickly than others – either based on utility or in some cases due to federal mandates – as in the case of airbags (Litman, 2014). Thierer (2013), based on past history postulated that consumer's attitudes towards new technologies follow a cycle of initial apprehension and/or resistance, gradual adaptation and then, eventual assimilation of the technology into the society. Technologies that were initially viewed as intrusive and fiercely resisted, often become not just accepted, but become essentials with time. (Thierer & Hagemann, 2014). It is very likely that the same pattern would follow with AVs.

Understanding consumers' perceptions about AVs and the influencing factors towards the intended adoption (when AVs become available in the market) is one way of understanding whether the penetration of this emerging technology will likely be any different from its contemporaries. These factors directly impact their introduction into the market and provide the basis for effective planning for the future with AVs.

Several public opinion surveys (J.D.Power, 2012; Intel, 2013; Cisco, 2013; Casley et al., 2013; Carinsurance.com, 2013; Seapine Software, 2014; Pew Research Center, 2014; Insurance.com, 2014; Howard & Dai, 2014; Schoettle & Sivak, 2014; Kyriakidis et al., 2014) and expert opinion/focus group studies (KPMG, 2013; Underwood, 2014) have been conducted in the recent past in order to understand some aspects on consumer perception and market penetration of AVs. These studies mostly provide topline analysis on some of the perception and adoption scenarios, but do not deeply investigate the influence of multiple factors such as consumers' perceptions about AVs in combination with their demographic and other attributes (for instance, familiarity with AVs, current travel characteristics, and crash history) in order to come up with additional insights into the observed differences in intended adoption of AVs.

**1.3 Objectives**

This study aims to address some of the gaps in the literature by setting out the following objectives:

I. Conduct a survey to elicit the following information:
   a. respondents' perceptions and attitudes toward AV technologies;
   b. respondents' intentions to adopt the technology when it becomes available.

II. Analyze the collected data on all aforementioned aspects toward the identification of various demographic, attitudinal, and other factors that might influence the consumer adoption of AVs.

In order to fulfill these objectives, the research team started out with a university population survey in April 2015 focussing on the students, faculty, and staff at the University of South Florida (USF). Simultaneously, as the data collection efforts were taking shape at USF, the research team entered into an agreement with the American Automobile Association (AAA) – South Division in order to conduct a similar survey across their membership. AAA is a non-profit, federation of motor clubs across North America with more than 50 million members across the United States of America and Canada (AAA, 2014).

This thesis will document the efforts taken up with both the University as well as the AAA surveys. The research team focused efforts on the university population because universities are often a fertile ground for testing and early adoption of new technologies. Further, university students represent the new generation that is more tech-savvy (than the general population) and comprises a considerable share of future adopters of emerging technologies. Therefore, this thesis will provide a unique opportunity to compare and contrast the findings from a university population survey with that of the members of a national level automobile organization that are at the forefront of automotive advocacy, and research. The combination of these populations would likely provide better insights as they would incorporate the opinions of a large cross section of socio-demographics.

### 1.4 Organization of the Thesis

The remainder of this thesis is organized as follows. Chapter 2 provides an overview of the literature and some findings from the most recent public opinion as well as expert opinion/ focus group surveys. Once an overview is provided, the chapter proceeds to showcase some current deficiencies in research. Chapter 3 presents details on the survey questionnaire design and data processing efforts. This chapter provides details on the questionnaire design, data distribution as well as data cleaning and processing efforts for both the USF and the AAA surveys. Chapter 4 discusses on the dataset summary statistics for the variables of interest to this thesis. Even though the surveys involved data collection on many other aspects, it must be noted that the data presented in this chapter is only with relevance to this thesis. Chapter 5 delves into the model estimation efforts undertaken during this study. Ordinal logistic models were employed to analyze consumers' perceptions on the benefits, concerns, and their intended adoption of AV technology (when they become available). Detailed results are provided for each model followed by a discussion of some of the main findings. Finally, Chapter 6 summarizes the key conclusions from this study and provides recommendations for future research opportunities.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This chapter begins with a discussion of some of the previous studies that have been done in order to understand consumers' perceptions and their intended adoption of autonomous vehicles. The studies have been divided into public opinion surveys as well as expert opinion/focus group surveys. Lastly, the chapter also contains a section which discusses the presence of knowledge gaps/deficiencies in the current literature.

## 2.2 Public Opinion Surveys

J.D.Power (2012) conducted an opinion survey of 17,400 vehicle owners, measuring their interest, and purchasing intent for emerging automotive technologies – both before and after revealing the respective market price of these technologies. Among vehicle owners, males between the ages of 18 and 37, living in urban areas were most interested in fully autonomous driving at market price. Prior to knowing the price, 37% of the respondents said they "definitely would" or "probably would" purchase AV technology in their next vehicle purchase. After learning that the estimated market price would be $3,000, this number dropped to 20%.

Intel (2013) conducted a survey of 1,000 adults in the U.S. examining their attitudes toward driverless cars. Over two-thirds of the respondents stated that they would not be comfortable inside an AV. An overwhelming percentage of respondents (55%) noted that innovation in safety features were more important than infotainment systems (4%). Improving fuel efficiency was noted as the biggest benefit (22%) while less traffic congestion (21%), relief of vehicle occupants from driving and navigational responsibilities (13%), enhanced productivity (11%), and a higher speed limit (4%) were other benefits noted. When it came to concerns, 76% of the respondents were worried about relinquishing complete control, higher speed capacity or the ability of the car to navigate and reach destinations without the driver's input.

Cisco (2013) conducted a survey of 1,500 consumers across 10 countries with the objective of understanding consumer preferences and influencers in automobile buying and driving. It was shown that 57% of consumers, globally, trust AVs. Sixty percent of the U.S. respondents indicated interest in riding in an AV, and almost half of these respondents (48%) were willing to let their children ride in these AVs too.

Casley et al. (2013) conducted a survey to understand public opinion about AVs. The survey of 467 responses was based on the hypothesis that the average consumer's appeal to AVs would be mostly influenced by the overall safety of the vehicle. Cost was hypothesized to be the second most influential aspect while legality (legislation) was ranked third on the appeal of an AV. Other influences such as a more productive use of travel time, increased driving efficiency, demographics, and income were also examined. Eighty-two percent of the respondents reported safety as the most important factor affecting their adoption followed by legislation (12%), and costs (6%).

Carinsurance.com (2013) surveyed 2,000 respondents and found that about 20% of the drivers would buy a fully autonomous vehicle if they were available. When told that an 80% discount would be provided on car insurance, it was found that 34% of the respondents were "very likely" and an additional 56% were willing to "consider the option" to buy an AV. When asked what they would do with their new free time, a majority of the respondents (26%) said they would text/ talk with friends. While three-fourths of the respondents felt that they would not trust AVs to take their kids to school, only 36% of them felt that computers were capable of the same quality of decision-making as human drivers were. The survey results also indicated that the majority of the respondents (54%) would trust traditional automakers (such as Honda, Ford or Toyota) the most to deliver the AV technology. It is interesting to note that customers would trust a start-up automaker such as Tesla (18%) over software giants such as Google or Microsoft (15%) or consumer product companies such as Apple or Samsung (12%).

Seapine Software's (2014) survey of 2,039 adults showed that 88% of them were worried about riding in AVs. This figure rose to 93% when adults aged 65 or over were filtered out as a separate group, while it decreased to 84% when filtered among the 18 to 34-year-old respondent demographic. Equipment failure was a worry for 79% of the respondents. Other concerns noted during the survey were liability (59%), hacking (52%), and the collection of personal data by auto companies, insurers, advertisers and municipalities (37%). Pew Research Center's (2014) survey showed that 48% among the 1,001 respondents would like to ride in an AV. Fifty-nine percent of college graduates would be interested in giving driverless cars a try, while 62% of those with a high school diploma or less would not.

Insurance.com (2014) surveyed 2,000 licensed drivers in order to understand their opinions about AVs. Results showed that only 25% respondents would never buy an AV. This figure decreased to 14% when the possibility of an 80% cheaper car insurance premium was promised. Sixty-one percent of the respondents said that they would make better decisions than the computer and only 31% of them would let the computer drive the vehicle at all possible times. Three-fourths of the respondents (76%) indicated that they would not trust AVs to take their child to school. Interestingly, when asked if they would prefer their AV hitting another car or a pedestrian (given the choice), 79% of the respondents said that they would rather let the AV hit another car.

Howard and Dai (2014) surveyed 107 respondents on their opinion of AVs using a questionnaire and a video. Safety (77%) and convenience (61%) were the most attractive features of AVs, while liability (70%) and cost (69%) were the least attracting of AVs. Forty-six percent of the respondents believed that AVs should operate with normal traffic while 38% felt the need for separate lanes. J.D. Power (2014) conducted another survey of 15,171 vehicle owners to follow up their efforts from 2012 (and 2013) with the aim of measuring interest on emerging automotive technologies. After being told that the market price for AV technology would be USD 3,000, a fourth of the respondents (24%) expressed interest in purchasing the AV technology – up from 20% in 2012 (J.D. Power, 2012), and 21% in 2013 (J.D. Power, 2013).

Schoettle and Sivak (2014) conducted a survey across the U.K., the U.S., and Australia to understand and examine differences in public perception about AVs. Seventy-one percent of the respondents in the U.S had previously heard about AVs, higher than the U.K (66%), or Australia (61%). When asked on the expected benefits of Level 4 (fully self-driven) AVs, two-thirds of the U.S. respondents expected fewer crashes while 73% of them expected improved emergency response to crashes. A shorter travel time was the least expected benefit, according to the U.S. respondents (45.9%). When queried on the concerns, 53% of the U.S. respondents were very concerned about possible confusions on the part of AVs during unexpected situations. Safety consequences from equipment/system failure were the second most concerning at 51% while learning to use AVs was the least concerning aspect for the U.S. respondents with only 29% respondents being very concerned about it. Additionally, it was found that 25% of the respondents were willing to pay an extra USD 2,000 to have Level 4 AV technology on a vehicle they own or lease, in future. When asked what activity they would do during the time inside an AV, 35% of the U.S. respondents said they would watch the road even though they would not be driving. Females were found to be more concerned about AVs than males and were also more cautious about the expected benefits from AVs.

Kyriakidis et al. (2014) conducted a crowd-sourcing internet survey of 5,000 individuals from 109 countries investigating user acceptance, and adoption of AVs. Respondents indicated that manual driving was more enjoyable over fully automated driving. They were more comfortable transmitting data to surrounding vehicles than to insurance companies or tax authorities. There was more concern over the misuse of Level 4 AVs than safety, or liability. Twenty-two percent of the respondents were not willing to pay more than USD 1,000 for a Level 4 AV whereas 5% indicated they were willing to pay more than USD 30,000 for the same. Lastly, on the adoption of AVs, 69% of the respondents expected fully automated vehicles to achieve a 50% market share by 2050.

### 2.3 Expert Opinion/Focus Group Studies

KPMG (2013) conducted a focus group study with 32 licensed drivers from Los Angeles (CA), Chicago (IL) and Iselin (NJ). All participants were 21 years or older, completing high school and college or vocational school, owning at least a vehicle with an annual family income in excess of USD 50,000. Results indicated that women were more likely to be willing to use AVs than men. Participants from CA were more open to such vehicles than those from IL and NJ. In contrast to the discussion on normal cars, there is more discussion on handling, safety, trust, and fuel economy in an AV as against engine, transmission, and styling in normal cars.

Begg (2014) surveyed over 3,500 London transport professionals for their views on specific issues related to the use of AVs in London. Twenty percent of the professionals believed that NHTSA Level 4 AVs would be commonplace on U.K. roads by 2040. Sixty percent of the professionals agreed that AVs would improve the safety for all road users, and supported the idea of driverless trains on the London underground.

Underwood (2014) conducted a survey with 217 AV experts who participated in the Automated Vehicles Symposium 2014. Eighty percent of the participants had a graduate professional degree (Masters, and/or Ph.D.), 31% worked in academic institutions, 24% in the automotive industry, 13% in consulting firms, and 17% in the government. Results showed that legal liability and regulation were reported as the most difficult barriers towards the deployment of fully automated vehicles. The experts felt that social and consumer acceptance aspects were the least difficult barriers, 27% felt that automated systems should be twice as safe as what they were today before they could be used in public, and 60% of the respondents felt that automated driving systems would be sold as original equipment on new vehicles, as against retrofits to existing vehicles. Lastly, two-thirds of the experts also felt the need for vehicles to communicate with each other for the successful implementation of fully automated systems.

