Smart City Research Cluster

Final Research Report, Part 1

FedEx Institute of Technology

1. Research Executive Summary

Connected Autonomous Vehicles (CAVs) have the potential to revolutionize transportation. Recent technological breakthroughs in CAV technology have led manufacturers to promise a level of automation by 2020. Among some of the expected benefits of CAVs are a reduction in collisions, increased fuel efficiency, and decreased congestion on the roadways. CAVs will also make transportation easier for disabled, elderly, and children who are unable to operate a traditional vehicle on their own. However, before CAVs are ready to integrate into the vehicle fleet, there are a number of important questions which must be answered. Questions about liability, safety, security, legality, registration, and privacy must be addressed before CAV technology can be fully adopted by the public. In order for policymakers to adequately prepare for CAVs, a reasonably accurate estimation of the market penetration rate of CAVs is needed. Predicting the number of CAVs that will need to be accommodated will allow policymakers to develop appropriate legislation.

The objective of this research is to understand, model, and predict CAV market penetration over time. We conducted a survey of University of Memphis employees to understand the perception of users towards CAVs. The model is based on Diffusion of Innovations (DoI) theory, which states that an individual is influenced by both personal desire and social pressures to adopt innovations. A synthetic population and network of unique agents are generated from survey data, and these agents choose to adopt or reject CAVs based on various factors such as personality, socioeconomic status, perceived barriers to adoption, and connections to other adopters.

In order to model adoption of CAVs among the university employees, we collected two sets of data: seed and marginal datasets. We conducted a survey to (i) understand how individuals rely on their social network when purchasing a CAV, (ii) how influential the work social ties are, compared to non-work social tis, and (iii) establish a seed for the population synthesis model. The survey comprised of four sections. The first and second sections pertain to personal- and household-level socioeconomic questions. The third section tries to understand various aspects of social network at work, and how individuals rely on their work social ties when purchasing CAVs. The fourth section intended to quantify perceptions toward adopting CAVs.

Key findings. We obtained the following results:

The starting page of the survey on a cellphone device is illustrated in Figure 1, and the survey is attached. Among 4,504 employees of the University of Memphis, 2,465 employees were contacted through email and asked to complete the survey. We received 334 complete responses (13.5%) in seven days which is a promising rate of response in the field of transportation. The majority of respondents were female (63.6%). The data suggest that individuals consider relatively equal weights for the information they receive from their work and non-work social networks. On a seven-point scale (1 = *very unreliable* to 7 = *very reliable*), individuals consider an average reliability score of 5.58 (σ=1.08) for the information they receive from their peers while the reliability scores for media and car dealer were 3.79 (σ=1.36) and 3.63 (σ=1.44), respectively. This validates the argument that people heavily rely on their peers when adopting a radical innovation.

