Bryant University

HONORS THESIS

The Implications of Self-Driving Cars on Insurance

BY Amanda LoBello

ADVISORS • Jim Bishop and Phyllis Schumacher

Submitted in partial fulfillment of the requirements for graduation with honors in the Bryant University Honors Program

MAY 2015

Table of Contents

ABSTRACT

Self-driving cars, also known as autonomous vehicles, are being researched and tested by automakers, technology industry leaders, and other institutions. Lawmakers and politicians are discussing the legislation that will affect the fate of such technology. Primary benefits include safety, mobility, free time, less traffic, and green effects. However, there are also obstacles to the implementation of self-driving vehicles including consumer acceptance, legal liability, and cost. With the potential shift in responsibility from driver to automaker, rating factors for insurance may change, weighing more heavily on the model of the car as a factor. The fate of auto insurance is in the demand for autonomous vehicles by consumers, as business leaders react on data, not ideas. This project measures demand for self-driving cars and applies the results to how auto insurance will change. A survey was distributed in order to determine students' experience with car insurance and their attitudes on self-driving technology. The survey group is divided between general students and those with some insurance knowledge. By using the demand findings from the survey as well as existing data for older driver populations, we are better able to predict the demand and liability of self-driving cars and how auto insurance will be priced.

INTRODUCTION

With the rise of self-driving technology, various industries are questioning if and how they should respond to autonomous vehicles[1]. The goal of this project was to determine if there is a demand for self-driving cars and how that will affect the insurance industry. First, a survey was distributed at Bryant University in order to assess college students' current driving habits, their experience with car insurance, and their attitudes toward self-driving technology. This project assessed the demand for self-driving cars among college students, as they will most likely be the first group that will be able to purchase driverless cars. The Baby Boomer generation is the group most likely to use autonomous vehicles for purposes of elderly mobility. However, the possibly of technology and demand changing over the next twenty or so years would make our findings trivial. Also, current Baby Boomers cannot predict their future impairment with regards to driving, which would affect their demand for driverless vehicles. Thus, the potential for extrapolation has caused us to disregard the Baby Boomer generation for purposes of this study.

Next, the survey results were analyzed using non-parametric tests. One analysis was to see if the differences in the rankings of five benefits[2] of self-driving cars were significantly different. Other areas of study included indicating whether or not college major or gender had an influence on indicated usage of driverless cars. This survey was used as a preliminary study to estimate the demand for self-driving cars. The survey results were compared to benchmarks for driverless car usage that were noted in the literature review. After comparing

[1] Please note that this paper will use the terms "autonomous vehicle," "driverless car," and "self-driving car" interchangeably.
[2] The five benefits respondents rated from most to least important were increased safety, increased mobility, decreased auto insurance premiums, less gas, and less traffic.

the survey results to other scholars' opinions toward autonomous vehicles, the benchmarks were used to estimate the change in the frequency and severity of auto insurance claims. Benchmarks were also used to predict the decrease in auto insurance premiums paid by customers.

Overall, the results of the demand helped predict the implication of driverless cars on auto insurance. The existing research did not strongly predict the effects of self-driving cars on insurance. This paper determined how auto insurance will exist in the future, with regards to demand for self-driving cars, and the implications on frequency and severity of claims. It was important to determine how much responsibility the individual will have versus the auto manufacturer in case of accident. This project compared college students' attitudes toward self-driving technology to other studies in order to create benchmarks for predicted self-driving car usage. This estimated future autonomous vehicle usage of about 10% market penetration will lead to a 3-4% decrease in the frequency of auto claims. Moreover, this will result in about a 30- 40% decrease in auto insurance premiums for the 10% of people who do adopt self-driving technology.

Summary of findings[3]:

- There was a significant difference in the rankings of increased safety and increased mobility at the $\alpha = .10$ level.
- There were differences in the rankings of increased safety and decreased auto insurance premiums, decreased gasoline consumption, less traffic.
- There was no evidence of a difference in indicated self-driving car usage distributions by gender.
- There was a difference in the indicated self-driving car usage distributions between actuarial and non-actuarial majors.
- There was a difference in the indicated increase in purchase price distributions over a car without self-driving capabilities between actuarial and non-actuarial majors.

[3] An α=.05 significance level was used unless otherwise indicated.

- There was no evidence of a difference in the likelihood to purchase a self-driving vehicle distributions between actuarial versus non-actuarial majors.
- There was no evidence of a relationship between respondents' current car value and their indication of self-driving car usage.
- There was no evidence of a difference in the indication of self-driving car usage distributions between those respondents with insurance experience versus those without insurance experience.
- There was evidence of a relationship between age and indication of self-driving car usage.
- There was no evidence of a difference in the increased safety and decreased auto insurance premium rankings between those who currently pay for their auto insurance versus those who do not.

LITERATURE REVIEW

Introduction

The existing body of literature on the topic of self-driving cars went into great detail about its benefits and costs, upon which most scholars agree. However, scholars did not agree about the timeline for implementation and the demand of self-driving cars, two factors that will weigh significantly on the outcome of auto insurance. There was not much research being conducted regarding autonomous vehicles' effects on auto insurance. This is due to the fact that many scholars believed that it will be years before the self-driving car will be part of our mainstream culture. Although there was very little information on self-driving cars' effects on auto insurance, the few opinions available were in disagreement. Scholars had not yet determined how much responsibility drivers will have in case of accidents, if at all, or even if auto insurance will exist. Nevertheless, the few opinions that were available served as guidance to connect survey findings back to the insurance industry impact.

Technology & Timeline: What is a Self-Driving Car and When Will It Be Available?

The technology for autonomous cars is on a continuum from complete human control to entire computer control, making it difficult to assess the timeline for implementation. Of course, the time to market depends on the definition of a self-driving car. Both the National Highway Traffic Safety Administration (NHSTA) and IHS have released "autonomous level definitions" which explained each phase of self-driving cars, clarifying this continuum. According to Bill Windsor, an associate vice president of consumer safety at Nationwide Mutual, the story of self-driving cars will be similar to autopilot on airplanes- although the technology is there, human oversight is still required (Klayman 2012). Ben Klayman, from *Insurance and Technology Online,* took a very liberal approach to the issue of self-driving cars by predicting that human-driven cars will be used in the future for amusement. Similar to how horses were once used for transportation and are now used for play, modern cars may become used for amusement purposes (Klayman 2012). Ian Bogost, a contributing editor at *The Atlantic*, cited science-fiction author Isaac Asimov's article in the 1964 *New York Times* predicting self-driving technology fifty years into the future, 2014. He described these cars as equipped with "robot brains" to set predetermined destinations and make decisions quicker than humans. *The Economist* also explained how self-driving cars will "talk" to each other through a 4G mobile broadband network. This will enable cars to send warnings or signals to each other and predict weather and traffic ahead (Driverless Cars: Look, No Hands!).

RAND Corporation, a nonprofit company that aids policymaking through research and analytics, published the report *Autonomous Vehicle Technology: A Guide for Policymakers*, peer reviewed both internally and externally. RAND was very optimistic in saying that eventually these cars will be able to drop people off at work and may lead to car-sharing programs, instead of individual ownership (Anderson, et. al 2014). Thomas Frey is a futurist researcher for Google, executive director of the DaVinci Institute, and has presented and written books on his futurist studies. Frey's profession was reflected in his writing as he looked far into the future, without fully analyzing the obstacles needed to overcome in order to get there. Frey was an advocate for autonomous cars' success and believed that although it will be an expensive project at first, governments will eventually mandate self-driving technology. Frey predicted a world in which cars will communicate with one another through cameras and other sensors that will notify cars where other vehicles are. In order to do this, Frey forecasted "intelligent roads" which will further enable autonomous vehicles to communicate with one another. Three effects of these predictions, Frey argued, are lane, distance, and time compression; self-driving technology will allow lanes to change widths, cars to drive closer to each other, and vehicles to increase speed, all while increasing safety. Frey also argued that vehicles will show less information about the driving experience on the dashboard, and more entertainment features, such as movies, music, and even offer body massages (Frey 2012).

The journal *Mechanical Engineering* explained self-driving cars as being able to perceive the world around them in order to safely drive the vehicle. Joseph D'Allegro, journalist of business, finance, and automobiles, envisioned seats that do not face forward and cars that drop employees off at work and pick them up at the end of the day. D'Allegro also noted that people will send off their cars to run errands that without self-driving cars, time constraints might limit. However, he failed to address how self-driving cars would actually do the shopping, such as buying groceries.

These predictions were similar to self-driving car technological improvements seen in the past decade. The Insurance Information Institute (III) cited that federal agencies have approved of vehicle–to-vehicle (V2V) technology that allows cars to communicate with each other. Soon to be added is technology similar to black boxes, which will record data moments before an accident. In fact, insurance companies are already offering reduced rates for consumers who have telematics technology in their vehicles.

The technology of self-driving cars can be traced back to a project by Sebastian Thrun, director of Stanford University's AI Laboratory, in his attempt at the DARPA (U.S. Defense Advanced Research Project Agency's) Grand Challenge. The first DARPA Grand Challenge, in 2004, saw failure by all fifteen teams. In fact, not one team was able to drive more than eight miles of the course. The next DARPA Grand Challenge was in 2005 and five teams were able to drive the entire 132 mile course. Thrun created the Stanley robot car, which won the $2 million grand prize to its second Grand Challenge after driving over 125 miles in desert conditions, all without a human driver.

Next, DARPA created an Urban Course in 2007 that challenged self-driving vehicles to navigate through congested areas. The cars were challenged to obey safety laws, navigate through busy intersections, and determine alternative routes if roads were blocked. Six teams successfully completed this course. An area for improvement was that the Urban Challenge did not expect autonomous vehicles to react to traffic signals or people walking on the street. Since then, Thrun is responsible for making Google's self-driving Priuses, which contain Velodyne laser rangefinders and other radar sensors. Thrun argued that self-driving technology is a computer science issue because its success relies on appropriately collecting and analyzing data, and making proper decisions from that data.

Auto manufacturers across the globe are also researching and testing self-driving vehicles. Peter R. Thom and Timothy A. Logsdon, associates of a firm that consults automotive engineers, noted a Society of Automotive Engineers study that found that 90% of all vehicle innovations from 2008-2010 were electronic. Examples included features such as self-park, adaptive cruise control, blind-spot monitoring, forward-collision warnings, and lane-departure warnings. As of 2010, the biggest advances in automotive technology included anti-lock braking systems (ABS), traction control, and electronic stability control (ESC) (Thom 2010). On August 27, 2013, Nissan Motor Company announced that it would bring the self-driving car to market by 2020 (How Autonomous 2013). *The Economist* mentioned the European Ford Focus with limited autonomous capabilities such as driving itself and maintaining a reasonable distance in traffic, steering itself into a parking spot, and warning the driver if he or she is speeding. General Motors is working on an autonomous car that will be available by 2016. Although this car will be able to drive itself, drivers still have to be prepared to take control of the vehicle. Audi's technology includes radar and LIDAR, light, detection, and ranging (Fast Approaching 2013). D'Allegro noted that many cars already have front-crash prevention systems and some are equipped with self-park technology. Journalist Jerry Hirsch mentioned the failed testing of a parking assistant in a Toyota Prius hybrid and how consumers are still skeptical of their safety in autonomous vehicles. White explained that between 2014 and 2016, auto makers will build cars with "traffic jam assist" systems for low-speed situations including automation of breaks, steering, and speed. Other technology improvements include automating a car up to speeds of 40 mph by 2019.

Self-driving cars have also lead to other technological advances, not necessarily related to the car itself. As of 2011, the European Union-sponsored Safe Road Trains for the Environment (SARTE) project has been focused on creating platoons where cars can travel in bunches and rely on a lead human driver. This technology boasts benefits in terms of aerodynamics and cost-efficiency. Alex Wright, writer, researcher, and designer, noted barriers to this type of experience, such as limited mobility (2011). Another technological implication of self-driving cars will be the production of "black boxes" for cars, similar to those found in planes, in order to monitor what happens in cars moments before crashes (Abkowitz 2014). KPMG noted that the integration of communication- and sensor-based technologies may better deliver safety, mobility, and autonomous capability than either approach in isolation. Benefits of this integration would be realized in the areas of timing and cost, a substitution for human senses, less error due to redundancy in safety, functionality, and infrastructure investment (Self-Driving Cars: The Next Revolution 2012).

Lloyd's of London discussed other types of autonomous vehicles, which they referred to as unmanned aircraft systems (UAS). Unlike self-driving cars, UAS are not limited to work on existing roads and there are no size specifications. Although they may seem more advanced than autonomous vehicles, Lloyd's noted that UAS have been used commercially for years in Japan. UAS are used in agriculture, public services, aerial surveillance, media, and delivery. UAS are used in agrarian areas such as Brazil and Japan, and are used to monitor irrigation or frost, check for diseases, apply pesticides, and more. As far as public services, UAS can be used in search and rescue missions or to fight forest fires. Lloyd's also discusses other uses for autonomous vehicles such as marine, spacecraft, specialty industry usage, trains, and military usage (Automated Vehicles 2014).

