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MASTER'S THESIS

MARKETING APPROACHES TO ADOPTION OF AUTONOMOUS VEHICLES

Ljubljana, April 2025 TEJA KOREN

AUTHORSHIP STATEMENT

The undersigned, Teja Koren, a student at the University of Ljubljana, School of Economics and Business, (hereafter: UL SEB), author of this written final work of studies with the title Marketing approaches to adoption of autonomous vehicles, prepared under the supervision of Assoc. Prof. Mateja Kos Koklič

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LIST OF ABBREVIATIONS

ABS – Anti-lock Braking Systems
ADAS – Advanced Driver Assistance Systems
AI – Artificial Intelligence
DNN – Deep Neural Networks
IoT – Internet of Things
LiDAR – Light Detection and Ranging
MaaS – Mobility-as-a-Service
NHTSA – National Highway Traffic Safety Administration
OEM – Original Equipment Manufacturers
R&D – Research and Development
SAE – Society of Automotive Engineers
UNECE – United Nations Economic Commission for Europe
U.S. – United States
V2V – Vehicle-to-Vehicle

1 INTRODUCTION

Research shows that the current transportation system is unsustainable, which makes alternatives, such as autonomous vehicles, an important topic of the future transportation system (Heineke et al., 2024). The studies predict that, by 2030, the autonomous vehicle market will become a part of the broad transportation system, leading to safer transportation, better traffic flow, increased accessibility and a more environmentally friendly solution (Statista, 2023). However, the adoption process and its success rely heavily on consumer trust, governmental support and technical implications.

While low levels of autonomous driving (SAE Level 1 and Level 2) are being incorporated into daily transportation systems, the integration of highly autonomous vehicles (SAE Level 3 and Level 4) remains uncertain, due to unclear regulations, mixed public perception, issues with technology testing and ambiguous industry actions. Seeing how emerging technology is followed by a slow adoption process opened up the question of what is causing the market gap.

The aim of this thesis was to analyse how to bring autonomous vehicles closer to the market. To clarify, what I mean by the term autonomous vehicle is SAE Level 4. This means a vehicle capable of operating in self-driving mode, but only in certain environment and under certain limitations, such as a human driver being present and able to intervene at any point, in case needed. This was done by examining four main viewpoints: consumer perception of autonomous technology, key factors influencing consumers to use autonomous features in vehicles, the main limitations causing the biggest delays in the autonomous vehicle industry, and last but not least, how marketing and communication strategies could support the adoption process of autonomous transportation systems.

The main goal was to highlight the benefits of autonomous vehicles, analyse the main concerns, research the widespread implementation, and analyse consumer perception, understanding and openness to this emerging technology. By analysing these data, the research focused on identifying patterns in consumer behaviour, exploring barriers to technology acceptance, and helping to identify market opportunities.

To achieve the above, the research adopted different methods to explore consumer knowledge, awareness and perception of autonomous vehicles, identify social concerns, analyse the current industry landscape, recognise market opportunities and research the role of marketing in improving public acceptance. The empirical study was divided into two sections, the industry viewpoint and consumer perception. The industry insights were collected through in-depth interviews with key industry players. This helped identify the main industry challenges, the industry perspective on consumer adoption and the current strategy shaping autonomous vehicle development. Based on the qualitative findings and literature review, I set up research hypotheses for consumer research. The consumer study

was conducted through an online survey, aiming to assess consumer knowledge, perceptions, the biggest concerns and openness to autonomous vehicle technology. All the collected data was analysed using statistical methods and hypothesis testing, to provide valuable insights for future research.

The thesis is structured in six chapters. The first one provides an introduction, the second describes the autonomous vehicle market from the development process to the current state of the technology, dives into the impact of autonomous technology on transportation systems, presents current industry trends, regulations and guidelines, and provides an overview of the European automotive industry. The third chapter provides a detailed picture of the adoption process. It covers consumers' attitudes toward autonomous vehicles and practical use cases in the market. This section also touches on the facilitators and barriers of the adoption process, and provides a role of marketing for high-technological products. The fourth chapter outlines the empirical research of this thesis and is divided into qualitative and quantitative analyses. It also presents the purposes and goals, research methodology and data analysis of each study. The fifth chapter interprets the results, highlights market potentials and recommendations, and provides research limitations and opportunities for future research. The sixth chapter provides a conclusion, followed by a literature list and appendices.

2 AUTONOMOUS VEHICLE MARKET

Cars are no longer seen as just objects that get us from point A to point B, but rather as transportation services capable of driving, reading and sensing the environment without human input. Such vehicles are called autonomous. Autonomous vehicles operate with Artificial Intelligence (AI), use self-driving functions and can be controlled without human intervention (Wang et al., 2021).

Research shows that the current way of transport is unsustainable. For example, in Europe, on average, only two people occupy a single vehicle, leading to more cars on the road and unnecessary traffic congestion, especially during rush hours. This pushes people to consider alternatives, such as shared e-bikes, shared mobility and public transport. The commercial use of robotic taxis and shared autonomous vehicles could also be one of the potential solutions (Heineke et al., 2023).

As the automotive industry progresses and evolves, autonomous vehicles are set to transform the way we view transportation and will impact consumer attitudes and behaviour (McKinsey, 2023). Next Move Strategy Consulting (Statista, 2023) has projected that the size of the global autonomous vehicle market will surpass 2.2 trillion U.S. dollars by 2030, bringing many growth opportunities for the automotive sector.