### 2.4 Presence of Knowledge Gaps in the Current Literature

There are some knowledge gaps in the literature for understanding how consumers' perceptions along with their demographic factors influence their intended adoption of AV technology. Therefore, it becomes cumbersome to address any particular concerns that might disrupt the widespread adoption of AV technology. Not just that, but a number of additional, important factors that might influence perceptions, and intended adoption are not discussed in the literature. Some examples include familiarity with AVs, influence of current travel characteristics, and the history of being involved in traffic crashes. Most previous studies only involve a descriptive, univariate analysis of demographic differences in perceptions and the influence of demographic/attitudinal/other factors influencing the intended adoption of AVs.

While these analyses are insightful, they do not attempt to disentangle the influence of one factor from the other. For instance, simply looking at the demographic differences without looking into the consumers' perceptions might suggest that these demographics are the primary causal factors behind the differences observed in the intended adoption of AVs. However, it is likely that the observed demographic differences in the intended adoption of AVs are a consequence of the demographic differences in consumers' perceptions of the benefits and concerns regarding AVs. This thesis fills this gap by conducting a multivariate analysis of different factors in order to disentangle one from the other. This kind of additional insight will aid in the identification of the main causes behind the observed differences in adopting AV technology. This can also help in devising, and targeting specialized educational and marketing campaigns aimed at particular groups of the population.

# CHAPTER 3: SURVEY DESIGN AND DATA PROCESSING

Since the study involved investigations across multiple population segments, the research team designed tailor-made stated preference surveys for dissemination and subsequent data collection. The Research Integrity and Compliance Office at The University of South Florida processed this study and determined it as "Exempt" from the Institutional Review Board review (IRB#: Pro00016056).

## 3.1 Survey of the USF Population

This section talks in detail about the survey questionnaire design and data processing for the survey of the USF population. The details regarding the survey for AAA members are discussed in the next section.

### 3.1.1 Questionnaire Design and Data Collection

The survey for the students, faculty, and staff of the USF system (all three campuses – Tampa, St. Petersburg, and Sarasota-Manatee) was designed using SurveyMonkey (SurveyMonkey, 2015) and distributed for data collection among the university population for duration of 3 weeks during the month of April 2015. The customized survey for the university population consisted of 94 questions divided into the following three sections:

I. *General Information*: This section included respondent demographics (e.g., age, gender, educational level, household size, and annual household income), information on their current travel characteristics (e.g., most commonly used mode for various trips, average one-way distance, total time spent on travel per day), their crash history (e.g., vehicle damage level, injury severity level), and information on their vehicle purchase inventory (e.g., number of vehicles in the household, total purchase price), including available safety/automation features in their current vehicles.

II. *Consumer Perception of Autonomous Vehicles (AVs)*: This section included questions on respondents' familiarity with AVs before taking this survey, their likelihood of using AVs (before being queried on the benefits and concerns), their perception on the benefits with AVs, their perceptions on the concerns, and other aspects related to autonomous vehicles (AVs), their likelihood of using AVs after being queried on the benefits and concerns (when they become available). This section also included questions on their preferred way of using AVs (e.g., own, rent, use as transportation service), their willingness to pay for AVs, and lastly, their willingness to include safety and automation features.

III. *Anticipated Impacts of Autonomous Vehicles (AVs)*: This section included questions aimed at understanding the potential impacts of AVs on individuals' travel behavior (e.g., most preferred activity inside the AV, future vehicle size, impact on housing location), and future transportation systems (e.g., willingness to use different types of shared AVs, and potential concerns regarding the use of shared AVs).

### 3.1.2 Data Distribution Process

Data distribution channels were sought in order to distribute the survey to the students, faculty, and staff of the USF system. Several channels were considered:

I. Survey invitation emails were sent to all the academic departments at USF. The emails were addressed to the contact personnel in the department, who would then distribute it among the various department listservs.

II. Permissions were sought from the various offices in order to distribute the survey to the USF population through official channels – the Office of Graduate Studies (OGS), the Office of Undergraduate Studies (OUS), and Human Resources (HR). While the personnel at HR rejected the request, the OGS approved the request to be sent to all the graduate students via email with one reminder – a week to 10 days after the initial blast. The personnel at OUS agreed to send the survey invitation to a random sample of 10,000 USF undergraduates.

III. Lastly, the news regarding the survey was distributed through the official student government newsletter, which carried an inset article along with a small description, and a link. This was distributed to all the members of the USF system via two emails in the span of a week.

### 3.1.3 Data Cleaning and Quality Control

A total of 1156 responses were recorded from the students, faculty, and staff at USF during the data collection period of 3 weeks. Not all these responses were of good quality. Therefore, the responses were subjected to quality control procedures and sanity checks. Individual surveys were removed based on the following four criteria:

I. If respondents were younger than 18 years,

II. If respondents failed to answer at least until the section on concerns regarding AVs (38 out of the 94 questions),

III. If respondents completed the survey in 7 minutes or less (estimated average time for finishing the survey was 20 minutes), or,

IV. If respondents answered most questions with the same categorical response (respondent answering all As, all Bs etc.), suggesting that they were likely not thinking much about their answers.

It was found that four respondents belonged to category I, and 226 respondents belonged to category II. Categories III and IV had two respondents respectively. Thus, after quality control, only 922 of the 1156 responses were deemed fit for further analysis. In order to further analyze the influencing factors on consumers' perceptions and intended adoption of AVs, estimation of ordinal logistic models were proposed.

Successful application of ordinal logistic models (also known as ordered logit models) required that there be no missing entries among any variables of interest. Therefore, respondents with missing entries in any one of the variables of interest had to be removed from the analysis. A further 122 respondents were removed through this process, thus leaving a final sample size of 800 for subsequent modeling and analysis.

### 3.2 Survey of the AAA Membership

This section talks in detail about the survey questionnaire design and data processing for the survey of the AAA membership.

#### 3.2.1 Questionnaire Design and Data Collection

The survey for the AAA membership was designed using the web survey platform "Qualtrics", and distributed for data collection among the members of AAA South for a period of 3 weeks in June 2015. The customized survey for the AAA membership was slightly altered, taking into consideration the feedback, and general experience with the USF survey. The majority of these alterations were confined to Section III on the anticipated impacts of autonomous vehicles (AVs). The ordering of some of the questions was altered in Sections I & II, with a minor relocation of certain questions for better flow and data retrieval. The altered survey consisted of 75 questions divided into the following three sections:

I. *General Information*: This section included respondent demographics (e.g., age, gender, educational level, household size, and annual household income), information on their current travel characteristics (e.g., most commonly used mode for various trips, average one-way distance, total time spent on travel per day), their crash history (e.g., vehicle damage level, injury severity level), and information on their vehicle purchase inventory (e.g., number of vehicles in the household, total purchase price), including available safety/automation features in their current vehicles.

II. *Consumer Perception of Autonomous Vehicles (AVs)*: This section included questions on respondents' familiarity with AVs before taking this survey, their likelihood of using AVs (before being queried on the benefits and concerns), their perception on the benefits with AVs, their perceptions on the concerns, and other aspects related to autonomous vehicles (AVs), their likelihood of using AVs after being queried on the benefits and concerns (when they become available). This section also included questions on their preferred way of using AVs (e.g., own, rent, use as transportation service), their willingness to pay for AVs, and lastly, their willingness to include safety and automation features.

III. *Anticipated Impacts of Autonomous Vehicles (AVs)*: This section included questions aimed at understanding the potential impacts of AVs on individuals' travel behavior (e.g., most preferred activity inside the AV, future vehicle size, impact on housing location), and future transportation systems (e.g., willingness to use different types of shared AVs, and potential concerns regarding the use of shared AVs).

### 3.2.2 Data Distribution Process

AAA South (henceforth referred to as AAA in this thesis) agreed to assist the research team with the data collection process. The process involved the following:

I. A random sample of 60,000 members from AAA was chosen for the study.

II. Survey invitation emails were sent out through the Qualtrics survey distribution feature in order to reach out to these 60,000 members.

### 3.2.3 Data Cleaning and Quality Control

A total of 2,338 responses were recorded (response rate of 4%) from the members of AAA. Not all of these responses were of good quality. Therefore, the responses were subjected to quality control procedures and sanity checks. Individual surveys were removed if they belonged to one of the following four criteria:

I. If the respondents did not accept consent to take part in the survey

II. If respondents failed to answer at least until the section on concerns regarding AVs (42 out of the 75 questions),

III. If respondents completed the survey in 7 minutes or less (estimated average time for finishing the survey was 15 minutes), or,

IV. If respondents answered most questions with the same categorical response (respondent answering all As, all Bs etc.), suggesting that they were likely not thinking much about their answers.

It is important to note the changes in criteria for the AAA survey with respect to the USF survey. The USF survey had instances of respondents being less than 18 years of age; this was not observed in the AAA survey. In contrast, the AAA survey recorded 91 participants who belonged to category I – refusing consent to take part in the survey. This was not observed during the USF survey. In addition to this, 198 respondents belonged to category II, 48 respondents belonged to category III and 41 respondents belonged to category IV. In order to successfully estimate ordinal logistic models, a further 169 respondents with at least one missing entry among the variables of interest were removed. Thus, a final sample size of 1,791 was used for subsequent modeling and analysis.

# CHAPTER 4: DATASET SUMMARY STATISTICS

This chapter discusses in detail about the summary statistics of the variables of interest obtained during the data collection process.

## 4.1 Respondent Demographics, General Travel Characteristics, and Crash History

Table 4-1 describes the summary statistics of respondent demographics, their current travel characteristics, and crash history variables for both the USF and AAA surveys. The AAA survey polled higher shares of males than the USF survey. While older individuals (respondents ≥ 65 years) constitute only 2% of the university sample, 40% of the AAA members belonged to that category. In comparison to the demographics of the AAA sample, the university sample stated a higher share of respondents under the age of 30, a higher share of highly educated respondents (at least a bachelor's degree), and a lower share of respondents from high-income households (at least $100,000 per annum). It was also seen that AAA members enjoyed higher car ownership levels than respondents from USF. That is not very surprising, considering the comparisons between a largely student-centric segment of population (USF) to a much older, more financially stable segment of population (AAA). On the topic of representativeness, both the USF and AAA members were fairly representative in terms of gender and household income.

Among current travel characteristics, it was seen that a higher share of AAA members experienced one-way commute times of 60 minutes or more. It is likely that a majority of the university population stays in and around campus limits and therefore, these levels of variation in one-way commute times are reasonable. A higher share of AAA members also experienced total daily travel times of 60 minutes or more, in comparison to their USF counterparts.

Table 4-1 Summary Statistics of Respondent Demographics, General Travel Characteristics, and Crash History

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Explanatory Variable** | **Mean** | **SD** | **Min** | **Max** | **Mean** | **SD** | **Min** | **Max** |
| **Demographics** | | | | | | | | |
| Gender of respondent : Male | 0.37 | 0.48 | 0 | 1 | 0.59 | 0.49 | 0 | 1 |
| Age of respondent : 30 years or older | 0.43 | 0.5 | 0 | 1 | 0.99 | 0.12 | 0 | 1 |
| Age of respondent : 50 years or older | 0.13 | 0.34 | 0 | 1 | 0.81 | 0.39 | 0 | 1 |
| Age of respondent : 65 years or older | 0.02 | 0.15 | 0 | 1 | 0.4 | 0.49 | 0 | 1 |
| Ethnicity of respondent : Hispanic | 0.11 | 0.31 | 0 | 1 | 0.04 | 0.19 | 0 | 1 |
| Educational attainment : Bachelor's degree or above | 0.69 | 0.46 | 0 | 1 | 0.35 | 0.48 | 0 | 1 |
| Annual Household Income : $100,000 or more | 0.23 | 0.42 | 0 | 1 | 0.42 | 0.49 | 0 | 1 |
| Household size: 3 or more members in the household | 0.29 | 0.46 | 0 | 1 | 0.27 | 0.44 | 0 | 1 |
| Presence of at least 1 dependent member in the household | 0.33 | 0.47 | 0 | 1 | 0.22 | 0.42 | 0 | 1 |
| Household vehicle ownership | 2.18 | 1.07 | 0 | 5 | 3.18 | 1.03 | 1 | 6 |
| Current status at USF : Student | 0.8 | 0.4 | 0 | 1 | N/A | | | |
| Current employment status: Unemployed | N/A | | | | 0.47 | 0.5 | 0 | 1 |
| Immigration status: International resident | 0.06 | 0.24 | 0 | 1 | N/A | | | |
| **Current travel characteristics and crash history** | | | | | | | | |
| Most common commute mode: Drive Alone | 0.68 | 0.47 | 0 | 1 | 0.63 | 0.48 | 0 | 1 |
| One way travel time for commute trips: 60 minutes or more | 0.12 | 0.32 | 0 | 1 | 0.35 | 0.48 | 0 | 1 |
| Total daily travel time: 60 minutes or more | 0.44 | 0.5 | 0 | 1 | 0.73 | 0.45 | 0 | 1 |
| Crash history: involved in a crash | 0.64 | 0.48 | 0 | 1 | 0.76 | 0.43 | 0 | 1 |
| Complete vehicle damage during the crash | 0.11 | 0.31 | 0 | 1 | 0.22 | 0.41 | 0 | 1 |
| Fatal, incapacitating or major injuries during the crash | 0.1 | 0.3 | 0 | 1 | 0.1 | 0.3 | 0 | 1 |

## 4.2 Consumers' Opinions on Familiarity and their Perceptions on the Benefits with AVs

Table 4-2 shows respondents' opinions about their familiarity with AVs (before taking this survey), as well as their perceptions on the benefits with AVs. It was quite surprising to note that AAA members were more familiar (only 17.3% *not at all familiar* with AVs vs 26.5% from the USF sample; 6.8% *extremely familiar* vs 4.9% from the USF sample) with AVs before taking the survey. While it is probable that AAA members are more informed than their non-AAA counterparts partly due to the advocacy and member outreach endeavors from AAA themselves, it was still interesting to note how these members displayed higher levels of familiarity with AVs over a much younger and supposedly more tech-savvy university population.

