THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF RISK MANAGEMENT

THE EFFECT OF AUTONOMOUS TRUCKING ON COMMERCIAL AUTOMOTIVE INSURANCE

LISA M. WINTERS
SPRING 2019

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Risk Management
with honors in Risk Management

Reviewed and approved* by the following:

Ron Gebhardtsbauer
Professor of Risk Management
Thesis Supervisor

Steve Putterman
Professor of Risk Management and Faculty-In-Charge of the Actuarial Science Program
Honors Advisor

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

This paper analyzes how commercial automotive insurance will be affected by the introduction and adoption of autonomous trucks by businesses. With an increasing number of companies researching and testing the use of this new technology, anticipating the necessary changes and effects that it will have is an imperative step for both insurance companies and society.

After an overview of the concept of autonomous trucking and a description of the expected steps toward full autonomy, the changes in commercial insurance that will be required at each milestone of the progression will be identified. These changes will include insurance coverages that are predicted to be dropped, changed, or added in response to the new level of autonomy. Additionally, the predicted effects on premiums, claims, and underwriting and additional risks linked to the transition will be discussed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to thank my thesis supervisor, Ron Gebhardtsbauer, for encouraging me to take on this topic and supporting my work throughout the research and writing processes. Your comments and revisions have been incredibly helpful in refining my ideas and getting them on paper.

I would also like to thank my honors advisor and faculty reader, Steve Putterman, for keeping me on track and always being available to listen to my thoughts and provide feedback.

Lastly, I would like to thank my best friends for listening to me talk through my topic endlessly and for being the best support system I could have asked for over the last four years. I wouldn't have made it to this point without you guys!

Chapter 1

Introduction

Autonomous trucking is a term that describes the automation of the driving function of commercial trucks. While this idea may still sound futuristic, it is actually already being tested on the roads in some locations. The first commercial use occurred in October 2016 when an Uber and Anheuser-Busch partnership delivered 45,000 cans of beer after driving over 120 miles on the highway in Colorado with no driver directly behind the wheel (Reuters). As this new technology is integrated into business and everyday life, it is important to consider how the commercial automotive insurance industry will be affected and how it will need to change in order to adapt.

Chapter Two provides descriptions of the current insurance coverage options for non-autonomous commercial trucking. Similar to car insurance, liability insurance is mandatory for commercial trucks. However, there are additional coverages that are optional, but very commonly purchased, that are discussed as well.

The path that autonomous trucks are likely to take toward becoming fully autonomous is discussed in Chapter Three. Logically, commercial trucks will not go directly from fully non-autonomous to fully autonomous. Both technological innovation and human resistance to change would not allow this drastic shift without any intermediate steps. A few autonomous features models are described as possibilities for these transitional steps, followed by the final, fully autonomous design.

Chapter Four analyzes the commercial trucking insurance coverages that will be needed for the autonomous features models by considering current coverages that would no longer be needed, current coverages that would need to be adapted to fit the autonomous features models, and coverages that do not currently exist, but would need to be created. Chapter Five uses the same considerations to analyze coverages for the fully autonomous model.

Predicted changes to claims, premiums, and underwriting systems of commercial trucking insurance coverages are assessed in Chapter Six. The frequency and severity of claims are explained and related to the cost of premiums, which are predicted to decrease after autonomous vehicles are popularized. Rating categories and variables that will be dropped or added are also discussed in relation to premiums and how they can be added to underwriting models.

Chapter Seven discusses some of the additional risks that will come along with automating the driving of commercial trucks. Legislative, cyber, terrorism, ethical, and reputational risks are all explained and possible remedies are offered.

Lastly, Chapter Eight will conclude by highlighting the predicted timeline toward autonomy and the steps that should be taken by all affected parties along the way to ensure that society is fully prepared for this huge transitional undertaking.

Chapter 2

Current Commercial Truck Insurance Coverages

While personal car insurance is mandatory and covers the same fundamental expenses - liability, collision, and medical - for every person driving a car, commercial truck insurance can vary widely for different trucks and drivers. Coverages that must or should be purchased depend on situations such as what and how much the truck is carrying, whether or not the driver personally owns the truck, and whether or not the truck will be driven on non-job related trips. Therefore, there is a much greater variety of insurance options for commercial trucks than there are for cars, and the effect of autonomy will be different due to the number of coverages that must be adapted.

It is currently mandatory for commercial non-autonomous trucks to have public liability insurance (Commercial Truck Quotes, LLC). This insurance covers bodily injury, which pays for the hospital bills of people injured in accidents, and property damage, which pays for repairs to property damaged in an accident (Commercial Truck Quotes, LLC). The minimum amount of coverage of this kind that is legally required depends on the type and amount of freight that is being carried (Commercial Truck Quotes, LLC). Public liability insurance is the only coverage that is legally mandatory in every situation, but in practice, many other coverages are also legally or essentially necessary.

Coverages that are legally mandatory only in some situations include bobtail insurance and physical damage insurance (Commercial Truck Quotes, LLC). Bobtail insurance covers a truck driver's liability when they are driving the truck without a trailer attached (Peachstate

Insurance). If a driver owns their own truck, they are not required to have bobtail insurance, but if a driver leases a truck, the lease agreement can require it (Commercial Truck Quotes, LLC). Physical damage insurance covers a driver's own truck from damages in accidents and is only required if the truck is being financed (Commercial Truck Quotes, LLC). If the truck is owned outright rather than being financed, this type of insurance is not required because the owner can decide if they want to take on the risk themselves or not. Often, purchasing the insurance will be a better option since large trucks are quite expensive and would be a large loss for an individual to cover.