To make the adoption process of high-technological advancement more appealing and easier to acquire, the automotive industry, manufacturers and businesses must raise awareness and

educate potential customers, to build trust and gain acceptance of the technology (Patel et al., 2022). Furthermore, a close alignment with the overall adoption strategy with customer expectations is needed, due to strong ethical involvement (Sparrow & Howard, 2017).

2.1 Description of autonomous vehicles

2.1.1 The history of autonomous vehicles

Autonomous vehicles are one of the popular research projects and discussion topics (Faisal et al., 2019). The name, autonomous, originates from the Greek words auto, meaning »self« and nomos standing for »govern« indicating the autopilot system used (Ondruš et al., 2020).

The history of autonomous vehicles goes way back to the 1920s, when the first concept of such technology was introduced. The initial research and development (R&D) phases were introduced by the General Motors and Radio Corporation of America, Samoff Laboratory. One of the first contributions was the radio-controlled vehicle, called the Pontiac Phantom. The car was controlled remotely by a radio communication system, and did not yet have a computer-driven system (Shladover, 2017). It was only in the 1980s that Carnegie Mellon University created and presented the first autonomous self-sufficient vehicle. The vehicle was called NavLab 1, had a computer-controlled system, and was capable of navigating itself and avoiding obstacles (Takács et al., 2018).

In the late 80s and 90s, many research institutions and automotive manufacturers showed interest in this new emerging field. This led to several innovations, such as the twin cars VaMP and VITA II, developed within the European EUREKA Prometheus program, Navlap developed at Carnegie Mellon University and the ARGO vehicle introduced by VisLab engineers at Parma University in the U.S. (Claussmann et al., 2020).

Over the past decade, the potential of autonomous vehicles has gained global attention within research centres and car manufacturers, resulting in many technological advancements that are being incorporated into most modern vehicles on the market.

2.1.2 Defining autonomous technology

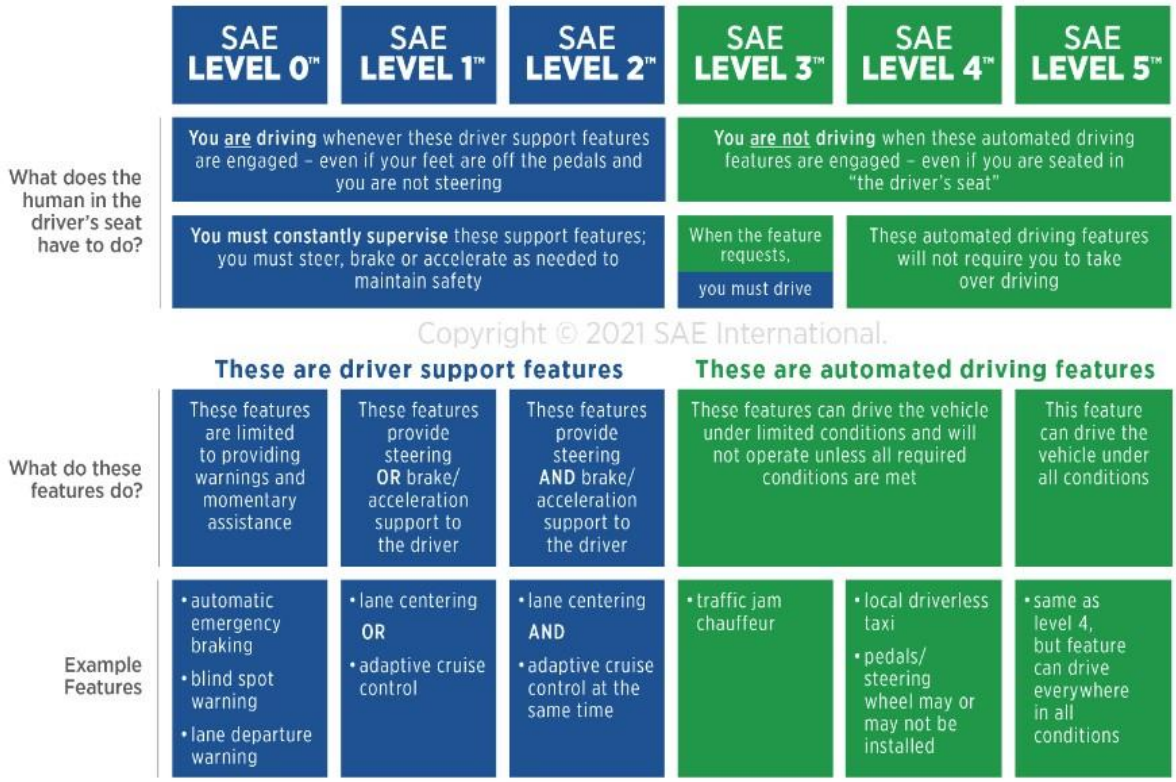
Based on the definition by the Society of Automotive Engineers (SAE) International, the level of automation is classified into six categories, Level 0 to Level 2 (human drive with partial driving automation support), and from Level 3 to Level 5 (featuring limited or fully automated driving) (SAE International, 2021).