As shown, the timeline for self-driving cars is continuous; however, scholars seem to agree that autonomous technology is among us and is rapidly expanding. The definition of self-driving cars, as discussed above, influenced how the survey was worded. For instance, one of the questions on the survey asked respondents to what degree would self-driving vehicles need to be autonomous in order for the respondent to use it (Insert footnote with exact question). This will inevitably affect the demand for self-driving cars among the continuum of technology from complete human control to total computer control. If consumers want a car that can be driven either by the human or the car, depending on the setting, then the insurance for self-driving cars will be different than a car that is completely computer controlled. The definition of a self-driving car affects insurance because of the liability aspect; if cars are able to switch between computer and human control, the driver and the auto manufacturer may both be at fault in case of accidents. The liability will affect insurance premiums because of pricing variables based on demographics of the driver may change to variables relating to the auto manufacturer. Ultimately the demand for self-driving technology and the degree to which cars are computer-controlled will affect the insurance liability and therefore the pricing of policies.

Legislature and Testing

The U.S. Department of Transportation allows states to decide on limited testing, but not sales, within their boundaries. As of October 2014, only four states, Nevada, Florida, California, and Michigan, have approved the testing of self-driving cars on its roads. Whether or not they are accepting of self-driving cars, many scholars believe that legislation pertaining to the testing of self-driving cars is needed in order to promote safety. David L. Strickland, from the National Highway Traffic Safety Administration (NHTSA), noted that there are three key areas for preliminary research including human factors and human-machine interface, initial system performance requirements, and electronic control system safety. Kirk Steudle, Director of the Michigan Department of Transportation on behalf of the *American Association of State Highway and Transportation Officials* (AASHTO), argued in favor of self-driving vehicles as a solution to safety problems. He said that legislation is needed in order for research to improve and to prepare for the future of self-driving cars. Dr. Raj Rajkumar from Carnegie Mellon University argued the following considerations for policymakers: slow progression from human to computer control, research and development investments integral to the success of autonomous vehicles, legislation to keep pace with technological improvements, policies to address cyber security issues, and an open mind that these barriers should not deter self-driving technology research because of the benefits such as savings on highway spending (How Autonomous 2013).

Dr. Joshua Schank, President and CEO of the Eno Center for Transportation, identified obstacles to self-driving technology and recommended policy initiatives. The barriers addressed included an initial cost of $100,000 per vehicle, lack of liability and licensing standards, and security and privacy concerns. Recommendations included increasing research in order to decrease costs, developing federal guidelines for licensing, and creating standards for liability, security, and data privacy (How Autonomous 2013). Swanson (2014) argued that states should allow testing of self-driving vehicles. Once they are deemed safe for the general public, Swanson argued that federal legislation must be made through the NHTSA.

DARPA is not the only institution testing this technology, as safety is crucial in the success of self-driving cars. On August 7, 2012 Google proclaimed that its autonomous vehicle had driven over 300,000 miles without an accident. Although many cite this fact as groundbreaking evidence that autonomous vehicles are safe, they fail to mention the multiple times drivers had to take control of the car due to safety issues (Dudley 2015). This vehicle is completely autonomous, meaning it has no steering wheel, no pedals, and no brakes. A potential improvement for Google's Prius is integrating self-driving technology with Google Maps. This will enable cars to predetermine their routes, and be aware of data before travel even begins (Wright 2011). Volvo expects consumers to test its self-driving cars by 2017. Volkswagen has been testing its A7 sedan, which includes a traffic jam pilot system, controlled speed, stopping, and staying in a lane, on Tampa highways. This vehicle can do all this up to 40 mph and when the brake or steering wheel is touched, the car becomes driver-controlled again. It will be interesting to watch legislation regarding self-driving vehicles as it will determine the fate of auto manufacturers and related institutions.

The definition of a self-driving car ultimately affects the legislation and vice versa. For instance, cars that will operate with both human and computer control will be legally discussed in a different manner than cars that have complete computer control. On the other hand, if, for instance, cars with complete computer control are deemed illegal because of the impossibility of human interference in accidents, then the definition of self-driving cars will be affected. Lawsuits regarding self-driving cars will shape legislation and the technology that is allowed to be brought to market.

Self-Driving Vehicle Benefits

Safety

According to the NHTSA, over 34,000 people died due to car accidents in 2012, with 93% of deaths due to driver error. Since the transition away from horses, car crashes have killed twenty five million people. In fact, car crashes are the leading cause of death from ages 3 to 33. Without a doubt, this is a problem that must be solved and self-driving cars are a potential solution. Kevin Maney, best-selling author, award-winning columnist, and lecturer claimed that it is “stupid” to give humans the power to control cars (2014). Many tests have shown that self-driving cars are safer than human-driven cars. In fact, Volvo’s cars with collision avoidance systems had 27% fewer property damage liability claims and fewer claims for bodily injury. Acura and Mercedes-Benz saw similar results with 14% fewer damage claims in their cars with collision avoidance systems (Hirsch 2012). Hirsch pointed out that if all passenger vehicles were equipped with just four sensor-based notification systems- (1)

forward collision warning, (2) land departure warning, (3) blind spot detection, and (4) headlights that pivot based on direction of the vehicle- that 1/3 of fatal crashes and 1/5 of injury crashes could have been prevented or have been less severe (Hirsch 2012). The NHTSA noted 34% and 59% decreases in accidents for vehicles with ESC technology for cars and SUVs, respectively. Moreover, stability control prevents 71% of car and 84% of SUV rollovers (Thom 2010). The Department of Transportation estimated that V2V technologies will prevent 76% of crashes (Self Driving Cars and Insurance 2014). Ron Actuarial Intelligence found that collision avoidance systems in private cars resulted in a 45% decrease in bodily injury claims. The Institute for Highway Safety (IIHS) and the Highway Loss Data Institute (HLDI) reported lower property damage liability and collision claims for cars with forward-collision warning systems. Tuttle, contributor for TIME Magazine, cited that researchers have claimed that if 10% of cars today were autonomous, that would reduce yearly accidents and deaths by 211,000 and 1,100, respectively. If this number was changed to 90%, the respective figures would be 4.2 million and 21,700, showing just how much room for improvement there is in this industry. Tuttle did not include a source for these statistics.

Maney cited the Tesla Model S to illustrate the benefits of autonomous vehicles. The Model S uses twelve sensors, one camera, and radar in order to interpret speed limits, stay in a lane, and recognize outside objects. Maney also noted that the Model S performs better in adverse weather. Tesla CEO Elon Musk claimed that about 90% of daily driving on highways could be done on autopilot by November 2015 (Maney 2014). The Google self-driving car also hints that autonomous vehicles may be safer than their human-controlled counterparts. As of 2014, the only accident the Google car encountered was a fender bender when a human was in control of the vehicle (Swanson 2014).

Ron Actuarial Intelligence has maintained a large pool of data from various auto insurers since April of 2010 in order to ensure the insurer's stability and determine fair rates for policyholders. They found that vehicles equipped with forward collision warning (FCW) and lane departure warning (LDW) features had frequency of claims reduced by 45% compared to cars without this technology (Actuarial Research). As shown, one of the biggest benefits to self-driving vehicles are their safety.

Mobility

Another potential benefit of autonomous vehicles is mobility. However impaired to drive, people will be able to go where they want, when they want. In fact, blind people will be able to travel solo, demonstrated during Google's self-driving Prius test run in which a blind man was driven to work. It is expected that there will be 72 million people age sixty-five and older in the U.S. by 2030. Currently, about 80% of those age 65 and older hold valid driver's licenses and live in areas that depend on a car as their main form of transportation. Almost 90% of these people claim they will live in these suburban or rural areas for the rest of their lives. Due to the shift in demographics, Bryant Walker Smith, law professor at the University of South Carolina, predicts that we will see a rapid demand of autonomous cars by 2025 (Dudley 2015).

Luis E. Ferreras, associate engineer in the road and highway division of Parsons Corporation, cited one of the National Academy of Engineering's *Grand Challenges* of mobility for elderly and disabled people as one of the leading problems in the area of transit. Laura Hedli, contributor for Wall Street Journal, interviewed Brad Templeton, who consulted the Google car team in 2011-2012 and now is a professor at Singularity University. Templeton argued that self-driving cars, "robocars," are a "natural fit for a retirement community" because of the lack of mobility due to old age and living in suburban areas. Templeton argued that since public transit is usually difficult to find in suburban areas, elderly people are forced to move, or their mobility is at risk. People would be more likely to use a robocar than sell their house (Hedli, 2014).

Not only can autonomous cars benefit the elderly, but they can also prevent drinking and driving. According to the NHTSA, over 10,000 people died due to drunk-driving car accidents in 2012. This is equivalent to one death every 51 minutes. Not only is this an emotional problem, but it is also financial as these accidents cost our nation over $37 billion per year. With self-driving vehicles, individuals who want to drink do not have to worry about finding a safe ride home. Similarly, there is no longer the worry of drunk drivers on the roads late at night or on holidays. Whether impaired by alcohol, old age, or eyesight, autonomous vehicles may be the solution to safe mobility.

Free Time

According to the United States Department of Transportation, individuals spend fifty one minutes commuting to work per day. This is an issue for 87% of the working population who commute to work by car only (Thrun, 2010). Keith Goffin, professor of innovation and new product development at the Cranfield School of Management, argued that the self-driving experience will be more relaxing, as the driver will not have to deal with driving directions and traffic. Many scholars, including Goffin, argued that individuals will now be able to use their time more effectively, checking emails and working straight from their car. Parents will be able to watch their kids in the backseat and business professionals can nap on their way to business trips. According to a 2013 study, the average mom drives her children nearly 1,250 miles per year. A 1995 Surface Transportation Policy Project found that mothers spend over

50% of their time driving their kids around. Fairchild (2014) has claimed that in the last twenty years this number has only increased. In 2013, the labor force participation rate for mothers with children under 18 was 70%. As shown, there is a huge potential for self-driving cars for moms who are tired of chauffeuring their kids around. Moreover, with the decreasing rate of stay-at-home moms, a driverless car may be the perfect complement to a mother as a working professional.

Decreased Insurance Premiums

Although there is not much being said about the insurance of self-driving cars, it is possible that they may bring decreased insurance premiums. Data has shown that cars with autonomous features are safer, in the fact that there are fewer property, liability, and other claims[4]. Due to fewer car accidents, insurance companies will be paying fewer claims out, therefore reducing insurance premiums. In 2013, CarInsurance.com polled 2,000 individuals through an online marketing research company, OP4G, to analyze demand for self-driving vehicles. 34% of participants responded they "very likely" would buy or consider buying a self-driving car if it guaranteed an 80% discount on their insurance. 56% of respondents said they would consider it. 20% of the surveyed people responded they would buy an autonomous vehicle, regardless of the amount of premium discount. According to OP4G, the survey has a margin of error of 2.2% (90% of U.S. Drivers, 2013). With the fixed costs of insurance each month, consumers may find it beneficial to adopt autonomous cars and cut down on their monthly bills.

[4] Please refer to the Safety Section, beginning on page 18.

Traffic

In 2007, Americans spent about 36 hours in traffic (Ferreras, 2014). With the mass market of self-driving vehicles, Frey (2012) predicted that 10-20 times as many vehicles will be able to drive on highways. If cars are driving faster, then fewer cars will be on the roads at any given time. Frey (2012) forecasted that roads will be able to repair themselves, even in traffic, and that adverse weather will have virtually no effect on passengers' safety. The National Academy of Engineering's *Grand Challenges* reported that maintenance and improvement of highways and integration of transportation systems constitute the other leading problems in the area of transit. Need for improved transit can be seen in highway data such as the 5% highway capacity ratio, or the total surface number of vehicles that take up a highway surface. Thus, 95% of the highway is used as buffers for cars due to limitations in human driving. This will be improved by self-driving platoons, which will enable cars to drive within inches from each other.

Energy & Pollution

34% of the energy of the U.S. is due to cars (Thrun, 2010). With the rise of self-driving cars that drive faster and are stuck in less traffic, improvements will be seen in energy and pollution. RAND Corporation noted that self-driving vehicles will be 4-10% more fuel efficient than cars today because of their ability to accelerate and decelerate smoothly. Fuel economy could also be improved with self-driving cars because they will be able to drive closer together, reduce traffic, and be lighter in weight (Anderson et. Al 2014).

Cost

According to the NHTSA, crashes have cost the U.S. $230 billion per year since 2000 (How Autonomous, 2013). Thus, if self-driving cars are implemented, the total cost of accidents to our economy will decrease. In fact, Fairchild (2014) noted that driverless cars could reduce accident-related expenses by $400 billion a year. Although self-driving cars will likely be sold for more than what vehicles sell for today, consumers may see savings elsewhere. Templeton stated that they will either be sold for a monthly fee or will be used like a taxi. For the former, the driver would also have to pay for gasoline and some insurance and maintenance. However, if robocars are used like taxis, individuals can call them to their door, similar to the service Uber provides.[5] Templeton noted that self-driving cars will be much cheaper because 60% of a taxi fee is for the driver (Hedli, 2014). Thus, it may be more economical for homeowners to own fewer cars. Many scholars see the eventual rise of car-sharing which, without the cost of human labor to drive, will be significantly less expensive than owning a car (Frey, 2012). Thrun (2010) and Johnson (Fairchild, 2014) both noted that a car is usually the second most expensive item for homeowner's with yearly costs around $9,000. However, the cost of cars could decline due to driverless technology. As far as repair costs, the number of collisions are predicted to decrease, but the cost of the technology may not necessarily lead to a total reduction in cost of crashes. Thus, it is difficult to assess whether or not the rise of self-driving cars will save consumers money in the long run.