Optional coverages that are not legally mandatory, but are operationally crucial include cargo insurance, non-trucking liability insurance, and trailer interchange insurance (Owner Operator Direct). Most shippers will not do business with a trucking company that does not have a sufficient amount of cargo insurance to cover the cost of the goods being hauled in the truck's trailer (Commercial Truck Quotes, LLC), so a truck that will be hauling goods for another company is essentially required to have cargo insurance, and a truck that will be hauling its own company's goods would be smart to have it as well. Similar to the value of a truck itself, the value of the cargo a large truck can carry can get very expensive, and could potentially be a very large loss for an individual if they don't have cargo insurance. Non-trucking liability insurance is equivalent to public liability insurance in terms of what it covers, but differs in that it applies during time periods when the truck is not being used for a job, but rather for any other personal use (Peachstate Insurance). Lastly, trailer interchange insurance covers physical damage to a trailer that is not owned by the truck driver or their leasing company (Owner Operator Direct). This makes sense from the name, which implies that the trailer is exchanged between two

parties, making the receiving party liable for the other party's property while it is in their possession.

Chapter 3

Path to Full Autonomy

Commercial autonomous trucks are on the road, but the path to full autonomy has just started. The Society of Automotive Engineers (SAE) has a published guide to the main levels of autonomy, and these have become the industry standard ("Automated Vehicles for Safety"). The levels are outlined in the table below and will be expanded upon in the following sections.

SAE Levels of Autonomy	
Level 0 (L0)	No automation
Level 1 (L1)	Driver assistance
Level 2 (L2)	Partial automation
Level 3 (L3)	Conditional automation
Level 4 (L4)	High automation
Level 5 (L5)	Full automation

Figure 1: SAE Levels of Autonomy

L0: No Automation

Vehicles with no automation component fall into L0: No Automation. In this case, the driver handles every function of driving at all times. This level is not of very much interest to the progress of autonomous vehicles and their insurance, so it will not be discussed any further throughout this paper.

L1-L3: Driver Assist Vehicles

Vehicles with an advanced driver assistance system (ADAS) that can help the driver with one function at a time fall into L1: Driver Assistance ("Automated Vehicles for Safety"). This means that the vehicle can assist with steering, braking, maintaining speed, or accelerating, but cannot combine these functions to perform them simultaneously. An example of this level is a vehicle with cruise control.

Vehicles that can combine these functions to perform two or more driver assist features at the same time fall into L2: Partial Automation ("Automated Vehicles for Safety"). For example, a vehicle that can use both cruise control and lane-centering at the same time would be at this level (Reese). Most trucks on the road at this time fall into the L1 and L2 categories.

Lastly, vehicles with an automated driving system (ADS) that can perform all functions of driving under specific circumstances fall into L3: Conditional Automation ("Automated Vehicles for Safety"). Common circumstances that may determine whether or not the ADS can take over include traffic, road conditions (e.g. whether lines are available), and weather (such as snow or rain making lines invisible) [6]. Even in perfect conditions, the human driver must still be paying full attention to take over if the circumstances change.

The purpose of this paper is to analyze how insurance will be affected by the progression of truck autonomy, and insurance will not differ between these levels. Therefore, these three levels will be combined into one category that will be referred to as "driver assist vehicles." The main aspect that unifies these three levels is that the human driver must be paying full attention at all times in these types of vehicles. Most trucks on the road today belong to this group. The jump from these levels to the next two levels is a much bigger jump in in technology that

switches the primary control from the human driver to the vehicle itself, creating a need for a different insurance method.

L4-L5: Autonomous Vehicles

Vehicles with an ADS that can monitor its own environment and perform all functions of driving under certain circumstances fall into L4: High Automation ("Automated Vehicles for Safety"). Circumstances that would inhibit the ADS in a vehicle at this level include dirt roads and severe weather, but as long as the vehicle is not encountering these situations, the human driver does not need to be paying attention to the driving function of the vehicle. Therefore, the only thing that the driver would need to be paying attention to in an L4 vehicle is making sure that the driving condition does not reach any severe circumstances that would inhibit the vehicle from navigating. This is the goal of many autonomous truck companies right now, but they remain in testing phases and are not yet on the roads for commercial purposes. Autonomous trucks at this level include, but are not limited to, those designed by Waymo and Volvo (pictured below). Within 20 years, it is expected that most trucks on the road will fall into the L4 category.

Figure 2: L4 Autonomous Trucks Designed by Waymo (left) and Volvo (right)

Vehicles with an ADS that can monitor its own environment and perform all functions of driving under any circumstances fall into L5: Full Automation ("Automated Vehicles for Safety"). Since all conditions are acceptable for L5 vehicles, the driver would not be required to pay attention to either the driving function or the surrounding conditions at any time during a drive. It is questionable whether technology will ever advance to this level. John Krafcik, CEO of Alphabet's autonomous vehicle company, Waymo, believes that there will always be some constraint on autonomy (Wall Street Journal). At the WSJ Tech's D.Live Conference, he made the comment, "I like to joke that I'm not L5, so it would be amazing if we could get technology to be L5 (Wall Street Journal)." I personally do not believe that this level will be reached because there are factors outside of human control that can make it impossible for an autonomous truck to navigate. For example, if snow covers the road, lines, and signs, it doesn't matter how good the cameras and sensors in the truck are – there will be nothing for it to use in order to navigate. However, there are certainly steps that can be taken to get autonomous technology as close to L5 as possible, and many of these are regulatory. Sticking with the snow example, if laws are put into place that require snow to be cleared within a certain amount of time, the length of time that autonomous trucks are unable to navigate can be significantly limited. Other restrictions to reaching L5 autonomy and possible regulations to limit the restrictions are depicted in the table below.

L5 Restrictions & Regulations	
Restriction	*Regulation*
Snow covered road	Clear snow within x hours
Unclear lines	Repaint lines every x months
Sign visibility	Fix damaged signs within x days
Dirt road	Must be marked on map services

Figure 3: L5 Restrictions & Regulations

On the other hand, autonomous technology of any kind would have seemed completely impossible some time ago, so there's always a chance that the autonomy that seems impossible right now will be figured out at some point in the future, making L5 reachable after all.

Again, the purpose of this paper is to analyze how insurance will be affected by the progression of truck autonomy, and insurance will not differ between these levels. Therefore, these two levels will be combined into one category that will be referred to as "autonomous vehicles." The unifying aspect of these two levels is that the human driver does not need to be paying attention to the driving function of the vehicle (the driver only needs to pay attention to the surrounding conditions for L4 vehicles).

