Disruptive Innovation and the Impact
of Fully Autonomous Vehicles on the
Auto Insurance Industry

By
Michael Allen

Faculty SIP Advisor
Charles Stull, Department of Economics and Business
A Paper submitted in partial fulfillment of the requirements for the degree of Bachelor of Arts at Kalamazoo College
2015
Abstract

This piece marries the theories of microeconomics, insurance and disruptive innovation and applies them to self-driving cars in the auto insurance industry. Through a qualitative forecast of the auto insurance industry using forecasts of the impact of self-driving cars, it is predicted that large, established firms will have difficulty and may fail when dealing with all of the changes that self-driving cars will bring once they fully penetrate the automobile market. The argument is made through employing a hypothetical rate model and basic ratemaking principals. The ratemaking model is manipulated with predicted aspects of self-driving cars in mind.

Preface

I first became interested in the topic of self-driving cars during my internship over the summer of 2015. I was working for a large financial company that specialized in vehicle aftermarket insurance products, the most common being a vehicle service contract. During the internship, I assisted my management in compiling data to eventually be used in the ratemaking process for new vehicles. During this research, I stumbled on a few articles about self-driving cars, and once I found an interest, that interest developed into a passion. I really wanted to connect my internship to my senior individualized project, and this piece is the outcome of that desire.

I would like to acknowledge those who helped me in my pursuit of greater knowledge in this field. First, I thank Dr. Charles Stull, for his guidance and input throughout the creative process. He pointed me to a few sources that he thought might be
helpful as well as reassured me that the speculative nature of this piece was not damning in nature. Second, although he had no direct input on this piece, I would like to thank Dr. Clayton Christensen for his work on disruptive innovation, the centerpiece theory of this paper. Without the development of this theory, this paper would look entirely different in content. I would like to thank all those who I worked with over the summer, especially my two managers for their guidance and help. Finally, I thank my family for their constant support throughout this project and my college years.
Table of Contents

I. Introduction ................................................................................................................. 1
II. Literature Review ........................................................................................................ 3
   A. Self-driving Cars ................................................................................................. 3
   B. Auto Insurance Industry ..................................................................................... 6
   C. Disruptive Innovation Theory ............................................................................ 10
III. Analysis .................................................................................................................... 13
   A. Historical Backdrop ......................................................................................... 13
   B. Basic Ratemaking Model .................................................................................... 14
   C. Regulatory Issues .............................................................................................. 16
   D. Profit Margins of Established Firms .................................................................. 18
   E. Disruptive Innovation on the Auto Insurance Market ....................................... 19
   F. The Attacker ....................................................................................................... 22
IV. Conclusion ............................................................................................................... 24
V. Bibliography ............................................................................................................. 26
I. Introduction

Imagine a world with carbon emissions reduced, traffic-related fatalities reduced, traffic congestion reduced, commute time reduced, and auto insurance rates reduced. This world is slowly becoming a reality as companies such as Audi, Bosch, Mercedes-Benz, Delphi Automotive, Google, and Nissan have begun looking into self-driving technologies. In fact, Google already has prototypes of their self-driving car on the road. Despite this fact, some experts do not foresee full penetration of the automobile market for many years\(^1\) (if they even see it). Luckily, most experts and automakers alike do see self-driving cars as inevitable progress as being safer and more reliable than the status quo.

When making such a drastic change to one of the largest industries in the United States, it is inevitable that related industries will feel the ripples in the water. Consider everything that goes into the manufacturing and maintenance of an automobile: steel, rubber, plastic, glass, paint, skilled labor, oil, petroleum, aftermarket custom products, leather, etc. An actual list of all the related and affected industries would be exhaustive, therefore for this paper, consider only one: auto insurance.

One of the main reasons society desires self-driving cars (aka fully autonomous vehicles) is that they are believed to be inherently safer than human drivers. Auto insurance rates are nearly directly related to the likelihood of a collision (as will be

\(^1\) According to an article by Forbes (Fehrenbacher, 2015) full autonomy could be deployed by Tesla in 3 years time, and in early October of 2015 just deployed their beta autopilot. The autopilot can parallel park itself and can steer itself at highway speeds and perform lane changes.
shown later on). This is great news for consumers, for as traffic collisions decrease, the rates for auto insurance will follow suit.

