View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Repositório da Universidade Nova de Lisboa

NOVA School of Business & Economics

Automated Driving

and the Future of the Vehicle Insurance Industry

Master Thesis for NOVA School of Business & Economics
2017
Supervisor: Prof. Melissa Prado
By Maximilian Tigges

Table of Contents

Introduction

While the invention of the automobile has brought individual mobility to a new level for people around the world, we are about to enter the next significant phase of mobility with automated vehicles (AVs) which are much closer to reality than some might think. In the following thesis, I will give the reader an overview about relevant historic steps, benefits and issues and real-world examples before moving on to examine the effects this disruptive innovation might have on the insurance industry.

History

It was almost 100 years ago when the first automated car in history drove the streets of Milwaukee in 1926. A local newspaper, the *Milwaukee Sentinel*, reported the following on December 8th, 1926: “Driverless, [the “ghost car”] will start its own motor, throw in its clutch, twist its steering wheel, toot its horn, and it may even “sass” the policeman at the corner. The “master mind” that will guide the machine as it prowls in and out of the busy traffic will be a radio set in a car behind. Commanding waves sent from the second machine will be caught by a receiving set in the “ghost car.” While this example is obviously far from the vision we have of automated driving (AD) today, it gives a good impression of one of the first steps made in the advance of AD and the eagerness of humans to reach the next technological level and continue to work on their vision of mobility.

Already thirty years later, the Radio Corporation of America (RCA) went as far as saying that it had discovered the “highway of the future” and that “operating the system of the future will be as simple as it seems fantastic” as RCA was talking about a visionary concept which became part of what we know as *smart roads* today. In 1958’s January issue of *Electronic Age*, RCA further explains: “Passing the above sign as you enter the super-highway, you reach over to your dashboard and push the button marked Electronic Drive. Selecting your lane, you settle back to enjoy the ride as your car adjusts itself to the prescribed speed. You may prefer to read or carry on a conversation with your passengers - or even to catch up on your office work. It makes no difference for the next several hundred miles as far as the driving is concerned. Fantastic? Not at all. The first long step toward this automatic highway of the future was successfully illustrated by RCA and the State of Nebraska on October 10, 1957, on a 400 -foot strip of public highway on the outskirts of Lincoln."

The autonomous highway was believed by RCA to be the concept for the future, reducing human casualties, material damage and traffic jams and RCA was sure that the concept was going to be the next big thing in the USA's mobility revolution. However, the gigantic costs to upgrade national infrastructure as well as political and corporate concerns hindered the project from reaching its desired scale.

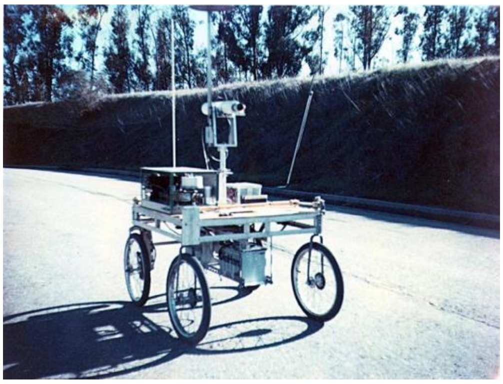


Figure 1 Stanford Cart (Source: exhibits.stanford.edu)

During the 1960s and 1970s major advances were being made by a team of researchers at Stanford University as they equipped a simple cart with cameras while adding additional visual and computing capacities over the years. Hans Moravec, who did his PhD in Philosophy at Stanford University while working on the Stanford Cart, was able to report a gigantic step forward in 1979: "The cart successfully crossed a chair-filled room without human intervention in about five hours."

Another milestone was reached by Tsukuba Mechanical Engineering Laboratory. The Japanese company was able to equip a car with "two cameras that used analogue computer technology for signal processing" (T. Vanderbilt, 2012). This car was the first 'real automated car' and had a maximum speed of 30 km/h but required guidance from an elevated rail.

Today, Ernst Dickmann is seen as one the most important pioneers in the history of automated driving. He worked as an aerospace engineer at the Bundeswehr University in Munich on the topic in the 1980s and 1990s and caught the world's attention by travelling from Munich to Odense, reaching 180 km/h in a Mercedes S-Klasse that "travelled fully automatically for about 95% of the distance" (E. Dickmann). This success is of strategic importance to the ideas of automatic driving today, because it “redirected research away from cars guided by inductive signals received from buried cables toward vision-based systems for lateral guidance” (T. Vanderbilt, 2012).