Chapter 4

Commercial Insurance for Driver Assist Trucks

The changes that should be made to commercial insurance for driver assist trucks are based on determining who is at fault in an accident: the human driver or the truck itself. With simple driver assist features such as cruise control and lane centering, insurance currently works the exact same way as it did before there was any automation (and may eventually reduce the premiums). Despite the truck's programs having some control, it is assumed that the human driver has the capability of taking over in circumstances that the truck is not able to navigate, and thus the human driver is responsible for any mistakes. There is a problem with this system. In the case that an accident is actually caused by a faulty driver assist program, the driver will be held liable unless they can prove in court that a human driver or a comparable automated driving system would have performed better in the same situation (Halsey). This means that the driver's insurance company could end up paying for claims that, if automakers were legally obligated to take immediate responsibility for all mishaps when the program is in action, should actually be paid for by the manufacturer as a product liability claim.

As driver assist features increase to L3 status and trucks can self-navigate a whole trip under ideal conditions, this issue intensifies. It is easy to foresee situations in which lawsuits will arise if there is not a regulatory solution put in place beforehand. For example, consider an L3 driver assist truck that is cruising down the highway under computer control. The truck should be expected to remain in its lane and manage its own speed based on the speed limit as well as the speed of the vehicle in front of it. If a car pulls out in front of the truck and a glitch in the system stops the truck from decelerating to avoid hitting it, the resulting accident would be a fault of the driver assist program because it is expected to be able to handle that situation. Regardless of the

fault, however, the human driver would be held initially liable until they can prove otherwise. Many lawsuits due to situations like this one are currently occurring within the car industry due to issues with systems such as Tesla's Autopilot (JD Supra, LLC).

The issue with this thought process is that these types of trucks are already on the road. While they haven't been in the news as much as cars of the same autonomy level, it is certainly not because they don't exist. Because of this, introducing new regulation may upset those companies that have already made business and investment decisions based on the current lack of regulation or worry those companies that have not yet made their decisions about getting into the market. Therefore, a solution must be found that prepares the market for mishaps and mistakes while not disrupting the progress that is currently being made.

The solution that I propose is for the United States to follow the lead of the Automated and Electric Vehicles Act of 2018 passed in the United Kingdom. Glen Clarke, the Head of Transformational Propositions at Allianz UK, has described this bill as a way for consumers to "carry on business as usual" while still having regulation in place as a starting point (Allianz UK). Essentially, the same type of insurance is still purchased by the same consumers from the same insurers as was previously done. When claims are made, the insurer determines their payout in the same way that they always have. However, if the driver or insurer feels that it was the fault of the vehicle that caused the accident, the insurer can then handle the claim separately with the manufacturer or software provider (Allianz UK). Using this process, the consumer is not thrown into an entirely new world of insurance right away, so companies will not be as hesitant to get involved with the new technology.

The downside of this transitional regulation is that it is not permanent. It has been recognized that once vehicles are fully autonomous and there is no human driver required to be

behind the wheel at all, there will have to be an entirely different insurance model (Allianz UK). This model will be discussed in the following chapter.

Chapter 5

Commercial Insurance for Autonomous Trucks

The new model of commercial insurance for autonomous trucks will require much more than a simple regulatory and legal adjustment. Instead, the coverages that are currently available will need to be fundamentally altered. Each of the current commercial truck insurance coverages can be analyzed to determine whether they will no longer be needed or will need to be adapted to fit the new technology. Additional coverages that don't currently exist may also need to be created.

Coverages that will be inherently unnecessary with autonomous trucks that are completely driverless include the bodily injury coverage of public liability insurance and the bodily injury coverage of non-trucking liability insurance for people inside the autonomous truck. This is a simplifying aspect of trucks compared to cars due to the main purpose of each autonomous vehicle. The purpose of autonomous trucks is to transport goods from one location to another, so once trucks are completely driverless, they will have no reason to have any people on board at all. With no people residing in the truck, there is no longer any risk of bodily injury, rendering the bodily injury coverages of both types of insurance pointless and unneeded. On the other hand, the purpose of autonomous cars will still be to transport people, so the risk of bodily injury still exists for people inside the vehicle even though a person will not be driving. The risk of bodily injury to people in other vehicles still exists regardless of whether the autonomous vehicle is a truck or a car. Since this is the only bodily injury risk for autonomous trucks, this

risk can easily be separated into its own insurance coverage, and can be purchased at a lower cost since there are less people at risk than in non-autonomous trucks.

The most common alteration to current truck insurance coverages will come from a change in who must purchase it. The property damage coverage of public liability insurance, bobtail insurance, physical damage insurance, cargo insurance, the property damage coverage of non-trucking liability insurance, and trailer interchange insurance will all need to be purchased by the truck manufacturer rather than the driver of the truck. In the past, the human driver needed the coverage to apply to their own driving in case of an accident. With no human driver, the software that is programmed to take over the driving function becomes the "driver" of the truck, so the software must be the object that is protected by these insurance coverages. This essentially turns claims of these types into product liability claims rather than the usual car accident claims (Griffith Law). While truck manufacturers might not want to pay these extra insurance premiums on behalf of the software that they choose to include in their vehicles, it is widely believed that they will pay them because the lowered risk of accidents will eventually reduce their premiums (Griffith Law). The extent of this reduction and the reason for it will be discussed further in the following chapter. Additionally, assuming that insurance follows this path of changes, truck manufacturers will have no choice but to pay the premiums in order to sell their trucks and have them on the road.

Lastly, there are a number of insurance coverages or insurance-like funds that may need to be created to account for new risks created by autonomous technology. These possibilities include (1) cybersecurity insurance (in case someone hacks the truck's software), (2) terrorism insurance, and (3) a robotics fund. Each of these coverages already exist in some capacity, but have just not yet been applied to autonomous vehicles. Cybersecurity already exists in many

capacities, but would need to be adapted to fit the specialized issues that arise from autonomous technology. Many companies and organizations are in the process of working on this already, and these ideas will be discussed further in the Cyber Risk section of Chapter 7. Terrorism insurance is another possibility that may need to be adapted and developed to fit the specific needs of autonomous technology, and will also be discussed further in the Technological Abuse and Terrorism Risk section of Chapter 7.