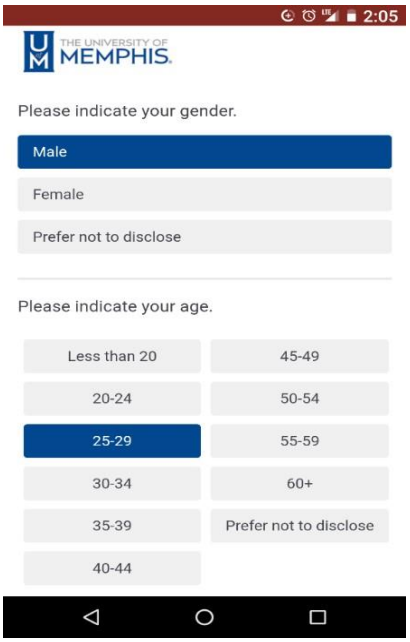
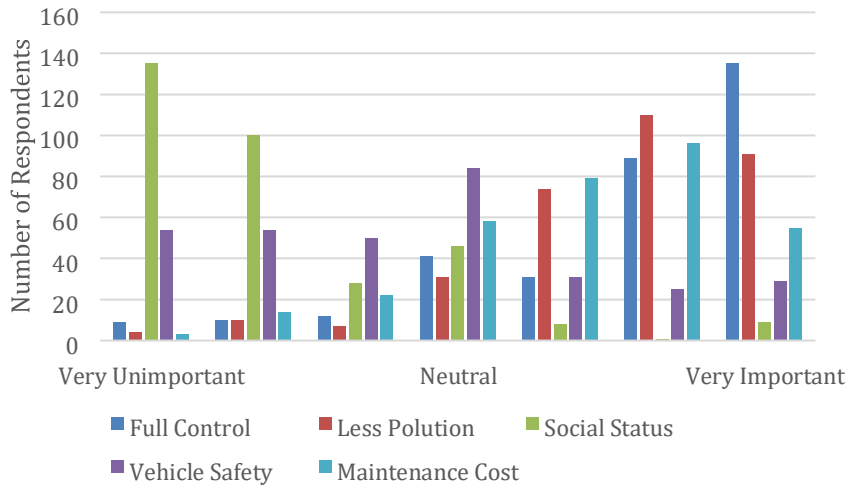
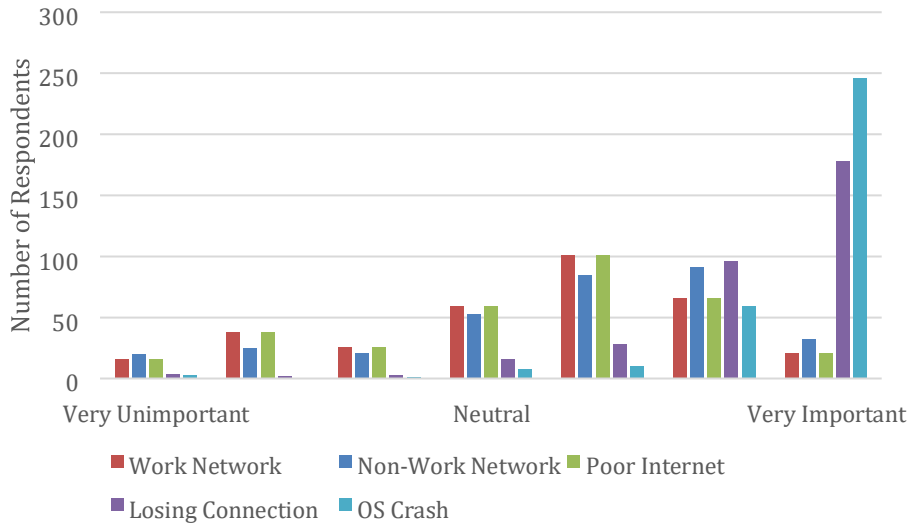
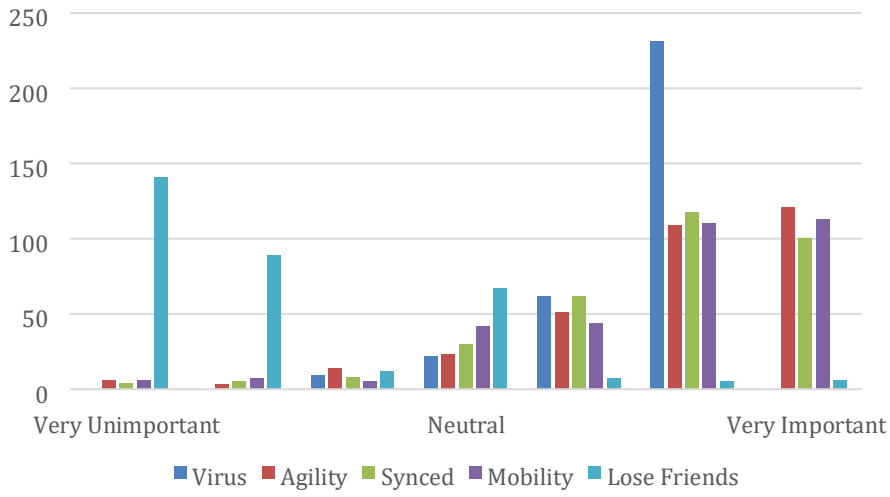


Figure 1: Starting page of the survey on a cellphone device

Respondents were also asked to consider the importance of various characteristics of CAVs, detailed in Figures 2-4 below. The potential social effects of adopting a CAV seem to be judged as unimportant, whereas safety issues such as the possibility of contracting a virus, losing connections, and OS crashes are very important. Economic and environmental effects of CAVs are also seen as important.