In 1997 Toyota was the first automotive company to include an adaptive cruise control system while mass producing its Toyota Celsior, designated for the Japanese market. This allowed the vehicle by using the LIDAR-technology to slow down the car when needed, without actually activating the brakes.

The US military came up with several prototypes during the early 2000s and was able to prove that it was possible to move in inhospitable territory and without colliding with trees and rocks. However, the challenge set up by the military agency DARPA in 2004 could not be met by any of the competing teams which made it obvious that it was still a long way to go until reliable self-operating military vehicles would become reality in the world’s most demanding conflict zones. Only one year later and with a doubled prize money of two million US-Dollars, a similar challenge by DARPA was successfully completed by five vehicles, including the winning team from Stanford University with their automated Volkswagen Touareg.

Since 2008, driverless trucks by the Japanese manufacturer Komatsu standardly operate in mines in Australia, improving logistics, efficiency, safety and productivity. Most major truck manufactures are working on automated freightliners and special-purpose vehicles today as the demand for commercial AVs is estimated to be enormous (Roland Berger, 2015). Commercial AVs further deserve attention as they are perfect for highly standardized tasks such as farming or mining and companies possess the financial strength to speed up development as well as market entry.

In 2009, Google privately began developing automated cars, believing the future to require intelligent mobility services for ever-growing mega cities as well as wanting to make usage of their giant data pool to offer ambitious convenience services to users. Since the beginning of public test drives in 2010, “Google's fleet of seven autonomous Toyota Prius hybrids has racked up more than 140,000 miles with only occasional human intervention. The cars use data from Google Street View coupled with data from cameras, LIDAR and radar to determine the car's position on a map." (T. Vanderbilt, 2012). The Google-setup has been a grand success story so far even though the company still usually places a driver behind the steering wheel in case of a system's failure or an emergency.

Since October 2015, owners of Tesla's Model-S are able to make usage of the company's Autopilot technology, which allows the vehicle to manoeuvre almost autonomously on highways even though Tesla emphasizes that they have "repeatedly warned [Tesla drivers] that Autopilot is not synonymous with fully autonomous driving. Tesla is very clear with what we're building, features to assist the driver on the road" (B. Berman, 2015). Many owners of such equipped Tesla cars however cared little about the firm's advice and excitedly tested the new possibilities in 'real' traffic, leading to multiple near incidents since then, not including the deadly accident of Joshua Brown who was running Autopilot in the moment of his crash in 2016 (R. Abrams & A. Kurtz, 2016).

An increasing number of governments is now working on updating their legislation in order to make automated driving possible on public roads. Currently, there are six levels of automation ranging from Level 0, which refers to tools consulting the driver who is in full control over the vehicle, to Level 5, which refers to autonomous driving and makes a human driver redundant. The levels in between represent a steady shift from 'traditional' to autonomous driving with AVs taking over an increasing number of tasks from humans.

Of course, many different national approaches result in many different ideas and regulations and it would go beyond the scope of this work to introduce the reader to all of the discussed concepts. However, I would like to mention that many governments around the world only intend to allow a certain degree of automation for now and will continue to require a passive driver on the driver's seat who is expected to be constantly ready to become active and take control over the vehicle once the system demands it or fails to act convincingly on upcoming threats. Fully autonomous driving still faces major challenges, which I will discuss later, and is unlikely to be publicly introduced in any country before 2020 while especially legal and regulatory queries may further delay a widespread introduction (K. Brauer, 2016).

Benefits of Automated Driving

As by now, the reader has seen a summarized path that automated driving has taken over the years but what exactly is it that makes humans so excited and willing to invest time and money in advanced automation? In the following chapter I will introduce the major advantages of AVs, with the chapter being divided into three major topics which are Safety, Convenience and Economic and Ecologic Factors.

Safety

The prevention of accidents and the increased safety of AV passengers is one of the strongest arguments of the AV lobby, forecasting a decrease in accidents by up to 90% (M. Bertoncello & D. Wee, 2015). Highly automated cars would be able to save 30,000 lives a year in the US alone and lead to savings in the health sector of around $276 billion (A. Ozimek, 2014). To put those numbers in perspective, statistically each fatality comes along with eight hospitalized victims and 100 who require medical care at emergency rooms. Until such high levels of automation are reached that will reduce accidents rates tremendously, automated systems will assist the driver in steering, switching lanes and controlling the speed in order to make roads a lot safer.