The SAE classification has been approved by the United Nations and is used worldwide (Claussmann et al., 2020). As mentioned, SAE divides the automation into six different categories, ranging from Level 0 to Level 5:

- Level 0: “Momentary Driver Assistance”
  Assistance is only in the form of alerts and warnings, while the driver remains in full control, with no operational assistance.
- Level 1: “Driver Assistance”
  The fully responsible driver is being alerted by the system in the form of adaptive cruise control and lane assistance (minor correction of steering or accelerator /brakes).
- Level 2: “Additional Assistance”
  Similar to Level 1, however, system assistance is controlling both steering and acceleration/braking. This function is also known as a highway pilot.
- Level 3: “Conditional Automation”
  Automated vehicles are performing various driving tasks, leaving control to the driver if required. However, the driver must be available to take on the operation at any point.
- Level 4: “High Automation”
  Puts the driver in the role of a passenger with no need to be involved in driving. Driving is automated and operated fully by the system. However, this operation is limited to certain services and areas.
- Level 5: “Full Automation”
  Present full automation taken from Level 4 that can be performed in all areas, with no restrictions and constraints.

A summary of the SAE Automation Level categories is presented in Figure 1.

Figure 1: SAE Levels of driving automation



Source: SAE International (2021).

To understand how the technology can change the market we need first to understand how it operates. The autonomous driving system is built based on sensor technology, machine learning, algorithms and AI.

- Sensor technology – there are over 100 sensors featured in today's vehicles, which collect data from various factors in the vehicle. The sensors measure variables, collect information and send it to the control system, facilitating passenger, emission and vehicle control and assuring driver safety (De Locht & Van Den Broeck, 2020).
- AI – the development of AI is on the rise, with the potential to assist, control and improve the operation of future vehicles. However, high-quality AI takes time, and requires large investments in human-in-the-loop data, training and testing before it can be applied and used in the market (Gonzalez, 2022).
- Machine learning – is one of the main technologies in the area of AI, and is used to detect patterns, separate objects in the picture, and indicate information to provide reliable outputs (Shima et al., 2016). As the precision of machine learning is highly important, many tests will be needed to help reduce any errors or any biased behaviour (Xu, 2021).

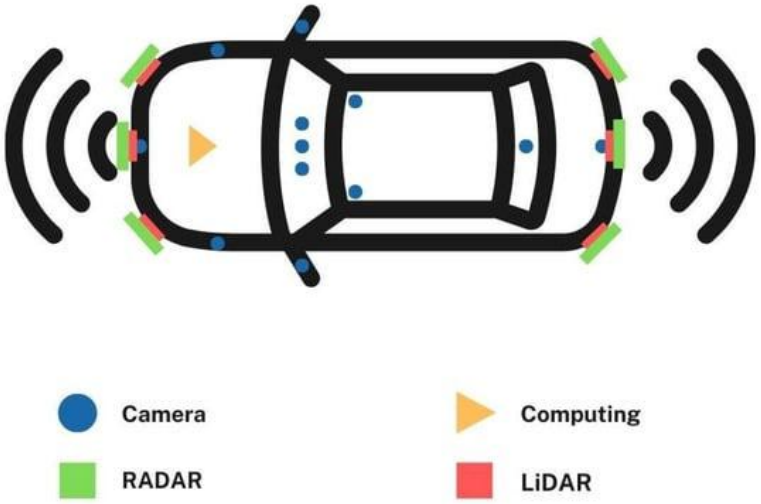
Sensor technology, AI and machine learning form the autonomous driving system. This technology allows the vehicles to detect surrounding objects, predict scenarios and develop behavioural models (Shima et al., 2016).

What made the biggest difference and advanced the machine learning models are the so-called deep neural networks (DNN), which help to interpret complex visual situations into real-time and on-spot decisions. DNN is a widely used data-driven modelling technology, that operates on layers, nodes and edges. This results in expressing a relationship, no matter the nonlinear and complex system, and leads to greater learning capability (Chonghyo et al., 2023). DNN has therefore become widely used in many industries, leading to promising AI solutions in our daily lives, used in the autonomous sector, smartphones, games and even drones (Kyuho, 2021).

The autonomous driving system works based on collecting information from the surrounding environment with sensing technology and predicting the scenarios using cameras, light detection and ranging (LiDAR) and radar sensors – presented in Figure 2 (Jebamikyous & Kashef, 2022).

- Cameras – used for collecting information about the objects and surroundings. By analysing the shape, colour and pattern, the information is collected and read as an object (traffic signs, double lines etc.), and, if applicable, translated into classification tasks (stop, merge, regulate speed).
- LiDAR – sensors used to detect, recognise and specify the object location. The advantage of the technology is its high persistence, no matter the weather or lighting conditions.
- Radar sensors – less precise compared to cameras and LiDAR technology, using a computer system to generate a full picture of the environment that is measured.

Figure 2: Sensors in autonomous vehicles

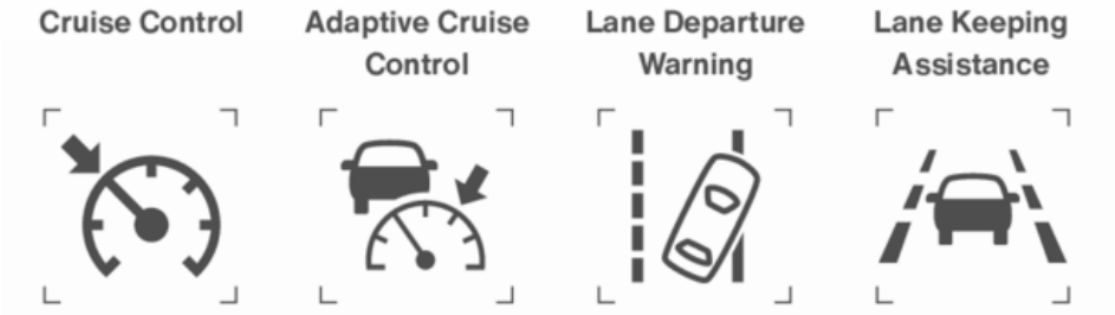


Source: Parekh et al. (2022).