Figures 2-4 Perceived importance of CAV attributes

The reported influence of a reduction in pollution and a change in social status matches with other data collected in the survey. Respondents were asked to rank the importance of various attributes of a vehicle such as the price and quality of a vehicle, environmental impact, and the effect the vehicle may have on their image. Unsurprisingly, the price and quality of the vehicle are the most important characteristics. Personal image is generally seen as unimportant, whereas the environmental impact of the vehicle is seen as somewhat important to potential buyers. Figure 5 shows this data below.

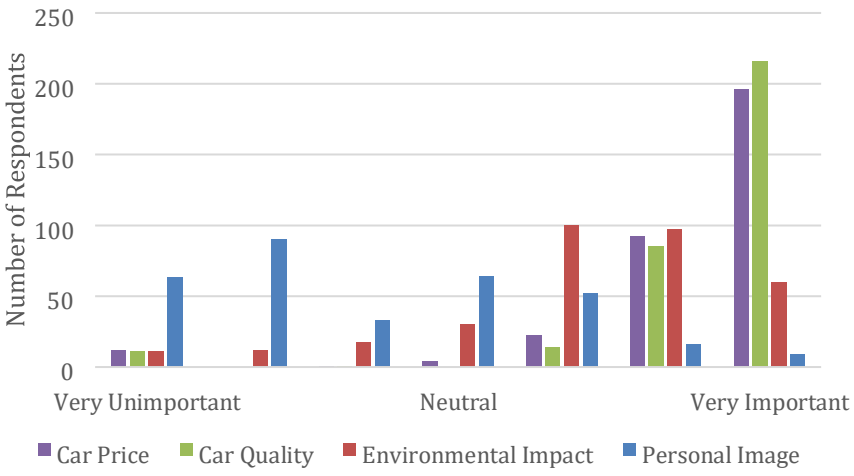


Figure 5 Perceived importance of vehicle attributes

Information on vehicle purchasing patterns was also gathered. The majority of respondents reported purchasing a vehicle every 5 or 10 years. When asked their intent to change vehicles over the next three years, the majority of respondents reported no changes, with buying a new vehicle and selling the current vehicle as a distant second option. This data is presented in Figures 6 and 7 below.