The last new coverage mentioned above, a robotics fund, is not exactly an insurance policy, but uses risk pooling in a similar way, making it applicable to this discussion. Already being used in the UK to mitigate the risk that comes with new technology, a robotics fund is a promising fit for autonomous technology. Rather than paying premiums, companies that produce robotics that have the potential to create harm pay a robotics tax (Allianz UK). Viewing this fund as a form of insurance, this tax essentially acts as a mandatory premium. The taxes are contributed to the compensation fund, which can be thought of as the reserves that an insurance company would hold in order to pay out claims. When harm is done by a machine, the robotics fund can help pay for the damages (or "claims"), lessening the burden on companies and encouraging further innovation and progress.

Chapter 6

Claims, Premiums, and Underwriting

The changes to the insurance coverages will impact the commercial insurance industry in a big way, but perhaps the largest change will come from the cost and usage of this new model. The drivers of this major change will be the claims, premiums, and underwriting systems propelled by technological advancement. Each of these factors will be analyzed under the assumption that the path to full autonomy will be followed to at least level four where a driver is not present in the vehicle.

Claims

An insurance claim is defined as "a formal request to an insurance company for coverage or compensation for a covered loss or policy event ("Insurance Claim")." In other words, when an event occurs that a policyholder believes should be covered by their purchased insurance policy, they submit an insurance claim to their insurance company in order to receive a payment. The two most important aspects of claims are the frequency and the severity, and both of these aspects are expected to change drastically with the transition to autonomous vehicles.

The frequency of claims is directly linked to the frequency of accidents. If there are more accidents, there will be a greater number of insurance claims, and if there are less accidents, there will be a lesser number of insurance claims. Commercial vehicle claims primarily stem from three sources: vehicle breakdown, environmental factors, or driver error ("The Most

Common Causes…"). In a study done by the Federal Motor Carrier Safety Administration to find the more specific top causes, it was found that 15 of the top 20 factors leading to commercial vehicle claims were caused by an action of the driver ("The Most Common Causes…"). Overall, drivers are far more likely to be the cause of an accident than the vehicle or the road conditions ("The Most Common Causes…"). Autonomous vehicles are expected to greatly reduce the number of accidents due to their ability to take this human error out of the picture. In California, there have been 34 accidents reported since 2014 that involved self-driving cars. Of these 34 accidents, an autonomous vehicle was only at fault in four of the occurrences, and only one of those four was in autonomous mode ("How Autonomous Vehicles…"). Despite the media frenzy that inevitably occurs when an autonomous vehicle is at fault in an accident, it is inarguable that the technology is successful at removing the risk of human error, which is a large contributor to vehicle accidents and insurance claims. For that reason, expert consensus is that accident rates (and therefore claim frequency) will drop as more autonomous vehicles get on the roads. Since approximately 94 percent of serious crashes are due to human error ("Automated Vehicles for Safety"), this drop could be as dramatic as eliminating 94 percent of accidents. However, the increased safety and decreased costs of using autonomous trucks could encourage companies to use trucking more often than they had previously, increasing the number of trucks on the road, and therefore increasing risk. Additionally, introducing autonomous technology to the roads creates new risks that didn't previously exist. For these reasons, the drop will probably not be quite as high as 94 percent immediately, but could reach this level eventually.

Claim severity, on the other hand, depends on the monetary amount of bodily injury and physical damage done in an accident. The bodily injury average severity has been steadily rising,

but relatively stable in recent years, both before and after the recession ("Average Severity"). This makes sense due to the fact that medical costs have also been steadily rising, so claims must be higher in order to pay for the same amount of medical treatment after an accident. This portion of severity will be reduced in autonomous trucks because there will be no human in the vehicle, but will not be reduced to zero since there will still be humans in other vehicles on the road that could be affected. The table below, provided by the Federal Motor Carrier Safety Association in the Unit Costs of Medium and Heavy Truck Crashes report, can be used to roughly estimate the percentage of costs that could be eliminated by having no human in the autonomous truck and the corresponding decrease in premiums.

Truck crash type	Annual Number of Crashes*	Medical Costs	Emergency Services	Property Damage	Lost Productivity from Delays	Total Lost Productivity	Monetized QALYs Based on VSL=$3 Million	Total Cost per Crash	QALYs
Straight truck, no trailer	150,032	3,545	186	5,512	6,371	22,385	25,735	56,296	0.2154
Straight truck with trailer	16,430	4,535	198	8,346	6,668	27,862	32,691	71,758	0.2736
Bobtail	13,118	4,320	185	7,279	7,590	22,900	24,816	58,055	0.2077
Truck-tractor, 1 trailer	240,601	6,492	191	8,622	6,047	34,228	48,041	97,574	0.4021
Truck-tractor, 2 or 3 trailers	7,974	23,680	281	28,746	6,788	96,917	141,549	289,549	1.1846
Unknown medium/heavy truck	5,717	3,219	176	7,196	5,164	25,171	39,868	63,343	0.3337
All medium/heavy trucks	433,872	5,606	191	7,847	6,231	30,582	40,655	91,112	0.3402

Table 1: Costs per Crash by Truck Type Involved in Crash, 2001-2003 (in 2005 dollars)

The bottom line of the table provides an overall average medical cost of $5,606 per truck crash for all medium and heavy trucks. Since this data comes from 2001-2003, it is safe to assume that there was a driver in each of the trucks, since autonomous trucks were not on the road at this time. Further assuming that the average truck crash affected one car and that the average car had two people in it, this means that the medical costs are covering the injuries of three people, the truck driver and the two car passengers. Thus, we can roughly expect about one

third of medical costs, $1,868, to be eliminated when there is no longer a driver in an autonomous truck. By dividing this amount by the total average cost per crash, $91,112, it is determined by the medical costs that can be eliminated by moving to autonomous technology make up about 2 percent of total costs. Thus, premiums can be expected to decrease by roughly an additional 2 percent due to the removal of bodily injury risk within the autonomous truck (in addition to the larger decreases discussed earlier, due to lower frequencies of crashes).