Some of the main technical advancements to enrich the safety and comfort of the driving experience come from the connectivity, communication and integration of the technology into a network that enables better prediction and adaptation based on the surrounding elements, with the features listed below and presented visually in Figure 3 (Claussmann et al., 2020):

- Cruise Control
- Adaptive Cruise Control
- Lane Departure Warning
- Lane Keeping Assist
- Lane Change Assist
- Intelligent Speed Adaptation
- Automatic Emergency Breaking

Figure 3: Graphical symbols designed for automated vehicles



Source: Perrier (2022).

2.1.3 Current status of autonomous vehicles

The (low-level) autonomous technology is nothing new in the vehicle market. However, its implications present a rather slow and delayed process. Applying autonomous technology to the vehicle market will reshape the existing transportation concept, influence changes in road design, change current traffic patterns, and even impact the environmental footprint of transportation. The possibility of travelling with no or limited vehicle control will change the "driving" experience and might lead to a safer experience (Patel et al., 2022). However, as advanced technology, such as AI and machine learning, will be featured in this innovation, ethical considerations could and are expected to play an important role in the integration process of bringing the technology from the testing stage to widespread practice in the market (Garikapati & Shetiya, 2024).

It is important to understand the meaning of technological innovation. As described by Diaconu (2011), innovation stands for the introduction of something new to the market, which affects economic and environmental factors and reshapes production and consumption. Meaning innovation refers to the technology that is not only produced, but also used and applied on the market.

New technology brings many advancements as well as challenges due to the complex system and the potential disruptions to the wider transportation system and society. Due to the advanced technology used, many factors need to be evaluated and considered before market implementation, such as vehicle safety, regulations, limitations of the technology and potential challenges, industry capabilities, public perception and level of acceptance (Othman, 2021).

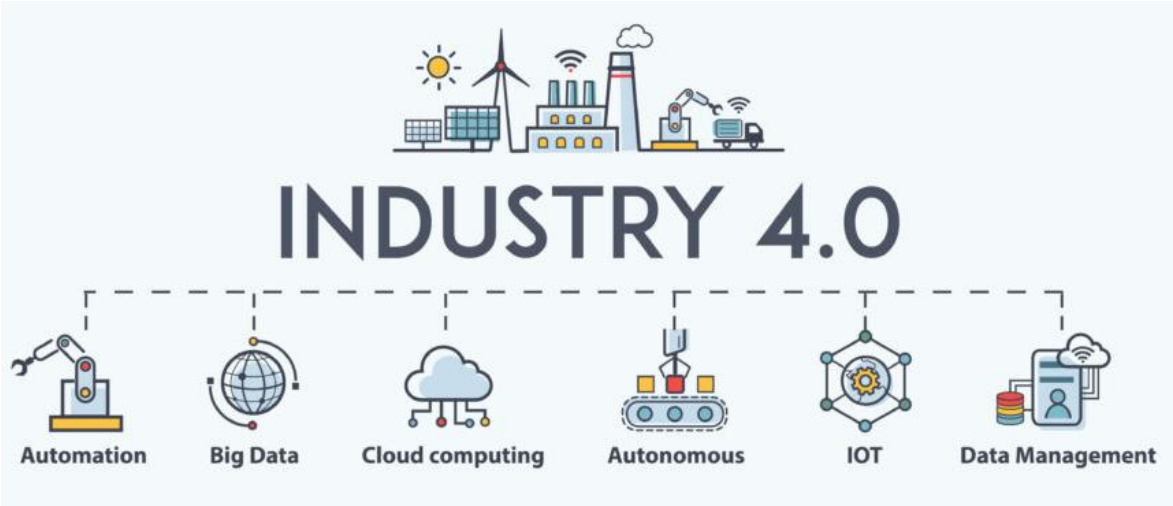
To conclude, shifting the focus from supply to demand can present a challenge, especially when the market and regulations are not defined clearly, which is why autonomous vehicles cannot yield their full potential. Therefore, it is crucial that manufacturers and businesses bring the technology closer to the customers, and set up a well-defined action-based strategy that will be aligned with the overall guidelines and safety regulations in the automotive industry. An important factor is also to gain consumers' trust in the technology (Dubey et al., 2022).

2.2 Impact of autonomous technology on transportation

The impact of technology goes beyond the vehicle features. Autonomous vehicles aim to transform the user experience, increase road safety and open new business opportunities (Intel Newsroom, 2017). The technological advancement originated in the Industrial Revolution, which impacted the development of the vehicle market heavily. Industry 3.0 shaped the foundation of autonomous vehicles by introducing big data and automated features. In 2011, the fourth industrial revolution was introduced, known as Industry 4.0. The new era, presented in Figure 4, highlighted the power of the network, machine learning,

AI, Internet of Things (IoT) and cyber-physical systems (Fragapane et al., 2022). Both trends combined helped advance the framework of autonomous vehicles and started influencing the automotive industry.

Figure 4: Components of Industry 4.0



Source: DAT4.Zero (2024).

Looking ahead, we can already see the initial footprints of Industry 5.0. The new industrial revolution embraces the power of society, resilience, adaptable technologies and sustainability (Xu et al., 2021). This trend will potentially (re)shape the development of autonomous vehicles and restructure the transportation system.