Convenience

Not everyone enjoys steering a car through traffic and AVs can help to save an average driver around 50 minutes of driving per day which results in a global daily saving of one billion hours (M. Bertoncello & D. Wee, 2015). This could result in a gigantic increase in one’s productivity and therefore lead to global economic growth. Beyond that, it could also help passengers to relax, watch a film, check their social media, have a meal or take a nap. Furthermore, AVs would especially improve mobility for elderly and children who might be unable to drive a car themselves. Of course, AVs would ease the challenges of parking and emergency reactions as sensors are able to process information much faster and more precisely than the human brain. Another positive factor is that once AVs take over, speeding, provocative driving, obstruction or other undesirable human inclinations are likely to become an offence of the past.

Economic and Ecologic Factors

In addition to the aforementioned savings in the health sector from fatal crashes and increase in individual productivity, one also needs to consider savings from non-fatal crashes and time savings. Adam Ozimek, who researched the financial outcome in an article written for Forbes in 2014, argues that AVs are able to generate savings of $642 billion in the US per year, using conservative assumptions. Beyond such benefits, AVs are also to benefit the global economy in playing a significant role in what is known today as Industry 4.0 and is expected to become the standard in all industrialized countries. “AV technologies could help to optimize the industry supply chains and logistics operations of the future, as players employ automation to increase efficiency and flexibility. AVs in combination with smart technologies could reduce labour costs while boosting equipment and facility productivity. What’s more, a fully automated and lean supply chain can help reduce load sizes and stocks by leveraging smart distribution technologies and smaller AVs.” (M. Bertoncello & D. Wee, 2015). Furthermore, AVs would lead to an enormous economic relief for people with lower incomes since financing their own car is a tremendous financial burden for millions of people. Fully automated and shared AVs would allow people to use a car on demand and only pay for absolutely necessary distances. This increases the mobility of all individuals and promotes social inclusiveness.

While it might be overly optimistic to assume traffic jams might vanish, AVs can certainly help to make traffic flow more smoothly by optimizing routes and generally reduce the numbers of vehicles, assuming autonomous on-demand car sharing becoming a staple in future cities. Smart technology will also lead to a decrease in fuel consumption, benefitting our planet’s energy resources and the ozonosphere. The overall environmental footprint of AVs is hard to predict, however. Considering multiple scenarios, AVs could decrease energy consumption by 90% or increase it by 200% (DOE, 2013). Why is that? On the positive side and considering an optimal usage, AVs could reduce the number of cars and carparks since often today, the driver of a car only uses the car for a small amount of time each day and leaves it parked for most of the day. AVs therefore would lead to the redundancy of many carparks that could be converted into green, public spaces and double the positive environmental effect. Smart usage of AVs could also lead to a better occupancy rate of vehicles, instead of today's image where many cars in traffic jams only accommodate the driver. The application of electric AVs would further improve air quality, at least in major cities. On the negative side, "the biggest potential downside of driverless cars for the environment is that automation could dramatically increase the total number of miles travelled by American vehicles" (J. Worland, 2016). This includes the idea of people taking an AV instead of walking or riding a bike and public transport might potentially see a decrease in ridership and therefore an increase in overall-costs which in many countries can expected to be transferred to all citizens. Being able to sleep, work or enjoy entertainment during the ride, the number of commuters could further increase as people appreciate lower suburban rent in contrast to exploding real estate prices in most prosperous metropolises and would not have to pay hefty parking prices any longer.

Challenges of Automated Driving

As mentioned before, widespread public usage of AVs seems unrealistic before 2020, given the number and complexity of challenges the industry and regulators are still facing in 2017. So, what exactly are the main issues that prevent AVs from redesigning our entire close and mid-range mobility? Again, I will only introduce the most significant challenges including Software Issues, Cyber Security and Economic Challenges.

Software Issues

It is safe to assume that the software required to make AVs reliable and safe is extremely advanced and complex. It needs to process data from multiple sensors, online sources, mapping services, traffic sources and satellites in addition to the driver's input. "Each Tesla vehicle generates gigabytes of information, which is used to train its self-driving software, but the company is willing to divulge data only when it suits them. Companies like Tesla and Uber would rather hang onto their data (which they see as vital for competitive advantage) communicate only among their own vehicles, keep regulators at arm's length and keep their machine learnings private." (J. Stilgoe, 2017). In order to navigate precisely, AVs require extremely detailed mapping services which go far beyond publicly available tools such as Google Maps, Apple Maps or Here Maps in their current form. Google is trying to upgrade their map service to offer accuracy within ten centimetres (K. Brauer, 2016). Another so far unsolvable software problem is related to unforeseeable events that might result from irrational human behaviour or wild animals. It is a lot easier for AVs to communicate with each other using their predictable and standardized behaviour instead of having to deal with human irrationality.