The physical damage average severity has been largely dependent on economics ("Average Severity"). When the economy is doing well, a greater number of new cars with more modern, expensive technology are bought and sold. Repairing this costlier technology is obviously more expensive as well, so the average severity rises during strong economic times ("Average Severity"). For example, during the recession and immediately following, average annual severity for physical damage only increased by 0.27 percent, but once the economy had stabilized and begun to recover, this percentage jumped to 3.10 percent ("Average Severity"). Although this severity correlates with economics, the underlying cause is the cost of the technology, and autonomous technology will certainly be more expensive to purchase and repair. Therefore, we can expect this portion of severity to increase as autonomous vehicles become more prevalent.

Overall, as autonomous trucks and other vehicles work their way on to the road, accident and claim frequency will be greatly reduced due to the elimination of human error causation. However, the average severity of claims will increase as the rising cost of physical damage severity will likely outweigh the reduction in bodily injury severity.

Premiums

An insurance premium is the monetary amount that a policyholder pays in order to obtain insurance coverage. This amount is based on the cost of claims that the insurance company expects to pay; thus, generally, a decrease in frequency and/or severity of claims would lead to a decrease in premiums and an increase in frequency and/or severity of claims would lead to an increase in premiums. Similar to claims, this means that there are two main factors at play in predicting how premiums will change as autonomous trucks grow in popularity: frequency of accident occurrences and cost of accident claims. In the past section, it was explained why the frequency is expected to decrease and the cost, or severity, is expected to increase. These two forces, therefore, counteract each other's effects on premiums, so one must be stronger than the other in order to determine which way premiums will move.

During the transition period, it is expected that the increase in severity will outweigh the decrease in frequency, raising premiums. In fact, many people are seeing their car insurance premiums rising right now despite purchasing cars with driver assist programs that should be decreasing the frequency of claims (Heaps). The average rise in premiums in the United States in 2012 was 2.2 percent, in 2013 was 3.2 percent, and in 2014 was 3.3 percent (Heaps). The reasoning is twofold. First, not enough vehicles on the road have the features that are supposed to lower accident frequency, so even if a vehicle with the features does not cause an accident, it can still very well be involved in an accident that was caused by a vehicle without the features. Second, the technology is expensive, so the slightly lower number of accidents is still leading to a higher total cost. The same phenomenon is bound to occur when high-tech, expensive autonomous trucks are in higher numbers, but still low proportions relative to the total number of

vehicles on the road. After the transition period passes, the majority of vehicles on the road will be high-level driver assist or autonomous. Experts predict that the drastic reduction in accidents at this time will have a much greater impact on overall costs, and that insurance premiums will be reduced as a result (Huckstep).

Looking at premiums from such a high level perspective is helpful for understanding the overall effects of moving toward an autonomous world, but it is also a vast oversimplification of the insurance rating process. If total claim cost was the only variable used in determining premiums, then every driver would pay the same insurance premium, and we know that's not the case. In reality, rating categories are created based on a variety of variables, and different drivers are charged different amounts based on their category's amount of risk. For example, State Farm uses the following variables to create their rating categories: insurance policy and deductible, vehicle type, how often and far the vehicle is driven, driving location, past driving record, credit history, age, sex, and marital status (State Farm). Hopefully it is obvious from this list that some of the rating variables for autonomous vehicles will be dropped (e.g. age) or fundamentally altered (e.g. vehicle type).

Some rating variables will no longer be necessary or useful, some new ones will need to be created, and others will remain the same. Common rating variables that will no longer be useful in insuring autonomous vehicles include past driving record, credit history, age, sex, and marital status. Past driving record and credit history are currently used as variables because they correlate with current driver behavior (Huckstep). However, when the "driver" is the car's software rather than a human, there will be different, better rating variables than these. Credit history, age, sex, and marital status are all directly related to the driver, which will no longer be applicable when there is no human driver. New rating variables for autonomous vehicles that

could potentially replace the past driving record include SAE level of autonomy, software sophistication, and the developer of the software. Automation level would take into account the probability of getting into an accident as well as the relative cost of technology at risk in the vehicle. Even if every car on the road were fully autonomous, there would still be differences in software skill and accuracy, and therefore a difference in risk depending on what software is installed in the car. Insurance policy and deductible, vehicle type, how often and far the vehicle is driven, and driving location will all still be valid and useful rating variables for autonomous vehicles for the same reasons that they are currently used.

Underwriting

Insurance underwriting is the process of evaluating the risk of a potential client and determining how much coverage to offer them at what price. Underwriters use the risk classification information discussed in the previous section in order to do so. The procurement of risk variables that are currently in use is no problem; underwriters have been doing it for decades and have models to quickly produce quotes with minimal effort. However, in order to evaluate the risk of an autonomous vehicle based on its SAE level of autonomy or software sophistication, more information will be needed and new models will need to be created. Determining the automation level of a vehicle will be simple enough – underwriters already use vehicle type, and automation level can easily be determined from this information – but data on each of the new levels will be needed in order to build the new variable into a pricing model accurately. Software sophistication could be determined by finding out what software is installed in the vehicle, but again, data on each type of software would need to be collected in order to build the pricing

model accurately. With so many companies testing autonomous vehicles, this data definitely exists, but is currently owned and controlled by the vehicle manufacturers. Getting access to this data is a huge problem and opportunity that may require legislation to ensure a smooth transition. If it were simply a matter of using the data for pricing, it may be left up to insurers to decide how to proceed with obtaining the information. However, vehicle data will also need to be accessible by insurers for purposes of determining fault in claims processing (Allianz UK), so it is likely that regulation will be the necessary route.

Chapter 7

Additional Risks

As with the introduction of any new piece of technology, there are additional risks that may not be fully understood before the widespread introduction of autonomous trucks. However, it is best to expect and prepare for as many side effects as possible, of which there are many, to provide as seamless of a transition as possible. These additional risks include legislative, cyber, terrorism, ethical, and reputational risk.