Table 4-2 Consumers' Opinions on Familiarity and their Perception on the Benefits with AVs

| | **USF Population Survey (n=800)** | | | **AAA Membership Survey (n=1791)** | | |
|---|---|---|---|---|---|---|
| **Familiarity with AVs** | **Not at all familiar** | **Slightly/Moderately familiar** | **Extremely familiar** | **Not at all familiar** | **Slightly/Moderately familiar** | **Extremely familiar** |
| Familiarity with AVs before taking this survey | 26.5 | 68.7 | 4.9 | 17.3 | 75.9 | 6.8 |
| **Perception of benefits with AVs** | **Unlikely** | **Don't know/ Can't say** | **Likely** | **Unlikely** | **Don't know/ Can't say** | **Likely** |
| Fewer traffic crashes and increased roadway safety | 17.5 | 13.5 | 69.0 | 17.9 | 26.2 | 55.9 |
| Less traffic congestion | 40.2 | 13.3 | 46.5 | 41.0 | 30.2 | 28.8 |
| Less stressful driving experience | 23.2 | 9.5 | 67.3 | 24.1 | 22.6 | 53.4 |
| More productive (than driving) use of travel time | 18 | 8.6 | 73.4 | 21.4 | 27.2 | 51.4 |
| Lower car insurance rates | 35.7 | 18.5 | 45.8 | 35.0 | 31.5 | 33.5 |
| Increased fuel efficiency | 17.9 | 17.3 | 64.8 | 19.4 | 30.7 | 49.9 |
| Lower vehicle emissions | 24.1 | 22.8 | 53.1 | 22.9 | 41.6 | 35.5 |

USF respondents indicated three main benefits with AVs – (1) more productive use of travel time; (2) fewer traffic crashes and increased roadway safety; and (3) less stressful driving experience. AAA respondents indicated three main benefits with AVs – (1) fewer traffic crashes and increased roadway safety; (2) less stressful driving experience; and (3) more productive use of travel time. Even though there are marginal differences in the rank ordering of the benefits, both population segments felt that these would be the three main benefits with AVs. Both the

AAA and the university members also firmly believe that less traffic congestion with AVs is most unlikely.

It is also worth noting though that a higher percentage of AAA members were not ready to take a firm stand on some of the benefits with AVs, in comparison to their university counterparts (higher percentages observed under the *Don't know/Can't say* columns for AAA survey, vs USF).

### 4.3 Consumers' Opinions on their Perception on the Concerns Regarding AVs

Table 4-3 Consumers' Opinions on the Perception on their Concerns Regarding AVs

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Perception of concerns regarding AVs** | **Not at all concerned** | **Slightly/ Moderately concerned** | **Extremely concerned** | **Don't know/ Can't say** | **Not at all concerned** | **Slightly/ Moderately concerned** | **Extremely concerned** | **Don't know / Can't say** |
| Safety of the AV occupants and other road users | 7.1 | 52.6 | 36.5 | 3.8 | 4.2 | 51.9 | 24.9 | 19.0 |
| System/equipment failure | 2.0 | 44.6 | 50 | 3.4 | 2.9 | 46.7 | 30.5 | 19.9 |
| Performance in (or response to) unexpected traffic situations, poor weather conditions | 6 | 44.1 | 46.1 | 3.8 | 3.1 | 48.9 | 27.8 | 20.2 |
| Giving up control of the steering wheel to the vehicle | 14.6 | 38.5 | 42.3 | 4.6 | 8.4 | 46.6 | 26.8 | 18.3 |
| Loss in human driving skill over time | 21.5 | 45.9 | 28.4 | 4.2 | 6.8 | 49.0 | 27.8 | 16.4 |
| Privacy risks from data tracking on my travel locations and speed | 15.6 | 47.4 | 32.0 | 5.0 | 7.4 | 43.1 | 28.6 | 19.2 |
| Difficulty in determining liability in the event of a crash | 15.0 | 49.4 | 30.1 | 5.5 | 5.9 | 41.1 | 25.0 | 28.0 |

Table 4-3 shows consumers' opinions about their perceptions on the concerns regarding AVs. USF members indicated three main concerns with AVs – (1) system/equipment failure; (2) performance in unexpected traffic situations and poor weather conditions; and (3) giving up control of the steering wheel to the vehicle. Similarly, the three main concerns with AVs voiced by the AAA members were – (1) system/equipment failure; (2) privacy risks from data tracking on my travel locations and speed, and (3) performance in unexpected traffic situations and poor weather conditions.

Note how there are slightly different concerns in the minds of the two segments of the population. As seen under the benefits, a higher percentage of AAA members were not ready to take a firm stand on some of the concerns regarding AVs. AAA members are considered to be more risk conservative than their non-AAA counterparts. So it is likely that they may have adopted a more cautious *wait-and-watch* approach in order to better understand the benefits and concerns regarding AVs, before voicing their opinion.

**4.4 Consumers' Opinions on their Intended Adoption of AVs**

Questions on intended adoption were asked at two stages along the survey – (1) before the respondents were introduced to the benefits and concerns; and (2) after the respondents were introduced to the benefits and concerns regarding AVs. This was done in order to understand the effect of providing the information about the anticipated benefits and concerns on respondents' intended adoption of this new technology. It was hypothesized that providing the respondents with an idea on the anticipated benefits and concerns would enable them to process more information and make them more certain about their intended adoption (or non-adoption) of AVs.

Table 4-4 Consumers' Opinions on Their Intended Adoption of AVs

| | USF Population Survey (n=800) | | | AAA Membership Survey (n=1791) | | |
|---|---|---|---|---|---|---|
| **Intended adoption of AVs (before asking the questions on benefits and concerns)** | **Unlikely** | **Don't know/ Can't say** | **Likely** | **Unlikely** | **Don't know/ Can't say** | **Likely** |
| Likelihood of using AVs when they become available | 31.0 | 26.5 | 42.5 | 41.2 | 24.2 | 34.6 |
| **Intended adoption of AVs (after asking the questions on benefits and concerns)** | **Unlikely** | **Don't know/ Can't say** | **Likely** | **Unlikely** | **Don't know/ Can't say** | **Likely** |
| Likelihood of using AVs when they become available | 34.3 | 19.8 | 45.9 | 41.9 | 18.8 | 39.4 |
| **Intended adoption of AVs for different trip purposes** | **Unlikely** | **Don't know/ Can't say** | **Likely** | **Unlikely** | **Don't know/ Can't say** | **Likely** |
| Likelihood of using AVs for commute trips | 9.4 | 18.8 | 71.8 | 9.5 | 23.3 | 60.6 |
| Likelihood of using AVs for grocery trips | 13.9 | 20.0 | 66.1 | 12.3 | 19.3 | 66.8 |
| Likelihood of using AVs for long distance business trips | 7.0 | 23.0 | 70.0 | 9.9 | 26.7 | 55.5 |
| Likelihood of using AVs for long distance leisure trips | 8.4 | 19.4 | 72.2 | 7.9 | 17.1 | 74.0 |

Table 4-4 displays the respondents' opinions about their intended adoption of AVs when they become available. Forty-two percent of the university respondents expressed interest in using AVs before being introduced to the benefits and concerns. Once the benefits and concerns were introduced, it was observed that the percentage of respondents likely to use AVs had increased from 42% to 46%. A similar 4% increase was observed among the AAA members as well – with the percentage of respondents expressing interest in using AVs increasing from 35% to 39%. It was also observed that there was a similar pattern of increase in the share of respondents who had become more certain of their non-adoption of AVs, once they were made aware of the benefits and concerns (an increase from 31% to 34% among the university members; and from 41% to 42% among the AAA members). In terms of magnitude, however, it was seen that more individuals were moving towards the positive direction (adoption) than to the negative direction (non-adoption).

It seems that the questions on perceptions (benefits and concerns regarding AVs) had "warmed up" the respondents to process more information, and make them more certain about their adoption (or non-adoption) of AVs. This was reflected when the aspect of intended adoption was brought up for a second time in the survey. Thus, the attitudinal/perceptional questions are not only useful in their own right, but also assist respondents to better respond to subsequent questions as they are more likely to consider the above-mentioned benefits and concerns in a real setting. When asked about the likelihood of using AVs different trip purposes (commute, grocery, long distance business and long distance leisure), almost three-fourths of the university and AAA respondents were likely to use AVs for long distance leisure trips. These numbers were slightly less for other trip purposes. It was seen that the AAA members were least likely to use AVs for long distance leisure trips. This may be indicative of the preferences of a more senior as well a more financially affluent population segment.

# CHAPTER 5: MODEL ESTIMATION

The main motive of this chapter is to provide an overview of the modeling efforts undertaken in this study. The goal of this exercise was to identify various demographic, attitudinal, and other factors that might influence consumers' adoption of AVs. In order to understand the factors influencing consumers' adoption of AVs and successfully disentangle the influence of one factor from another, it is worthwhile to look deeper into the individual aspects influencing AV adoption. Therefore, this study used ordinal logistic models to analyze consumers' familiarity, their perceptions (on the benefits and concerns) toward, and intended adoption of AV technology. The following model classifications are explored in this chapter:

I. Ordinal logistic model estimates of consumers' familiarity with AVs
II. Ordinal logistic model estimates of consumers' perceptions on the benefits with AVs
III. Ordinal logistic model estimates of consumers' perceptions on the concerns with AVs
IV. Ordinal logistic model estimates of consumers' intended adoption of AV technology

## 5.1 Suitability of Ordinal Logistic Model Estimations

Ordinal logistic regression is primarily used to predict the relationship between an ordinal dependent variable and two or more independent variables that are ordinal or of continuous-level, by estimating probabilities utilizing a logistic function (Grilli & Rampichini, 2014). It is a common mistake to analyze ordered outcomes by employing linear regression models because the usual assumptions for regression models are not met, especially due to its failure to model the true nonlinear relationship in the data (Lu, 1999). The ordinal logit or ordinal probit model, on the other hand, accounts for the ceiling and floor effects and avoids using subjectively chosen scores that are assigned to the categorical variables (Hanushek and Jackson, 1977). Even though the outcomes are discrete in nature, multinomial logit models do not account for the ordinal nature of the outcomes (Greene, 1997), and are therefore avoided in this study.

All the dependent variables in the current study – (1) the familiarity level with AVs before taking the survey, (2) the likelihood of each of the seven benefits occurring with AVs, (3) the level of concern regarding the anticipated concerns regarding AVs, and (4) the likelihood of intended adoption of AVs are all ordinal in nature. A systematic process of variable selection, addition, transformation, and elimination was followed to arrive at the final model specifications using Stata 13 (StataCorp, 2013). Covariates with the |t-statistics| corresponding to values than 90% significance (t-stat = 1.645) were removed. McFadden's pseudo R-square was used as a measure of the model goodness of fit.

### 5.2 Ordinal Logistic Model Estimates of Consumers' Familiarity with AVs

Table 5-1 shows the ordinal logistic model estimates of the influence of demographics on consumers' familiarity with AVs for both the university and AAA surveys. Model estimation results indicate gender-level differences in familiarity with AVs. These results are on expected lines with results from previous studies (Danise, 2015) who have shown the need for gender-specific educational campaigns for the successful adoption of new technology. This study has reaffirmed that the society stands to gain by the inclusion of women in AV-related discussions and decisions in the future. While international residents showed higher levels of familiarity with AVs in the university survey, respondents with higher educational levels and a household income in excess of $100,000 were found to be more familiar with AVs. Results also indicate how respondents over the age of 65 in the AAA sample were less familiar than their younger counterparts.