While good for the consumer, this may be dangerous for established auto insurance firms. The framework theory of disruptive innovation predicts a bleak future for the largest auto insurance firms in these tumultuous times. The values of established firms do not mesh well with this emerging market. Their restrictions due to their interdependencies inhibit their mobility. Many of today’s top auto insurance firms may not survive the wave of disruptive innovation on their doorstep.
II. Literature review

This study will proactively look at a nearly inevitable future where self-driving cars are the norm and attempt to predict the impact that this market disruption will have on the auto insurance industry. To make this prediction, this study must first define self-driving cars as well as all the relevant technologies associated with self-driving cars. Next, a compelling argument will be made for the improved safety of self-driving cars. Once the argument towards the merits of self-driving cars’ safety is sound, the connection between safer cars and lower insurance rates will be made. To do so, a thorough understanding of ratemaking principles and the regulatory framework surrounding auto insurance must be attained. Following that, the connections between the microeconomics of insurance and Clayton Christensen’s work on disruptive technologies must be established. Once established, these two theories will make a forceful case for why insurance companies should worry, and how they should react to this disruption. Finally, this study will delve into the murky waters of liability, to see if any inherent changes will need to be made for auto insurance policy.

A. Self-Driving Cars

First of all, a self-driving car (synonymous with fully autonomous vehicle) is defined by Business Insider “as any car with features that allow it to accelerate, brake, and steer a car’s course with limited or no driver interaction” (Greenough, 2015). Some may separate autonomous vehicles further by what they can communicate with, like vehicle-to-vehicle (V2V) versus non V2V. V2V refers to “a system designed to transmit basic safety information between vehicles to facilitate warnings to drivers concerning impending crashes” (Harding, et al., 2014). The NHTSA, however, offers the most
sophisticated definition for self-driving cars, proposing a tiered system breaking automobiles into five different levels of autonomy. Level 0 is an automobile where the driver has complete control over the motor, brakes and everything. Level 1 is function specific or allows for 1 or more specific functions to be assisted. Level 1 includes features like electronic stability control. Level 2, combined function automation, allows for control of at least two functions to be ceded to the car. The NHTSA offers the example of adaptive cruise control in combination with lane centering. Level 3 is known as limited self-driving automation where all control is handed over to car and its programming in certain specific environments, but where control may be transferred back over to the driver with sufficient warning. Level 4 is full self-driving automation (NHTSA, 2013). Under this definition, there may not even be a steering wheel. This is the type of technology most people picture when thinking of self-driving cars, and is the definition that will be used in this piece.

Currently, no cars are available to the public that satisfy this Level 4 definition, however, automakers like BMW, Tesla, and Nissan and tech company Google are working toward bringing Level 4 cars to market. In fact, in October of 2015, Tesla rolled out an update to all of their cars enabling their new autopilot features, landing them in the Level 2 category (Fehrenbacher, 2015), which is an exciting step in the direction of full autonomy. These manufacturers have different strategies on developing the technology, but essentially the two plans are to either bring self driving technology to market incrementally the way Tesla has begun to do, or bring it to market as a fully autonomous vehicle in one go (Adams, 2015). For the purposes of this article, only the all or nothing
approach Google is taking\(^2\) will be studied and assumed, and only Level 4 autonomy will be of interest.

According to a study done by Daimler Chrysler and Mercedes Benz, the three main causes of rear end collisions are the following: “Driver’s braking reaction comes too late; driver’s braking reaction is not vigorous enough; or misinterpretation of the traffic situation by the driver, especially regarding the deceleration of the preceding vehicle” (Breuer, Faulhaver, & Gleissner). Autonomous vehicles will be able to “sense and possibly anticipate lead vehicles’ braking and acceleration decisions,” (Fagnant & Kockelman, 2015) limiting the potential for rear end collisions greatly. The anticipation factor would be present for the aforementioned V2V style cars. This is one example of many that illustrates how self-driving cars will make driving safer.

Of course, the car and specific scenarios of improved safety aren’t the main topic here, except to the extent which the Google Car increases traffic safety and lessens collisions. The likelihood of a collision goes hand-in-hand with rate making principles in the simplest form; the less likely it is that a claim will be made on each policy, the lower the cost to the insurer (Werner & Modlin, 2010). A simple model has been constructed which will later be explained in detail to demonstrate how this works. As the cost to underwrite policies decreases for the insurance companies, regulation and the invisible

\(^2\) Chris Urmson, director of the Google Car project said after allowing regular people test out the prototype car “We saw that despite being told this was a prototype, despite moving at high speed on the freeway, they were over-trusting it. We had a guy who was sitting in the front seat, he pulls out his phone charger from the back seat, then turns back again for his laptop sets it up on the seat, and does all this without looking out the windshield. The whole time the thing has been moving fast down the freeway. He believed in the technology enough that he just trusted it. And as these things get more capable we think that faith will only grow. That really worries us. That is why it is extremely tough to get from incremental improvement to full self-driving.” (Adams, 2015)
hand of the market should pull the price for the consumer down toward where supply meets demand. The price should move downward as the cost of goods sold falls. Assuming a perfectly competitive market, as costs to underwrite auto insurance policies fall, firms will adjust their prices to equal the now lower marginal costs (Varian, 2010). While the profit margins may not change, the profits themselves will decrease with a lower price.