However, without market implications, the customers are not able to take on the full advantages of the evolving technology. As with most innovations, the market implications of autonomous vehicles follow the classical S-curve model that is adapted from Everett Rogers' book *Diffusion of Innovations (1962)*. As illustrated in Figure 5, an initial concept of new technology follows a slow adoption process before reaching full market penetration. The stages start with the development, testing, approval, commercial release, product improvement, expansion, market diffusion, maturation of the product, and, eventually, saturation, which, after some time, usually ends with a decline (Campisi et al., 2021).

Currently, autonomous vehicles are reaching the beginning stage of development and testing. The automotive industry predicts that autonomous vehicles will soon reach commercial release, making technology more accessible and reliable in the market (Krysiuk, 2021).

Figure 5: Innovation S-Curve model

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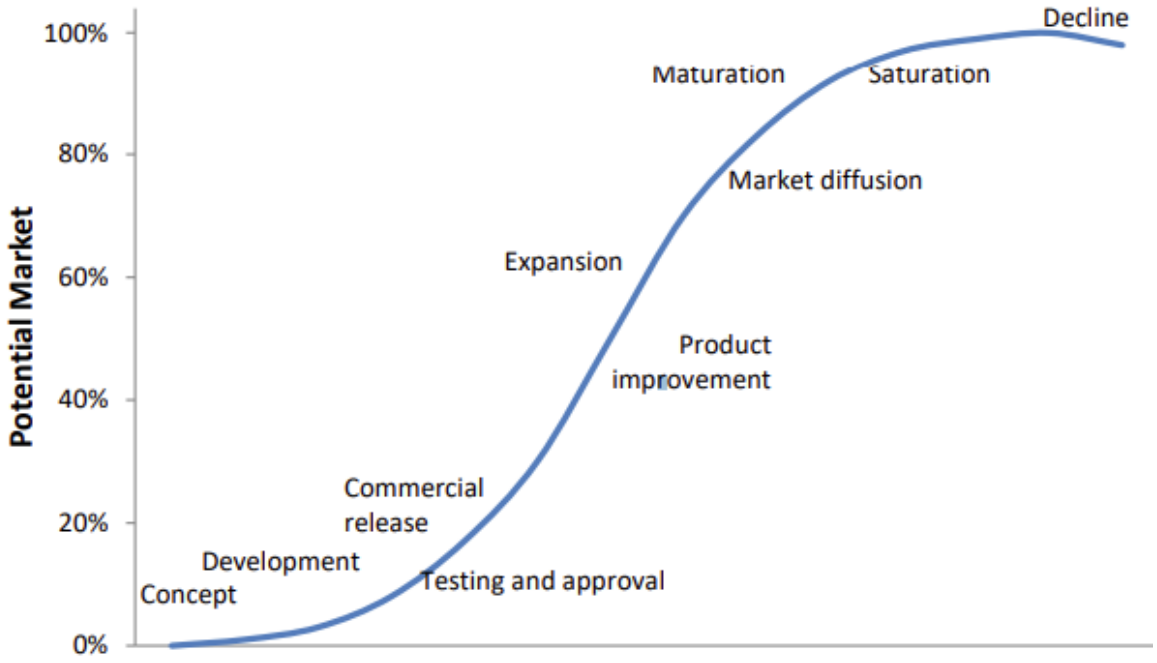


Source: Campisi et al. (2021).

When forecasting the impact of autonomous vehicles, it is important to consider all potential bodies, such as the automobile industry, car manufacturers, developers, key policy-makers, governments, insurance companies and the research community (Victor et al., 2023), and factors such as road safety, user experience, mobility-as-a-service (MaaS) and the environment. Each factor is described in more detail in the following sub-chapters.

Road safety. Autonomous technology has significant potential to improve traffic capability, efficiency and safety (Lu et al., 2020). Namely, the biggest reason for car accidents are human mistakes (Curto et al., 2021), caused by abuse of alcohol, speeding, the use of electronic devices and driver distractions. Based on the analysis, an average driver faces up to seven disruptions per hour. With autonomous technology, these elements could be limited or reduced, creating a dramatic shift in road safety (Catlin et al., 2024).

Statistics predict that, with the use of autonomous technology, the percentage of car accidents will drop by 80% by 2040. This will be achieved with advanced radars, sensors and optical cameras, simplifying the human input in driving. The highly autonomous cars can already keep a safe distance from vehicles, stop in case of an obstacle appearing on the road, adjust the steering wheel to keep the vehicle driving within the road lines and assist with parallel parking (Ondruš et al., 2020), resulting in safer driving and a more relaxed driving experience.

User experience. Based on the research, autonomous technology will lead to many benefits. With highly autonomous vehicles, drivers will have much fewer tasks, resulting in less stress and new opportunities (Greenwald & Kornhauser, 2019). The users of highly autonomous

vehicles will be able to spend time “driving” for leisure, work, or other activities. A study estimates that almost one hour per day will be saved each day (Bertoncello & Wee, 2015), which could, for example. reduce office hours and much more.

Mobility-as-a-service. Related to the previous point, being more in the role of a passenger than an active driver will drag along many changes and opportunities. Potentially, we will not have to worry about where to park, or how to drop the car at one location and pick it up at another. Namely, by shifting the private use of classic vehicles to shared autonomous vehicles, this could be much easier and more convenient for users. Based on McKinsey's research (Heineke et al., 2023), 56% of people are willing to switch from private use of vehicles to a shared system. Since 2010, more than 100 billion U.S. dollars have been invested in shared-mobility businesses. The movement is also supported by more than 150 municipalities, due to the potential of lower emissions and more sustainable ways of transport (Heineke et al., 2023). A study also shows that more than 45% of consumers would be willing to choose autonomous vehicles over public transport, walking or cycling (Booth et al., 2019).