Legislative Risk

While the United States is advancing quickly ahead in the development of autonomous technology, one aspect of the industry that is falling behind is legislation. The United States is lacking in comprehensive legislation regulating the safety and usage of autonomous vehicles and has not yet created any new laws determining how liability will be changed in the event of an accident involving an autonomous vehicle.

Beginning with safety and usage regulation, the federal government, via the National Highway and Transportation Safety Administration, has released general guidelines for the testing and implementation of the new technology. The latest guidelines are titled A Vision for Safety 2.0. This document clarifies to states that they are able to determine their own timeline for testing and implementation and recommends safety standards to be enacted by state legislatures – there are no mandatory compliance requirements ("Self-Driving Vehicles Enacted Legislation"). Unfortunately, only 29 states and Washington D.C. have enacted legislation regarding autonomous vehicles, leaving 21 states without any mandatory regulation ("Self-

Driving Vehicles Enacted Legislation"). This is a major risk to trucking companies that often travel through many states on a single trip. If one state decides not to allow autonomous trucks or to only allow trucks with certain safety components, but a trucking company has already invested in expensive autonomous technology that does not meet the requirements, this would be a major loss. In order to avoid this situation, the United States should adopt comprehensive usage and safety regulations rather than making voluntary suggestions to state legislatures. Since the McCarran Ferguson Act of 1945 requires that insurance be regulated by the states, it might have to be done through the National Association of Insurance Commissioners (NAIC), who create model legislation for each state to enact. In this case, the United States government could pass laws to encourage states to use the model legislation (or be subject to punitive measures).

Beyond the basic usage regulation, the United States also lacks liability legislation. For non-autonomous trucks, when the truck is at fault in an accident, the truck driver, company who hired the truck driver, or trucking company who hired the driver can be sued by the plaintiff (Premack). For an autonomous truck, the logical party to be sued is the company who made the truck or software installed in the truck, but this is impossible under current liability law (Premack). Allowing states to move forward with putting autonomous vehicles on the road without changing the liability law to allow citizens to bring the correct party to court in the case of an accident is a danger to road safety and the industry as a whole. The United States must make up for its legislative lapses before the autonomous vehicle industry can safely advance.

Cyber Risk

In 2014, over 50 percent of vehicles sold in the United States were already connected on an internal network via electrical control units (ECUs) built into the vehicle's system (Toews). As autonomous technology progresses and as more old trucks are retired, this connectivity will increase rapidly. The positive side of the connectedness is that autonomous vehicle "communication" can increase the safety of the driving function of the vehicles. Unfortunately, this same connectivity also provides more opportunities for cyberattacks. If a hacker gains access to a single ECU, they could take over control of the engine, brakes, GPS, and many other aspects of the vehicle. With no human driver in an autonomous truck to recognize a problem, there are an infinite number of scenarios in which a cyber takeover could go horribly wrong.

Cybersecurity is viewed by many as the largest issue facing autonomous vehicles today, but it has also been a threat to non-autonomous vehicles for many years. For this reason, there are a variety of preventive solutions already in existence and use today. Preventive solutions that are already being installed in vehicles include reinforcement software on individual ECUs, network flagging software for the vehicle's internal communication network, and software for the units connecting the vehicle's network to the outside world (Toews). Each of these levels of software is able to detect problems that can then be corrected remotely by cloud security services (Toews). Though these systems have been in use for some time without any major breaches occurring, cyber risk will be amplified by the increased connectivity of autonomous vehicles, so additional coverage via insurance may become more desirable.

Terrorism Risk

With no human present in an autonomous truck, the risk of terrorism through technological abuse arises. For example, a bomb could be planted in the truck while there is no human there to identify a suspect, call the police, or otherwise handle the situation. Autonomous trucks already have some preventive measures to address this issue, primarily cameras. One autonomous truck created by Waymo has 19 cameras on the dome, which Waymo CEO, John Krafcik, believes is enough to know the profile of any person coming close enough to the vehicle to cause a problem (Wall Street Journal). However, having a suspect is only part of the problem – stopping any terroristic actions remains a problem that Krafcik states companies "need to be thoughtful in early planning" in order to avoid (Wall Street Journal). For these situations, terrorism insurance may become an important coverage for autonomous vehicles, especially trucks.

Ethical Risk

Ethical risk revolves around the classic trolley problem: you see a runaway trolley headed down a path where it will hit five people. You stand next to a lever that can change the path of the trolley so that it will only hit one person. Is it more ethical to do nothing and allow the trolley to kill five people or to pull the lever and divert the path of the trolley to kill one person?

This situation is a simplified version of the complicated decisions an autonomous vehicle has to be fitted to make. Current autonomous software is set to prioritize road users in the following order: small children, pedestrians, cyclists, motorcyclists, cars, and trucks (Wall Street Journal). Additional considerations have to be made for the number of each of these road users in

a group. Waymo CEO, John Krafcik, claims that the benefit of autonomous technology is that the sensors can see so far ahead that autonomous vehicles typically won't get into situations where they have to decide (Wall Street Journal). However, the risk remains that if this situation were to occur, the public could react badly to the ethical judgments that software manufacturers have coded into the driving programs and protest the usage of the technology, rendering the new and improved insurance coverages useless.

Reputational Risk

As the responsibility for the driving function of a vehicle is shifted more and more to the vehicle rather than a human driver, the blame for a mistake or an accident is also shifted. This blame has become apparent in recent accidents such as the Uber collision in March 2018. In this accident, a car with an Uber self-driving system was on a test drive in the dark. While it was winding around a curve, a person stepped out into the street walking their bicycle and was hit by the car. Immediately, the public spoke out negatively about autonomous vehicles and Uber's testing methods, and the media covered the event extensively. After analysis of the accident, it was determined that the autopilot software had not experienced any failures in terms of how it was programmed to react. The program was set up so that when an emergency brake was needed, the system depended on the human driver to intervene (Wamsley), so it was actually the driver's responsibility to recognize the situation and use the emergency brake. Many who viewed the video of the crash believe that even if the human driver had been in control the entire time, an accident was nearly inevitable due to the dim lighting and poor timing of the person walking out into the road. However, reports followed that the driver was streaming a television show and was

looking down at the screen right before the crash (Wamsley), which surely did not improve the situation. However, these reports did not receive nearly as much attention or media support as the original accident, leaving many with a distaste for Uber because of the incident.