Before this impact is felt, there must be an adoption stage for new technologies. Fagnant and Kockelman have compiled present market conditions and made predictions on safety, emissions and economic benefits yielded from autonomous vehicles at the 10%, 50%, and 90% adoption levels by market share (Fagnant & Kockelman, 2015). This study is most interested in predictions made for the 10% adoption levels, when the technology is just beginning to disrupt the market, but in some cases will refer to the other levels. At 10% adoption, they predict 1100 lives saved per year, 211,000 fewer crashes and comprehensive cost savings of $17.7 billion (Fagnant & Kockelman, 2015). They also predict 50% in cost savings for auto insurance companies from a base of $1,000 per year (Fagnant & Kockelman, 2015).

B. Auto Insurance Industry

According to a study by Lloyd’s of London shown in Figure 1, the value of the total gross premiums written by motor vehicle insurance companies in the US was over $206 billion 2013, and projected to steadily increase to $358 billion by 2025 (Lloyd's of London). Based on the lack of any sharp drops in the chart, it is clear that Lloyd’s does not foresee self-driving cars to have any significant impact on the policies being written in the next decade. Despite Lloyd’s lack of concern for self-driving cars, some insurance
companies have already expressed their concern over the potential threat to their business, which could be in the market by the 2020's (Preston, 2015).

**Gross Insurance Premium in the US by Year**

![Graph of gross auto insurance premium in the US by year]

Figure 1: The gross auto insurance premium in the US is expected to rise steadily through 2025, according to a study done by Lloyd's of London (Lloyd's of London). These projections are a historical account year-over-year of the total market premium for auto insurance from 2009 to 2013, then market forecasts from 2014 and beyond. These forecasts do not account for self-driving cars and their eventual impact on auto insurance.

In addition to industry and economic changes inherent to the disruptive technology itself, there is the matter of the law, and its response to this great change. Currently, only four states and DC have any sort of law even recognizing self-driving cars, however, other states continue to debate the issue (Davies, 2015). Even when all the law is on the books in regard to self-driving cars, there will inevitably be a second battle in the courts to refine the meaning of the word used in legislation.

The most important question to be answered by the law is who will retain liability during an accident? Cohen is convinced that companies manufacturing self-driving cars will need to be wary of product liability laws (Cohen, 2015), but what about consumers?
Fagnant (2015) is convinced that many liability issues will be guided by the handling of current day semi-autonomous technologies like drive assist or adaptive cruise control. With the frequency of collisions decreasing, will auto insurance become obsolete? There aren't any analysts predicting that self-driving cars will completely eliminate accidents, but in the event of an accident where no human drivers are involved, who is liable? Fagnant and Kockelman (2015) weigh in, predicting that autonomous vehicles manufacturers may be held liable for incidents that would be outside of human control, increasing the radius of the sphere containing all the things a company may be held liable for in the event of a collision. California may have established a standard black box style system of accountability by requiring 30 seconds of sensor data storage prior to a collision to establish fault (Fagnant & Kockelman, 2015).

Specific to Google's self-driving car and other Level 4s is the lack of any option to let a human drive the car. This leads some to believe that Google will face product liability claims, leading for the firm to seek their own insurance against these claims (Lehrer, 2014). People have been buying auto insurance for so long, they may be uncomfortable totally abandoning that form of risk mitigation, and therefore we could see a resurgence in no-fault insurance (Lehrer, 2014). No-fault insurance is actually an umbrella term for four different types of insurance: 1) Pure no-fault, where there are no tort claims for bodily harm, consumers claim damages from their own insurers and damages for pain and suffering are eliminated, 2) Modified no-fault, where consumers are provided "limited immunity from tort action" where tort action can be taken for losses above the amount recovered from coverage, 3) Choice No-fault, where consumers can elect to be held to the no-fault system or the tort system, and 4) Expanded First-Party or
Add-on Coverage, where there is no exemption from tort liability, and an injured party may sue for losses beyond what their first party coverage covers (Vaughan & Vaughan, 1972). Lehrer seems to be referring to pure no-fault, as it would be difficult to make a case that a driver of a car was at fault when there is no driver. For the purposes of this article, it will be assumed that the entire auto insurance market of the US is pure no-fault.