<u>Other</u>

Autonomous vehicles have an unlimited number of potential benefits. In the long term, RAND cites other benefits, which include fewer "negative externalities", such as the probability another person will have an accident because of traffic congestion, and the potential for families to live more remotely. Ferreras also talks about how cars will be able to

[5] Uber is a transportation service in which cars are hailed by users through a smartphone application which shows drivers whereabouts and cost for the trip. Uber employees drive their personal car and are background-checked before hire.

communicate with each other, the roads, the Internet, and public transportation management centers. This will allow autonomous vehicles to drive closer to each other, obtain information about traffic and weather, and provide information to emergency services about a crash (Ferreras 2014).

Self-Driving Vehicle Barriers

By 2035, IHS Automotive estimated that there will be 11.8 million self-driving car sales worldwide. By 2055, IHS Automotive predicted that 90% of cars today will be replaced with autonomous cars (Juiliussen, 2014). KPMG and the Center for Automotive Research predicted that self-driving cars will begin to be sold in 2019 with essential infrastructure for mass consumption to be in place by 2025 (Larino). IHS Automotive predicted that self-driving cars will be marketed around 2025 and the first self-driving only cars will be sold around 2030. Light argued that four benefits will increase the demand for self-driving cars, including telematics, collision avoidance, automated enforcement, and robot cars (O'Donnell). According to the Celent report, the biggest factor contributing to the potential for self-driving cars is how these four technologies will be allowed to be used, determined by key players such as legislators, regulators, voters, and manufacturers (O'Donnell). However, before benefits of self-driving cars can be realized by society, there are several obstacles to overcome. The Institute for Electrical and Electronics Engineers surveyed 200 self-driving car experts and found that the top three roadblocks to the idea are legal liability, policy makers, and consumer acceptance (III). The AASHTO also cited barriers to self-driving cars such as vehicle costs, AV licensing, litigation, perception, security, privacy, and missing research

(Preparing a Nation, 2013). This section will expand on consumer acceptance, liability issues, and cost.

Consumer Acceptance

KPMG began the analysis of adoption by relating it to the transition from the horse to the car. As problems with horses arose, such as the high maintenance costs to feed horses and the amount of manure they exert, the car seemed like a perfect solution. However, public sentiment was not all positive since cars were feared by horses and were shot at by farmers. In the 1900s, early car adoption led to class warfare and disagreement through public literature. One letter writer noticed the car was "meeting with the usual hostile reception accorded to every innovation, especially if those people with plenty of money take to it first" (Self-Driving Cars, p. 12). A similar pattern seems to be happening with autonomous vehicles. From 1900 to 1920 car ownership expanded significantly, from 8,000 to 8 million. However, KPMG also realized a technological innovation in mobility that did not take so well: electric vehicles. KPMG has noted that demand for EVs never escalated because of the high costs and infrastructure problems. From June 10 to June 27, 2013, KPMG conducted three focus groups in Los Angeles, California, Chicago, Illinois, and Iselin, New Jersey. The focus group was paired with quantitative data from KPMG's Mass Opinion Business Intelligence (MOBI), which collects and organizes data in real time into usable data.

KPMG's focus group related to autonomous vehicles found that although people were hesitant toward accepting the technology at first, if they were presented with the right "value proposition," their approval increased and they were even willing to pay a premium for it. This value proposition includes shorter commute times, reduced traffic-related variability, and the function to switch between human and computer control. An interesting point found from the KPMG focus group was that men were more likely to give up car ownership than women, as women see cars as a place to hold their belongings. The willingness to give up a car in favor of mobility on demand services, like Uber, could have dramatic effects on the car manufacturing industry (Self-Driving Cars: Are We Ready, 2013).

Another finding from KPMG was that the way people buy cars will change as auto manufacturers may have to compete with technology industry leaders, such as Google and Apple. Last, the need to purchase cars could decrease, with the rise of services like Lyft and Uber. As expected, the individuals in the focus group who were most passionate about driving were the least inclined to use autonomous vehicles. However, they were also the group with the biggest increase in willingness to use self-driving vehicles at the end of the study. However, KPMG failed to note that this is expected because a low ranking leaves the most room for improvement. KPMG also found that individuals who drove premium cars, versus mass market ones, were more willing to purchase self-driving vehicles. KPMG believes this is true because they have the willingness and ability to pay a premium for luxury and are used to more features than the average car.

One of the more interesting points was the gender difference in why respondents would or would not use a self-driving vehicle. The median score for acceptance was 6.5 for women and 6.0 for men at the beginning of the focus group, and those numbers changed to 8.25 and 7.5, respectively. Women reported benefits such as focusing on their children in the backseat and not worrying about having a drink with dinner. Men were hesitant to use self-driving cars because they are afraid of being forced to stay in one lane and go the speed limit. An incentive that caused a majority of people to be more open to self-driving cars was special lanes for self-driving vehicles. These lanes would move at a constant speed, guaranteeing a predetermined arrival time. One of the biggest hesitations among consumers was the question of safety. However, participants laughed at the mention of the NHTSA influencing their opinions.

KPMG presented base case, aggressive, and conservative scenarios for adoption, insinuating that the company is not quite sure what demand will look like. Factors that will affect adoption include cost, driver education, technology, legislation, infrastructure investment, consumer acceptance, and geopolitical factors, among others. KPMG argued that the factors involved in consumer acceptance will be building trust through proved safety ratings; appealing to the right demographics, namely the young and the old; selling the value proposition; and keeping consumers informed (Self-Driving Cars: The Next Revolution, 2012).

Innovation Group and Consumer Intelligence surveyed 1,500 United Kingdom drivers to assess their opinions on auto insurance policies. They found that in England, 74% of drivers said they would support telematics, which monitor the insured’s driving, in return for reduced premiums. Scottish drivers were the biggest fans of this at 83% (Innovation UK, 2014). Innovation Group and Consumer Intelligence found only 7% of British drivers said they would purchase a self-driving vehicle, proving that consumer acceptance is one of the biggest barriers to market (Innovation UK, 2014). According to CEO of General Motors, Mary Barra, the average American consumer is not ready for driverless cars. Bara believed the lack of consumer acceptance is due to the unwillingness of drivers to allow technology to be in control. At a discussion on technology developments at Fortune’s Most Powerful Women Summit in California, Claire Hughes Johnson, the VP of self-driving cars for Google, spoke about driverless cars. Similar to Barra, Johnson noted an unwillingness to allow a car to be in control, especially if children were passengers. David Dudley, contributor to *AARP the Magazine*, would agree with this statement as he compares the act of driving to having a "natural-sounding conversation, that machines struggle to imitate" (Dudley 2015). However, when the panel's moderator at Fortune's Women Summit, Fortune Senior Editor Michal Lev-Ram, asked the audience who would allow their kid in a self-driving car, nearly everyone raised their hands. Fortune believed this was because the moms were tired of chauffeuring their children around (Fairchild, 2014).

Tuttle (3013) cites a study by Chubb Group of Insurance Companies that found only 18% of consumers would be interested in a self-driving car. Similarly, a poll from CarInsurance.com found that 20% of individuals would agree to own an autonomous vehicle. According to Forbes, two-thirds of the people who are weary of the idea of self-driving cars say they do not feel comfortable about the lack of control. What stood out in this article is that 9/10 of the people in the CarInsurance.com survey responded they would own a self-driving car if it guaranteed their premiums would be only 20% of their current payments. This poll also showed that 75% of individuals believe that they can drive better than a computer (Tuttle 2013).

Kyle Stock, associate editor for BusinessWeek, argued that the demand for self-driving cars will not take off because of the fact that they do not have human emotions and therefore cannot make moral decisions in case of accidents. He cited Noah Goodall, a University of Virginia scientist, who argued, "There is no obvious way to effectively encode complex human morals in software." Goodall argued that automakers should consider "deontology," in which a car is programmed to follow set rules regarding ethical concerns, or "consequentialism" in which the car acts to ensure a maximum benefit. However, Stock argued that these solutions are flawed. For instance, should a car save its passenger at the expense of vehicles and passengers around it? Stock brought up the point of ethics because it affects not only the consumers, but also the automakers, research scientists, and policy makers. Similarly, Doug Newcomb, auto technology expert, and author of car-related publications such as *Car Audio for Dummies*, addressed the ethical issue of self-driving cars. Autonomous cars will be pre-programmed to follow certain, specific directions, but what happens if the car cannot account for a pedestrian in front of a car? Newcomb brought up the trolley dilemma, which asks if it is okay to save the majority at the expense of one person's life.

A robotics blog, Robohub, polled its readers to see their opinions on the "tunnel problem." They polled 113 people, 20 female and 93 male and 43% between the ages of 25 and 34. These individuals were asked if they were in a self-driving vehicle and about to enter a tunnel and a child ran in front of the car, should you run over the child or swerve and hit the side of the tunnel entrance? Surprisingly, 64% of the participants believed the car should continue and run over the child. Only 24% thought it would be a difficult decision and 28% thought it would be a moderately difficult decision. These findings should be analyzed with caution, however, as Robohub is only polling people who enter their website. Therefore, this survey is not representative of all Americans' beliefs. The poll also asked respondents who should decide whether the child or the tunnel gets hit: the manufacturer, the lawmakers, or the passenger of the car. 44% said that the passenger should choose, 33% said the lawmakers, 12% said manufacturers and 11% said other. This shows that although passengers will not be driving in autonomous vehicles, they still want to be able to be in control in accidents (Newcomb, 2014).

Marek Reichman, director of design at Aston Martin since 2005, spoke on behalf of Aston Martin opposing driverless cars because it contradicts the brands' values of luxury and unparalleled driver experience. Reichman compared self-driving cars to going from listening to your favorite symphony live versus listening to it on an MP3. He argued that Aston Martin vehicles engage the senses, making the physical act of driving an integral part of the brand experience. Additionally, Reichman cited that in 100 years, Aston Martin has made only 70,000 cars, a number that a mass-market auto manufacturer has the capability to make in a few days. He pointed out that self-driving cars are a form of mass-transit, which is inconsistent with Aston Martin's values. He argued that what makes Aston Martin vehicles desirable are the luxury and rarity of them; self-driving cars will not support luxury vehicles (Reichman, 2013). Although he realized that many people enjoy the experience of taking a relaxing drive, Goffin (2013) is a proponent of self-driving vehicles. To address the notion that people will miss having control of driving themselves, Maney asked readers if they still thought rollercoasters were fun even if they are not driving them. I think this is a bit of a stretch since cars will most likely not be racing over one hundred miles per hour, looping around, and taking intense drops (Maney, 2014). Eric Chan, a chief engineer at Ricardo and the SARTRE project's primary contractor argued that self-driving technology could be inhibited by drivers' unwillingness to relinquish control and be within inches from other vehicles (Wright, 2011).

Ariel Arieff, journalist and author of architecture and design, argued that less time should be spent developing autonomous cars and more time developing public transportation. Arieff noted that Americans are purchasing fewer cars, driving less, and getting fewer licenses. Meanwhile, the reliance on public transit and car-sharing is increasing. Arieff did not explain where these statements come from.

Legal Liability

One of the biggest issues with self-driving cars is the legal liability, as it may be so severe for auto manufacturers that they may be hesitant to continue research of self-driving vehicles. Either cost-benefit analysis may ensue, or manufacturers and their supplies may run out of business (Self-Driving Cars and Insurance, 2014). In fact, The Association of California Insurance Companies argued for the manufacturer to be fully responsible for any accidents these self-driving cars would have (Self Driving Cars and Insurance). The RAND Corporation study has devoted an entire chapter to the liability implications of self-driving vehicles and how the legal liability may deter automakers from building autonomous vehicles, even if they are safer than ordinary cars (Anderson, et. al., 2014). The International Association of Defense Counsel (IADC) Committee members create monthly newsletter on practical issues. This newsletter is based on new automotive technology, including ride-sharing, autonomous vehicles, event data recorders, and texting. John G. Browning, partner of Lewis Bisgaard & Smith and member of the IADC's Technology Committee, addressed the liability aspect of self-driving cars. He foresaw liability moving from the driver to the manufacturer, since the driver is no longer responsible for being attentive. Browning's biggest concern was that the possibility for lawsuits and defamation may cause auto manufacturers to halt the production of self-driving vehicles. He said that the manufacturers will need some sort of incentives or legal exemptions in order for them to pursue autonomous technology.

Another complication is the possibility that the self-driving technology does not respond to emergencies as effectively as humans. For instance, a human will know that if a ball rolls in front of a car, a child will most likely be chasing after it. Autonomous technology may not respond to this appropriately, leaving responsibility to be questioned (Browning, 2014). In an overview to the 113th Congress about self-driving vehicles, Thomas Petri noted that both liability and cyber security issues are the biggest barriers to self-driving technology. One potential barrier that should be researched further is accidents due to other automated transportations, such as the Metro. Eleanor Holmes Norton, on the Subcommittee on Highways and Transit representing the District of Columbia, noted a 2009 Metro crash killing nine people and causing the mandate of Metros to be operated manually. Similar situations could arise with self-driving cars (How Autonomous, 2013). Lloyd's noted risks to self-driving cars such as liability when the driver is switching control between themselves and the vehicle. Lloyd also noted that there may still be driver error with self-driving cars because, for instance, they may follow satellite navigation in times where common sense would lead them not to.