Table 5-1 Consumers' Familiarity with AVs – Ordinal Logistic Model Estimates

| Response Variable | Familiarity with AVs before taking this survey - USF | | Familiarity with AVs before taking this survey - AAA | |
|---|---|---|---|---|
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -1.409 | -9.49 | -1.054 | -11.09 |
| Age of the respondent: 65 or above | N/A | | -0.258 | -2.78 |
| Educational attainment : Bachelor's degree or higher | -- | -- | 0.195 | 2.07 |
| Annual Household Income : $100,000 or more | -- | -- | 0.282 | 3.07 |
| Immigration status : International | 0.539 | 1.87 | N/A | |
| Crash history : Involved in a crash | -0.304 | -2.14 | -0.224 | -2.17 |
| **Thresholds** | | | | |
| Cut 1 | -0.594 | -4 | -1.309 | -11.88 |
| Cut 2 | 1.71 | 15.31 | 0.867 | 8.03 |
| Cut 3 | 3.745 | 19.81 | 3.121 | 22.78 |
| **Log Likelihood** | | | | |
| Initial | -943.358 | | -2169.926 | |
| Convergence | -891.246 | | -2089.031 | |
| **Pseudo R-square** | 0.0552 | | 0.0373 | |
| **N** | 800 | | 1791 | |

### 5.3 Ordinal Logistic Model Estimates of Consumers' Perceptions on the Benefits with AVs

Respondents' opinions were sought on the likelihood of 7 anticipated benefits with AVs (introduced earlier in table 4.2), and ordinal logistic models were estimated for each of these benefits. Results are as shown in tables 5-2 through 5-8.

For each of the benefits, two model specifications were estimated. The first model estimated the influence of respondent demographics, their current travel characteristics, and crash history on consumers' perceptions on the benefits with AVs. Once this first model was estimated, the final list of variables from this model specification was used as explanatory variables in the second model specification which added "familiarity with AVs" as an additional variable. For all the results presented, two major columns are present – the first major column is for the university survey (titled USF Population Survey) while the second column provides results from the sample collected from AAA members (titled AAA Membership Survey).

Table 5-2 Consumers' Perceptions on Fewer Traffic Crashes and Increased Roadway Safety with AVs – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Fewer traffic crashes and increased roadway safety*** | | **Fewer traffic crashes and increased roadway safety**** | | **Fewer traffic crashes and increased roadway safety*** | | **Fewer traffic crashes and increased roadway safety**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.754 | -5.42 | -0.395 | -2.69 | -- | -- | -- | -- |
| Age : 50 or above | -0.639 | -3.05 | -0.628 | -2.97 | -0.28 | -2.51 | -0.294 | -2.66 |
| Educational attainment : Bachelor's degree or higher | -- | -- | -- | -- | 0.299 | 3.22 | 0.269 | 2.96 |
| Annual Household Income : $100,000 or more | -- | -- | -- | -- | 0.217 | 2.52 | 0.149 | 1.71 |
| Current status at USF : Student | 0.481 | 2.58 | 0.436 | 2.27 | N/A | | | |
| Immigration status : International | -0.547 | -1.91 | -0.676 | -2.34 | N/A | | | |
| Crash history : Involved in a crash | -0.304 | -2.14 | -0.267 | -1.87 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | 0.73 | 7.96 | N/A | | 0.438 | 8.12 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.384 | -9.05 | -1.2 | -3.97 | -2.95 | -23.6 | -1.897 | -11.08 |
| Cut 2 | -0.829 | -3.75 | 0.371 | 1.38 | -1.859 | -18.2 | -0.807 | -5.17 |
| Cut 3 | -0.056 | -0.261 | 1.177 | 4.38 | -0.56 | -6.12 | 0.516 | 3.37 |
| Cut 4 | 1.774 | 7.82 | 3.145 | 10.8 | 1.059 | 11.15 | 2.192 | 13.4 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1116.214 | | -1116.214 | | -2633.514 | | -2633.514 | |
| Convergence | -1093.534 | | -1060.454 | | -2617.245 | | -2586.365 | |
| **Pseudo R-square** | 0.0203 | | 0.05 | | 0.0062 | | 0.18 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

### 5.3.1 Benefit – Fewer Traffic Crashes and Increased Roadway Safety

Table 5-2 shows the ordinal logistic model estimates of consumers' perceptions on fewer traffic crashes and increased roadway safety from AVs. Estimation results from show how older individuals (respondent age ≥ 50 years) are less likely to perceive this benefit with AVs. Results also show how international residents (as seen under the university model) were less likely to see this benefit than their domestic counterparts. There were no international respondents in the AAA sample, so this variable was not considered for analysis in the models using data collected from the AAA survey. Women were more skeptical of the possibility of fewer traffic crashes with AVs. Respondents who were involved in a crash were less likely to foresee fewer traffic crashes and increased roadway safety with AVs. This variable turned out to be insignificant in case of the AAA model.

On the other hand, university students, highly educated individuals (at least a bachelor's degree), and respondents from high-income households (at least $100,000 per annum) had positive effects on the perception of this benefit. Once the familiarity is added into the model specification, a significant positive association is found between familiarity and consumers' perception of this benefit (as shown by the high value of t-statistics in Table 5-2).

### 5.3.2 Benefit – Less Traffic Congestion

Table 5-3 shows the ordinal logistic model estimates of consumers' perceptions on less traffic congestion with AVs. Estimation results show that women and older individuals (respondent age ≥ 50 years) are more skeptical of less traffic congestion with AVs. International residents, unemployed individuals, and respondents with prior crash history were also found to be more skeptical about this benefit. Unemployed individuals are likely to not undertake as many trips as their employed counterparts and certainly, not a lot of trips during the morning and evening peak hours. This might be one reason as to why they do not foresee this benefit with AVs. Respondents with higher educational levels (at least a bachelor's degree) and those who majorly drove alone to work have a positive association with the perception of lesser traffic congestion.

Table 5-3 Consumers' Perceptions on Less Traffic Congestion with AVs – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Less traffic congestion*** | | **Less traffic congestion**** | | **Less traffic congestion*** | | **Less traffic congestion**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.509 | -3.79 | -- | -- | -0.234 | -2.71 | -- | -- |
| Age : 50 or above | -0.731 | -3.93 | -0.736 | -3.94 | -0.321 | -2.75 | -0.32 | -2.76 |
| Educational attainment : Bachelor's degree or higher | -- | -- | -- | -- | 0.191 | 2.15 | 0.163 | 1.83 |
| Current employment status : Unemployed | N/A | | | | -0.232 | -2.58 | -0.193 | -2.14 |
| Most commonly used mode for commute trips : Drive Alone | 0.234 | 1.72 | 0.23 | 1.69 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | 0.527 | 6.53 | N/A | | 0.331 | 6.21 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -1.723 | -8.28 | -1.276 | -3.85 | -1.939 | -16.5 | -1.312 | -8.14 |
| Cut 2 | 0.313 | 1.69 | 0.784 | 2.456 | -0.412 | -3.91 | 0.219 | 1.43 |
| Cut 3 | 0.867 | 4.62 | 1.356 | 4.22 | 0.873 | 8.15 | 1.521 | 9.63 |
| Cut 4 | 2.254 | 11.14 | 2.801 | 8.36 | 2.278 | 18.24 | 2.95 | 16.91 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1206.028 | | -1206.028 | | -2728.475 | | -2728.475 | |
| Convergence | -1190.01 | | -1173.571 | | -2712.266 | | -2696.487 | |
| **Pseudo R-square** | 0.0133 | | 0.0269 | | 0.0059 | | 0.0117 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

As seen earlier, a significant positive association was found between familiarity (when added to the model specification) and consumers' perception of less traffic congestion with AVs (as shown by the high value of t-statistics in Table 5-3). The addition of familiarity even led to the statistical insignificance in the female variable.

### 5.3.3 Benefit – Less Stressful Driving Experience

Table 5-4 shows the ordinal logistic model estimates of consumers' perceptions on less stressful driving experience with AVs. Estimation results show that well educated respondents are more likely and women are less likely to perceive less stressful driving experience with AVs.

Table 5-4 Consumers' Perceptions on Less Stressful Driving Experience with AVs – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Less stressful driving experience*** | | **Less stressful driving experience**** | | **Less stressful driving experience*** | | **Less stressful driving experience**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.342 | -2.02 | -- | -- | -0.19 | -2.2 | -- | -- |
| Age : 50 or above | -- | -- | -- | -- | -0.291 | -2.56 | -0.295 | -2.62 |
| Educational attainment : Bachelor's degree or higher | 0.265 | 1.9 | 0.284 | 2.02 | 0.316 | 3.52 | 0.287 | 3.19 |
| Most commonly used mode for commute trips : Drive Alone | -- | -- | -- | -- | 0.211 | 2.36 | 0.178 | 1.98 |
| Total daily travel time : 60 minutes or more | -- | -- | -- | -- | -0.178 | -1.82 | -0.203 | -2.07 |
| Familiarity with AVs before taking this survey | N/A | | 0.598 | 7.13 | N/A | | 0.335 | 6.31 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.798 | -16.75 | -1.807 | -8.2 | -2.31 | -16.38 | -1.638 | -9.12 |
| Cut 2 | -1.166 | -11.08 | -0.15 | -0.82 | -1.16 | -9.13 | -0.487 | -2.87 |
| Cut 3 | -0.688 | -6.99 | 0.347 | 1.92 | -0.134 | -1.08 | 0.549 | 3.27 |
| Cut 4 | 0.699 | 7.04 | 1.811 | 9.31 | 1.492 | 11.49 | 2.206 | 12.41 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1139.431 | | -1139.431 | | -2728.475 | | -2721.818 | |
| Convergence | -1134.18 | | -1110.833 | | -2705.618 | | -2688.003 | |
| **Pseudo R-square** | 0.0046 | | 0.0251 | | 0.006 | | 0.0124 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

Older individuals (respondent age ≥ 50 years) and individuals who travel more per day (total daily travel time ≥ 60 minutes) have a negative association towards the perception of less stressful driving experience with AVs. As respondents grow older, they are more likely to be impatient at the wheel, and, therefore, more skeptical about a less stressful driving experience. They probably think it won't change much with the advent of AVs too. Additionally, the more time we spend on our travel on a daily basis, the more we are likely to be stressed. Therefore, these results are in line with prior expectations.

Respondents who currently drive alone are expectant of a less stressful driving experience. It is likely that riding in an AV would eliminate them from the stressful nature of driving alone to accomplish their daily activities. The inclusion of the familiarity variable in the model specification leads to a significant positive association between familiarity and the prospect of less stressful driving experience with AVs. This also leads to statistical insignificance of gender-level differences in the perception of this benefit.

**5.3.4 Benefit – More Productive Use of Travel Time**

Table 5-5 shows the ordinal logistic model estimates of consumers' perceptions on more productive use of travel time with AVs. Estimation results show that older individuals (respondent age ≥ 50 years), and respondents with a prior crash history are less likely to perceive more productive use of travel time with AVs. It is very likely that older individuals and those who have experienced a crash before are more likely to be skeptical (or a general distrust) about the self-driving capabilities of AVs. Therefore, they are likely to experience lesser productivity during their travels. It was also observed that women and respondents with larger household sizes (3 or more members) were less likely to experience more productivity during their travel time. Members of larger households would be more inclined to travel together (owing to the presence of children or dependent members), leading to more distractions during travel. Therefore, they may not truly get to enjoy the benefits of more productive travel times, even with AVs.