At first, there is potential for human misperception to adversely affect the policy writing procedure, as some people believe that without a human driver, the cars will not be as safe (Fagnant & Kockelman, 2015). As mentioned earlier, when applied to real people, the opposite seemed true, that people were too trusting of the prototype technology (Adams, 2015). It is uncertain how auto insurance companies will react compared to average people on perceptions of safety and unfortunately speculation is largely all that can be done as of now on the subject.

According to Vaughan, all states save for Illinois regulate insurance rates to some degree with the following axioms in mind: rates must be adequate to cover losses, rates must not be excessive, and rates must not discriminate unfairly (Vaughan & Vaughan, 1972). Under the broad guidelines of the introduced axioms, the states have all chosen to regulate their rates in different ways (Hunter, Feltner, & Heller, 2013). For this study, it will be assumed that because rates are not to be excessive, as the cost falls for insurance (on the firms end) the price will drop as well. Also, because firms cannot discriminate unfairly, firms must hold to practices that they would if customers were driving traditional cars instead of self-driving cars.
Further, insurance premiums are based on multiple factors, one of which is the “size and probability of loss” (Rees & Wambach, 2008). The self-driving technology is designed to lessen the frequency of accidents as well as lessen the impact of unavoidable accidents, thus lowering both the size and probability of loss. It is intuitive that a claim for a minor dent would cost less than totaling a vehicle.

C. Disruptive Innovation Theory

Referring back to Figure 1, the Lloyd’s study implicitly states what is already known: the potential market for smaller profits will not be attractive to the established firms. The Lloyd’s survey captures and inherent belief in the status quo. As disruptive innovation theory dictates, as the market for these smaller profits increases and cannibalizes the traditional auto insurance policy market, firms will most likely try to move upstream in the market, meaning they will seek out ways to mitigate any loss of market share by seeking out consumers who will pay higher prices (Christensen C., The Innovator’s Dilemma, 1997). In the insurance world, this equates to riskier customers more likely to make a claim on their policy. Christensen, the father of disruptive innovation theory, states that this move invariably creates a “vacuum” in the lower end (Christensen C., The Innovator’s Dilemma, 1997), the end less expensive to a customer, of the market, making it easier for a firm savvy with the disruptive innovation to gain market traction. Christensen (1997) postulates that this strategy will cause large firms to push up and up toward higher margins until some new entrant pushes them all the way out of the market.

After Christensen’s seminal work on disruptive innovation, many have tried to further or discredit the theory. Both Markides (2006) and then Christensen and Raynor
(2003) have tried to segment disruptive innovation into subgroups. Markides suggests that it should be segmented as radical product innovation and business model innovation, where radical product innovation is a brand new-to-the-world product or service that has enough value inherent to it to disrupt a market, where business model innovation is a new way of conducting business of old products (Markides, 2006). Christensen and Raynor merely differentiate high-end, sustaining innovations from low-end, disruptive ones. Markides segmentation is a useful description, because the two types of innovation he defines are very different in nature. For example, Netflix beating Blockbuster by directly mailing movies to their customers is very different from digital memory switching from hard-disk to flash memory.

Lucky for the established firms, Jay Paap and Ralph Katz (Paap & Katz, 2004) offer potential solutions in first anticipating and then conquering disruptive technologies. First and foremost, they suggest looking toward customer needs before looking at the technology to supposedly satisfy those needs. When self-driving cars inevitably disrupt the auto insurance market, consumers will need a cheaper policy, one that reflects their true likelihood of a claim. Christensen would counter the ease that Paap and Katz claim disruptive technology can be spotted, as he cites resource dependence,\(^3\) as an insurmountable barrier to acknowledge disruption for the danger that it is. If current customers and consumers are happy with the status quo and a firm decides to change up

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\(^3\) Originally coined by Pfeffer and Salancik (1978), resource dependence are the constraints on a company caused by their interdependencies with other firms and external factors involved in getting its product to market. Christensen considers resource dependence theory to be the phenomena in which "Customers effectively control the patterns of resource allocation in well-run companies. In the case of disruptive innovation, this equates to the difficulties of an established insurance company allocating resources toward their customers driving traditional automobiles and those driving self-driving cars. Investors might be wary of such strategy, seeing these two lines of business as ways of cannibalizing the other line."
its model, it may upset those which provide the firm its money and success. No manager wishes to displease their customer base to serve what they view as a fringe market.

Beyond resource dependence theory, there is the issue of the company’s value network, a term Christensen (1997) refers to as “the context within which a firm identifies and responds to customers’ needs, solves problems, procures input, reacts to competitors, and strives for profit.” A large firm does not normally see value in an emerging, risky, low margin market, and does not have any share of the initially niche customer base. Recall that every market must start off small, no matter how big they eventually become. If a company’s value network is only geared toward insuring traditional human-driven cars then their value network may prohibit them from writing policies for self-driving cars.