Reputational risk for the manufacturer is also an issue because if auto companies are hesitant to produce autonomous vehicles in fear of compromised reputation, they may not seek the technology in the first place. Cyber risk is also an issue since autonomous vehicles will most likely be integrated with smart phones. This could cause the leaking of personal data, burglar tracking when homeowners are traveling, and even cyber terrorism in the form of large-scale immobilization of cars (Automated Vehicles, 2014). Smith argues that one of the biggest liability issues concerns graduated licenses that allow those who are now unable to drive to operate autonomous cars. He predicts that one of the biggest moral questions regarding this issue is "…how safe is safe enough?" (Dudley 2015). Although safety and mobility are both benefits to self-driving cars, there may be a struggle between them due to concerns such as graduated licenses. In many cases, moral questions are at the heart of legal liability issues, making the progression toward self-driving vehicles a slow one.

Cost

According to IHS Automotive, the self-driving technology will first add $7,000 to $10,000 per car in 2025, but will drop to $3,000 over the next decade (Juiliussen). Marik Brockman and Anand Rao of Pricewaterhouse Coopers (PWC) noted that although cars have improved in design and safety, auto insurance premiums have remained roughly the same when inflation is taken into account. According to Brockman and Rao, the barriers to reduced premiums include high repair costs due to increased technology, increased medical costs for injuries, and glitches in the technology (Brockman). Arieff (2013) also believed that self-driving cars will not be in high demand because of their cost. She argued that individuals who cannot afford a car today will most likely not be able to afford a driverless one. As previously mentioned, it is difficult to declare whether overall costs for consumers will increase or decrease due to self-driving cars, making cost a potential benefit and burden.

Industry Effects

KPMG explained that a reduction in crashes will hurt steelmakers and maintenance and repair shops, but will benefit electronic suppliers. Emergency rooms and hospitals would also see fewer crash victims, affecting the demand for those in the health services industry. Governments will lose the revenue from traffic fees, but will also need fewer highway patrol officers, mitigating government expenditures. Businesses may also see productivity increases from their employees now that their commutes are shorter and they are able to work while commuting (Self Driving Cars: The Next Revolution, 2012). D'Allegro has argued that the need for parking spaces will decrease, leaving more city acreage for other uses. He also foresaw governments spending their $30 billion allocated toward highways being spent other places. Other industry impacts would be a loss of jobs in other transportations- such as taxis, limousines, and trains- and banks that lend their money to car buyers (D'Allegro, 2014).

Automakers

According to Lux Research, automakers and technology companies are expected to make $87 billion off of self-driving cars (D'Allegro, 2014). KPMG and the Center for Automotive Research released a study which showed Google's laser-based Light Detection and Ranging system costs $70,000, a figure that will affect both the market price of the autonomous technology, but also repair costs. Although self-driving cars will cost more than regular cars at first, the market price may come down due to mass production. Moreover, if self-driving vehicles are rented through fleets, the entire auto industry could change. Frey (2012) has predicted that automakers will not sell, but loan cars through fleet operators, which will pay a monthly fee instead of an upfront charge. This will lead automakers to make cars that will last millions of miles. According to Frey, automakers will have the potential of earning ten times as much per vehicle than they do today due to increased duration of the car's life as well as these monthly fees from fleet operators (Frey, 2012). D'Allegro has argued that at first automakers will see an increase of $600 billion in autonomous car sales, but this will soon plummet due to car-sharing (D'Allegro, 2014). In theory, the entire auto industry could change due to self-driving cars.

Insurance

KPMG notes that self-driving vehicles will change underwriting models, and may even eliminate car insurance altogether (Self-Driving Cars: The Next Revolution, 2012). Steve Sorenson, EVP Product Operations at Allstate Insurance, has argued that the severity of claims will be difficult to predict because of the potential high costs of the new technology combined with fewer accidents. The net total of these two factors will determine if the severity of claims will increase or decrease with elf-driving cars (Mui, 2014). D'Allegro argued that auto insurance companies will at first see higher profits due to fewer and less severe claims, but will eventually lose a significant part of their business. He also pointed out the possibility of eradicating mandatory car insurance. Regardless if the automaker or the individual will be responsible for paying these premiums, there will be a lot of business lost due to the fact that there will be fewer accidents (Abkowitz, 2014). The Celent report identified that private passenger and commercial auto premiums account for 39% of the total premium for U.S. P&C insurers in 2011, which would drop to about 13% if the demand for autonomous cars increases over the next ten years. They also predicted a 5% and 4% decline in auto liability premium and physical damage, respectively. The total P&C industry premium would drop by 9% from 2013 to 2017 (Larino). As far as underwriting, pricing variables may more heavily rely on type of car and less on characteristics of the driver.

Brockman and Rao have proposed four ways that the self-driving car scenario can play out. In "risk shifting," the cause and probability of an accident would shift from driver error to manufacturer's technology. This would in turn make the auto manufacturer responsible for coverage, causing auto insurers to restructure their entire products. In a "risk sharing" scenario, individuals would pool risk with one another in order to significantly reduce their premiums. This would cause more people to be able to avoid insurance, leading to an increase in total premium. The third scenario, "risk slicing", recognized an increasing amount of people live in urban areas, leading demand to sharing transportation in a "pay-per-use model." According to Brockman and Rao, over 80% of the U.S. and over 50% of the world lives in urban areas. A Frost and Sullivan research study in 2012 found that the car sharing market could hit $10 billion by 2020. By 2016 urban car sharing in North America will include 4.4 million members and be worth $3billion. Low frequency drivers may lead to decreased premiums and the demand for renting cars may cause insurers to make more types of coverage. Last, the researcher's "risk reduction" scenario cited Google's 300,000 miles of autonomous driving without an accident to suggest a complete overhaul of the system (Brockman).

Besides automakers and individuals, some proposed that insurers will pay 100% of the damage regardless of who's at fault, otherwise known as no-fault insurance (Abkowitz). RAND Corporation suggests no-fault auto insurance similar to the National Childhood Vaccine Injury Act, which does not hold the manufacturer of the vaccine responsible for severe illness upon vaccination in fear of low supply of vaccines.

Anthony O'Donnell, writer on technology and insurance, interviewed Donald Light, senior analyst at Celent, a research analytics and consulting firm. Light argued that although today 40% of the property and casualty industry is due to U.S. auto insurance premiums, this figure will drop to 13% and the entire industry will drop by 26% by 2022. Additionally, car damage will decrease from 14% to 3% by 2022, according to the Celent report (O'Donnell). The Celent report suggested auto insurance leaders plan to expand their products, seek mergers and acquisitions, sell the company, or decline in market share (O'Donnell).

Chunka Mui, managing director of consulting agency Devil's Advocate Group, Mike Boyle, CEO at Perseus Technical Strategies, and Chris McMahon, senior editor of Insurance Networking News, argued that there are three key problems regarding autonomous technology that CIOs will face: developing a way to collect and organize new, large amounts of data, creating new products and services quicker than usual, and managing their costs due to the potential to lost revenues. The size and specificity of data due to self-driving technology cannot be handled by current claims, underwriting, and other insurance systems. This data will include date, time, speed, GPS, acceleration or deceleration, and fuel consumption. Mui, Boyle, and McMahon argued that the new systems will most likely happen on "the cloud," outsourced, and then integrated into insurance companies' systems. Advanced analytics skills are one of the key differentiators between industry leaders and their unsuccessful counterparts. With technology rapidly changing, researchers forewarn that insurance companies must create new products and services and insurance rates faster than they are used to. New actuarial and predictive models will be needed, which will take over the current administrative systems. Of course, the rating factors such as driving records and age of driver would not be as telling about claims. The last obstacle is for insurance companies to manage their costs because self-driving cars may cause premiums to be a fraction of what they are now, hurting auto companies' revenues.

According to a report by Ron Actuarial Intelligence LTD, forward collision warning (FCW) and lane departure warning (LDW) systems were shown to reduce frequency of claims by 45%. In turn, Ron Actuarial recommends a 15% discount on rate selection for vehicles with these features. Lloyd's suggests that self-driving cars will lead to cyber coverage by insurance companies. Cyber insurance will most likely evolve with autonomous technology. For instance, cyber security may need to include bodily injury and physical damage if they are all linked to self-driving vehicles. Unlike other scholars in this area, Lloyd's believes that car owners will always be at least partially responsible for their cars. Autonomous vehicles will at first be more expensive that typical cars, making them more susceptible to theft and damage.

Lloyd's also sees the increase in use of telematics, so that insurers can price based on exposure, rather than estimates. Although extensive software will be needed, technology such as black boxes will be more telling of why and how accidents occur. If cars did become completely driver-free, Lloyd's predicts that cars may be insured through product liability insurance, rather than auto insurance, as models of the cars would be the significant variable. Lloyd's suggests that insurers may even push liability limits for manufacturers, as that was the case for airplanes under the Warsaw Convention of 1929 (Automated Vehicles 2014).

Overall, most of the literature agreed on the benefits to driverless cars and the obstacles to their success. There was argument about when level four autonomous cars would be manufactured and sold to consumers. Moreover, the demand for driverless cars was vague, but a projected 10% adoption was usually a benchmark. As of April 2015, there is limited research on driverless cars' effects on auto insurance. This is especially true about the severity of claims as the net effect of increased repair costs and decreased car accidents was unknown. Last, legal liability was one of the biggest controversies, with nearly no one in agreement.

METHODOLOGY

The first step of this project was to gather a variety of literature in order to understand what scholars are saying about self-driving cars. Key benchmarks to note are that both Warren Buffett and the Eno Center for Transportation predicted that about 10% of total cars would be comprised of driverless cars in the early adoption stage of around 2030. Most studies cited decreases in the frequency of claims, but were hesitant to predict changes in severity, as it is difficult to assess the potential damage in case of a driverless car accident. Although there will be an increase in severity of claims of driverless cars because of the cost to repair the technology, this increase is negligible compared to the destruction of cars and lives from car accidents today.

Next, a survey was distributed to students at Bryant University in February of 2015 in WRIT 106, Writing Workshop, and AM 422, Life Contingencies II, classes[6]. This enabled the comparison of demand among the general public to those with a math background as WRIT 106 is a degree requirement taken at the freshmen level whereas AM 422 is taken only by actuarial majors and minors at the junior or senior level. Students enrolled in AM 422 have knowledge about insurance because of their mathematical background and seniority, allowing them to have some experience in the insurance industry. Therefore, survey results were used to compare attitudes toward self-driving cars between a group representing the Bryant students and a group representing people with some insurance knowledge. It is important to note that the survey was distributed only to college students because they would most likely be the first generation to experience fully-autonomous vehicles when the technology, legislature, and demand would enable these cars to be brought to market. The survey

[6] Please see Appendix A for survey in full.

determined students' interest in driving, their experience with car insurance, and their attitudes on self-driving technology. The survey also collected demographic information in order to compare by gender and age.

The survey consisted of thirty questions and was distributed through Qualtrics Survey Software. An online distribution of the survey guaranteed that all questions were answered by students and that rankings did not appear more than once[7]. Additionally, the Qualtrics system calculates basic statistics, such as mean, variance, and minimum and maximum points. The survey began with two introductory paragraphs informing respondents what the survey would be used for, as well as a brief overview of self-driving cars, hinting at some benefits and limitations. It was important not to make the introductory paragraph leading, as to skew the results.

After conducting the survey, statistical tests were used to analyze the data. Nonparametric tests, including the Wilcoxon Signed Rank Test and the Mann- Whitney U Test, were used to test whether or not the results were significant. The former was used to compare differences in rankings between two dependent groups. Paired t-tests were not used since we could not assume normality due to a relatively small n[8]. Since the rankings of the benefits were not independent from one another, tests that assume independence, such as ANOVA, were not appropriate. The null hypothesis was that rankings of the two benefits were the same against the alternative hypothesis that the rankings of the benefits were not the same. Mann-Whitney U Tests, the non-parametric alternative to t-tests, were used to compare two independent groups. Comparisons included by gender, actuarial versus non-actuarial

[7] During a sample test of the survey, a respondent ranked characteristics on a 1-5 scale of importance rather than ranking the benefits from most to least important.
[8] There were 48 respondents of the survey.

majors, and respondents who have had experience in the insurance industry versus those who have not.

An interesting hypothesis in the literature review was that individuals who drive expensive cars would not be in favor of self-driving cars because they are more likely to enjoy driving. In order to compare attitudes toward driverless cars by car value, the respondents' current vehicles were appraised. Then, a regression was ran in order to see if there was a relationship between current car values and indicated driverless car usage. Kelley Blue Book was used to appraise each car[9]. The three variables from the survey used to calculate the values of the vehicles were their year, make, model, and mileage. A potential improvement for the survey would be to ask respondents the mileage of their car. Since that question was not asked, an average of 12,000 miles per year was used. To calculate each cars' mileage, 12,000 miles per year was multiplied by its age in years. 3,000 miles was added on to this in order to cover the partial year[10].

After the survey results were analyzed using non-parametric tests, the findings were connected back to the insurance industry. First, assumptions were made from the survey results in combination with key statistics from the literature review. These assumptions allowed for an estimate of driverless car usage by percentage of the population and as a percentage of total driving time. These usage statistics allowed for a prediction of the decrease in frequency and severity of auto insurance claims. This allowed for the estimation of the decrease of auto insurance premiums paid by those who do adopt driverless cars. Once again,

[9] Kelley Blue Book was used rather than Edmunds because the latter listed vehicles available for purchase in the area, regardless of the mileage. For instance, a 1997 Volkswagen Gulf that should have had over 200,000 miles on it only had about 75,000 miles on a listing on Edmunds, and therefore was not comparable.
[10] The survey was taken in March of 2015. 3/12*12000= 3,000 miles.

these numbers were estimates of the future world of auto insurance. This was a preliminary survey to analyze the overall implication of autonomous vehicles on the insurance industry.