Cyber Security

Beyond safety concerns, a study by PwC shows that cyber security is the issue that consumers are the most afraid of (PwC, 2016). Indeed, there are major concerns whether hacking would enable individuals to steal or hijack cars, rob private data, immobilize a city or even murder someone by commanding a car to crash against a wall or drive off a bridge, just to indicate the severity of this issue. In fact, a Tesla car was successfully attacked by Chinese hackers in 2016 while previously "a group of researchers at the University of South Carolina were able to fool the Tesla Model S's autopilot system into perceiving objects where none existed or in other cases to miss a real object in Tesla's path" (O. Solon, 2016). In another case, Chrysler was forced to recall cars after researchers showed they could take control of the car via simple text messages, allowing hackers to "affect driving systems from the GPS and windscreen wipers to the steering, brakes and engine control" (S. Gibbs, 2015).

Economic Challenges

Envisioning the amount of people who are driving vehicles as part of their work today, it becomes obvious that not everyone can easily find another job and many might become unemployed. This does not limit to taxi drivers but also includes metro drivers, bus drivers, pilots, captains and other carriers that can possibly make use of advanced automation systems. Including the expected increase in safety, the number of people that might lose their jobs increases drastically as this would lead to less casualties and therefore less medical staff would be needed. Beyond the public sector, also car mechanics, firefighters, petrol station employees and traffic policemen among others might lose their jobs as well.

Another complicated issue is the question of charge in case of an accident. Whose fault is it and who should be held responsible? The driver for not reacting quickly enough or violating the instructions by not paying enough attention to street life? The software provider because of a system failure? The hardware manufacturer because a sensor malfunctioned? The developer of the mapping service because there was a tiny deviation or a newly built sideway that had not been registered yet? All such matters are extremely important for insurers because once an accident occurs, the person involved would like to receive some compensation, considering an insurance was concluded. This leads me to the next chapter which shall give the reader a better understanding of viable options for insurers and insurees.

Insurance

Up to the present, vehicle insurance had been mostly computed considering the driver’s ability to maintain a good safety record as well as the value of the insured vehicle and the driver’s age and experience. Insurers therefore had to look at the person’s claims history and driving records in addition to using complex statistical data in order to calculate a worthwhile premium (Y. Noguchi, 2017). This model is being called dated by an increasing number of industry experts and certainly needs to be adjusted as vehicle insurers are expecting the biggest changes to their business in decades.

Since it is quite unlikely that highly automated cars will cover public roads before 2020, it is more realistic that the levels auf automation will gradually increase over the coming years as more and more people open up to the idea of automated driving and show interest in replacing their current cars with AVs. However, considering the cost of replacing one's vehicle plus the additional cost of a more expensive automated car, it becomes clear that we will enter a much longer transitional period than many tech-enthusiasts would like to believe. For decades to come, there might be a mixed fleet of vehicles consisting of automated cars and trucks as well as conventional vehicles or vehicles with a low level of automation.

This transitional period can be a blessing or curse for insurers as some already have called for the death of the entire vehicle insurance industry, expecting accidents to decrease significantly in the long run. The auditing firm KPMG conducted a major research on the consequences of AVs on the insurance sector in 2015 and came to the conclusion that the market may decrease by 60% until 2040.