In any event, it is clear that while the exact safety benefits aren’t entirely known, self-driving cars are expected to have a tremendous overall positive impact of traffic safety, with some experts predicting self-driving cars to eventually be 90% safer than the status quo (Fagnant & Kockelman, 2015). Due to insurance regulation, as the roads become safer we can expect to see insurance rates fall as well, because rates “must not be excessive” (Vaughan & Vaughan, 1972). The market will develop a need for an insurance company that is willing to insure the self-driving cars at its initially tiny size. This arrangement is the optimal environment for disruption to occur. The impact of that disruption will be discussed in the following section.
III. Analysis

A. Historical Backdrop

Humanity has been dreaming of self-driving cars since the early 1900’s and now nearly 100 years later, automobile manufacturers and Google are well on their way to accomplishing the once impossible. The Google car, among the competitors, stands out as it constantly captures the spotlight and headlines through its development. Some experts have predicted that by 2022, self-driving cars may be commonplace (Fagnant & Kockelman, 2015). Of course, the driving force behind the development of this technology is the hope that it will lead to fewer traffic fatalities, relief of traffic congestion, carbon emissions reduction, less ownership of cars, easier city parking and more free time for those with long commutes. Time will tell if self-driving cars will benefit society the way they are expected, but for the time being it’s clear that they will have an impact on many different industries around the world.

If self-driving cars are truly safer than the status quo, the auto insurance industry will be affected. At merely 10% market adoption, 211,000 fewer collisions are estimated to occur annually, equating to $5.5 billion saved (Fagnant & Kockelman, 2015). Who normally foots that bill? Companies such as All State, State Farm, Progressive, and AAA, some of the largest insurers in the US, end up paying the bill for the claims made on the policies they offer to their customers.

From a cursory glance, the $5.5 billion in savings seems like a blessing to the insurance companies; however, in the long run self-driving cars could prove problematic for these behemoth companies. In fact, disruptive innovation theory (Christensen C. ,
The Innovator's Dilemma, 1997) would tell us that these companies are likely doomed. As this new and radical technology sweeps through industry, the large, established insurance leaders will be ill equipped to deal with the changes it brings and could fail.

B. Basic Ratemaking Model

When an insurance company is writing a policy, several factors are taken into account, such as driving record, the area they'll be driving in, the type of car they are driving, and in some cases age, sex and other ethically uncertain items to predict the likelihood that the policyholder will make a claim on their policy (Bosari, 2013). Ultimately, the actuarial team writing the policy generates a percentage likelihood that an accident will occur during the time period of the policy. The company also determines the average cost of each claim made on a policy. Therefore, they have the percent chance of an accident occurring, as well as the expected amount they will need to pay out in the event of a claim.

In this example, we have $X_1$, the event of a collision, and $X_2$, the event of no collision. With parameters $n$ and $p$, where $n$ is the number of insurance policies a company is holding and $p$ is the probability of a collision. Finally, we have the parameter $c$, or the cost that a company pays on average per accident. Therefore, one may state this association as the probability that a firm will have to pay out some cost $C$ is equal to $p$ for each policy $n$. 
\[ C \begin{cases} X_1 \text{ accident } P(X_1) = p; C = c \\ X_2 \text{ no accident } P(X_2) = 1 - p; C = 0 \end{cases} \]

\[ E(X) = \sum_{i=1}^{n} P(X_i)X_j \]

\[ E(X) = pX_1 + (1 - p)X_2 \]

\[ \text{Cost for each policy} = \frac{E(X)}{n} \]

To illustrate this simple model, let \( p = 0.02 \), let \( n = 1,000 \), and let \( c = $25,000 \). In other words, for a hypothetical insurance company with 1,000 separate auto insurance policies, there is a 2% chance that a claim will be made against any given policy. Also, the average cost of each claim is $25,000. Therefore, the average cost for each of the 1000 policies is $500. With financing costs, agent markups and other fees, suppose the total price reflected on to the consumer is $1,000. All in all, we have a price of $1,000 for an auto insurance policy in this basic model. The advantage of this basic model is that the parameters can easily be modified to reflect potential changes associated with fully autonomous vehicles, while the simplified nature of the model is a clear disadvantage.