HYPOTHESES

The first section of survey questions assessed students' current experience with driving by asking how often they drive, what type of car they drive, and if they pay for their own car insurance. It is important to know how often respondents drive because that will affect the amount of time they would use a self-driving car if they were given the opportunity. The type of car a student drives may also be telling of their attitude toward self-driving vehicles because current literature shows that those who drive higher-end vehicles are more likely to drive for pleasure. Thus, one hypothesis was that the responses of students who drive more expensive cars will show that this group has a weaker demand for self-driving vehicles and would use one less often than those with average- or below-average- priced cars. The survey also asked students if they currently pay for their own car insurance in order to understand the percentage of students who pay for their car insurance and how that affected the responses to other questions. If respondents answered yes to this question, they were asked to estimate their total yearly car insurance payments. The hypotheses related to this question were that (1) a majority of college students do not pay for their own car insurance and (2) those that do pay for their own car insurance would later rank reduced auto insurance premiums higher on the list of benefits of self-driving vehicles than students who do not pay for their own auto insurance.

The next question asked to rank the importance of five benefits to self-driving vehicles: increased safety, decreased car insurance premiums, increased mobility, less gasoline consumption, and less traffic. As stated above, one hypothesis was that those who paid for their own auto insurance would rank reduced premiums higher on their list of importance. To add on to this hypothesis, those that do not pay for their own car insurance would more likely favor increased safety, mobility, and traffic. Parents that pay for their child's car insurance may be more likely to pay for their child's gas, making those respondents more likely to rank decreased gas usage lower on their list. I predict that increased safety will be the number one benefit to students as drunk driving is an issue in the U.S. that affects most individuals, whether it be personally or through media awareness.

The next two questions of the survey are open-ended and ask students to explain the benefits and drawbacks of self-driving cars, respectively. These questions were meant for students to express attitudes, opinions, and concerns that may not have already been addressed in the previous questions. These questions were put in place in order to allow students to share their thoughts and opinions, which may have not been addressed in the literature review. The other purpose of open-ended responses was to help answer what about autonomous vehicles needs to develop or change before the demand will be high among college students.

Questions twelve through sixteen asked respondents to indicate under what conditions they would use a self-driving vehicle. These conditions included the degree of the following: increased safety, reduced premiums, increased mobility, less gas, and less traffic. A question above ranked these five benefits, however this area of the survey pinpoints respondents' exact needs in order to use a self-driving vehicle. For instance, the first of this set of questions asked the percentage of car accidents in the U.S. that needed to be guaranteed to be prevented in order for the respondent to be interested in self-driving vehicles. The responses to this question would also determine the demand for self-driving technology along the continuum of self-driving technology from complete human control to complete computer control because the closer this technology is to the latter, the higher the percentage of car accidents prevented. The hypothesis was that at least 50% of car accidents must be prevented, as self-driving technology is such an expansive change and would not be worth all the legal, insurance, and other implications without a guarantee of increased safety. The next question asked the percentage discount on auto insurance premiums needed to be guaranteed in order for respondents' interest in self-driving vehicles. As explained above, those that pay for their own auto insurance premiums will likely favor a larger reduction in premiums than those respondents that have their premiums paid for them by their parents. A significant difference in the percentage reduction between the two groups was hypothesized. The next question asked exactly where on the continuum from human control to complete computer control respondents would be interested in this technology. The purpose of this question was to see if students are interested in a car with complete computer control, or if they want the option to be able to drive the car themselves. This will undoubtedly affect the insurance because if the latter is most in-demand, then insurance needs to be able to cover both when the driver is in control and when the car is in control. The option to alternate between human and computer control will also affect other variables, such as safety, as the total frequency and severity of car accidents may not change much if individuals are not taking full advantage of total computer control.

The last two questions of this section deal with the reduction in gas and traffic needed to guarantee students' interests in self-driving technology. As indicated above, it was predicted that those students who pay for their own car insurance will favor higher reductions in gas than those who have their insurance premiums paid for them because they are more likely to pay for more of their gasoline. An underlying variable here could be that those who do not pay for their own gasoline may be more environmentally-conscious, so they may not see a reduction in gas from an economic standpoint, but from a green one. Last, the commute time reduction will rely on students' current driving habits.

Question seventeen of the survey asked respondents how likely they would be to buy a self-driving car if all conditions in questions twelve through sixteen were met. The hypothesis here is that most people would say would be very likely to buy a self-driving car if all of their conditions were met. Those that respond unfavorably of the purchase of self-driving vehicles may love their current car, have economic barriers not to purchase one, or may not realize the benefits of self-driving cars. This question was important because it will show those respondents that are against self-driving technology in general and why.

The next question asked students what percentage of the time they could see themselves using the self-drive feature considering commutes to school and work and drinking and driving. This question was important because it added a perspective of how often students will want to use the self-drive feature versus human control. The amount of time that students currently spend in traffic or searching for a designated driver may have affected their responses. The hypothesis was that students will want to use a self-drive feature more than 75% of the time, given the car meets their conditions above. Although college students may not be commuting off-campus regularly, they would favor a safe ride to bars off campus and commuting to and from their hometowns on long weekends and holidays.

The next question asked respondents how much more they would be willing to pay for a car with self-driving capabilities. Without a doubt, their current and expected car-purchasing habits will affect this response[11]. It was expected that most students would be conservative in

[11] This area is addressed in the Limitations Section of this paper as it is difficult for respondents to estimate their future driving habits into the future, without a frame of reference.

their estimates here because they do not have full time jobs yet. The answers to this question were important because they indicated when respondents are willing to purchase a self-driving vehicle. If cars with autonomous capabilities are more expensive than cars without these capabilities, then the demand may be weak. That would indicate that the prices of the cars would have to come down, through mass production due to demand from other demographic groups, before these students would be willing to buy them. Although prices for driverless cars may be higher, the frequency of repair costs would be lower because of increased safety, but the severity of repair costs could be more expensive because of the cost to repair this new technology.

The last section of questions asked respondents to give demographic information such as age, class year, gender, major, minor, home country and state (if from the U.S.). It also asked if students have had experience in the insurance industry. I expected that most students in AM422 would have had some experience in insurance and that very little to no one in the STAT 201 would have had experience in the insurance industry.

Overall, it was predicted that college students will be receptive to self-driving cars. As a demographic with few current expenses, it was believed that reduced premiums and gasoline costs will not be as important as benefits such as increased safety and mobility. It was expected that decreased commute times to be less important than safety and mobility, but more important than reduced premiums and gasoline. Another belief was that students would want to see drastic benefits before they consider using a self-driving vehicle due to the possible drawbacks. It was predicted that many of the younger respondents may not take into consideration the legal liability issues concerning self-driving vehicles or that auto insurance will have to change if there is demand. However, it was predicted that most students will want to purchase and use a self-driving vehicle if their desired conditions can be met.

SURVEY RESULTS

Tables 1 and 2 show the demographics of the survey respondents. Key things to note are that about 60% of the respondents were female and 37.5% were male. According to Bryant University website, 41% of students are female, 59% male. This may indicate that our sample was not representative of the entire Bryant student body. However, gender was not a significant factor when compared to students' indicated driverless car usage. The average age of respondents was 20.085. Out of our survey sample, 56.25% were actuarial majors. None of the respondents were actuarial minors. All but one of the respondents were from the U.S.[12] As for home state, 34%, 27%, and 20% of American citizens were from Massachusetts, Connecticut, and Rhode Island, respectively. 50% of respondents were freshmen, 44% were seniors, and 6% were juniors. This shows that the survey was not representative of all classes at Bryant, but that is because we wanted to compare actuarial majors and those with experience in the insurance industry versus the general population. 69% of respondents have not had experience in the insurance industry. 50% of the students took the survey in Life Contingencies II whereas 48% of students took the survey in Writing Workshop[13].

Table 1
Summary of the Key Demographics of Respondents

Demographics		
Gender	62.5% Female	37.5% Male
Major	56.25% Actuarial	43.75% Non-Actuarial
Car Value	10.42% Expensive	89.58% Not Expensive
Insurance Experience	31.25% Insurance Experience	68.75% No Insurance Experience

[12] The respondent who was not from the U.S. was from Russia.
[13] One student chose the "other" category for the class he/she took the survey in, but failed to indicate which class.

Table 2
Respondents by State of Residence

State	Number of Respondents
CA	1
CT	12
MA	15
ME	2
NJ	2
NY	2
RI	9
SC	1
Blank	3
Total	47

Please note that there were 48 respondents. The reason why n is relatively small was that we wanted to compare actuarial majors in their senior year, in order to ensure they have had experience with insurance in the classroom and potentially during an internship, versus the Bryant students in general most likely did not have insurance experience. Furthermore, the availability of non-parametric tests allowed for analysis with a smaller n, since normality is not a requirement. Therefore, this paper mainly used non-parametric tests.

More than 60% of respondents drive at least once a week, showing that they are a group that is familiar with driving. The second question asked about the car the student currently drove. As expected, students drive a variety of different types and years of cars. About 20% of respondents pay for their own car insurance. I will later show whether or not there is a statistically significant difference in the ranking of the decreased insurance premiums benefit among those that pay for their own car insurance and those who do not. While only 20% of students pay for their own car insurance, over 35% claimed that they knew how much their auto insurance costs per year. These eighteen respondents who claimed they knew that yearly cost of their car insurance had a range of responses from $600 to $2600. The average yearly cost of auto insurance among respondents is $1233[14].

As shown in the following table, the benefit of increased safety had the highest ranking with a mean of 1.92. The lowest ranking was the benefit of less traffic with a mean of 3.55. All five categories were each ranked the best and worst benefits by respondents. The comparison section of this paper shows that there were statistically significant differences in rankings of these five categories.

Table 3
Summary of Benefit Rankings

Statistic	Increased Safety	Decreased insurance premiums	Increased Mobility	Less gas	Less traffic
Min Value	1	1	1	1	1
Max Value	5	5	5	5	5
Mean	1.92	3.06	3.24	3.22	3.55
Variance	1.74	1.39	2.15	1.64	1.67
Standard Deviation	1.32	1.18	1.47	1.28	1.29

Please note that the students ranked each benefit from most to least important. Therefore a higher- ranked benefit had a lower score.

The open-ended responses allowed for psychological analysis of attitudes toward self-driving cars. 62.5% of students had concerns about the safety of autonomous vehicles, especially with regards to technology malfunctions. Many of these respondents believed that humans are more reliable than technology when it comes to driving a vehicle. Almost 30% of respondents expressed hesitation toward self-driving cars because of distrust of other drivers.

[14] A response of $40 was deleted since it was not a realistic amount of car insurance to pay each year.

In general, these respondents believed that autonomous vehicles would make society more reliant on technology than it is now, which was viewed as a lazy behavior. What was interesting is that cars are already starting to become self-correcting with features such as blind spot monitoring and forward crash prevention, yet respondents showed an overall distrust of the technology. It was also interesting that nearly 15% of respondents expressed distrust of both technology and human drivers. These people were hesitant to believe that autonomous vehicles were safer than human-controlled cars, yet they also expressed feelings that humans are not to be trusted with driving, either. Clearly, respondents were weary about both the technology and how consumers would respond to it.

About 10% of the respondents expressed concerns about self-driving cars because of the fact that there are people who enjoy driving. As suggested by the literature review, those that drive more expensive cars than the average may be more likely to enjoy driving and therefore may have a weaker demand for autonomous vehicles. The survey analyses section of this paper shows that there was no relationship between current car values and indicated driverless car usage. In the open-ended section, almost 20% of respondents had concerns over cost. This may have been because the survey did not mention how much self-driving cars would cost. As shown in the literature review, there is still disagreement about the price of autonomous vehicles, as prices will ultimately depend on demand. Only one respondent expressed security concerns about self-driving cars. Again, this may have been because hacking was not mentioned in the introduction to the survey.

The following tables show under what conditions respondents would use a self-driving vehicle.

Table 4
Desired Conditions in Order for Respondent Purchase of AV

Change Required for AV Purchase	Increased Safety	Decreased Insurance Premiums	Decreased Gas Consumption	Less Traffic
At least 10% reduction	10.42%	12.50%	18.75%	22.92%
At least 20% reduction	20.83%	33.33%	22.92%	29.17%
At least 5% reduction	10.42%	12.50%	10.42%	12.50%
At least 50% reduction	35.42%	33.33%	31.25%	27.08%
At least 75% reduction	22.92%	8.33%	16.67%	8.33%

Table 5
Desired Condition of Increased Mobility in Order for Respondent Purchase of AV

Level of Mobility	Percentage of Respondents
Limited self-driving capabilities such as self-parking and driving in a lane with traffic up to 30 mph.	14.58%
Moderate self-driving capabilities such as self-park, driving in a lane with traffic up to 60 mph, and self-navigation through GPS.	16.67%
Complete self-driving capabilities, but the driver could switch between self-drive and human control modes.	64.58%
Complete self-driving capabilities and the driver cannot have any control over the car.	4.17%

With regards to safety, most respondents (35% of them) expressed that they would need at least 50% of accidents to be prevented. The next most popular category was that at least 75% of accidents would be prevented with 23% of respondents. These numbers proved that consumers need to believe that self-driving cars are involved in fewer accidents than human-controlled cars. If at least 50% of car accidents were prevented by self-driving cars, then over 75% of the respondents could have seen themselves using an autonomous vehicle. About one third of respondents claimed that auto insurance premiums must be discounted at least 20% in order for them to use self-driving vehicles. Another 33% of respondents claimed auto insurance premiums must be discounted at least 50% in order for them to use self-driving vehicles. Only 8% of respondents needed car insurance premiums to be discounted by at least 75% in order for them to use autonomous vehicles. Therefore, over 90% of respondents would use self-driving cars if auto insurance premiums were to be cut by 50%.