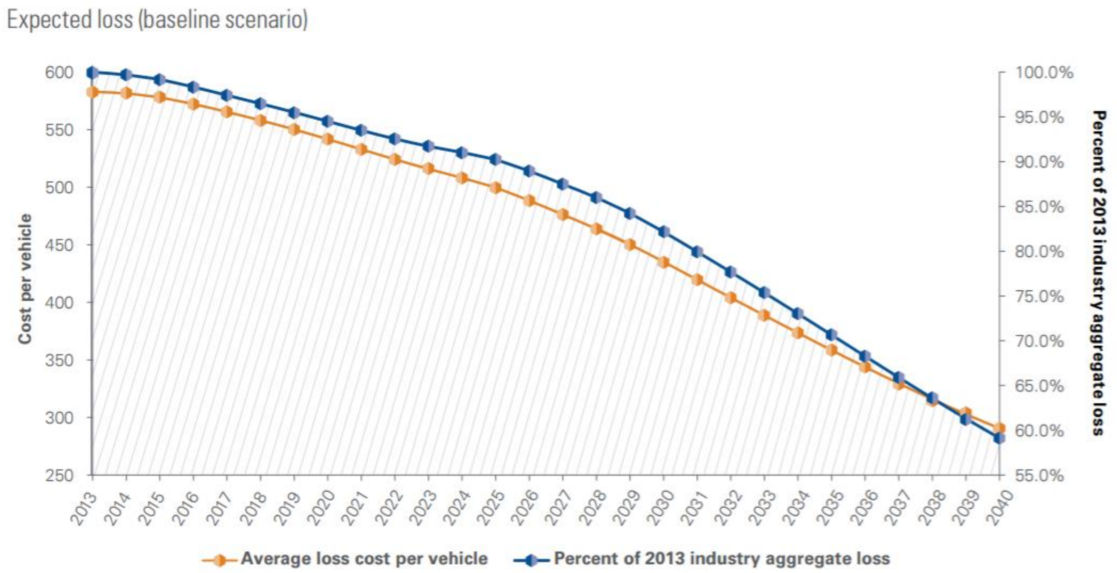


Figure 2 Expected industry loss (Source: KPMG, 2015)

Such a drastic shift in demand is expected to cause a major disruption in the motor insurance market and put major pressure on existing players. This is likely to result in much lower vehicle insurance premiums and "within a six-year period just over USD 20 billion would be trimmed from annual premiums as a result of increased road safety enabled by automated car technology [just in the 14 largest car markets]. By 2020, approximately 260 million connected cars will be on the roads worldwide. Since modern upscale cars are equipped with dozens of sophisticated sensors, there are vast streams of driver data that could be aggregated, processed, analysed and harnessed for different purposes" (Swiss Re & HERE, 2016).

The availability and traceability of data makes it much easier for insurers to estimate risk and assign charges. Gerry Bucke, general manager for the British insurer Adrian Flux, considers his firm "to be the first of its kind in the UK – and possibly the world [in the dedicated AV insurance market]" (as cited in The Guardian, 2016). Already today, many vehicle manufacturers equip some of their models with standardized automation such as parking or braking systems. When active, those systems can take the entire control over a vehicle for a limited amount of time and therefore raise the question whether the manufacturer of the parking software or the driver is to charge in case of a parking accident. Adrian Flux agrees that an estimated 90% decrease in accidents could lead to lower premiums, however the firm is naturally far from believing in the redundancy of their industry (J. Kollewe, 2016). Currently, Adam Flux offers discounts to those clients who already own an automated vehicle with a statistically proven increase in safety. However, issues such as overnight parking or statistically dangerous locations of the vehicle probably will continue to demand insurance. Special policies tailored to AVs can exploit additional revenue streams by offering coverage for "failure to install vehicle software updates and security patches, subject to an increased policy excess; satellite failure or outages affecting navigation systems, or failure of the manufacturer's vehicle operating system or other authorised software; loss or damage caused by a failure to manually override the system to prevent an accident should the system fail; and loss or damage if the car gets hacked" (J. Kollewe, 2016).

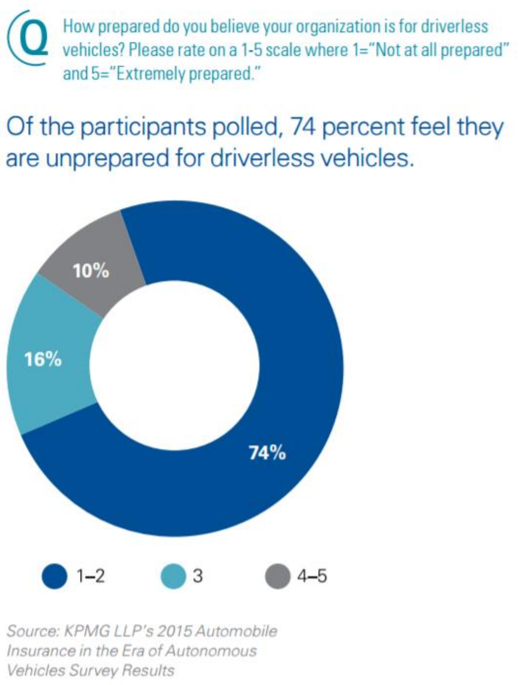
Even though new streams of revenue might be possible, the overall future still does not look too bright. The following paragraph, which appeared in The Guardian (Rob Davies) in May 2016, gives a good impression of an industry that might be shaken by disruptive innovation:

> *Insurance analyst Barrie Cornes, of stockbroker Panmure Gordon, warned that firms with a strong presence in motor insurance, such as Admiral or RAC, were under threat. He said*

specialist motor insurers would have to diversify into other areas. "Businesses will have to transform or motor insurers are going to die," Cornes said. "It's a number of years before we get there and there will be a transition period during which premiums are still going to be high. But it could well be that [motor insurers] move into home insurance, pet insurance and other areas."