Table 5-5 Consumers' Perceptions on More Productive Use of Travel Time with AVs – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **More productive (than driving) use of travel time*** | | **More productive (than driving) use of travel time**** | | **More productive (than driving) use of travel time*** | | **More productive (than driving) use of travel time**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.424 | -3.09 | -- | -- | -- | -- | -- | -- |
| Age : 50 or above | -0.62 | -3.24 | -0.61 | -3.17 | -0.584 | -5.15 | -0.607 | -5.37 |
| Educational attainment : Bachelor's degree or higher | -- | -- | -- | -- | 0.153 | 1.68 | -- | -- |
| Annual Household Income : $100,000 or more | -- | -- | -- | -- | 0.236 | 2.73 | 0.2 | 2.33 |
| Household size : 3 or above | -0.292 | -2.03 | -0.32 | -2.23 | -- | -- | -- | -- |
| Most commonly used mode for commute trips : Drive Alone | -- | -- | -- | -- | 0.326 | 3.65 | 0.301 | 3.36 |
| Crash history : Involved in a crash | -0.322 | -2.32 | -0.351 | -2.51 | -0.213 | -2.16 | -0.175 | -1.77 |
| Familiarity with AVs before taking this survey | N/A | | 0.51 | 6.05 | N/A | | 0.334 | 6.26 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.451 | -9.05 | -1.928 | -6.19 | -2.904 | -22.81 | -2.028 | -11.98 |
| Cut 2 | -0.776 | -3.46 | 0.535 | 1.96 | -1.651 | -15.64 | -0.775 | -5.04 |
| Cut 3 | -0.263 | -1.19 | 0.576 | 2.11 | -0.376 | -3.84 | 0.511 | 3.36 |
| Cut 4 | 1.132 | 5.03 | 2.018 | 7.15 | 1.169 | 11.48 | 2.088 | 12.95 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1075.834 | | -1075.834 | | -2691.471 | | -2691.471 | |
| Convergence | -1063.106 | | -1048.924 | | -2656.748 | | -2638.393 | |
| **Pseudo R-square** | 0.0118 | | 0.025 | | 0.0129 | | 0.0197 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

Respondents with higher household incomes (at least $100,000 per annum), high education levels (at least a bachelor's degree), and those who use drive alone mode for their commute trips were more likely to feel more productive during their travel time with AVs. As shown in the previous sections, the inclusion of the familiarity variable leads to a significant positive association with more productive use of travel time in AVs. However, gender-level differences in perception of this benefit cease to exist with the addition of familiarity into the model specification.

### 5.3.5 Benefit – Lower Car Insurance Rates

Table 5-6 Consumers' Perceptions on Lower Car Insurance Rates with AVs – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Lower car insurance rates*** | | **Lower car insurance rates**** | | **Lower car insurance rates*** | | **Lower car insurance rates**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.363 | -2.74 | -0.282 | -2.01 | -- | -- | -- | -- |
| Age : 50 or above | -0.547 | -3.01 | -0.546 | -3 | -0.36 | -3.29 | -0.363 | -3.32 |
| Educational attainment : Bachelor's degree or higher | -- | -- | -- | -- | 0.165 | 1.86 | -- | -- |
| Familiarity with AVs before taking this survey | N/A | N/A | -0.141 | 1.68 | N/A | N/A | 0.169 | 3.27 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -1.605 | -8.15 | -1.355 | -5.5 | -1.914 | -16.5 | -1.595 | -9.97 |
| Cut 2 | 0.001 | 0 | 0.251 | 1.08 | -0.861 | -7.97 | -0.542 | -3.52 |
| Cut 3 | 0.767 | 4.26 | 1.017 | 4.35 | 0.452 | 4.22 | 0.773 | 4.99 |
| Cut 4 | 2.035 | 10.57 | 2.291 | 9.29 | 1.888 | 15.73 | 2.216 | 13.35 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1250.264 | | -1250.264 | | -2774.631 | | -2774.631 | |
| Convergence | -1242.17 | | -1240.757 | | -2767.381 | | -2763.747 | |
| **Pseudo R-square** | 0.0065 | | 0.0076 | | 0.026 | | 0.0039 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

Table 5-6 shows the ordinal logistic model estimates of consumers' perceptions on lower car insurance rates with AVs. Estimation results show that older individuals (respondent age $\geq$ 50 years) and women are less likely to perceive these benefits with AVs. In line with previous results, there exists a marginal positive association between highly educated individuals (at least a bachelor's degree) and their perception of lower car insurance rates with AVs.

The inclusion of familiarity shows a lack of a very significant association. It is likely that consumers may not choose to invest on AVs merely for the promise of lower car insurance premiums. In the AAA model, the addition of the familiarity diminished the educational level differences in the perception of lower car insurance premiums. This is likely due to the positive influence of higher education levels on familiarity (established earlier, in table 5-1).

**5.3.6 Benefit – Increased Fuel Efficiency**

Table 5-7 shows the ordinal logistic model estimates consumers' perceptions on increased fuel efficiency with AVs. Estimation results show that older individuals (respondent age $\geq$ 50 years) are less likely to perceive increased fuel efficiency with AVs. It was also determined that university students, respondents with higher educational levels (at least a bachelor's degree), and higher annual household incomes (at least \$100,000 per annum) were more likely to perceive increased fuel efficiency with AVs.

As expected, familiarity had a positive impact on the perception of increased fuel efficiency with AVs, when added to the model specification. Respondents who exhibited higher levels of familiarity with AVs were more positive about increased fuel efficiency benefits with AVs.

Table 5-7 Consumers' Perceptions on Increased Fuel Efficiency with AVs – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Increased fuel efficiency*** | | **Increased fuel efficiency**** | | **Increased fuel efficiency*** | | **Increased fuel efficiency**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Age : 50 or above | -- | -- | -- | -- | -0.268 | -2.42 | -0.267 | -2.42 |
| Educational attainment : Bachelor's degree or higher | -- | -- | -- | -- | 0.167 | 1.85 | -- | -- |
| Annual Household Income : $100,000 or more | 0.487 | 3.07 | 0.504 | 3.16 | -- | -- | -- | -- |
| Current status at USF : Student | 0.375 | 2.09 | 0.37 | 2.06 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | N/A | 0.314 | 3.82 | N/A | N/A | 0.314 | 5.86 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.902 | -12.65 | -2.282 | -8.16 | -2.773 | -23.7 | -1.976 | -13 |
| Cut 2 | -1.1 | -6.95 | -0.482 | -2.13 | -1.489 | -17.11 | -0.692 | -5.24 |
| Cut 3 | -0.182 | -1.21 | 0.443 | 1.99 | -0.057 | -0.73 | 0.754 | 5.8 |
| Cut 4 | 1.558 | 9.69 | 2.216 | 9.33 | 1.898 | 20.19 | 2.739 | 18.51 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1129.05 | | -1129.05 | | -2560.225 | | -2560.225 | |
| Convergence | -1123.581 | | -1116.216 | | -2555.489 | | -2539.922 | |
| **Pseudo R-square** | 0.0048 | | 0.0114 | | 0.0018 | | 0.0079 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

### 5.3.7 Benefit – Lower Vehicle Emissions

Table 5-8 shows the ordinal logistic model estimates of consumers' perceptions on lower vehicle emissions with AVs. Estimation results show that women are less likely to perceive lower vehicle emissions with AVs. As the number of cars in the household increases, respondents were once again less likely to perceive the said benefit with AVs. It was seen that Hispanics were more optimistic about lower vehicle emissions while respondents who traveled in excess of 60 minutes a day were more skeptical about the possibility of lower vehicle emissions with AVs. It was also seen that familiarity, when added, had a positive association with lower vehicle emissions.

Table 5-8 Consumers' Perceptions on Lower Vehicle Emissions with AVs – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Lower vehicle emissions*** | | **Lower vehicle emissions**** | | **Lower vehicle emissions*** | | **Lower vehicle emissions**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.318 | -2.38 | -- | -- | -- | -- | -- | -- |
| Ethnicity : Hispanic | -- | -- | -- | -- | 0.428 | 1.91 | 0.446 | 1.99 |
| Total daily travel time : 60 minutes or more | -- | -- | -- | -- | -0.19 | -2.11 | -0.175 | -1.94 |
| Number of cars in the household | -0.123 | -2.06 | -0.116 | -1.95 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | N/A | 0.246 | 3.08 | N/A | N/A | 0.199 | 3.73 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.924 | -14.27 | -2.534 | -9.97 | -2.78 | -11.46 | -2.366 | -8.89 |
| Cut 2 | -1.314 | -8.16 | -0.924 | -4.19 | -1.508 | -6.49 | -1.095 | -4.26 |
| Cut 3 | -0.282 | -1.84 | 0.11 | 0.51 | 0.309 | 1.35 | 0.732 | 2.86 |
| Cut 4 | 1.31 | 8.06 | 1.71 | 7.48 | 1.971 | 8.32 | 2.406 | 9.09 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1198.1 | | -1198.1 | | -2547.552 | | -2547.552 | |
| Convergence | -1193.271 | | -1191.331 | | -2543.376 | | -2536.417 | |
| **Pseudo R-square** | 0.004 | | 0.0056 | | 0.0016 | | 0.0044 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable.

### 5.3.8 Findings from Consumer's Perceptions on the Benefits with AVs

The models on consumers' perceptions on the benefits with AVs have been evaluated and the results are as shown in Tables 5-2 through 5-8. Results showed the existence of gender-level differences in consumers' perceptions of the benefits with AVs. Women were more skeptical of the benefits with AVs than men. This could partly be because of the gender-level differences that exist in the familiarity with AVs (already shown through results in table 5-1). It is felt that the inclusion of women in AV related discussion and discourse may prove vital to change the skepticism on the perceived benefits with AVs.

Older individuals (respondent age ≥ 50 years) were found to be more skeptical about the benefits with AVs. It is likely that older individuals are less confident of these emerging vehicle technologies and prefer to confine themselves to more ubiquitous forms of transportation. Higher educational levels (at least a bachelor's degree) and higher annual household incomes (at least $100,000 per annum) may expose individuals to a better quality of discussion and discourse on AVs, and that could possibly play a role in shaping their positive opinions on the benefits with AVs. Additionally, a good section of the highly educated and wealthier individuals would constitute the early adopters of new technologies; AVs would most likely be no different from the other cases.

Although not seen in all cases, it was dubious to find the growing skepticism among the international residents towards the perception on the benefits with AVs. This is more so because internationals enjoyed greater levels of familiarity than their domestic counterparts, and, therefore, the results are against common intuition. It seems probable that greater familiarity with AVs is leading to more skepticism towards their potential benefits. International residents may also be portraying such tendencies due to the obvious cultural differences and their past experience with technology. Most of the international residents may belong to developing economies where new technologies are slower to penetrate, and often depend on their reception in more developed economies like the U.S.

Familiarity with AVs had a significant positive association with most perceived benefits, as explained by the high values of t-statistics. However, a note of caution needs to be pointed out as these variables are potential sources of endogeneity in the model (correlation between the error terms in the model and also the possible influence of familiarity on perceptions).

## 5.4 Ordinal Logistic Model Estimates of Consumers' Perceptions on the Concerns with AVs

Tables 5-9 through 5-15 show the ordinal logistic model estimates of consumers' perceptions on the concerns regarding AVs. Respondents' opinions were asked on the likelihood of 7 anticipated concerns regarding AVs (already introduced in table 4-3), and ordinal logistic models were estimated for each of these concerns. As in the benefits models discussed in the previous section, two model specifications were estimated – the first model estimated the influence of respondent demographics, their current travel characteristics, and crash history on consumers' perceptions on the concerns with AVs. Once this first model was estimated, the final list of variables from this model specification was used as explanatory variables in the second model specification which added "familiarity with AVs" as an additional variable.

### 5.4.1 Concern – Safety of the AV Occupant and Other Road Users

Table 5-9 shows the ordinal logistic model estimates of consumers' perceptions on the safety of the AV occupant and other road users. Estimation results show that women are more concerned about the safety of the AV occupant and other road users. The presence of at least 1 dependent member in the household made respondents more concerned about safety. International residents were more concerned about safety than their domestic counterparts. As in the previous estimation results, perhaps the increased familiarity and exposure is making them more skeptical of the AV technology.

Table 5-9 Consumers' Perceptions on Safety of AV Occupant and Other Road Users – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Safety of the AV Occupant and Other Road Users *** | | **Safety of the AV Occupant and Other Road Users ****| | **Safety of the AV Occupant and Other Road Users *** | | **Safety of the AV Occupant and Other Road Users**** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.347 | 2.56 | -- | -- | 0.308 | 3.52 | 0.229 | 2.54 |
| At least 1 dependent member in the household | 0.3 | 2.17 | 0.287 | 2.05 | -- | -- | -- | -- |
| Immigration status : International resident | 0.631 | 2.01 | 0.795 | 2.52 | N/A | | | |
| Crash history : Involved in a crash | 0.23 | 1.68 | 0.233 | 1.69 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | -0.568 | -6.8 | N/A | | -0.194 | -3.52 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.516 | -15.72 | -2.534 | -9.97 | -3.322 | -25.55 | -3.73 | -21.31 |
| Cut 2 | -0.874 | -7.71 | -0.924 | -4.19 | -1.912 | -22.49 | -2.31 | -16.15 |
| Cut 3 | -0.691 | -6.05 | 0.11 | 0.51 | 0.841 | -11.52 | -1.234 | -9.21 |
| Cut 4 | 0.653 | 5.87 | 1.71 | 7.48 | 0.927 | 12.53 | 0.539 | 4.08 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1096.399 | | -1096.399 | | -2511.327 | | -2511.327 | |
| Convergence | -1086.686 | | -1066.282 | | -2505.114 | | -2498.89 | |
| **Pseudo R-square** | 0.0089 | | 0.0275 | | 0.0025 | | 0.005 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

Respondents who have been involved in a crash before were more concerned about the safety of the AV occupants and other road users. Lastly, the addition of familiarity into the model specification brought about a negative association with consumers' perception on safety. It can be seen that increasing familiarity led to less concern on the safety of AV occupants and other road users. The addition of the familiarity variable further also leads to statistical insignificance of gender-level differences in the case of the university survey.