As far as mobility, 65% of students claimed that they would use a self-driving car if it had the ability to be both computer and human controlled. Only 2 students claimed they would be interested in a car that was only computer-controlled. This information showed that the demand for these cars lie in the fact that their driving can be overruled by humans in accident-prone situations. Over 50% and 80% of the respondents showed that they would use a self-driving car if it were to reduce gas by 20% and 50%, respectively. This indicated that in relation to accident prevention, the demanded percentage reduction in gasoline was relatively low. If commute times were to be reduced by 20%, 65% of respondents would be interested in using a self-driving vehicle. However, this number may be difficult to reach if the roads consist of both computer- and human-controlled vehicles.

The following table shows the likelihood that students would purchase a self-driving car, given their desired conditions concerning safety, mobility, gas consumption, traffic, and insurance premiums were met.

Table 6
Likelihood of Purchase, Given Desired Conditions Would Be Met

Likelihood	Percentage of Respondents
Very Unlikely	6.25%
Unlikely	4.17%
Somewhat Unlikely	6.25%
Undecided	12.50%
Somewhat likely	37.50%
Likely	25.00%
Very Likely	8.33%

About 70% of respondents were at least somewhat likely to use a self-driving car if the conditions in the five previous questions were met. 10% of students responded that it would be very unlikely or unlikely for them to use a self-driving vehicle, even if the benefits matched their desires in terms of reduced auto insurance premiums, commute times and gasoline and increased safety and mobility.

Question 18 asked "considering commutes to school/ work, drinking and driving, and other situations where you may want a self-driving car, what percentage of your total driving time could you see yourself using a car with complete self-driving capabilities?" The following table shows the respondent indication of self-driving car usage.

Table 7
Indicated Self-Driving Car Usage as a Percentage of Total Driving Time

Indicated Self-Driving Car Usage (as a Percent of Total Driving Time)	
Mean	42.08%
Standard Deviation	29.51%

When asked what percentage of the time students could see themselves using a self-driving vehicle, the mean was about 43% of the time with a variance of almost 9%. The range was from 0% to 100% showing that students have strong opinions about autonomous vehicles[15].

The following table shows the percentage increase respondents indicated they would be willing to pay for a self-driving car over a car without self-driving capabilities.

Table 8
Respondents' Indication of AV Purchase Price over Vehicle without Self-Driving Capabilities

Percentage Increase in AV Price	Percentage of Respondents
No purchase	12.50%
0% more	16.67%
10% more	37.50%
20% more	31.25%
Over 20% more	2.08%

When asked how much more students would be willing to pay for a car with self-driving capabilities, 38% chose "10% more", 31% chose "20% more", and 17% chose "0% more." 13%, responded that they would not purchase a self-driving vehicle.

[15] The responses "If possible I would use self-driving capabilities always. I don't like to drive" and "All of the time if it can handle driving in the snow" were changed to 100% each. Some respondents gave hours per week instead of percentages. In this case, each hour was equivalent to 10%. A midpoint was calculated for respondents that gave a range of values.

SURVEY ANALYSIS

Comparing Differences in Benefits

Anderson- Darling tests for normality proved that neither the safety nor the mobility rankings were distributed normally (p=.005 for each). Due to the fact that the safety and mobility rankings were not normally distributed, we used non-parametric tests. The Wilcoxon Signed Rank Test was used in order to determine whether or not the differences in the rankings of each were significant. Students ranked each of the five benefits[16] from most to least important. The following table shows each benefit ranking with its respective mean and standard deviation. The z-score and p-values shown in the table are the output from the Wilcoxon Signed Rank Test when each benefit ranking was compared to the number one ranking, safety.

Table 9
Summary Statistics of Benefit Rankings

Benefits	Mean	Standard Deviation	Z-score	P-value
Increased Safety	1.9375	1.3274	-	-
Decreased Insurance Premiums	3.0417	1.1843	2.8868	0.0019
Decreased Gasoline Usage	3.2292	1.2922	2.8868	0.0019
Increased Mobility	3.2708	1.4694	1.4434	0.0745
Less Traffic	3.5208	1.2881	2.8868	0.0019

As shown from the table above, increased safety was the highest-ranked benefit on average with a mean of about 1.94. The null and alternative hypotheses using the Wilcoxon Signed Rank Test are as follows:

Ho: The two populations are the same.

[16] The five benefits were increased safety, increased mobility, decreased auto insurance premiums, decreased gasoline consumption, and less traffic.

Ha: The two populations are not the same.

When increased safety was compared to increased mobility, the null hypothesis was rejected at the $\alpha = .10$ level ($p = 0.0745$) as evidence showed there was a difference between the populations of the rankings of safety and the rankings of mobility. When comparing safety to decreased premiums, decreased gas consumption, and decreased traffic, each had a p-value of .0019. We rejected the null hypothesis at the $\alpha = .10$ level as evidence showed that there was a difference between the populations of the rankings of safety to decreased premiums, decreased gas consumption, and decreased traffic. The higher p-value for the mobility ranking than the other rankings indicated that increased mobility was ranked higher than increased safety more times that any of the other variables were ranked higher than increased safety. Another explanation for this was that the increased mobility rank had the highest standard deviation. On average, respondents ranked safety at a 1.938 and mobility a 3.271 out of 5 level of importance.

Comparing Results by Gender

Next, a Mann- Whitney U Test was used for gender comparison of indicated self-driving car usage, given the students' desired conditions were met[17]. The indicated autonomous vehicle (AV) usage was given by respondents as a total percentage of driving time. We fail to reject the null hypothesis at the α=.10 level (p= .1842) as no evidence showed that there was a difference in the indicated self-driving car usage by males and females. In this case, a larger sample would have been advantageous in order to ensure confidence in the comparison. Once again, the average indicated autonomous vehicle usage by respondents was about 42%. We see here that there was not a significant difference between genders.

Comparing these results to the literature review, gender was also not significant in reducing the frequency of claims for level 1 autonomous vehicles that were equipped with Mobileye lane departure warning (LDW) and forward collision warning (FCW) systems, according to Ron Actuarial Intelligence. However, gender was important according to a study by KPMG. They noted that women were more willing to ride in a driverless vehicle, both before and after a focus group conducted by KPMG. However, the company failed to use statistical tests in order to prove whether or not these differences are significant.

[17] The MINITAB Output for the Mann- Whitney U Test for gender and AV usage is shown in Appendix B.

Comparing Results by Actuarial v. Non-Actuarial

Next, a comparison was made between indicated self-driving car usage by actuarial majors versus non-actuarial majors[18]. The null hypothesis is rejected at the α=.05 level (p= .0366) as there was evidence of a difference in the indication of self-driving car usage between actuarial majors versus non-actuarial majors. On average, actuarial majors responded they would use self-driving capabilities 50% of the time whereas non-actuarial majors would use them 30% of the time.

Another question on the survey asked respondents how much they would be willing to pay for a self-driving car versus a car without autonomous capabilities. For this question, a "1" indicated no desired to purchase an AV, "2" indicated a 0% increase in purchase price, "3" indicated a 10% increase in purchase price, "4" indicated a 20% increase in purchase price, and "5" indicated over a 20% increase in purchase price.

The purchase prices indicated by actuarial and non-actuarial majors were not distributed normally. Therefore, a Mann- Whitney U Test was used to compare the purchase price by major[19]. The null hypothesis was rejected at the α=.05 level (p= .005) as there was evidence of a difference in the indicated average purchase price of a self-driving car by actuarial majors versus non actuarial majors. Although the median indicated purchase prices for actuarial and non-actuarial majors were both three, indicating a 10% increase in purchase price, the distributions of the two groups were not the same.

Since self-driving car usage and increase in purchase price were both statistically significant, it was of interest to compare the likelihood to purchase an AV by actuarial majors

[18] The MINITAB Output for the Mann- Whitney U Test for major and AV usage is shown in Appendix C.
[19] The MINITAB Output for the Mann- Whitney U Test for major and purchase price is shown in Appendix D.

versus non-actuarial majors[20]. After asking students to rank the benefits of driverless cars and the conditions they would need to use one, the survey asked students the likelihood that they would purchase an AV. The likelihood was measured on a likert scale from 1 being very unlikely to 7 being very likely. We failed to reject the null hypothesis at the $\alpha = .10$ ($p = .34944$) level as no evidence suggested that there was a difference in the likelihood of students to buy a self-driving vehicle between actuarial and non-actuarial majors. Although the medians for actuarial and non-actuarial students were both 5.0 (i.e., somewhat likely), the test showed that the distributions between the two groups are not the same.

[20] The MINITAB Output for the Mann- Whitney U Test for major and likelihood to buy is shown in Appendix E.

Comparing Results by Current Car Value

A hypothesis generated by the literature review was that those who currently drive expensive cars will be less likely to use a self-driving vehicle than those with inexpensive cars because the former are more likely to enjoy driving and are used to luxurious vehicles. The cars of respondents were appraised through the use of Kelley Blue Book. The car appraisal process was a limitation to this study as many factors were estimated in the process. Therefore, the results of this section should be used with caution.

The distribution of car values among respondents did not follow a normal distribution. Next, regression was used in order to see if there was a relationship between a respondents' car value and their indicated self-driving car usage[21]. With a p-value of .96, the regression output showed that there was no evidence of a relationship between car values and indicated self-driving usage. However, these statistics should be used with caution because of the amount of estimation that went into appraising the cars. In order to improve the study, the survey should have asked more questions about the students' cars in order to more accurately value their cars[22]. Since the regression slope was 0 and the p-value was relatively high, it is unlikely that increasing the n would yield different results.

[21] The MINITAB output for the regression of car value v. usage is shown in Appendix F.
[22] Refer to limitations section to see car appraisal process in detail.

Comparing Results by Insurance Experience v. No Insurance Experience

Since some of the results for comparison of actuarial versus non-actuarial majors were statistically significant, it was of interest to compare by insurance experience versus no insurance experience. Indicated self-driving car usage was compared by students who have had experience in the insurance industry, such as an internship, versus those who have not[23]. We failed to reject the null hypothesis at the $\alpha=.10$ level ($p=.6627$) as there was no evidence that there was a difference in indicated self-driving car usage between those with insurance experience and those without insurance experience. The median of the insurance group was 40% and the median for the no insurance experience group was 50%, however this difference was not significant.

[23] The MINITAB output for the Mann- Whitney U Test between AV usage and insurance experience v. none is shown in Appendix G.

Comparison by Age

Since there were differences between actuarial majors versus non-actuarial majors, regression was used in order to investigate if there was a relationship between age and indicated self-driving usage[24]. All of the actuarial majors were either juniors or seniors and all of the non-actuarial majors were freshmen. Therefore, the variables of major and age could have been confounded. From the regression, there was evidence of a relationship between age and indicated AV usage at the α=.05 level (p= .015). A regression was also run on age and indicated purchase price[25]. There was also evidence of a relationship between age and how much respondents were willing to pay at the α=.05 level (p= .005). Therefore, the variables of age and major may have been confounded.

[24] The MINITAB output for the regression by age and AV usage is shown in Appendix H.
[25] The MINITAB output for the regression by age and indicated purchase price is shown in Appendix I.

Comparison by Respondents Who Currently Paid for their Auto Insurance v. Those Who Did Not

One of the hypotheses was that students who paid for their own auto insurance would rank decreased auto insurance premiums higher on the list of benefits than those who currently did not pay for their own auto insurance. Those who did not pay for their auto insurance premiums may not have fully understood the financial burden monthly payments may be. A Mann- Whitney U Test was performed in order to see if there was a difference in the rankings of decreased auto insurance premiums for those who currently pay for their own auto insurance and those who do not[26]. We failed to reject the null hypothesis at the $\alpha= .10$ level ($p=.5691$) as no evidence showed a difference in the ranking of decreased auto insurance between those who currently paid[27] for auto insurance versus those who did not.

[26] The MINITAB output for the Mann- Whitney U Test of decreased auto insurance ranking and those who currently paid for auto insurance v. those who currently did not is shown in Appendix J.
[27] Currently paid indicates that the students paid for auto insurance at the time the survey was taken.

LIMITATIONS

A limitation to the survey was that it was difficult to distinguish between increased safety and increased mobility. Drunk driving could be categorized under both. For instance, if students were concerned about getting a safe ride to a bar, their answers would rely on their interpretations of safety and mobility. A student may have ranked safety as a high benefit because they would not have worried about accidents due to drunk driving. Similarly, a student may have ranked mobility high on the list of benefits since autonomous vehicles would eliminate students' needs to find designated drivers. Although both students would be concerned with the avoidance of drinking and driving, their interpretation of the words "safety" and "mobility" may have affected how they ranked those benefits.