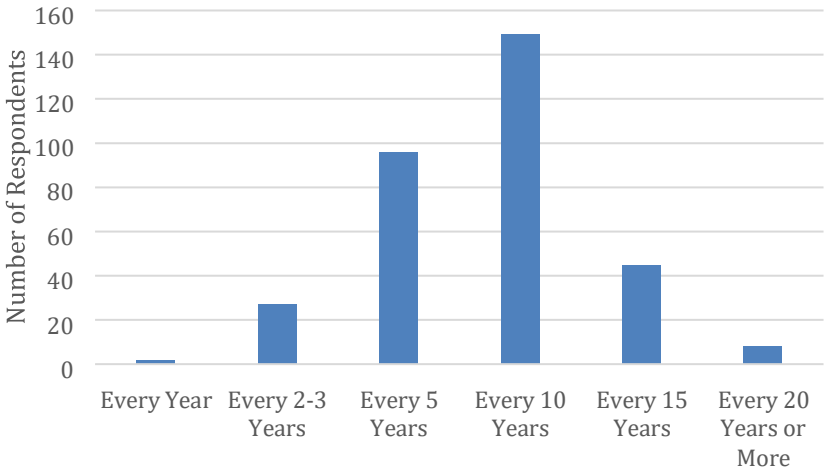


Figure 6 Frequency of vehicle purchases

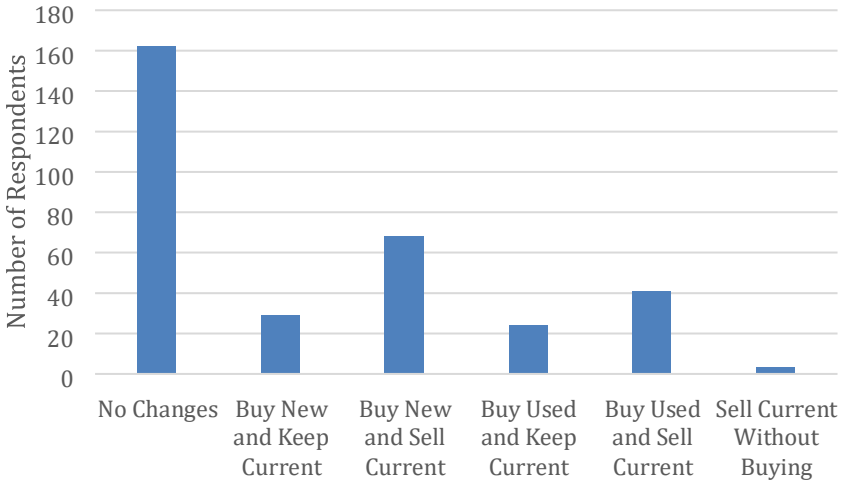


Figure 7 Intent to change vehicles in 3 years

The amount of money respondents are willing to pay for vehicles, CAV technology, and CAV maintenance was also gathered. Most individuals are unwilling to spend more than around $40,000 on a new vehicle, and few are willing to spend more than a few thousand dollars more on CAV technology. Many respondents reported that spending additional money maintaining a CAV system was not acceptable, although the majority of the responses indicate that a few hundred dollars would be a reasonable expectation. Figures 8-10 demonstrate this data.

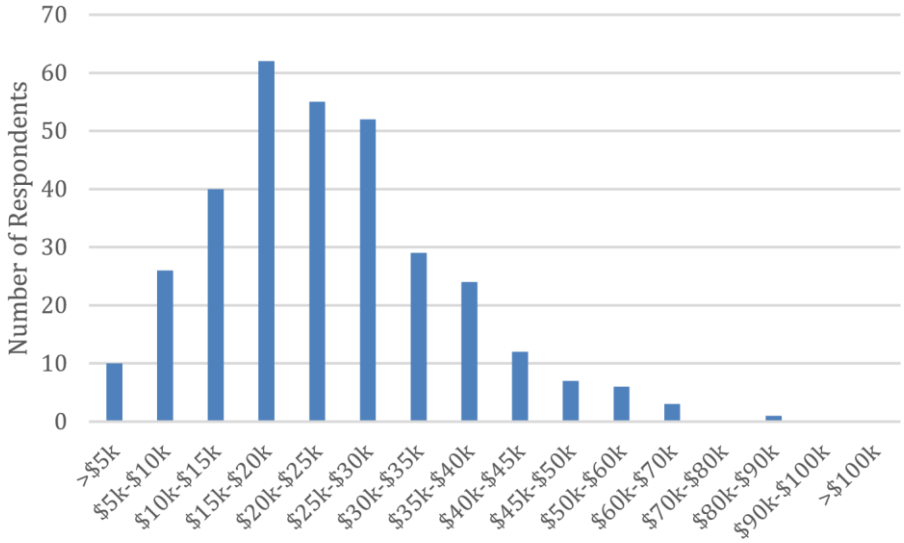


Figure 8 Willingness to pay for a vehicle

(1)