The autonomous technology itself can easily be combined with various transport models. It can continue to present a private vehicle or offer a shared service system. Based on the advantages and disadvantages of various application models, the appropriate users are identified in Table 1 (Litman, 2024).

Table 1: Advantages, disadvantages and typical users of autonomous vehicles

	Private Human-Driven Vehicles	Private Autonomous Vehicles	Shared Autonomous Vehicles	Shared Autonomous Rides
	Motorists own or lease, and drive, a vehicle.	*Households own or lease self-driving vehicles.*	*Self-driving taxis offer serve individuals.*	*Micro-transit serves multiple passengers.*
Advantages	Low costs. Always available. Users can leave gear in vehicles. Pride of ownership.	High convenience. Always available. Users can leave gear in vehicles. Pride of ownership.	Users can choose vehicles that best meet their needs. Door to door service.	Lowest total costs. Minimizes congestion, risk and pollution emissions.
Disadvantages	Requires driving ability, and associated stress.	High costs. Users cannot choose different vehicles for different uses. Likely to increase vehicle travel and associated costs.	Users must wait for vehicles. Limited services (no driver to help passengers carry luggage or ensure safety.	Least speed, convenience and comfort, particularly in sprawled areas.
Appropriate users	Lower- and moderate-income suburban and rural residents.	Affluent suburban and rural residents.	Lower-annual-mileage users.	Lower-income urban residents.

Source: Litman (2024).

Environmental impact. We should not forget about the environmental impact of the new emerging technology. Increasing the efficiency of driving aims to reduce greenhouse gas emissions by 6 % (Le Hong & Zimmerman, 2021). However, no conclusions can be made, as this depends highly on a few key factors, such as the use of autonomous vehicles, the type of power used in the vehicles, and the changes in the way transport will be seen and used (Massar, 2021).

All the changes described above are transforming autonomous vehicles into highly promising advancements (Claussmann et al., 2020). To see how autonomous technology impacts the vehicle market, the next sub-chapter will provide an overview of current trends in the market.

2.3 Trends in the autonomous vehicle industry

Currently, the biggest challenge and limitation of autonomous vehicles is operating in complex road systems with many unpredictable factors, challenging weather and poor road conditions (Krysiuk, 2021). Although there have been some technological advancements and adoption of low-level autonomous vehicles, there is still a wide gap before reaching a mass adoption of highly autonomous vehicles on the road.

The majority of autonomous vehicles on the road are experimental, with no established timeframe for commercialisation set by the leading industry players (Hawkins, 2021). As creating a sound business model is more challenging than the development of the technology itself (Corbyn, 2023), many companies are switching back to low levels of autonomous driving, which is limiting the full potential of the technology (Bebernes, 2022).

Looking at the bright side, the first adoptions are already in process. Stick Safety Standards and regulations applied in the European market support the developing, testing and practical implementation of highly autonomous vehicles on European roads. Currently, the most advanced and developed countries are Germany, followed by France, the United Kingdom and Switzerland (ioki, 2023).

Germany is a pioneering country that is shaping the autonomous framework worldwide. Back in May 2022, Germany became the first country that regulate the Level 4 safety and design of autonomous vehicles, introducing a full remote-control system and a new connected mobile system operating on the open roads. The implementation was kicked off mainly in regional and local public transport. A high level of trust results in fast changes in the market. So far, the Association of German Transport Companies has introduced 40 autonomous buses that are operating on the local and regional lines. This is a promising number; however, we must understand that most of the current technology is limited, and operates only on fixed lines with low speed limits (ioki, 2023).

The current trends predict more than 9,000 autonomous buses in Hamburg by 2030. This will transform the current understanding of shuttles and public transport systems and strengthen the understanding of autonomous technology. Aligned with the above trend, the shifts are impacting and influencing other European countries. As Germany sets the legal Standards, this will potentially impact further developments and harmonisation in the European Union (ioki, 2023).

2.4 Regulations and guidelines in the automotive industry

Autonomous vehicles have the potential to change and transform road-mobility. However, the way vehicles will impact customers, travelling and road areas depends heavily on the strategy of key mobility players (Heineke et al., 2023). In Europe, the automotive industry contributes to 14% of the manufacturing sector's overall production and capital investment, making it one of the most important industries (Ondruš et al., 2020).

The car industry is highly regulated, to ensure safety, environmental protection and fair competition, and while automatisation is becoming a new reality – both in theory and practice, most developed areas worldwide are already implementing new rules and guidelines for the (future) autonomous vehicle implementation (Wang et al., 2020).

In February 2022, the United Nations Economic Commission for Europe (UNECE) updated the "Framework Document for Automated/Autononomous Vehicles" (UNECE, 2022). This framework incorporates globally harmonised regulations for automated and autonomous driving, and aims to create a better-suited environment for this innovation. The primary focus of this guideline is the identification of key principles for autonomous vehicles reaching at least SAE Level 3 or higher. The framework identifies a list of essential concerns and fundamental principles of regulatory authorities to provide uniform definitions of safety. Currently, nine issues have been identified and agreed by the authorities (UNECE, 2022):

- System Safety – when autonomous mode is activated, the vehicle should limit the risk for the driver and other road participants, while still following the traffic regulations.
- Failsafe Response – the autonomous system should detect promptly when a failure in meeting safety conditions appears and react with a risk minimalisation response.
- Human Machine Interface / Operator Information – the autonomous system should feature an option for driver engagement when requested.
- Object Event Detection and Response – in predicted situations, autonomous vehicles should be able to identify and react to events that might occur.
- Operational Design Domain – manufacturers need to document the functionality and operation of the vehicle safety mode and specify important domain constraints.
- Validation for System Safety – manufacturers should demonstrate and validate the process with a sufficient system-engineering approach aligned with safety standards and road regulations, including hazard analysis, risk assessment and integration with the border transportation ecosystem.
- Cybersecurity – ensuring cyber-attack protection based on the best practices available.
- Software Updates – ensuring system updates, and providing post-purchase repairs and modifications when needed.
- Event Data Recorder and Data Storage System for Automated Driving Vehicles – having a function that gathers and stores the necessary data, and ensures the identification of the vehicle system and driver's state in case any crash appears.