Another limitation to the survey was the amount of time spent driving. Currently, students spend varying amounts of time driving each day as compared to themselves and other drivers. It was almost impossible for students to predict their driving habits ten years, or even five years down the road. This affected the answers to the question asking what percentage of the time students saw themselves using a self-driving vehicle.

The lack of a clear prediction of a cost of self-driving cars was also a limitation to the survey and analysis. Although cars may be more expensive at first because of the new technology, prices are expected to come down, as with all mass production. Also, although prices for the cars may be higher, the frequency of repair costs would be lower because of increased safety, but the severity of repair costs could be more expensive because of the cost to repair this new technology. The survey only allowed students to choose how much *more* they would be willing to pay for a self-driving vehicle, although in reality autonomous vehicles could be less expensive than their counterparts in the future.

Another limitation was the fact that the survey only asked respondents about their car's make, model, and year. In order to appraise a car using online car value calculators, other inputs, such as mileage, trim, and style, were needed. For each car, I chose the "standard equipment" and "sell to a private party" options. To appraise the cars on Kelley Blue Book I used two methods depending on two different cases. Case 1: the year, make, and model of a car would lead to at most 4 styles of cars. The price of each car was found by choosing "good" as the condition because 54% of cars are rated as "good" by Kelley Blue Book. Case 2: the year, make, and model of a car would lead to more styles of cars. Since it would take a significant amount of time to appraise each style individually, the value of the base style (no extra features) was used and "excellent" was chosen as the condition to make up for any extra features the car could have had. For the 2010 Audi, the respondent entered in "Audi" for the make and model. In this case, the base style, A3, was used. This yielded 3 different styles, whose prices were averaged. "Excellent" was used for the condition to make up for the fact that the respondent could have had an Audi that had more features than the base style. For the 2004 Volkswagen Beetle, Kelley Blue Book prompted to choose a category, hatchback or convertible. The base car and excellent condition were used for each the average of the two category's values were taken. A similar methodology for cars with similar procedures. Since there was a relatively high amount of estimation that went into calculating the value of each car, the regression output comparing current car value to self-driving car usage should be used with caution.

Another limitation to this study was that demand was not measured among elderly people. Without a doubt, the potential for increased mobility among the Baby Boomer generation is one of the greatest benefits. The demand for autonomous vehicles by the elderly population was not estimated in this study. Without knowing the exact time frame when self-driving cars will be brought to market, it is difficult to assess the elderly population would be and if their opinions on this technology would change by the time their driving would be affected by old age.

Last, a small n was another limitation of this survey. Although non-parametric tests allowed the analysis of distributions that were not normal, when comparison was made, the small n was problematic. If the n was increased, some of the comparisons may have shown statistically significant results. A small n also prohibited cross-section analysis. For instance, a comparison by gender and major was not appropriate since the n was not sufficient.

INDUSTRY IMPACT

In order to use the survey results and findings from the literature review to assess the insurance industry impact, assumptions were established. First, this paper assumed a 20% increase in price of a driverless car over one that does not have autonomous capabilities. According to the Eno Center for Transportation, driverless cars will cost $10,000 more with 10% self-driving car usage. This $10,000 will decrease over time in order to sell to a broader market as cars marketed to the middle class will be produced. Moreover, economies of scale will help this price to be reduced. Last, if the government does subsidize automakers that produce driverless cars, the cost of research and development will not fully be passed onto the customer.

The second assumption was that the cars will need to be shown to be safer than cars without autonomous capabilities. According to the survey, safety was the most important benefit to self-driving cars and needed the highest amount of change in order for students to indicate a willingness to use driverless cars. Research suggested that driverless cars will be safer than cars today. For instance, Ron Actuarial Intelligence found that vehicles equipped with Mobileye forward collision warning and lane departure warning had a 45% reduction in frequency of claims that cars without this technology. The Eno Center for Transportation noted 211,000 and 4.22 million crashes avoided each year with 10% autonomous vehicle usage and 90% autonomous vehicle usage, respectively.

Given our assumptions, made estimates on driverless car usage. Of our Bryant University respondents, 18.75% indicated they were either likely or very likely to purchase these cars and pay at least 20% more for them than cars today. The survey sample had an average of 42% usage of self-driving cars. It is important to note here that the driving frequency among potential self-driving cars is about the same as all drivers[28]. Multiplying these numbers together, we predicted that 7.85% of all cars would be driverless in the early adoption stage. This early adoption stage was based on our survey results, and therefore relied on college students' opinions of self-driving cars in March of 2015. Of course, when self-driving cars are closer to market, more media awareness of driverless cars may change consumers' attitudes toward self-driving technology. It is important to note that this 7.85% is relatively close to the 10% suggested by Warren Buffet in his interview with CNBC (*Warren Buffett on self-driving cars, "bad for our insurance business, 2015)*. He argued that there would be less than a 10% market penetration by 2030. Additionally, the Eno Center for Transportation noted a 10% driverless car usage in its first stage.

The demand for driverless cars in the next fifteen years is a factor of the technology available, cost, legislation, and liability. First, the technology available will dictate what consumers can and cannot expect in driverless cars. Technology may also affect the legislation of autonomous vehicles. The cost of driverless vehicles will determine whether they are marketed toward consumers who have history with luxury vehicles, or if they are geared to middle class America. As previously mentioned, the cost of self-driving vehicles will decrease over time in order to market to a broader audience. Economies of scale will also allow prices to decrease. Last, government subsidies may decrease the effect of the cost of production on the purchase price paid by the consumer. Legislation will deem the rules on how driverless cars can be used on the road. It will also determine where and how these cars

[28] The survey asked how often students drove on a weekly basis. 1 indicated "every day," 2 indicated "4- 6 times per week," 3 indicated "1-3 times per week," 4 indicated "Only when I am home on long breaks," and 5 indicated "Never." The entire survey sample had an average of 3.020833 whereas those that were defined as potential self-driving car users had an average of 2.95122.

can be sold. As of May 2015, the testing of self-driving cars is legal in only four states[29] and Washington D.C. The sale of autonomous vehicles is prohibited in the U.S. Therefore, legislation must be made in order to keep pace with the technology. Last, liability is a factor to the demand for self-driving cars. Liability is important for insurance purposes as it will dictate the rules up front on how to settle lawsuits and claims. If liability laws are not to auto makers' likings, they may halt driverless car production.

One of the main measurements insurance companies use to evaluate profitability is a loss ratio, which is defined as claims paid divided by premiums collected. For auto insurance business, this number tends to be around 60-70%. If insurance companies want to hold loss ratios constant, they will decrease their premiums proportionately to the amount that claims decrease. The loss ratio is contingent on the frequency and severity of claims. With 10% of the market using self-driving vehicles, the frequency of claims will decrease 4.5%[30]. The Eno Center of Transportation noted 1,100 lives saved due to driverless cars, assuming 10% driverless car usage. Currently, about 34,000 people die each year due to car accidents according to the NHTSA. Therefore, the severity of death claims will decrease about 3.23%. Both the severity and frequency of auto insurance claims will decrease exponentially as more people adopt driverless vehicles.

Overall, the results from the study conducted at Bryant University paired with existing research showed that with 10% autonomous vehicle usage, the insurance industry should expect about a 3- 4.5% decrease in their auto claims. For those that do adopt self-driving cars,

[29] The four states that allow the testing of self-driving cars are California, Florida, Michigan, and Nevada.
[30] Ron Actuarial Intelligence noted a 45% decrease in vehicles with LDW and FCW. At a 10% usage, the decrease in frequency of claims is 4.5%.

they should expect about a 30- 45% discount on their premiums[31]. Our findings are not far off from those of Celent Research who predicted a 5% and 4% decline in auto liability premium and physical damage, respectively (Larino)[32].

Overall, driverless cars are an exciting topic in the insurance world. As technology companies and automakers continue research and development of these autonomous vehicles, insurance companies must begin to analyze the implications of this on their business. Insurance companies must use legislation of self-driving cars to predict patterns of claims and help decide the liability under certain conditions. Although a decrease in frequency of claims is evident, the severity of claims is yet to be agreed upon by existing literature. This paper used preliminary research at Bryant University to assert that insurance companies can see about a 3.23% decrease in claims due to car accidents as driverless cars are adopted by 10% of the U.S. Those that do make the switch to self-driving vehicles will note a 30- 45% decrease in their premiums.

[31] This figure represents portions of auto insurance that directly has to do with driverless cars. Thus, coverages such as theft and window are not expected to have an effect.
[32] Celent predicts this decrease between 2012 and 2017.

APPENDICES

Appendix A – Self-Driving Car Capstone Survey

Self-driving Car Capstone Survey

Q10 Thanks for taking this short survey, which will be used on a Senior Honors Capstone Project. Your responses are appreciated!

Q1 Technology companies like Google and nearly every major car manufacturer are researching and testing self-driving vehicles. Self-driving cars boast benefits such as increased safety, lower insurance premiums, less gas demanded, less traffic, and increased mobility for the old, young, handicapped, or impaired by alcohol/ drugs. Since the car will control the movement and decision-making of the car, the liability of accidents may change from the driver to the auto manufacturer. Subsidies or special incentives by the government may be needed in order for auto manufacturers to take on the risk that this technology could bring.

Q2 How often do you drive?
- ❍ Everyday. (1)
- ❍ 4-6 times a week. (2)
- ❍ 1-3 times a week. (3)
- ❍ Only when I am home on long breaks. (4)
- ❍ Never. (5)

Q3 What type of car do you drive?
Make (1)
Model (2)
Year (3)

Q4 Do you pay for your own car insurance?
- ❍ Yes (1)
- ❍ No (2)

Q5 Do you know the cost of your car insurance within $100 per year?
- ❍ Yes (1)
- ❍ No (2)

Answer If Do you know the cost of your car insurance within $100 per year? Yes Is Selected
Q6 Please indicate how much your car insurance costs per year (within $100).

Q7 Please rank the following benefits to owning a self-driving car from most important to least important (1= most important, 5= least important)
______ Increased Safety (1)
______ Decreased insurance premiums (2)
______ Increased Mobility (3)
______ Less gas (4)
______ Less traffic (5)

Q8 Do you believe that self-driving cars are good for the general public? Why or why not?

Q9 At this point, what potential drawbacks do you see pertaining to self-driving cars?

Q11 For questions 12 through 16, please indicate under what conditions you would use a self-driving vehicle.

Q12 Safety
- ❍ If at least 5% of car accidents in the U.S. could be prevented. (1)
- ❍ If at least 10% of car accidents in the U.S. could be prevented. (2)
- ❍ If at least 20% of car accidents in the U.S. could be prevented. (3)
- ❍ If at least 50% of car accidents in the U.S. could be prevented. (4)
- ❍ If at least 75% of car accidents in the U.S. could be prevented. (5)

Q13 Insurance Premiums
- ❍ If your auto insurance premiums were discounted by at least 5%. (1)
- ❍ If your auto insurance premiums were discounted by at least 10%. (2)
- ❍ If your auto insurance premiums were discounted by at least 20%. (3)
- ❍ If your auto insurance premiums were discounted by at least 50%. (4)
- ❍ If your auto insurance premiums were discounted by at least 75%. (5)

Q14 Mobility
- ❍ If cars were to have limited self-driving capabilities such as self-parking and driving in a lane with traffic up to 30 mph. (1)
- ❍ If cars were to have moderate self-driving capabilities such as self-parking, driving in a lane with traffic up to 60 mph, and self-navigation through GPS. (2)
- ❍ If cars were to have complete self-driving capabilities, but the driver could switch between self-drive and human control modes. (3)
- ❍ If cars were to have complete self-driving capabilities and the driver cannot have any control over the car. (4)

Q15 Less gas
- ❍ If fuel usage would be reduced by 5%. (1)
- ❍ If fuel usage would be reduced by 10%. (2)
- ❍ If fuel usage would be reduced by 20%. (3)
- ❍ If fuel usage would be reduced by 50%. (4)
- ❍ If fuel usage would be reduced by 75%. (5)

Q16 Less traffic
- ❍ If commute times would be reduced by 5%. (1)
- ❍ If commute times would be reduced by 10%. (2)
- ❍ If commute times would be reduced by 20%. (3)
- ❍ If commute times would be reduced by 50%. (4)
- ❍ If commute times would be reduced by 75%. (5)

Q17 If these conditions in questions 12- 16 were met, how likely would you be to buy a self-driving car?

- Very Unlikely (1)
- Unlikely (2)
- Somewhat Unlikely (3)
- Undecided (4)
- Somewhat Likely (5)
- Likely (6)
- Very Likely (7)

Q18 Considering commutes to school/ work, drinking and driving, and other situations where you may want a self-driving car, what percentage of your total driving time could you see yourself using a car with complete self-driving capabilities?

Q19 How much more would you be willing to pay for a car with self-driving capabilities?