The risk that volatile public response to future accidents will affect the public perception of an autonomous vehicle company is what Lloyd's has called reputational risk (Lloyds). It would be difficult to ensure that the reputation of a company remains positive through the use of insurance. If the public opinion turns, trust is much harder to rebuild the second time than the first. Therefore, reputational risk is a risk that companies will have to acknowledge and take on, but they should mitigate it by taking advantage of all other risk-minimizing strategies discussed.

Chapter 8

Conclusion

Despite many obstacles standing between today's trucking and the progression to autonomy, the wheels of progress are in motion and are sure to keep moving forward. The shortest timeline predictions expect autonomous trucks with no human driver present to be common on highways in about two years (Neuhauser). The longer timeline predictions expect the same goal to take about a decade (Nichols). Most likely, different locations within the United States will differ in their transition times (Nichols). Mild-weathered locations with good infrastructure and low traffic volume may become hubs for autonomous trucking within the short, two-year time frame, while inclement weather, poor infrastructure, and high traffic volume are all factors that may increase the time frame out to a decade.

Regardless of when autonomy becomes commonplace, the time to start preparing is now. Throughout the entire progression, autonomous truck companies should be focusing on continuous improvement of their autonomous technology's driving ability and safety features. Legislatively, the United States should start immediately on passing a bill similar to the UK's Automated and Electric Vehicles Act to allow insurance companies to handle claims separately with truck manufacturers should any accidents involving autonomous trucks occur in the short-term. This will provide some time for the federal government to design and pass a comprehensive set of safety and usage legislation for all of the states, which should be the ultimate goal to have in place before autonomous trucks are out of the testing phase. Separate legislation should also start immediately with the goal of altering liability law to allow a truck manufacturer or software creator to be sued for fault in an accident. On the insurance side, data

ownership is the most pressing matter. It must first be determined who "owns" the copious data that is collected by autonomous trucks. Depending on who this owner is, insurance companies will know whether they can access the data of their clients or whether they should start their own data collection. Then, this data can be used to create new models for pricing insurance for autonomous trucks.

Viewing these steps as the major obstacles for autonomous trucks, it is clear that successful progression is not only up to autonomous truck companies. Moving forward is going to be a joint effort between autonomous truck companies, software creators, government, insurance companies, and society as a whole. Even if all of the steps go exactly as planned, society is going to take some time to accept and trust the new form of transportation. But when they do, shipping via autonomous trucks is going to be safer for all persons and vehicles on the road and cheaper for companies to insure.

BIBLIOGRAPHY

"Alleged Failures of Tesla Autopilot Drive Numerous Lawsuits." *JD Supra. JD Supra, LLC.* 13 Nov. 2018. Web. 24 Mar. 2019. <https://www.jdsupra.com/legalnews/alleged-failures-of-tesla-autopilot-89659/>

"Automated Vehicles for Safety." *National Highway Traffic Safety Administration. United States Department of Transportation.* Web. 24 Mar. 2019. <https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>

"Autonomous Vehicles and the Insurance Industry." *Insurance Tomorrow. Allianz UK.* 28 May 2018. Web. 24 Mar. 2019.

"Commercial Truck Insurance 101." *Owner Operator Direct.* Web. 24 Mar. 2019. <https://www.owneroperatordirect.com/commercial-truck-insurance-101/>

Kagan, Julia. "Average Severity." *Investopedia*. 9 Mar. 2018. Web. 24 Mar. 2019. <https://www.investopedia.com/terms/a/average-severity.asp>

Kagan, Julia. "Insurance Claim." *Investopedia*. 30 Jan. 2018. Web. 24 Mar. 2019. <https://www.investopedia.com/terms/i/insurance_claim.asp>

Halsey, Ashley. "When driverless cars crash, who gets the blame and pays the damages?" *The Washington Post.* 25 Feb. 2017. Web. 2 Apr. 2019. <https://www.washingtonpost.com/local/trafficandcommuting/when-driverless-cars-crash-who-gets-the-blame-and-pays-the-damages/2017/02/25/3909d946-f97a-11e6-9845-576c69081518_story.html?utm_term=.ff054e6e650>

Heaps, Russ. "Car Insurance: Driver-Assistance Technology Is Driving Up Insurance

Premiums." *Autotrader, Inc.* Jul. 2017. Web. 24 Mar. 2019. <https://www.autotrader.com/car-news/car-insurance-driver-assistance-technology-driving-267385>

"How Autonomous Vehicles Could Change Transportation Insurance." *American Team Managers Insurance Services.* Web. 24 Mar. 2019. <https://www.atminsurance.com/how-autonomous-vehicles-could-change-transportation-insurance/>

Huckstep, Rick. "Four Ways Autonomous Vehicles will Change Auto Insurance." *The Digital Insurer.* 3 Sept. 2018. Web. 24 Mar. 2019. <https://www.the-digital-insurer.com/blog/insurtech-impact-autonomous-vehicles-auto-insurance/>

"The Most Common Causes of Commercial Trucking Claims." *American Team Managers Insurance Services.* Web. 24 Mar. 2019. <https://www.atminsurance.com/the-most-common-causes-of-commercial-trucking-claims/>

Neuhauser, Alan. "The Race Is On After Feds Pave Way for Driverless Trucks." *U.S. News & World Report.* 15 Oct. 2018. Web. 24 Mar. 2019. <https://www.usnews.com/news/national-news/articles/2018-10-15/the-race-is-on-after-feds-pave-way-for-driverless-trucks>

Nichols, Greg. "Driverless? The uncertain future of the American trucker." *ZDNet. CBS Interactive.* 25 Oct. 2018. Web. 24 Mar. 2019. <https://www.zdnet.com/article/driverless-the-uncertain-future-of-the-american-trucker/>