The paper on the harmonisation of vehicle regulations also indicates four additional factors that have been agreed in the World Forum (UNECE, 2022):

- Vehicle Maintenance and Inspection – measuring, inspecting and documenting the vehicle maintenance and repair system.
- Consumer Education and Training – ensuring the right training and education to all stakeholders, and addressing the expected differences in using autonomous vehicles.
- Crashworthiness and Compatibility – due to both conventional and autonomous vehicles being present on the roads, the passengers of autonomous vehicles should be protected from collisions with other vehicles.
- Post-crash AV Behaviour – autonomous vehicles should immediately transition to a safe state when involved in a road accident.

Regardless of how fast the road-mobility will evolve, McKinsey's study suggests the following changes in mobility infrastructure (Heineke et al., 2023):

- Cities – policies are needed to ensure the shift from individual transportation options to more sustainable and shared transportation. Especially, larger cities will need to focus on more green zones, plan public space use better, invest in better transport systems, improve public transportation, set up shared MaaS concepts, such as shared bikes and e-scooters, and promote early adoption of shared autonomous vehicles and robotic taxis.
- Mobility players – collaborations with industry are needed to develop a well-functioning mobility ecosystem that will be able to handle the growing demand of passengers. Current research suggests customer-centric offers, with well-fitted price schemes and best quality services.
- Automakers – increasing demand in transportation will allow the auto industry to research, invest and bring better solutions to the market. This would not only benefit the market, but also open new revenue opportunities for the industry.

A well-established infrastructure is critical for the successful use and implementation of autonomous vehicles. Not only as a physical factor, but considering the nature of technology, data and digital components, it will need to be aligned and implemented strictly, based on the legal frameworks. This creates a significant challenge, requiring support from key industry players, regulatory institutions (International Transport Forum, 2023) and academia (Wang et al., 2022).

2.5 European automotive industry

Looking at the European market, in 2016, the European Commission released safety regulations on autonomous vehicles, based on the study that 95% of all car accidents involve a certain level of human error, and 75% are caused by human mistakes (European Commission, 2016).

In past years, the European Commission has adopted and updated a series of regulations that include various aspects of driver assistance measures. In 2022, the European Union created the legal basis for the self-driving trucks and buses that are already in the implementation phase. The EU General Safety Regulation document describes the legal framework and guidelines for autonomous vehicles in the European Union, and points out the safety measures that will help save lives and prevent injuries caused by car accidents. The European Commission also aims to improve public trust, boost innovations, and increase the competitiveness of the European automotive industry (European Commission, 2022).

The framework applies to all road vehicles, including cars, vans, buses and trucks, and allows technological advancement up to SAE Level 3, meaning safety features to assist the driver. The established guidelines cover testing protocols, cybersecurity Standards, data guidelines and storage, as well as the mandatory incident reporting required by all manufacturers of autonomous vehicles (European Commission, 2022).

In the past few years, the biggest challenges in the European automotive market were (European Parliament, 2019):

- Assuring appropriate road safety with harmonised regulations for non-automated vehicles.
- Defining the law in the case of a crash of autonomous vehicles, and clarifying who will take responsibility for it,
- Assuring data protection to guarantee the cyber safety of autonomous technology.
- Specifying the guidance for the use of Artificial Intelligence.
- Developing the necessary infrastructure needed before full market implementation.

Germany and France are the most advanced countries in the European autonomous vehicle market, and even shape the legal frameworks for autonomous vehicles on a global scale. Both countries are already focusing on bringing SAE Level 4 vehicles onto the streets. On the other hand, countries such as the United Kingdom, Ireland and Switzerland are currently implementing SAE Level 3 vehicles (ioki, 2023). In the upcoming years, it is expected that the growth of the autonomous vehicle industry in Europe will lead to new job openings, economic growth, safer roads, improved access to transportation and a smaller impact on the environment (European Parliament, 2019). A map with a full overview of the current development of autonomous vehicles in Europe is presented in Figure 6.

Figure 6: Map of SAE Level of automotive vehicles in Europe



Source: ioki (2023).

3 ADOPTION PROCESS OF AUTONOMOUS VEHICLES

Successful adoption requires customers' awareness of the technology and addressing any challenges that may come with it. As currently, the knowledge about autonomous vehicles is not well-exchanged, the automotive industry will need to take a step further (Rahman et al., 2021).

One of the crucial points is to provide consistent and transparent communication about safety standards, benefits provided, and regulatory compliance to build public confidence. To achieve this, the stakeholders must collaborate and work closely on providing a coherent overview that explains not just how autonomous vehicles work, but also how connected autonomous vehicles will improve urban mobility and contribute to better sustainability (Litman, 2024).

To fill in the knowledge gap in the market, a detailed list of the steps required before autonomous vehicle implementation is presented in Table 2, including the timeframe and policies required (Litman, 2024).