- I would not buy a self-driving car. (1)
- 0% more (2)
- 10% more (3)
- 20% more (4)
- Over 20% more (5)

Q20 Age

Q21 Gender

- Male (1)
- Female (2)

Q22 Major(s)

Q23 Minor(s)

Q24 Home Country

- U.S. (1)
- Other (2)

Answer If Home Country U.S. Is Selected

Q25 State

- ❍ AL (1)
- ❍ AK (2)
- ❍ AZ (3)
- ❍ AR (4)
- ❍ CA (5)
- ❍ CO (6)
- ❍ CT (7)
- ❍ DE (8)
- ❍ FL (9)
- ❍ GA (10)
- ❍ HI (11)
- ❍ ID (12)
- ❍ IL (13)
- ❍ IN (14)
- ❍ IA (15)
- ❍ KS (16)
- ❍ KY (17)
- ❍ LA (18)
- ❍ ME (19)
- ❍ MD (20)
- ❍ MA (21)
- ❍ MI (22)
- ❍ MN (23)
- ❍ MS (24)
- ❍ MO (25)
- ❍ MT (26)
- ❍ NE (27)
- ❍ NV (28)
- ❍ NH (29)
- ❍ NJ (30)
- ❍ NM (31)
- ❍ NY (32)
- ❍ NC (33)
- ❍ ND (34)
- ❍ OH (35)
- ❍ OK (36)
- ❍ OR (37)
- ❍ PA (38)

- ❍ RI (39)
- ❍ SC (40)
- ❍ SD (41)
- ❍ TN (42)
- ❍ TX (43)
- ❍ UT (44)
- ❍ VT (45)
- ❍ VA (46)
- ❍ WA (47)
- ❍ WV (48)
- ❍ WI (49)
- ❍ WY (50)

Answer If Home Country Other Is Selected

Q26 Please enter your (non-U.S.) home country

Q27 Class Year
- ❍ Freshman (1)
- ❍ Sophomore (2)
- ❍ Junior (3)
- ❍ Senior (4)

Q28 Have you had experience in the insurance industry (i.e, internship)?
- ❍ Yes (1)
- ❍ No (2)

Q29 What class are you currently taking this survey in?
- ❍ Math 422 (Life Con II) (1)
- ❍ WRIT 106 (Writing Workshop) (2)
- ❍ Other (3)

Answer If What class are you currently taking this survey in? Other Is Selected

Q30 If you selected "Other", please specify which class:

Appendix B- MINITAB Output for Mann- Whitney U Test of Indicated AV Usage by Gender

Mann-Whitney Test and CI: AV Usage_F, AV Usage_M

```
             N  Median
AV Usage_F  30  0.5000
AV Usage_M  18  0.3000


Point estimate for ETA1-ETA2 is 0.1500
95.1 Percent CI for ETA1-ETA2 is (-0.0500,0.3001)
W = 797.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.1867
The test is significant at 0.1842 (adjusted for ties)
```

Appendix C- MINITAB Output of the Mann-Whitney U Test for AV Usage by Major

Mann-Whitney Test and CI: AV Usage_Actuarial, AV Usage_NonAct

```
                     N  Median
AV Usage_Actuarial  27  0.5000
AV Usage_NonAct     21  0.3000


Point estimate for ETA1-ETA2 is 0.2000
95.2 Percent CI for ETA1-ETA2 is (-0.0000,0.4000)
W = 762.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0377
The test is significant at 0.0366 (adjusted for ties)
```

Appendix D- MINITAB Output of the Mann-Whitney U Test for Purchase Price by Major

Mann-Whitney Test and CI: Purchase Price_Act, Purchase Price_NotAct

```
                        N  Median
Purchase Price_Act     27   3.000
Purchase Price_NotAct  21   3.000


Point estimate for ETA1-ETA2 is 1.000
95.2 Percent CI for ETA1-ETA2 is (-0.000,1.000)
W = 791.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0073
The test is significant at 0.0050 (adjusted for ties)
```

Appendix E- MINITAB Output of the Mann-Whitney U Test for Likelihood to Buy by Major

Mann-Whitney Test and CI: Likelihoodtobuy_Act, Likelihoodtobuy_NotAct

```
                         N  Median
Likelihoodtobuy_Act     27   5.000
Likelihoodtobuy_NotAct  21   5.000


Point estimate for ETA1-ETA2 is -0.000
95.2 Percent CI for ETA1-ETA2 is (0.000,1.000)
W = 701.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.4117
The test is significant at 0.3944 (adjusted for ties)
```

Appendix F- MINITAB Output of Regression Analysis on AV Usage vs. Respondents' Current Car Values

Regression Analysis: AV Usage versus Car Value

```
The regression equation is
AV Usage = 0.425 + 0.000000 Car Value


Predictor         Coef     SE Coef     T      P
Constant      0.42503     0.06705  6.34  0.000
Car Value  0.00000037  0.00000732  0.05  0.960


S = 0.300500   R-Sq = 0.0%   R-Sq(adj) = 0.0%


Analysis of Variance

Source          DF       SS       MS     F      P
Regression       1  0.00023  0.00023  0.00  0.960
Residual Error  46  4.15382  0.09030
Total           47  4.15405


Unusual Observations

Obs  Car Value  AV Usage     Fit  SE Fit  Residual  St Resid
 14      19972    1.0000  0.4324  0.1044    0.5676      2.01R
 15      23122    0.5000  0.4335  0.1258    0.0665      0.24 X
 37      24445    0.1000  0.4340  0.1349   -0.3340     -1.24 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Appendix G- MINITAB Output of Mann-Whitney U Test on AV Usage by Insurance Experience v. None

Mann-Whitney Test and CI: AV Usage_Ins Exp, AV Usage_NoInsExp

```
                    N  Median
AV Usage_Ins Exp   15  0.4000
AV Usage_NoInsExp  33  0.5000


Point estimate for ETA1-ETA2 is -0.0500
95.2 Percent CI for ETA1-ETA2 is (-0.2498,0.2000)
W = 347.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.6645
The test is significant at 0.6627 (adjusted for ties)
```

Appendix H- MINITAB Output of Regression Analysis on AV Usage vs. Age

Regression Analysis: AV Usage versus Age

```
The regression equation is
AV Usage = - 0.497 + 0.0462 Age


Predictor     Coef  SE Coef      T      P
Constant   -0.4973   0.3672  -1.35  0.182
Age        0.04619  0.01816   2.54  0.015


S = 0.283535   R-Sq = 12.6%   R-Sq(adj) = 10.6%


Analysis of Variance

Source          DF       SS       MS     F      P
Regression       1  0.51977  0.51977  6.47  0.015
Residual Error  45  3.61765  0.08039
Total           46  4.13742


Unusual Observations

                         AV
Obs   Age             Usage     Fit  SE Fit  Residual  St Resid
 12  27.0            0.5000  0.7497  0.1322   -0.2497     -1.00 X
 14  29.0            1.0000  0.8421  0.1671    0.1579      0.69 X
 30  19.0            1.0000  0.3802  0.0458    0.6198      2.22R
 42  18.0            1.0000  0.3340  0.0561    0.6660      2.40R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Appendix I- MINITAB Output of Regression Analysis on Purchase Price v. Age

Regression Analysis: Purchase price versus Age_1

```
The regression equation is
Purchase price = - 0.74 + 0.182 Age_1


47 cases used, 1 cases contain missing values


Predictor     Coef  SE Coef      T      P
Constant    -0.740    1.245  -0.59  0.555
Age_1      0.18198  0.06159   2.95  0.005


S = 0.961372   R-Sq = 16.2%   R-Sq(adj) = 14.4%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   8.0689  8.0689  8.73  0.005
Residual Error  45  41.5906  0.9242
Total           46  49.6596


Unusual Observations

            Purchase
Obs  Age_1     price    Fit  SE Fit  Residual  St Resid
  1   21.0     1.000  3.081   0.151    -2.081    -2.19R
 12   27.0     5.000  4.173   0.448     0.827     0.97 X
 14   29.0     3.000  4.537   0.567    -1.537    -1.98 X
 20   22.0     1.000  3.263   0.183    -2.263    -2.40R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Appendix J- MINITAB Output for Mann-Whitney U Test of Difference in Decreased Auto Insurance Rankings for Those Who Currently Paid for their Auto Insurance v. Those Who Did Not

Mann-Whitney Test and CI: Ins Prem Rank_Do Pay, Ins Prem Rank_ Do Not Pay

```
                           N  Median
Ins Prem Rank_Do Pay       11   3.000
Ins Prem Rank_ Do Not Pay  37   3.000


Point estimate for ETA1-ETA2 is 0.000
95.0 Percent CI for ETA1-ETA2 is (-1.000,1.000)
W = 246.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.5810
The test is significant at 0.5691 (adjusted for ties)
```

REFERENCES

Abkowitz, A. (2014, Sep). *Do Self-Driving Cars Spell Doom for Auto Insurers?* Business Week.

Actuarial Research on the Effectiveness of Collision Avoidance Systems: FCW & LDW. Ron Actuarial Intelligence LTD.

Anderson, J., Kalra, N., Stanley, K., Sorensen, P., Samaras, C. and Oluwatola, O. (2014). *Autonomous Vehicle Technology: A Guide for Policymakers*. RAND.

Arieff, A. (2013, July 23). *Driving Sideways.* The New York Times.

Automated Vehicles: Handing Over Control: Opportunities and Risks for Insurance. (2014). Lloyd's.

Brockman, M., & Rao, A. (2013, January 8). The Reshaping of Auto Insurance | Insurance & Technology.

Browning, J. G. (2014). *Emerging Technology and Its Impact on Automotive Litigation*. Defense Counsel Journal, 81(1), 83-90.

Bogost, I. (2014). The Secret History of the Robot Car. *Atlantic*, *314*(4), 93.

Commuting in the United States: 2009. (2009). United States Census Bureau.

D'Allegro, J. (2014). How Google's Self-Driving Car Will Change Everything.

Dudley, D. (2015). No Driver, No Problem. *AARP the Magazine.*

Driverless cars: Look, no hands. The Economist. (2013, April 20).

Hirsch, J. (2012, Oct 21). *Self-driving Cars Approaching Quickly: Features May Help Avoid Crashes, but Glitches Remain.* Chicago Tribune.

Juiliussen, E., Ph.D., and Carlson, J (2014). *Emerging Technologies: Autonomous Cars- Not If, But When*. IHS Automotive.

Fairchild, C. (2014). *Driverless Cars, a Boon for Working Moms?* Fortune.Com, 1.

Fast Approaching: Driverless Cars. (2013). *Mechanical Engineering*, *135*(5), 12- 14.

Ferreras, L. E. (2014). The Driverless City. *Civil Engineering (08857024)*, *84*(3), 52-55.

Frey, T. (2012). Driverless Highways: Creating Cars That Talk to the Roads. *Journal of Environmental Health*, *75*(5), 37-40.

Goffin, K. (2013). A future with driverless cars on the roads is one to look forward to and embrace. *Engineering & Technology (17509637)*, *8*(10), 28.

Hedli, L. (2014, Oct 13). The Good Life - Why Self-Driving Cars Will Change Retirement: Older Adults May Well Be the First to Reap the Benefits of 'Robocars'. *Wall Street Journal*.

How Autonomous Vehicles Will Shape the Future of Surface Transportation: Hearing Before the Subcommittee on Highways and Transit of the Committee on Transportation and Infrastructure. 113th Cong. 1. (2013).

Innovation UK motor survey looks at consumer views on telematics and driverless cars. (2014, Feb 23). Insurance Newslink.

Klayman, B., & Reuters. (2012). *Self-Driving Cars: A Reality by 2025?* Insurance & Technology Online.

Larino, J. (2012). *Insurance Industry Sees Future with Self-Driving Cars.* New Orleans CityBusiness.

Maney, K. (2014). *Take Your Hands Off the Wheel of Death.* Newsweek Global, *163*(17), 52-53.

Mui, C., Boyle, M., & McMahon, C. (2014). How auto tech will alter I.T. *Insurance Networking News, 17*(03), 10.

Murray, R. (2007). Driverless cars. *Control & Automation*, *18*(3), 14-17.

O'Donnell, A. (2012, May 8). *Prepare for Deep Auto Insurance Premium Drop Scenario, Celent Report Advises*. Insurance & Technology.

Newcomb, D. (Oct 2014). *Who Should Be the Self-Driving Car's Moral Compass?* PC Magazine, 44.

Preliminary Statement of Policy Concerning Automated Vehicles. (May 2013). NHTSA.

Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers, and Policy Recommendations. (Oct. 2013). AASHTO Journal.

Reichman, M. (2013). *A Future with Driverless Cars on the Roads is Not One to Look forward to and Embrace*. Engineering & Technology *(17509637)*, *8*(10), 29.

Self-Driving Cars: Are We Ready? (2013). KPMG.

Self-Driving Cars and Insurance (Sept 2014). III.

Self-Driving Cars: The Next Revolution. (2012). KPMG.

Stock, K. (2014, April 3). *The Problem With Self-Driving Cars: They Don't Cry*. BusinessWeek.

Swanson, A. R. (2014). *Somebody Grab the Wheel!: State Autonomous Vehicle Legislation and the Road to a National Regime*. Marquette Law Review, *97*(4), 1085-1147.

Tuttle, B. (2013). *Consumers Love the Idea of Self-Driving Cars For One Reason*. Time.Com, 1.

Thom, P. R., & Logsdon, T. A. (2010). *The Art of Stopping*. Claims.

Thrun, S. (2010). *Toward Robotic Cars.* Communications of the ACM, *53*(4), 99-106. doi:10.1145/1721654.1721679

White, J. B. (2014, August 8). *How Do You Insure a Driverless Car?* Wall Street Journal - Eastern Edition. pp. B1-B2.

Wright, A. (2011). *Automotive Autonomy*. Communications of the ACM, *54*(7), 16-18. doi:10.1145/1965724.1965731

Zuby, D. (Apr 2014). *The Promise and Reality of Crash Avoidance Technology*. IIHS.

90% US drivers prefer self-driving cars to save on insurance: Survey. (2013). Insurance Snapshot, 5-6.