For the purposes of this study, we shall assume that only the parameter \( p \) will be affected by self-driving cars. In reality, self-driving cars would most likely affect all the

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4 There are numerous assumptions and simplifications made here. For example, insurance companies segment their customers proactively, to charge less for the safer customers than for the more risky customers more likely to have an accident. Companies have access to a plethora of information to gauge which customers are more likely to be in accident. Because this study is not subject to any single demographic, it is more useful to look at the policies in the broadest sense.
variables in the equation. For example, with such sophisticated technology equipped to cars, the potential for \( c \) to increase exists. Another speculation is that the number of policies written and sold by auto insurance companies is subject to change, but for this study and model it will be assumed to remain constant at 1,000.

The only way to decrease the parameter \( p \) is by making claims less frequent and by doing so, making collisions less frequent. Therefore, to lower the parameter \( p \), self-driving cars must lower the collision rates for each driver. Again Fagnant and Kockelman (2015) weigh in, estimating that fully autonomous vehicles may reduce traffic collisions by up to 60\%, leading to parameter \( p \) equal to 0.008. This leads to an overall cost of writing an insurance policies to $200 per. Although the law for each state is different, almost every state incorporates language within auto insurance regulation stating that rates “are not to be excessive” (Vaughan & Vaughan, 1972). Holding profit margins, finance costs, and agent markup proportionate to status quo rates, the new rate for the consumer is now $400 under this model. In a later section, the consequences on profitability will be studied as well.

C. Regulatory Issues

The insurance industry as a whole is strictly regulated to ensure that consumers are treated fairly, and that insurance companies do not fail (Vaughan & Vaughan, 1972). How each sector of the insurance industry is regulated is unique to that sector’s need. The auto insurance industry takes on many different forms and varies from state to state.

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5 Because there are too many states to analyze fruitfully while staying on topic, this study assumes that profit margins, finance costs and agent commissions will stay at a rate proportionate to status quo. This seems to be a reasonable interpretation of the language in regulation stating that rates are not to be excessive, because the insurance companies want to earn as large a profit as they can without breaking the law.
For example, automobile insurance is segmented into liability, medical payments, and physical damage (Vaughan & Vaughan, 1972). The liability portion covers a policyholder when their vehicle causes damage to a person other than the policy holder or causes damage to other people’s property (Vaughan & Vaughan, 1972). After the liability for an accident is determined, the insurance for the policy holder determined to be “at fault” pays up to a certain amount for bodily injury or physical damage. Medical payments insurance covers the insured for a certain amount of medical expenses resulting from an accident. Finally, physical damage insurance covers the insured for the policyholders own vehicle for either comprehensive coverage or collision coverage (Vaughan & Vaughan, 1972).

With these three different spheres of coverage in mind, the concept of no-fault insurance is easier to understand. In a no-fault insurance state, the often court-settled step of determining which participant in a collision is liable is circumvented. Instead, each policyholder makes a claim on their policy (Vaughan & Vaughan, 1972). The advantage of no-fault insurance is in the circumvention of the tort system, a system many believe to be wasteful and unfair (Vaughan & Vaughan, 1972). No-fault insurance is a friendly realm of legislative framework for self-driving cars from the perspective of a general user. Assuming that every car is a Level 4, in the event of a collision it is unlikely that the fault lay with either “driver.” In cases of collisions, does that mean that whoever programmed the car that caused the accident is at fault? Some experts believe that self-driving cars will expose auto manufacturers to product-liability claims (Cohen, 2015) for this very reason.
Therefore drivers and firms alike will continue to hedge their respective risks, and there will be an environment ripe for no-fault insurance and product liability insurance. It would be absurd to lay blame on occupants of either car as cars will no longer be human operated. In addition, no company wants to be exposed to potential litigation stemming from one mistake among millions of lines of code. As elaborated on in the literature review, there are different forms no-fault insurance, and although there is potential for variations, it seems logical that pure no-fault will become reality. Insurance companies will need no-fault insurance policies to exist if they wish for their own existence to continue. The tort system, already criticized as inefficient, could not possibly serve the market’s needs with the advent of Level 4s, so without the existence of no-fault, auto insurance companies will have no policies to write.

D. Profit Margins of Established Firms

Recall that by using the previously introduced ratemaking model, the total cost for the consumer was estimated at around $400. A report by NYU found that the average profit margin for an insurance company specializing in property and casualty (before interest, taxes, depreciation or amortization, EBITDA) was 16.15% (Damodaran, 2015). This means that a company under the conditions estimated by this report may only receive $64 profit per policy written, where before fully autonomous vehicles they would have received $162. If profits per policy written were to drop from $162 to $64, insurance companies would certainly be affected.
E. Disruptive Innovation

Established auto insurance firms will suffer greatly from the impact of self-driving cars because of a phenomenon known as disruptive innovation. In his work, Christensen (1997) lays out the five principles of disruptive innovation, and firms in the auto insurance industry fall in line with all five of the aforementioned principles.