### 5.4.2 Concern – System/Equipment Failure

Table 5-10 Consumers' Perceptions on System/Equipment Failure – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **System/Equipment Failure *** | | **System/Equipment Failure **** | | **System/Equipment Failure *** | | **System/Equipment Failure **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.337 | 2.41 | -- | -- | 0.447 | 5.03 | 0.447 | 5.03 |
| Age of respondent : 65 years or older | N/A | | | | -0.2 | -2.25 | -0.2 | -2.25 |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -0.153 | -1.71 | -0.153 | -1.71 |
| Annual household income : $100,00 or more | -0.324 | -2.06 | -0.355 | -2.24 | -- | -- | -- | -- |
| Household size : 3 or more members | 0.319 | 2.1 | 0.364 | 2.39 | -- | -- | -- | -- |
| Immigration status : International resident | 0.556 | 1.75 | 0.735 | 2.33 | N/A | | | |
| Crash history : Involved in a crash | 0.242 | 1.67 | -- | -- | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | -0.568 | -6.8 | N/A | | -- | -- |
| **Thresholds** | | | | | | | | |
| Cut 1 | -2.516 | -15.72 | -2.534 | -9.97 | -3.786 | -22.81 | -3.786 | -22.81 |
| Cut 2 | -0.874 | -7.71 | -0.924 | -4.19 | -2.158 | -19.44 | -2.158 | -19.44 |
| Cut 3 | -0.691 | -6.05 | 0.11 | 0.51 | -0.962 | -9.72 | -0.962 | -9.72 |
| Cut 4 | 0.653 | 5.87 | 1.71 | 7.48 | 0.593 | 0.097 | 0.593 | 0.097 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1096.399 | | -1096.399 | | -2484.259 | | -2484.259 | |
| Convergence | -1086.686 | | -1066.282 | | -2464.82 | | -2464.82 | |
| **Pseudo R-square** | 0.0089 | | 0.0275 | | 0.0078 | | 0.0078 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

Table 5-10 shows the ordinal logistic model estimates of consumers' perceptions on system/equipment failure with AVs. Estimation results show that women are more concerned about system/equipment failure with AVs than men, ceteris paribus. Interestingly, older individuals (respondent age $\geq$ 65 years) seemed to be less concerned about system/equipment failure. This is certainly against common intuition and warrants further investigation. Higher educational levels (at least a bachelor's degree) and higher household income (at least $100,000 per annum) made respondents less concerned about the potential issues regarding AVs.

Results also show that larger households were more concerned about system/equipment failure on board an AV. This is perhaps due to the presence of dependent members in larger households. International residents are more concerned about system/equipment failure on board an AV, than their domestic counterparts (as shown earlier). Respondents who have been in a crash before were more concerned about possible case of system/equipment failure on board an AV.

The inclusion of familiarity into the model specification presents interesting results. In one case (the university model), there is a significant negative association between familiarity with AVs and consumer's perception of system/equipment failure on board an AV. In fact, the addition of familiarity variable into the university data leads to statistical insignificance of gender-level differences and diminishes the influence of crash history on consumers' perception of the concerns regarding AVs. This is possibly due to the relation between these variables – gender and crashes with familiarity (established in table 5-1). However, in case of the AAA model, it was observed that the familiarity variable turned out to be insignificant. Perhaps, the effects of familiarity are strongly captured by the other variables (possibly the highly significant gender and educational level variables) in that model.

### 5.4.3 Concern – Performance in (or Response to) Unexpected Traffic Situations, Poor Weather Conditions

Table 5-11 Consumers' Perceptions on Performance in Unexpected Traffic, Poor Weather – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Performance in (Or Response to) Unexpected Traffic Situations, Poor Weather Conditions *** | | **Performance in (Or Response to) Unexpected Traffic Situations, Poor Weather Conditions **** | | **Performance in (Or Response to) Unexpected Traffic Situations, Poor Weather Conditions *** | | **Performance in (Or Response to) Unexpected Traffic Situations, Poor Weather Conditions **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.234 | 1.69 | -- | -- | 0.285 | 3.25 | 0.285 | 3.25 |
| Ethnicity of respondent : Hispanic | -- | -- | -- | -- | -0.41 | -1.75 | -0.41 | -1.75 |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -0.153 | -1.71 | -0.153 | -1.71 |
| Crash history : Involved in a crash | 0.337 | 2.38 | 0.344 | 2.41 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | -0.412 | -4.91 | N/A | | -- | -- |
| **Thresholds** | | | | | | | | |
| Cut 1 | -3.262 | -16.13 | -4.059 | -15.06 | -3.648 | -24.65 | -3.648 | -24.65 |
| Cut 2 | -1.59 | -13.37 | -2.361 | -11.33 | -2. 126 | -23.54 | -2. 126 | -23.54 |
| Cut 3 | -1.355 | -11.93 | -2.123 | -10.37 | -0.901 | -12.24 | -0.901 | -12.24 |
| Cut 4 | -0.062 | -0.61 | -0.813 | -4.21 | 0.777 | 10.63 | 0.777 | 10.63 |
| **Log Likelihood** | | | | | | | | |
| Initial | -957.253 | | -957.253 | | -2466.727 | | -2466.727 | |
| Convergence | -952.899 | | -942.116 | | -2459.943 | | -2459.943 | |
| **Pseudo R-square** | 0.0045 | | 0.0158 | | 0.0028 | | 0.0028 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

Table 5-11 shows the ordinal logistic model estimates of consumers' perceptions on performance in unexpected traffic situations and poor weather conditions with AVs. Estimation results show that women are more concerned about the performance of the AV in unexpected traffic/poor weather conditions. Hispanics and respondents with high educational attainment (at least a bachelor's degree) were less concerned about this issue. Crash involvement was found to have a positive association with consumers' perception of the performance of AVs under unexpected situations.

Finally, a similar effect (as to the concern on system/equipment failure) was observed in the case of the familiarity model (when added into the model specification). Even though familiarity with AVs has a negative association with consumers' perceptions on the concerns regarding AVs; it was only found to be statistically significant in the university model.

### 5.4.4 Concern – Giving Up Control of the Steering Wheel to the Vehicle

Table 5-12 Consumers' Perceptions on Giving Up Control of the Steering Wheel – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Giving Up Control of the Steering Wheel to the Vehicle *** | | **Giving Up Control of the Steering Wheel to the Vehicle **** | | **Giving Up Control of the Steering Wheel to the Vehicle *** | | **Giving Up Control of the Steering Wheel to the Vehicle **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.87 | 6.39 | -- | -- | 0.457 | 5.3 | 0.341 | 3.8 |
| Annual Household Income : $100,000 or more | -0.377 | -2.5 | -0.396 | -2.6 | -0.41 | -1.75 | -0.41 | -1.75 |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -0.206 | -2.32 | -0.182 | -2.05 |
| Crash history : Involved in a crash | 0.337 | 2.38 | 0.344 | 2.41 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | -0.412 | -4.91 | N/A | | -0.266 | -4.84 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -3.262 | -16.13 | -4.059 | -15.06 | -2.758 | -25.78 | -3.3 | -21.03 |
| Cut 2 | -1.59 | -13.37 | -2.361 | -11.33 | -1.501 | -18.08 | -2. 028 | -14.7 |
| Cut 3 | -1.355 | -11.93 | -2.123 | -10.37 | -0.649 | -8.54 | -1.166 | -8.83 |
| Cut 4 | -0.062 | -0.61 | -0.813 | -4.21 | 0.68 | 8.83 | 0.168 | 1.29 |
| **Log Likelihood** | | | | | | | | |
| Initial | -957.253 | | -957.253 | | -2737.611 | | -2737.611 | |
| Convergence | -952.899 | | -942.116 | | -2720.586 | | -2708.83 | |
| **Pseudo R-square** | 0.0045 | | 0.0158 | | 0.0062 | | 0.011 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

Table 5-12 shows the ordinal logistic model estimates of consumers' perceptions on giving up control of the steering wheel with AVs. Estimation results show that women are more concerned about giving up control of the steering wheel than men, ceteris paribus. It is likely that these observations are borne out of their reduced levels of familiarity (already established in Table 5-1). Other results show that respondents belonging to high-income households (at least $100,000 per annum), with higher educational levels (at least a bachelor's degree) were less concerned about the said issue regarding AVs.

Prior crash involvement was found to have a positive association with consumers' perception on giving up control of the steering wheel to the vehicle. Respondents involved in a previous crash were more likely to be concerned about giving up the steering wheel to the vehicle. Lastly, increasing familiarity with AVs makes it less concerning for the respondent to give up control of the steering wheel to the AV.

### 5.4.5 Concern – Loss in Human Driving Skill over Time

Table 5-13 shows the ordinal logistic model estimates of consumers' perceptions on loss in human driving skill with AVs. Estimation results show that women are more concerned about the loss in human driving skill over time than men, ceteris paribus. Students and highly educated individuals (at least a bachelor's degree), who mostly drove alone for their commute trips, were less concerned at the prospect of losing human driving skill over time, with the introduction of AVs. As seen in the previous cases, familiarity, when added to the model specification had a negative association with consumers' perceptions on loss in human driving skill across both the population segments. But its effect was found to be statistically insignificant in the AAA model.

Table 5-13 Consumers' Perceptions on Loss in Human Driving Skill over Time – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Loss in Human Driving Skill over Time *** | | **Loss in Human Driving Skill over Time **** | | **Loss in Human Driving Skill over Time *** | | **Loss in Human Driving Skill over Time **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.614 | 4.64 | 0.488 | 3.48 | 0.208 | 2.41 | 0.208 | 2.41 |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -0.256 | -2.88 | -0.256 | -2.88 |
| Current status at USF : Student | -0.499 | -3.01 | -0.494 | -2.98 | N/A | | | |
| Most common commute mode : Drive Alone | -- | -- | -- | -- | -0.155 | -1.76 | -0.155 | -1.76 |
| Familiarity with AVs before taking this survey | N/A | | -0.222 | -2.67 | N/A | | -- | -- |
| **Thresholds** | | | | | | | | |
| Cut 1 | -3.262 | -16.13 | -2.056 | -10.79 | -2.939 | -23.14 | -2.939 | -23.14 |
| Cut 2 | -1.59 | -13.37 | -0.99 | -5.58 | -1.589 | -15.58 | -1.589 | -15.58 |
| Cut 3 | -1.355 | -11.93 | -0.811 | -4.6 | -0.787 | -8.23 | -0.787 | -8.23 |
| Cut 4 | -0.062 | -0.61 | 0.242 | 1.38 | 0.653 | 6.85 | 0.653 | 6.85 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1197.684 | | -1197.684 | | -2737.611 | | -2737.611 | |
| Convergence | -1182.788 | | -1179.218 | | -2655.291 | | -2655.291 | |
| **Pseudo R-square** | 0.0124 | | 0.0154 | | 0.0033 | | 0.0033 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

### 5.4.6 Concern – Privacy Risks from Data Tracking on Travel Locations and Speeds

Table 5-14 shows the ordinal logistic model estimates of consumers' perceptions on privacy risks from data tracking with AVs. Estimation results show that women and respondents with at least one dependent member in the household were more concerned about privacy risks. Higher annual household incomes (at least $100,000 per annum), and higher educational levels (at least a bachelor's degree) made individuals less concerned about privacy risks with AVs. It is also noticeable that unemployment has a negative association to this concern regarding AVs. It is probable that respondents who are unemployed travel much less than their employed counterparts, so they may not foresee themselves being concerned about privacy risks through data tracking. Increasing familiarity reduced the concerns on privacy risks with AVs when added to the model specification.