In a more recent interview, Warren Buffett shares a similar opinion, stating "If they're [automated vehicles] safer, there's less in the way of insurance costs, [and] that brings down premium buy significantly" on CNBC on February 2017. He continues "If I had to take the over and under [bet] 10 years from now on whether 10 percent of the cars on the road would be self-driving, I would take the under, but I could very easily be wrong."

Considering the severity of the change ahead, the following graphs show an industry that might not be prepared ideally:



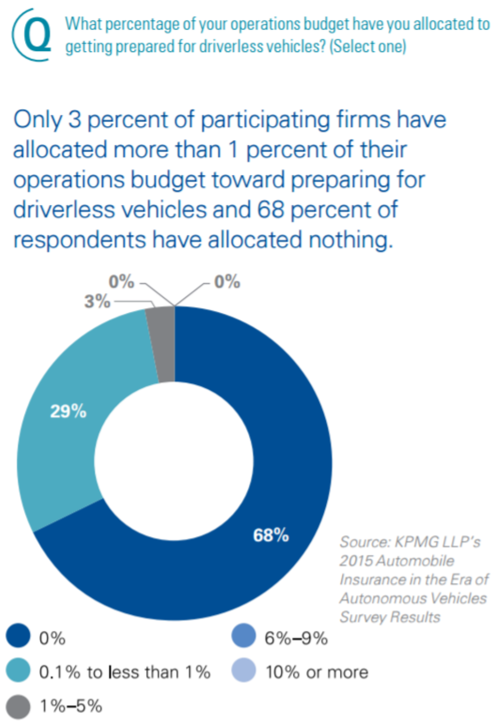


Figure 3 & 4 Insurance firms are unprepared (Source: KPMG, 2015)

When reviewing today's accident statistics, insurers are still far away from going out of business. And still, questions remain such as who currently has to pay for the damage caused by accidents such as the aforementioned fatal incident involving Tesla-driver Joshua Brown.

Florida lawmakers have introduced in 2012 that all firms currently experimenting with AVs on public roads are required to insure their vehicles. This means that in case a Tesla AV has an accident and it can be proven that the car was running on autonomous mode while being responsible for an accident, most of the charges will be directed to Tesla. "Prior to the start of testing in this state [Florida], the entity performing the testing must submit to the Department of Highway Safety and Motor Vehicles an instrument of insurance, surety bond, or proof of self-insurance acceptable to the department in the amount of $5 million" (Florida House of Representatives, 2012).

If we continue this way of thinking that manufacturers are responsible for their products' mistakes, this would basically mean that a major part of the premium that clients pay to insurers today would have to be directed towards manufacturers. Even though accidents are expected to decrease significantly through the automation of vehicles, it is likely that if all charges were directed to manufacturers this would increase the price of AVs significantly. Considering that due to their advanced technology, AVs with a high level of automation will already have a significantly higher price than 'traditional' vehicles, this would further increase the costs for consumers and therefore delay mass introduction to the market.

Manufacturers and service providers however seem relatively relaxed concerning this scenario that they might soon have to bear the majority of AV-related claims and basically act as an insurer for their clients. At least that is how they present themselves in public interviews: An Uber AV that was involved in a severe accident in Tempe, Arizone on March 29, 2017, did not seem to cause the company a major insurance-related headache. Instead, Uber calmly commented that all of their AVs are insured at levels that meet or exceed state laws (M. Sun, 2017). As long as test driving accidents remain exceptional, the results may seem tolerable for companies like Tesla or Uber, at least seen from a financial perspective. Yet, it is hard to imagine that manufactures or service providers would be entirely fine with acting as an insurer for all of their customers for a life-time, even taking over responsibility if customer's do not update their software or act unreasonably. In the long run, even considering a major decrease in accidents, this would create massive additional expenses for manufacturers related to accident claims. Additionally, manufacturers would be forced to enter a sector with all of its legal traps, that they have no experience with and would need to establish internal departments or external partnerships to deal with all related issues, of which there are many.

The following paragraph, taken from an article published in The Economist in September 2016, gives a good overview over the inconsistency of current legislation and an alternative solution, shifting the parts of the insurance-burden from manufacturers back to users and insurers.