1) Companies Depend on Customers and Investors for Resources
2) Small Markets Don’t Solve the Growth Needs of Large Companies
3) Markets that Don’t Exist Can’t Be Analyzed
4) An Organization’s Capabilities Define Its Disabilities
5) Technology Supply May Not Equal Market Demand” (Christensen C., The Innovator’s Dilemma, 1997)

The first principle deals partially with resource dependence theory (RDT) which states that firms have interdependencies on external factors related to their business. These interdependencies include investors, current customers, and public opinion (Pfeffer & Salancik, 1978). For auto insurance companies in the face of disruptive innovation, their investors will scoff at any proposals to begin underwriting driverless cars, because investors want companies to stay in their specialized fields and remain somewhat safe and predictable. As the adoption of self-driving cars takes its hold, customers of established firms who have not yet adopted will want a company’s full resources allocated to the product they purchased. Any perceived cuts to the service they receive will cause push back.

Regarding principle two, the initial market for auto insurance on self-driving cars will not be large enough to satisfy the needs of established auto insurance companies. At some point, there will only be a handful of people riding self-driving cars, and if they are insured at all, they will most likely be customized, one off policies. As the market
expands to a small portion of the overall auto market, there will be a need for a company that specializes in writing policies tailored to self-driving cars. This market will not be large enough to satisfy the growth needs of an All-State, or a Progressive until the penetration is at significant levels. By that point, there may already be a company in existence that has captured too many sales for second movers to catch up.

For principle three, markets that do not exist cannot be analyzed. Actuaries rely on historical data to suggest rates for car insurance policies. Without any data available on self-driving cars, (initially), firms will be undertaking a huge risk when writing policies for self-driving cars. This uncertainty and risk will continue until there are multiple years worth of collision data. Any reasonable manager will do everything they can to mitigate unnecessary risk. When given the option of writing policies without any data and writing status quo policies to traditional drivers, managers will certainly opt for the “safe” path.

Four, a company’s abilities define its disabilities. For this principle, consider the contract for an auto insurance policy. Companies have general policies in their internal systems that they modify case by case with the coverage amounts and negotiated price for each consumer. In every case, there is language employed that is present for a purpose stemming from corporate strategy, efficiency, regulation, liability, or function. These contracts should be airtight. When there are minor changes in regulation for instance, companies can adapt their previous general contract with whatever they need to do, which is sometimes as simple as changing the font size. When it comes to completely redefining the concept of an automobile or the definition of a driver, the modifications to the general contract will be much more complex, so much so that firms will be required
to draft a new contract from scratch. The resources required by the firm to draft a new policy will act as a deterrent to pursue business with the initial self-driving market.

Finally, technology supply may not equal market demand. To rewrite the policy from scratch, an insurance company may have to resort to hiring new staff, paying for legal consultation, modifying their loss reserve ratio, paying for their actuaries to receive new training and may end up paying for costs out of comprehension at this point. The rate of growth for policies on self-driving cars should be proportional to the rate of self-driving car penetration into the market. In the initial market for self-driving cars, an established firm will not see the incentive to risk their limited resources on a relatively tiny market.

The fulfillment of these five principles is evidence toward the notion that established auto insurance firms will opt to avoid underwriting self-driving policies. The five described principles all implicitly point to one fact: as self-driving cars begin to penetrate the market, auto insurance companies will not see the value in writing policies in such unknown territories. Christensen does not blame managers for allowing disruptive innovation to consume their companies; rather he declares the lack of perceived value they see is the only logical option under traditional theory. According to the manager deciding whether or not to invest in the emerging market, there is little value in alienating your customer base to attract an uncertain one. There is little value in speculating the returns of a market without any data. There is little value in hiring new employees and completely rewriting a general policy to fit the needs of those in a fringe market. There is little value in out supplying the initial demand for the fringe product. To the manager, there is little value in disruptive technology.
Based on the lack of perceived value, the managers of these firms will make the decision to not invest in the disruptive technology. Instead, these firms will move “up market” (Christensen C., The Innovator’s Dilemma, 1997). Christensen proposes that this usually equates to designing more proficient products that can be sold at a higher price. For the case of the insurance industry, moving up market equates to writing policies to riskier consumers, or to those with a higher likelihood of getting into a collision, and therefore making a claim. Companies may charge higher rates for these consumers based on their higher likelihood of an accident because they take on a greater risk to underwrite.

As established firms do move toward these riskier clients, the reward they receive will diminish in spite of the added risk. The riskier clients only make up a small portion of the market, and because these big firms move upstream together, the market for the risky clients will become competitive. To even do business with these clients, companies will have an uneven risk-reward balance. The uneven nature of this balance will cause issues for the established firms if the timing of their losses is poor.