Table 5-14 Consumers' Perceptions on Privacy Risks from Data Tracking – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | **AAA Membership Survey (n=1791)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Privacy Risks from Data Tracking on Travel Locations and Speeds*** | | **Privacy Risks from Data Tracking on Travel Locations and Speeds **** | | **Privacy Risks from Data Tracking on Travel Locations and Speeds *** | | **Privacy Risks from Data Tracking on Travel Locations and Speeds **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -- | -- | -- | -- | 0.25 | 2.9 | 0.25 | 2.9 |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -0.311 | -3.51 | -0.311 | -3.51 |
| Annual household income : $100,000 or more | -0.275 | -1.86 | -0.28 | -1.89 | -- | -- | -- | -- |
| Current employment status : unemployed | -- | -- | -- | -- | -0.244 | -2.87 | -0.244 | -2.87 |
| At least 1 dependent member in the household | 0.238 | 1.76 | 0.241 | 1.78 | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | -0.222 | -2.67 | N/A | | -- | -- |
| **Thresholds** | | | | | | | | |
| Cut 1 | -1.564 | -10.06 | -1.91 | -8.56 | -2.918 | -24.73 | -2.918 | -24.73 |
| Cut 2 | -0.33 | -2.32 | -0.67 | -3.18 | -1.661 | -17.86 | -1.661 | -17.86 |
| Cut 3 | -0.121 | -0.86 | -0.462 | -2.2 | -0.741 | -8.62 | -0.741 | -8.62 |
| Cut 4 | 0.892 | 6.15 | 0.551 | 2.59 | 0.469 | 5.52 | 0.469 | 5.52 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1189.299 | | -1189.299 | | -2702.97 | | -2702.97 | |
| Convergence | -1185.869 | | -1183.454 | | -2687.846 | | -2687.846 | |
| **Pseudo R-square** | 0.0029 | | 0.0049 | | 0.0056 | | 0.0056 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

### 5.4.7 Concern – Difficulty in Determining Liability in the Event of a Crash

Table 5-15 Consumers' Perceptions Difficulty in Liability Determination – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | AAA Membership Survey (n=1791) | | | |
|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Difficulty in Determining Liability in the Event of a Crash *** | | **Difficulty in Determining Liability in the Event of a Crash **** | | **Difficulty in Determining Liability in the Event of a Crash *** | | **Difficulty in Determining Liability in the Event of a Crash **** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | 0.361 | 2.71 | -- | -- | 0.329 | 3.76 | 0.23 | 2.54 |
| Age of respondent: 30 years or older | -0.391 | -3.04 | -0.393 | -3.05 | N/A | | | |
| Age of respondent: 65 years or older | N/A | | | | 0.229 | 2.62 | 0.202 | 2.29 |
| Educational attainment: Bachelor's degree or above | -- | -- | -- | -- | -0.206 | -2.32 | -0.178 | -2 |
| Immigration status: International resident | 0.507 | 1.84 | 0.58 | 2.09 | N/A | | | |
| Familiarity with AVs before taking this survey | N/A | | -0.423 | -5.31 | N/A | | -0.228 | -4.15 |
| **Thresholds** | | | | | | | | |
| Cut 1 | -1.638 | -12.56 | -2.387 | -11.49 | -2.957 | -24.64 | -3.43 | -20.56 |
| Cut 2 | -0.422 | -3.75 | -1.141 | -6.01 | -1.573 | -17.67 | -2.034 | -14.22 |
| Cut 3 | -0.188 | -1.69 | -0.902 | -4.8 | -0.253 | -3.19 | -0.706 | -5.23 |
| Cut 4 | 0.98 | 8.35 | 0.28 | 1.49 | 0.937 | 11.36 | 0.487 | 3.58 |
| **Log Likelihood** | | | | | | | | |
| Initial | -1194.414 | | -1194.414 | | -2685.546 | | -2685.546 | |
| Convergence | -1184.468 | | -1173.906 | | -2674.002 | | -2665.371 | |
| **Pseudo R-square** | 0.0083 | | 0.0172 | | 0.0043 | | 0.0075 | |
| **N** | 800 | | 800 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable

Table 5-15 shows the ordinal logistic model estimates of consumers' perceptions on the difficulty in liability determination with AVs. Estimation results show that women are more concerned about the difficulty in determining liability. While older individuals (respondents ≥ 65 years) were more concerned about liability determination, respondents aged 30 and above from the university sample were less concerned about the said issue. This is likely because of the distribution of age ranges within the two samples – the university sample contained only 2% of respondents who are 65 years or more (therefore it was not used for estimation), whereas 40% of the AAA members were found to belong to this category.

In line with the results from previous sections, international residents were more likely to be concerned with the difficulty in liability determination, with the introduction of AVs. Familiarity, when added to the model specification, was shown to have a significant negative association with the concerns regarding AVs, leading to a statistical insignificance of gender level differences in consumers' perception on the concerns regarding AVs.

### 5.4.8 Findings from Consumer's Perceptions on the Concerns regarding AVs

Prior to the inclusion of the familiarity variable, the influence of demographic variables such as gender, annual household income, and respondent educational level were observed on consumers' perceptions on the various concerns regarding AVs. Some of these demographic variables (such as gender) became statistically insignificant while the extent of influence of other demographics decreased upon the addition of the familiarity variable. This indicates the high influence of familiarity with AVs on consumers' perceptions on the concerns regarding AVs.

For instance, females are more likely to be concerned than males – possibly due to factors such as their lower levels of familiarity (explained in earlier sections) towards AV technology or their general propensity to be more risk conservative in comparison to males. High-income households (annual income ≥ \$100,000) and higher educational levels (at least a bachelor's degree) had a negative association with the potential concerns regarding AVs. While it is not straightforward as to what may be the possible reasons behind this behavior, the ordinal logit model estimates of the familiarity with AVs as a function of the demographics (see results in table 5-1) provide reasons to believe that this is due to the positive association of the said variables to the familiarity variable. In other words, it was established in the familiarity model that higher household incomes (annual income of at least $100,000), and higher education levels (at least a bachelor's degree) were found to have a positive association with familiarity.

Larger households (household size ≥ 3) showed a positive association with the potential concerns regarding AVs. This could be possibly due to the presence of children under the legal driving age, or other dependent members in these households. It was also determined that the younger respondents were less concerned while their older counterparts showed some concern regarding potential issues with AVs. Perhaps, the younger respondents are less concerned as a large proportion of them constitute the millennials who are not used to, and inclined to driving in comparison to their earlier generations (McDonald, 2015).

Despite enjoying more familiarity with AVs than their domestic counterparts, international residents seem to be more concerned about the different aspects regarding AVs. A similar trend was observed under the benefits where internationals were found to be more skeptical of the benefits with AVs. International residents may also be portraying such tendencies due to the obvious cultural differences and their past experience with technology. Most of the international residents may belong to developing economies where new technologies are slower to penetrate, and often depend on their reception in more developed economies like the U.S.

As expected, crash involvement made respondents more concerned about the different aspects regarding AVs. The significant negative association of the familiarity variable with consumers' perceptions on the concerns regarding AVs could be likely due to the possible endogeneity between the dependent and independent variables in the model. It is possible that familiarity with AVs influences a level of concern regarding potential issues with AVs.

### 5.5 Ordinal Logistic Model Estimates of Consumers' Intended Adoption of AV Technology

Tables 5-16 and 5-17 show the ordinal logistic model results for intended adoption of AV technology. Respondents were asked on their likelihood of using AVs at two stages along the survey – (1) before being queried on the benefits and concerns (the before model), and (2) after being queried on the benefits and concerns (the after model). For each adoption scenario, three different model specifications were estimated.

The first model estimated the influence of demographics, current travel characteristics, and crash history on intended adoption of AVs. The second model added "familiarity with AVs" as an additional variable into the variables obtained from the first model. All the statistically significant variables from the second model were used as explanatory variables for the third model and to this specification, each of the benefit and concern variables was added as additional variables. This kind of a model building approach enables to investigate the influence of each category of variables and also to disentangle the influence of one category from the other. Model estimation results are discussed below.

#### 5.5.1 Consumers' Intended Adoption of AV Technology – The Before Model

Table 5-16 shows the ordinal logistic model estimates of consumers' intended adoption of AV technology before they were queried on the benefits and concerns regarding AVs. Estimation results from the before model indicate the statistical significance of gender. As seen before in the case of familiarity with AVs and the perceptions on the benefits and concerns (tables 5-1 through 5-15), women are less likely to use AVs than men. Even after the inclusion of the familiarity variable, there is statistical significance on gender-level differences in AV adoption in the university model. But gender becomes statistically insignificant in the AAA model, as soon as familiarity is included into the model specification. Gender-level differences finally become statistically insignificant in the university model when the perception variables are added.

It can be seen in table 5-16 that respondents with higher educational levels (at least a bachelor's degree), belonging to high-income households (at least $100,000 per annum) had a positive association towards the likelihood of adopting AVs. Even though both these variables are statistically significant when familiarity is added into the model specification, they become statistically insignificant upon the inclusion of the perception variables during the 3rd stage.

Unemployed individuals were less likely to use AVs when they become available. This is one of the most straightforward results, as unemployment could bring into the forefront the debate on the affordability of AVs. Not only that, a section of the unemployed population may also be the older citizens who travel less and less as they age. Perhaps, they also don't see the benefits of AVs offsetting its cost or utility at the moment. Unemployment continues to be statistically significant even after the inclusion of the familiarity and perception variables, albeit with reducing influence. As household vehicle ownership increases, the likelihood of adopting AVs is seen to decrease. Lastly, familiarity with AVs has a positive influence on AV adoption. As familiarity with AVs increases, individuals are more likely to adopt them when they become available.

The next step is to understand the influence of the perception variables on AV adoption. In general, consumers' perceptions on the benefits have a positive influence on AV adoption, while their perceptions on the concerns have a negative influence on AV adoption. Results show that that (1) fewer traffic crashes and increased roadway safety, (2) more productive use of travel time, (3) less stressful driving experience, and (4) less traffic congestion are seen to be the benefits that have a positive influence on AV adoption. It was also shown that (1) giving up control of the steering wheel, (2) loss in human driving skill and (3) difficulty in liability determination were some of the key concerns affecting AV adoption. This doesn't mean that the other factors don't influence AV adoption, but it is merely that their effects are most likely captured by other variables in the model.

### 5.5.2 Consumers' Intended Adoption of AV Technology – The After Model

Table 5-17 shows the ordinal logistic model estimates of consumers' intended adoption of AV technology after they were queried on the benefits and concerns. Estimation results without the inclusion of familiarity and perception variables indicate the influence of gender. As seen before in the case of the perceptions on the benefits and concerns, females are less likely to use AVs than males. Even after the inclusion of the familiarity and perception variables, there is statistical significance on gender-level differences in AV adoption for the university sample. However, gender-level differences become statistically insignificant in the AAA model, as soon as familiarity is included into the model specification.

It can be seen that respondents with higher levels of education (at least a bachelor's degree), belonging to higher-income households (at least $100,000 per annum) have a positive association towards the likelihood of adopting AVs when they become available. Even though both these variables are statistically significant when familiarity is added into the model specification, they become statistically insignificant when the perception variables are added during the 3rd stage.

Individuals who mostly commute to work by drive alone mode are more likely to use AVs when they become available. It is likely that individuals who drive alone to work view AVs as a potential source for reducing the stress involved with driving. As household vehicle ownership increases, the likelihood of adopting AVs is seen to decrease. It was found that individuals who were involved in a crash were more likely to be skeptical and do not find new and emerging technologies to be trustworthy, decreasing their likelihood of adopting them. Familiarity with AVs has a positive influence on AV adoption. As familiarity increases, individuals are more likely to adopt AVs when they become available.

The next step was to understand the influence of the perception variables on AV adoption. As discussed previously, consumers' perceptions on the benefits generally have a positive influence on AV adoption while their perceptions on the concerns have a negative influence on adoption. It was found that (1) fewer traffic crashes and increased roadway safety, (2) less stressful driving experience, (3) more productive use of travel time, (4) less traffic congestion, and (5) lower car insurance rates were the benefits that have a positive influence on AV adoption, while (1) giving up control of the steering wheel, (2) loss in human driving skill, (3) system/equipment failure, and (4) difficulty in liability determination were the concerns that have negative influences on AV adoption.