> *Lawyers and insurers concur that liability will move from private car-owners towards manufacturers for crashes when a car is in autonomous mode. But under the current legal system in Britain and America an owner might still be blamed for an accident in self-driving mode if, say, he neglected to install the latest software update, says Richard Farnhill of Allen & Overy, a law firm. A manufacturer might equally well try to shift the blame to a components supplier. The best way to avoid endless blame-shifting and litigation may be what lawyers call a "strict" liability regime that automatically places responsibility on the owner. The insurer would keep an important role, of ensuring speedy victim compensation and assigning blame to the manufacturer or other at-fault parties. But that approach would still mean lower risk, and hence lower premiums, for insurers. That regime also assumes that private car ownership remains widespread. But autonomous cars in the future may well be owned and operated in fleets, perhaps by a souped-up Uber or by car manufacturers. Personal motor insurers would be out of luck. Only those who specialise in commercial fleet insurance would do well. Some manufacturers would simply "self-insure" and assume liability. Volvo, Google and Mercedes have said they will do so with their self-driving cars.*

As I mentioned earlier, national approaches regarding legislation differ vastly and I do not intend to go into detail for this work. Just to give the reader a better a better impression, “A recently passed Michigan law, for example, specifies an automaker assumes liability and insures every car in its fleet when driverless systems are at fault. In the U.K., Parliament is considering legislation specifying insurers should pay out claims in accidents relating to autonomous vehicles, though the insurers could recover those costs from automakers” (Y. Noguchi, 2017).

As the advance of AVs will happen gradually over a to be determined timespan, for now each incident will have to be looked at in great detail, determining faults and directing charges. This demands close collaboration between detectives, insurers, drivers, manufactures, industry experts and lawyers and therefore increases the cost of each incident requiring investigation exponentially. There are chances for decreasing investigation costs as well, since most AVs will gather a lot of driving related data that, considering national privacy laws, might be used to solve the case or simplify the investigation. Is it a zero-sum game in the end? No one knows and it is far too early to tell as we are still in the primal stages of an industry development that clearly asks for new concepts.

Conclusion

Considering that the challenges the vehicle insurance industry is facing are certainly significant, it was surprising to learn of the sector’s unreadiness and lack of convincing concepts to compensate revenue streams that are expected to decrease significantly by many industry experts. Even though some insurers have already presented ideas on how to generate new income through innovative business models that deal with new or upcoming threats, many firms lack a clear strategy how to deal with the scenario ahead of them. While the ‘traditional’ insurance scenario is mainly based on accident statistics and the driver’s competence, it is hard to imagine how this model will continue to function when accident rates drop by up to 90%, as experts predict. It is likely that the focus will shift from driveability to the reliability and preciseness of sensors and software. This might lead to claims being increasingly directed towards corporations that manufacture critical parts of AVs instead of individuals. Therefore, human behaviour will play a much lesser role in future insurance scenarios and insurers will have to establish direct cooperation with AV-manufacturers or exploit entirely new streams of revenues in order to survive. However, by now it is also way too early to call for the death of the insurance industry, as Hélène Chauveau, head of emerging risks at the French insurance firm AXA, emphasizes. Chauveau believes in the continuation of 'traditional' insurance businesses such as manufacturing flaws or theft with additional fields such as cyber threats or software issues gradually starting to increase in relevance. Whether established insurance firms continue to dominate the market or are cut out by emerging competitors remains impossible to predict. Certainly we can expect new insurance firms with innovative approaches trying to enter the market in case the established players are too slow or reluctant to adapt. Major changes in the market including greater competition is likely to benefit customers, as new insurance firms might try to build their entire model on upcoming technological advances instead of simply trying to follow-up. New players in this market might try to position themselves as the ideal solution for future mobility issues, using state-of-the-art technology to serve their clients and offer innovative solutions tailored to AVs. Therefore, many consumers might benefit from the development, enjoying safer roads, additional spare time and greener cities. Additionally, increased competition in the insurance market might lead to lower premiums or at least to more options and contemporary solutions for clients.

Bibliography

All sources last retrieved on May 25th, 2017.

History

T. Vanderbilt, 2012. https://www.wired.com/2012/02/autonomous-vehicle-history

E. Ackermann, 2016. http://spectrum.ieee.org/geek-life/history/selfdriving-cars-were-just-around-the-cornerin-1960

RCA, 1958. http://www.americanradiohistory.com/Archive-Radio-Age/Electronic-Age-1958-Winter.pdf#14

D. Hull, 2017. https://www.bloomberg.com/news/articles/2017-02-01/tesla-is-testing-self-driving-cars-on-california-roads

B. Berman, 2015. https://www.technologyreview.com/s/542651/drivers-push-teslas-autopilot-beyond-its-abilities/

N. Boudette, 2017. https://www.nytimes.com/2017/01/19/business/tesla-model-s-autopilot-fatal-crash.html?_r=0

R. Abrams & A. Kurtz, 2016. https://www.nytimes.com/2016/07/02/business/joshua-brown-technology-enthusiast-tested-the-limits-of-his-tesla.html