Premack, Rachel. "One of the biggest problems facing self-driving trucks has little to do with the technology." *Business Insider.* 12 Jul. 2018. Web. 24 Mar. 2019. <https://www.businessinsider.com/autonomous-trucks-self-driving-trucks-laws-2018-7>

Reese, Hope. "Autonomous driving levels 0 to 5: Understanding the differences." *Tech Republic. CBS Interactive.* 20 Jan. 2016. Web. 24 Mar. 2019. <https://www.techrepublic.com/article/autonomous-driving-levels-0-to-5-understanding-the-differences/>

Reuters. "Uber and Anheuser-Busch Make First Autonomous Trucking Beer Delivery." *Fortune.* 25 Oct. 2016. Web. 24 Mar. 2019. <http://fortune.com/2016/10/25/uber-anheuser-busch-first-autonomous-truck-beer-delivery/>

"Self-Driving Vehicles Enacted Legislation." *National Conference of State Legislatures*. 19 Mar. 2019. Web. 24 Mar. 2019. <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>

"These 7 Factors Determine Car Insurance Premiums." *State Farm. State Farm Mutual Automobile Insurance Company.* Web. 24 Mar. 2019. <https://www.statefarm.com/simple-insights/saving/these-7-factors-determine-car-insurance-premiums>

Toews, Rob. "The biggest threat facing connected autonomous vehicles is cybersecurity." *Tech Crunch. Verizon Media.* Web. 24 Mar. 2019. <https://techcrunch.com/2016/08/25/the-biggest-threat-facing-connected-autonomous-vehicles-is-cybersecurity/>

"Understanding the Difference Between Bobtail and Non-Trucking Liability Insurance." *Peachstate Insurance.* 3 Jul. 2013. Web. 24 Mar. 2019. <https://www.peachstateinsurance.net/blog/understanding-the-difference-between-bobtail-and-non-trucking-liability-insurance.aspx>

"Unit Costs of Medium and Heavy Truck Crashes." *Federal Motor Carrier Safety*

Administration. Mar. 2007. Web. 2 Apr. 2019. <https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/UnitCostsTruck%20Crashes2007.pdf>

Wamsley, Laurel. "Uber Not Criminally Liable In Death Of Woman Hit By Self-Driving Car, Prosecutor Says." *National Public Radio, Inc.* 6 Mar. 2019. Web. 24 Mar. 2019. <https://www.npr.org/2019/03/06/700801945/uber-not-criminally-liable-in-death-of-woman-hit-by-self-driving-car-says-prosec>

"What Are Interstate Trucking Insurance Requirements?" *Commercial Truck Insurance HQ. Commercial Truck Quotes, LLC.* Web. 24 Mar. 2019. <https://www.commercialtruckinsurancehq.com/what-are-interstate-trucking-insurance-requirements>

"Who Can Be Sued When A Driverless Car Causes An Accident?" *Griffith Injury Law.* Web. 24 Mar. 2019. <https://www.griffithinjurylaw.com/blog/automated-cars-may-affect-liability-in-crash-injury-lawsuits.cfm>

"WSJ Tech D.Live: Are We There Yet? The Future of Driverless." *WSJ's The Future of Everything. Wall Street Journal.* 14 Nov. 2018. Web. 24 Mar. 2019.

Yeomans, Gillian. "Autonomous Vehicles. Handing Over Control: Opportunities and Risks for Insurance." *Lloyd's*. 2014. Web. 24 Mar. 2019. <https://www.lloyds.com/~/media/lloyds/reports/-emerging-risk-reports/autonomous-vehicles-final.pdf>

ACADEMIC VITA

The Pennsylvania State University (University Park, PA) Class of 2019
Smeal College of Business | Schreyer Honors College
Major: Risk Management, Actuarial Science Option
Minors: International Business & Statistics

International Studies Institute (Florence, Italy)
Study Abroad, Summer 2017

ACTUARIAL EXAMS & VEE CREDITS

Exams P, FM, IFM - *Passed* *Most Recent - July 2018*
Exam SRM - *Credit Earned* *Dec 2017*
VEE: Economics, Corporate Finance, Applied Statistical Methods - *Credit Earned* *Dec 2017*

WORK EXPERIENCE

Wakely Consulting Group (Denver, CO) *May 2018-Aug 2018*
Actuarial Intern
• Conducted research on the interaction of risk adjustment and reinsurance in the ACA market
• Analyzed CSR eligible enrollees' plan selection patterns to aid in 2019 silver premium loading

---

CAMPUS INVOLVEMENT

Penn State Division I Field Hockey Team *June 2015-Nov 2019*
4-year Team Member, 3-year Letter Winner
• Practiced 20 hours per week in season, 8 hours out of season for continual improvement
• Strengthened knowledge of the responsibilities of teamwork and rewards of diligence every day

Sapphire Leadership Academic Program *Aug 2015-May 2019*
Community Service Chair *Jan 2016-Dec 2017*
• Organized community involvement opportunities for 200 members each semester
• Communicated with the Jared Box organization to create new campus initiatives
Leadership Development Chair *Aug 2018-Dec 2018*
• Coordinated the speaker logistics for the 2018 Sapphire Leadership Symposium
• Promoted involvement with the Symposium via social media and paper advertising

Penn State Dance Marathon *Nov 2017-Feb 2018*
Rules & Regulations Committee Member
• Studied the layout of the Bryce Jordan Center and the rules of THON for optimal security
• Secured Bryce Jordan Center and enforced rules during the 46-hour event to maintain safety
Finance Committee Member *Nov 2018-Feb 2019*
• Count coins and enter checks as they are collected to determine the total amount raised
• Credit amounts earned to organizations and dancers to determine the top fundraisers

Penn State Actuarial Science Club *Aug 2015-May 2019*
Active Member
Attend actuarial info sessions and presentations to increase knowledge of the employment field
Collaborate with students and faculty to prepare for actuarial exams

---

TECHNICAL SKILLS: R, SAS, SQL, Microsoft Excel/Word/PowerPoint