Recall the basic ratemaking model introduced in the Ratemaking model section as a way to illustrate the upstream danger. Instead of $p = 0.02$, these riskier clients with their traditional automobiles may have $p = 0.10$. In this scenario, the estimated average cost of each policy for the firm is $2,500; however, because the competing firms are battling for the scarce amount of risky clients remaining, they may only charge $3,000.

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6 An example of this is the subprime mortgage crisis. In the early 2000’s, banks were beginning to trend toward riskier and riskier clients to chase higher risk premiums. Unfortunately, these banks did not have the proper value network in place to evaluate the risks associated with the subprime market. When the housing bubble popped, and homeowners defaulted on their mortgages, banks suffered tremendous losses. These losses put many banks out of business (Duca, 2013).
This ratio is not proportional to the original 2:1 ratio proposed in the section “Ratemaking Model.” Although they do cover their costs if their actuaries made proper predictions, if they are wrong, the results could be catastrophic. Suppose they estimate $p = 0.10$, but in reality $p = 0.15$. Although the firm has already committed to the $3,000 price, they will suffer average costs of $3,750.

As an isolated incident, taking a $750 loss on a policy is no issue for even a small insurance company. In fact, insurance companies even plan to lose money on a portion of their policies. Under normal conditions, the insurance company will have a wide range of clients at different risk levels. The issue is that when the portfolio for the company becomes more and more one-dimensional, a misstep in ratemaking will be much more costly. The slimmer margin for error combined with the slimmer margin for profits will create an unfriendly environment for the established firms, one that may become impossible for these firms to continue to operate in.

F. The Attacker

The only way any damage can be done to the established players in the auto insurance industry is if there is an attacker to push them upstream in the market. As hinted at throughout this piece, the attacker will most likely be a new or small firm. Referring to an attacker as a singular entity is an incomplete picture. The “attacker” is a blanket term for entrants in an established market attempting to disrupt it. The attacker therefore includes all the failed entrants as well as the handful of successful companies. This means that while disruptive innovation paves the way for an entrant to gain control over a market, it does so through the trial and error process of many forgotten failures.
The five principles of disruptive innovation applied to an entrant yield starkly contrasting results. Entrants would have a relatively low amount of interdependencies to hold them back when compared to the established firms. The small fringe market of self-driving cars would be the perfect size for the company to grow with. Even though the market data is unavailable to the entrant the entrants risk much less by playing guesswork with the proper rates, comparing a $10 million portfolio with a $100 billion one. An entrant would still be in the midst of defining its capabilities, therefore it could more easily mold its capabilities to be optimal in the present day market. Finally, the entrant could be much more flexible to the fluctuating and unstable fringe market demand. In considering these five principles from both the attacker and the established firm, it is clear why they refer to entry during disruptive innovation as “the attacker’s advantage” (Christensen C., The Innovator's Dilemma, 1997).

IV. Conclusion

Refer back to Figure 1, the Gross Insurance Premium in the US by Year. This figure was chosen to be in this piece so that the current forecasts of the auto insurance market could be compared to an auto insurance market manipulated to account for the penetration of self-driving cars. Expert opinions vary on how long and to what degree Level 4’s will penetrate the market, but Fagnant and Kockelman (2015) predict that 90% penetration should eventually be expected. At this 90% penetration rate, they predict at least a 60% reduction in collisions. Assuming the price the prices for policies fall at a similar rate and that the 90% penetration happens linearly over 6 years, we will see a very different version of Figure 1. This makes the assumption that Level 4’s become available by 2020, the mark that Google has set for itself (Adams, 2015).
Figure 2: Gross Insurance Premium in The US by Year factoring for the penetration of self driving vehicles with the assumption that Level 4’s become available en mass by 2020.

Figure 2 shows how much the market for auto insurance policies may end up shrinking. With negative growth in the industry and massive growth needs by the top players, what can auto insurance firms do to survive? Unfortunately, in many historical instances that Christensen has shown, the top players do not survive (Christensen C., The Innovator’s Dilemma, 1997). As self-driving cars make the world safer for people, the world will dramatically shrink for auto insurance. The margins will get slimmer and slimmer and eventually we will begin to see new players in the auto insurance world. The process will occur out of a manifestation of the 5 principles of disruptive innovation. During the transition between traditional auto insurance policies and self-driving policies, we will witness the fall of many top firms. As these firms fall, new attackers will rise to take the place at the top of the industry, and then they too will need to worry about disruptive innovation.
V. Bibliography