Roland Berger, 2015. https://www.rolandberger.com/publications/publication_pdf/roland_berger_toward_the_autonomous_truck_20150126.pdf

Benefits

The Telegraph, 2015. http://www.telegraph.co.uk/news/uknews/road-and-rail-transport/11403807/How-a-driverless-car-will-benefit-you.html

C. Thompson, 2016. http://www.businessinsider.com/advantages-of-driverless-cars-2016-6/#traffic-and-fuel-efficiency-will-greatly-improve-2

M. Bertoncello & D. Wee, 2015. http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world

H. Learner, 2016. https://www.enotrans.org/article/autonomous-vehicles-can-improve-safety-accelerate-environmental-progress/

A. Ozimek, 2014. https://www.forbes.com/sites/modeledbehavior/2014/11/08/the-massive-economic-benefits-of-self-driving-cars/#20d399323273

NREL, 2013. http://www.nrel.gov/docs/fy13osti/59210.pdf

J. Worland, 2016. http://time.com/4476614/self-driving-cars-environment/

TIGER BCA, 2014. https://www.transportation.gov/sites/dot.gov/files/docs/TIGER%20BCA%20Resource%20Guide%202014.pdf

NHTSA, 2016. https://www.nhtsa.gov/press-releases/nhtsa-data-shows-traffic-deaths-77-percent-2015

Challenges

J. Stilgoe, 2017. https://www.theguardian.com/science/political-science/2017/apr/07/autonomous-vehicles-will-only-work-when-they-stop-pretending-to-be-autonomous

O. Solon, 2016. https://www.theguardian.com/technology/2016/sep/20/tesla-model-s-chinese-hack-remote-control-brakes

K. Brauer, 2016. https://www.forbes.com/sites/kbrauer/2016/03/02/top-10-autonomous-car-facts-when-will-self-driving-cars-arrive-whats-holding-them-up/2/#1d8e235b150c

PwC, 2016. http://www.pwc.com/us/en/industry/entertainment-media/publications/consumer-intelligence-series/assets/pwc-autotech-v18.pdf

S. Gibbs, 2015. https://www.theguardian.com/technology/2015/jul/21/jeep-owners-urged-update-car-software-hackers-remote-control

Insurance

The Economist, 2016. http://www.economist.com/news/business/21707598-self-driving-cars-are-set-radically-change-motor-insurance-look-no-claims

O. Suess & J. Foerster, 2016. https://www.bloomberg.com/news/articles/2016-09-11/self-driving-cars-to-cut-u-s-insurance-premiums-40-aon-says

PwC, 2017. http://www.pwc.com/us/en/financial-services/publications/autonomous-driving-insurance.html

S. Birnbaum, 2016. https://techcrunch.com/2016/11/08/the-insurance-impact-of-self-driving-cars-and-shared-mobility/

HERE & Swiss Re, 2016.
http://media.swissre.com/documents/HERE_Swiss+Re_white+paper_final.pdf

R. Davies, 2016. https://www.theguardian.com/business/2016/may/03/driverless-cars-dent-motor-insurers-volvo

J. Kollewe, 2016. https://www.theguardian.com/business/2016/jun/07/uk-driverless-car-insurance-policy-adrian-flux

E. Gurdus, 2017. http://www.cnbc.com/2017/02/27/buffett-self-driving-cars-will-hurt-the-insurance-industry.html

Insurance Information Institute, 2016. http://www.iii.org/issue-update/self-driving-cars-and-insurance

Florida House of Representatives, 2012.
https://www.flsenate.gov/Session/Bill/2012/1207/BillText/e1/PDF

M. Sun, 2017. https://www.csmonitor.com/Business/2017/0406/If-no-one-is-behind-the-wheel-in-an-autonomous-car-crash-who-pays

Y. Noguchi, 2017. http://www.npr.org/sections/alltechconsidered/2017/04/03/522222975/self-driving-cars-raise-questions-about-who-carries-insurance

KPMG, 2015. https://assets.kpmg.com/content/dam/kpmg/pdf/2016/06/id-market-place-of-change-automobile-insurance-in-the-era-of-autonomous-vehicles.pdf

Pictures / Graphs

Stanford University Libraries
https://exhibits.stanford.edu/uploads/spotlight/attachment/file/465/Cart.road.1978.2.jpg

Video

Tesla, 2016. https://www.tesla.com/videos/autopilot-self-driving-hardware-neighborhood-long?redirect=no