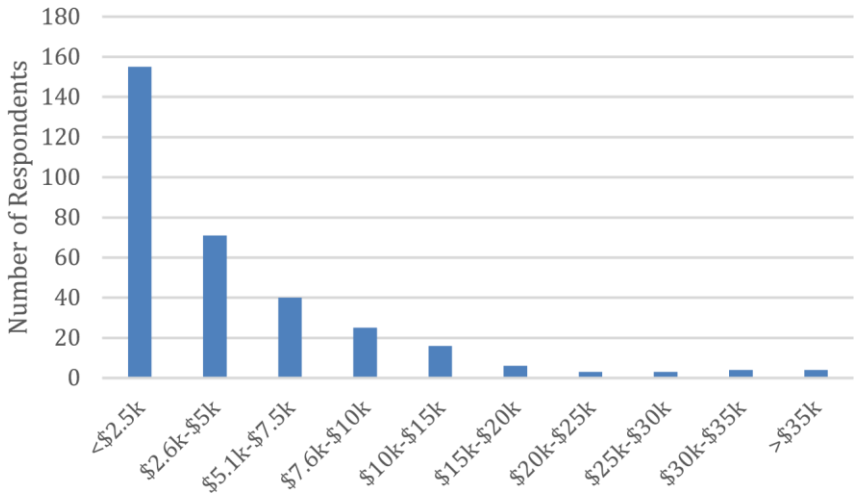


Figure 9 Willingness to pay for CAV technology

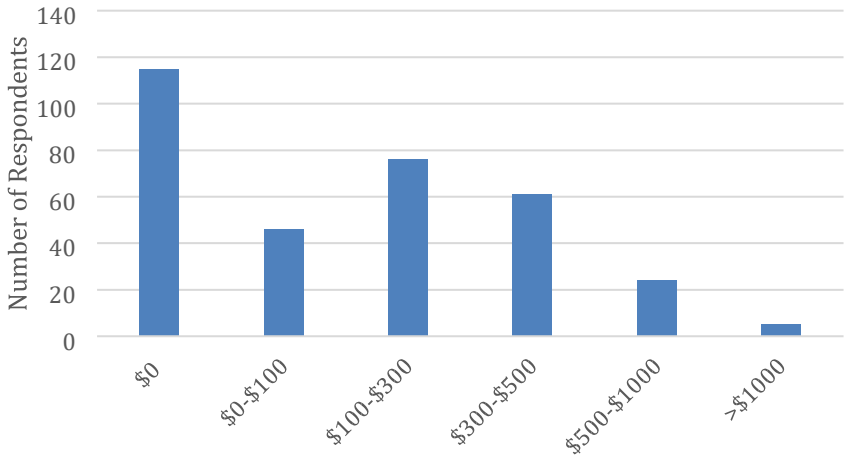


Figure 10 Willingness to pay for additional maintenance for CAVs

2. Describe any next steps in your research agenda that have emerged from this project. (E.g., Revisions to methodology, new research questions, etc.) (250 words)

We plan to extend the survey conducted at UoM to city of Memphis and conduct a population synthesis for the city of Memphis. The population synthesis can be further be used in the agent based model to to determine the diffusion of innovations CAVs in the city of Memphis.

3. List external funding that has been/could be leveraged by this project. Include grants/contracts awarded as well as pending funding opportunities.

This project has been leveraged by the following projects:

Modeling Adoption of Autonomous Vehicle Technologies by Freight Organizations, Freight Mobility Research Institute (FMRI), United States Department of Transportation, $179,523, Mishra, S. ($75,000), Golias, M., and Kaisar, E.

Smart City Innovation Hub: Phase I-Development of a Readiness Index, Research Investment Fund, University of Memphis, Division of Research and Sponsored Research Programs, $100,000, , Santo, C., Mishra, S., Golias, M., Jacobs, E, and Wang, L.

4. List any publications / conference presentations that have stemmed from this project.

Talebian, A., Simpson, J., and Mishra, S. (2017). Modeling Adoption of Automated and Connected Vehicles in a Smart City Using the Theory of Diffusion of Innovations. Presented at the AUVSI Symposium, San Francisco.
Talebian, A., and Mishra, S. (2018). Predicting the demand for connected autonomous vehicles: a new approach based on the theory of diffusion of innovation, Transportation Research Part-C. (Under review)

5. Summarize any student involvement in the project (e.g., classes that participated in the project, graduate assistants, PhD students, etc.) and list the number of students involved. Note whether the project has been connected to any doctoral dissertations.

(1) This project financially supported a graduate assistant for 6 months.

(2) The following students were involved:
Jesse Simpson, M.S. student in Civil Engineering
Huan Ngo, B.S. student in Civil Engineering

(3) The project was also supervised by post-doctoral fellow Dr. Ahmadreza Talebian.