Table 5-16 Consumers' Intended Adoption of AV Technology (The Before Model) – Ordinal Logistic Model Estimates

| | **USF Population Survey (n=800)** | | | | | | **AAA Membership Survey (n=1791)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Consumers' Intended Adoption of AV Technology – The Before Model*** | | **Consumers' Intended Adoption of AV Technology – The Before Model**** | | **Consumers' Intended Adoption of AV Technology – The Before Model***** | | **Consumers' Intended Adoption of AV Technology – The Before Model*** | | **Consumers' Intended Adoption of AV Technology – The Before Model**** | | **Consumers' Intended Adoption of AV Technology – The Before Model***** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.749 | -5.55 | -0.394 | -2.76 | -- | -- | -0.21 | -2.45 | -- | -- | -- | -- |
| Educational attainment : Bachelor's degree or above | -- | -- | -- | -- | -- | -- | 0.247 | 2.75 | 0.217 | 2.42 | -- | -- |
| Annual household income : $100,000 or more | 0.257 | 1.72 | 0.272 | 1.81 | -- | -- | 0.274 | 3.08 | 0.239 | 2.67 | -- | -- |
| Current employment status : unemployed | -- | -- | -- | -- | -- | -- | -0.352 | -4.07 | -0.322 | -3.74 | -0.248 | -2.73 |
| Number of vehicles in the household | -- | -- | -- | -- | -- | -- | -0.106 | -2.44 | -0.125 | -2.85 | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | 0.674 | 7.76 | 0.212 | 2.33 | N/A | | 0.387 | 7.21 | 0.127 | 2.2 |
| Fewer traffic crashes and increased roadway safety | N/A | | N/A | | 0.479 | 5.79 | N/A | | N/A | | 0.487 | 7.57 |
| Less congestion | N/A | | N/A | | 0.165 | 2.47 | N/A | | N/A | | 0.186 | 3.51 |
| Less stressful driving experience | N/A | | N/A | | 0.342 | 4.61 | N/A | | N/A | | 0.576 | 8.77 |
| More productive use of travel time | N/A | | N/A | | 0.359 | 4.96 | N/A | | N/A | | 0.35 | 5.87 |
| Give up control of the steering wheel | N/A | | N/A | | -0.37 | -6.13 | N/A | | N/A | | -0.309 | -6.81 |
| Loss in human driving skill over time | N/A | | N/A | | -0.211 | -4.37 | N/A | | N/A | | -0.25 | -5.44 |
| Difficulty in liability determination during a crash | N/A | | N/A | | -- | -- | N/A | | N/A | | -0.086 | -1.92 |

Table 5.16 (Continued)

| | USF Population Survey (n=800) | | | | | | AAA Membership Survey (n=1791) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Consumers' Intended Adoption of AV Technology – The Before Model*** | | **Consumers' Intended Adoption of AV Technology – The Before Model**** | | **Consumers' Intended Adoption of AV Technology – The Before Model***** | | **Consumers' Intended Adoption of AV Technology – The Before Model*** | | **Consumers' Intended Adoption of AV Technology – The Before Model**** | | **Consumers' Intended Adoption of AV Technology – The Before Model***** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| **Thresholds** | | | | | | | | | | | | |
| Cut 1 | -1.64 | -10.35 | -0.513 | -2.41 | 0.396 | 0.79 | -1.63 | -8.72 | -0.943 | -4.43 | 1.382 | 4.0 |
| Cut 2 | -0.773 | -0.79 | 0.372 | 1.79 | 1.604 | 3.16 | -0.824 | -4.48 | -0.133 | -0.63 | 2.649 | 7.62 |
| Cut 3 | 0.369 | 2.56 | 1.576 | 7.39 | 3.399 | 6.49 | 0.193 | 1.05 | 0.904 | 4.27 | 4.362 | 12.08 |
| Cut 4 | 1.591 | 10.18 | 2.891 | 12.41 | 5.354 | 9.9 | 1.491 | 7.89 | 2.236 | 10.16 | 6.383 | 16.88 |
| **Log Likelihood** | | | | | | | | | | | | |
| Initial | -1267.762 | | -1267.762 | | -1267.762 | | -2837.236 | | -2837.236 | | 2837.236 | |
| Convergence | -1250.203 | | -1219.315 | | -996.367 | | -2813.331 | | -2790.081 | | -2182.817 | |
| **Pseudo R-square** | 0.0139 | | 0.0382 | | 0.2141 | | 0.0084 | | 0.0166 | | 0.231 | |
| **N** | 800 | | 800 | | 800 | | 1791 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable; *** - models with the inclusion of perception variables

Table 5-17 Consumers' Intended Adoption of AV Technology (The After Model) – Ordinal Logistic Model Estimates

| | USF Population Survey (n=800) | | | | | | AAA Membership Survey (n=1791) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Gender : Female | -0.83 | -6.06 | -0.504 | -3.5 | -0.251 | -1.71 | -0.247 | -2.83 | -- | -- | -- | -- |
| Age of the respondent : 65 years or above | N/A | | | | | | -0.333 | -3.48 | -0.353 | -4.02 | -0.359 | -3.77 |
| Educational level : Bachelor's degree or above | -- | -- | -- | -- | -- | -- | 0.271 | 3.03 | 0.245 | 2.74 | -- | -- |

Table 5.17 (Continued)

| | USF Population Survey (n=800) | | | | | | AAA Membership Survey (n=1791) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| Annual household income : $100,000 or more | -- | -- | -- | -- | -- | -- | 0.267 | 3.0 | 0.242 | 2.71 | -- | -- |
| Most common commute mode : Drive alone | -- | -- | -- | -- | -- | -- | 0.171 | 1.81 | -- | -- | -- | -- |
| Number of vehicles in the household | -- | -- | -- | -- | -- | -- | -0.124 | -2.81 | -0.133 | -3.03 | -0.072 | -1.66 |
| Crash history : Involved in a crash | -0.219 | -1.68 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Familiarity with AVs before taking this survey | N/A | | 0.613 | 7.02 | -- | -- | N/A | | 0.366 | 6.86 | -- | -- |
| Fewer traffic crashes and increased roadway safety | N/A | | N/A | | 0.583 | 7.15 | N/A | | N/A | | 0.541 | 8.49 |
| Less congestion | N/A | | N/A | | -- | -- | N/A | | N/A | | 0.173 | 3.21 |
| Less stressful driving experience | N/A | | N/A | | 0.414 | 5.61 | N/A | | N/A | | 0.556 | 8.55 |
| More productive use of travel time | N/A | | N/A | | 0.353 | 4.8 | N/A | | N/A | | 0.414 | 6.92 |
| Lower car insurance rates | N/A | | N/A | | 0.174 | 2.92 | N/A | | N/A | | -- | -- |
| System/Equipment failure | N/A | | N/A | | -- | -- | N/A | | N/A | | -0.143 | -2.71 |
| Give up control of the steering wheel | N/A | | N/A | | -0.531 | -9.04 | N/A | | N/A | | -0.325 | -6.74 |
| Loss in human driving skill over time | N/A | | N/A | | -0.187 | -3.81 | N/A | | N/A | | -0.306 | -6.52 |
| Difficulty in liability determination during a crash | N/A | | N/A | | -- | -- | N/A | | N/A | | -0.105 | -2.23 |

Table 5.17 (Continued)

| | USF Population Survey (n=800) | | | | | | AAA Membership Survey (n=1791) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Response Variable** | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | | **Consumers' Intended Adoption of AV Technology – The After Model*** | | **Consumers' Intended Adoption of AV Technology – The After Model**** | | **Consumers' Intended Adoption of AV Technology – The After Model***** | |
| | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** | **Parameter** | **t-stat** |
| **Thresholds** | | | | | | | | | | | | |
| Cut 1 | -1.488 | -12.93 | -0.359 | -2 | 0.572 | 1.29 | -1.55 | -7.88 | -1.03 | -4.88 | 0.139 | 0.37 |
| Cut 2 | -0.491 | -4.98 | 0.657 | 3.8 | 2.088 | 4.58 | -0.674 | -3.49 | -0.157 | -0.75 | 1.611 | 4.25 |
| Cut 3 | 0.358 | 3.66 | 1.542 | 8.58 | 3.492 | 7.44 | 0.105 | 0.54 | 0.633 | 3.03 | 2.976 | 7.73 |
| Cut 4 | 1.927 | 15.61 | 3.195 | 15.2 | 6.083 | 12.3 | 1.643 | 8.24 | 2.203 | 10.11 | 5.468 | 13.67 |
| **Log Likelihood** | | | | | | | | | | | | |
| Initial | -1263.366 | | -1263.366 | | -1263.366 | | -2828.341 | | -2828.341 | | -2828.341 | |
| Convergence | -1243.122 | | -1219.461 | | -956.778 | | -2801.243 | | -2783.263 | | -2105.99 | |
| **Pseudo R-square** | 0.016 | | 0.0348 | | 0.2427 | | 0.0096 | | 0.0159 | | 0.2554 | |
| **N** | 800 | | 800 | | 800 | | 1791 | | 1791 | | 1791 | |

**Note:** * - models without the inclusion of the familiarity variable; ** - models with the inclusion of the familiarity variable; *** - models with the inclusion of perception variables

# CHAPTER 6: CONCLUSIONS AND FUTURE RESEARCH

## 6.1 Conclusions

This study offered a detailed examination on consumers' perceptions and intended adoption of autonomous vehicle (AV) technology based on the results from multi-population surveys – (1) a university level survey, and (2) a survey of members of AAA South. A university population and the membership database of a national level automobile organization were selected in order to obtain more representative opinions across all major demographics. It was important to elicit the opinions from all major age and income-based demographics because of the role that each stratum of society is set to play on the market penetration of emerging technologies like AVs.

Descriptive results showed that despite moderate levels of familiarity with AVs, 45% of respondents from the university sample and nearly 40% from the AAA sample are likely to use them when they become available. Nevertheless, a significant percentage of respondents have some concerns regarding AVs. Efforts need to be taken to increase the consumers' familiarity and improve their perceptions about these new technologies. Most previous studies have provided descriptive, univariate analysis of the demographic, attitudinal differences in public opinion/perceptions and intended adoption of AVs.

This study conducted a multivariate analysis of the influence of different factors to be able to disentangle the influence of one factor from the other. It was found that the influence of demographics significantly reduced (sometimes leading to statistical insignificance) once familiarity was included in the model specification. When applied to AV adoption, it was seen that familiarity with AVs and consumers' perceptions of the benefits and concerns regarding AVs were more influential in their future adoption. This suggests that although demographic differences exist in intended adoption rates of AVs, they are often due to demographic differences in the perceptions of the benefits and concerns regarding AVs; demographic influences reduced significantly after accounting for perceptions.

Lastly, a major element to encounter with these kinds of studies on eliciting opinions on emerging technology is the role of uncertainty. The small idea of asking the questions on intended adoption at two different stages across the survey showed the uncertainty in the minds of the respondent. It was found that even this minor alteration in the survey questionnaire process led to changes in information elicited from the respondent. Maybe it is a consequence of the respondent having to imagine these technologies in most cases but is a clear reflection on the need to tread with caution when dealing with possible forecasting on the factors influencing AV adoption based on these or any other contemporary studies on the subject. Maybe, a few months or a few years down the line, there may be some other positive or negative influences (completely unaccounted for, during the current, and past studies) which might play a superior role in consumers' perceptions and their intended adoption of autonomous vehicles. Therefore, it is very essential to account for the unexpected in these kinds of studies.

## 6.2 Future Research

The work conducted in this study could be extended in a few dimensions of interest. This section aims to provide possible directions that could be taken to extend this research and bring about more detailed, richer analysis.

### 6.2.1 Explore the Impacts of AV Adoption on Future Travel Behavior & Transportation Systems

Survey data were collected for understanding the influence of AVs on housing choices, future vehicular size and expected changes in travel patterns (maximum willing one-way distance for various trip purposes, the maximum amount of one-way travel time for various trip purposes, changes in total daily travel time etc.). It will be worthwhile to expand this research in order to investigate to see the impact of new and emerging vehicle technologies on future travel behavior and transportation systems.

### 6.2.2 Explore the Influence of Shared AV Modes on Future Mobility Systems

Survey data were collected on various aspects of shared AV modes including consumer willingness to use them, the frequency of use, and the willingness to accommodate additional travel distance/travel time in order to use shared modes. This section was typically used as the last section of the survey and often suffered from respondent attrition, leading to fewer sample sizes. It will be worth trying to uproot that section, and pursue it as a separate data collection effort to come up with more insightful data and results.

### 6.2.3 Explore Methodological Improvements

It has come to attention that there are a few shortcomings for the use of ordinal logistic regression to understand the influence of demographics, current travel characteristics, crash history, and consumers' perceptions (on the benefits and concerns regarding AVs) towards their intended adoption of AV technology. For instance, when models are estimated with intended adoption as the dependent variable, and some of the perception variables (benefits and/or concerns) as the independent variables, these are possible avenues for endogeneity. There are also cases with the presence of correlation between the error terms, which might not be effectively captured or mitigated by the use of ordinal logistic regression. To account for these anomalies, methodological improvements could be sought in future research. Modeling as random parameter models or other approaches like estimation as a structural equation model system that account for endogenous variables could provide some interventions.

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