Table 2: Steps and timeline needed for autonomous vehicles` implementation

Issue	Analysis Required	Policies Required	Time
Reliability and safety	Evaluate reliability and safety. Establish regulatory framework.	Define performance, testing and data requirements for AV operation on public roads.	2020-30
Overall travel impacts	Investigate travel changes, and likely benefits and costs.	Transport management to reduce congestion, accidents and emissions.	2020-2040
Local vehicle traffic impacts	Investigate changes in motor vehicle traffic and their impacts.	Decongestion pricing, vehicle restrictions, HOV priority, and policies that favor shared rides.	2020-40
Safety	Investigate new risks, crash impacts particularly to other road users.	Regulate AVs to ensure safety for all road users. Price and manage roads for safety.	2020-60s
Mobility for non-drivers	Autonomous vehicle availability and affordability to non-drivers.	Policies that ensure that AVs serve people with disabilities and low incomes.	2020-30s
Impacts on vehicle sharing	Quality of shared autonomous vehicles and rides	Regulate and encourage shared autonomous vehicles and rides	2030-40s
Energy and emission impacts	AV fuel type and consumption. Impacts on total vehicle travel.	Encourage efficient and electric AVs. Price and manage roads to minimize total vehicle travel.	2030-60s
Parking and passenger loading	Impacts on vehicle ownership and use, and parking and loading needs.	Reduce parking requirements and efficiently manage parking and curb space.	2040-50s
Roadway design	Impacts on roadway traffic and design needs.	Change roadway designs. Consider creating AV lanes. Determine their funding and pricing.	2050-70s
Plan for mixed traffic	Degree of conflicts between AVs and other road users.	Develop polices and facility designs to minimize conflicts and risks.	2040-60s
Autonomous vehicle mandates	Potential benefits of mandating AVs.	If benefits are very large, require all vehicles to be AVs and restrict human driving.	2060-80s

Source: Litman (2024).

3.1 Consumers' attitudes toward autonomous vehicles

Recent analysis shows that 84 % of people are interested in using autonomous vehicles (Du et al., 2021). However, the majority of people are unaware of autonomous technology or have limited knowledge about it. This is supported by the result that only 30% of respondents in the public survey knew about the standard classification of autonomous vehicles (Alsalman et al., 2021). Besides the low level of knowledge and awareness, additional reasons are causing the delay in the adoption of autonomous technology, such as ethical concerns (Wang et al., 2022), unclear guidelines and regulations in the industry (Heineke et al., 2024).

Studies have shown that consumers' biggest concern about autonomous vehicles is safety (Garidis et al., 2020), followed by the need to self-test the technology and gain knowledge on how the technology operates. To-date-research also confirms that consumer attitudes toward autonomous vehicles are affected strongly by social influence, expected performance, effort encountered and hedonic motivation (Erskine et al., 2020).

The key to bringing the technology closer to consumers is showcasing safety as a key feature of autonomous vehicles, highlighting the superior value of autonomous features and developing a well-defined market value proposition (Sandvik et al., 2024). Namely, if consumers do not understand and accept the accessible technology, even a highly advanced

state-of-the-art product with superior technical capabilities will not lead to market efficiency (Rahman et al., 2021). This means that successful communication is just as important as the implementation of the technology (US Department of Transportation, 2017). To add on, a study shows that people who experience automated car rides, either on-a-road or in a testing environment, show higher interest and trust in the autonomous features in vehicles (Feys et al., 2021).

3.2 Use cases from the autonomous vehicle market

Ethical concerns, complex questions and doubts will always be a part of complex technology implementation. Before the technology can meet a massive market, the vehicles need to ensure reliable technological functionality, careful data handling (Dingyi et al., 2018), and precise statistical testing supported by strong security Standards. An additional challenge of highly autonomous vehicles is enabling reliable performance in unstable driving conditions, complex situations and dynamic environments (Alawadhi et al., 2020). Knowing how strongly customer perceptions can influence the receptiveness to autonomous vehicles, it is critical to choose the right way to approach potential users. In other words, to make the transition from proof-of-concept to mass production, autonomous vehicles must prove enough safety, reliability and affordability (Kyriakopoulos et al., 2022).

Diving into practical examples, many companies, such as Toyota, Tesla, Honda, Ford and Uber, are competing to bring highly autonomous vehicles (SAE Level 4) to the European commercial market. The first company worldwide that had already succeed in reaching this milestone was Waymo in the U.S. (Marr, 2019). Another country leading in developing and testing autonomous vehicles is China, with the Apollo Project, AutoX, Xiaomi and Pony.ai.

Waymo is an autonomous driving technology company based in California, U.S. It all started as the development of *Google's Self-Driving Project* in 2009, and has now expanded to the first trial of a public self-driving commercial service in the field of Transportation, Delivery and Logistics. Its highly technological cars are provided to the customers as an experience test vehicle to be used in daily life, used as a taxi service model and accessible in the airport as an alternative transport solution (D'Allegro, 2022).

In addition, Waymo designed autonomous trucks for moving goods that provide advanced scheduling, dynamic routing, and maximise the network system (Waymo, 2023). Waymo brought the technology closer to the customers by addressing how crucial the adoption process is to the customers, not only as a product, but rather as an advanced service feature (D'Allegro, 2022).

The outcome of shifting the attention toward users has not only made autonomous vehicles more appealing to the public, but also helped to address customer needs better (Krafcik, 2017). To support that, the United Health Foundation statistics (2021) show that, in the U.S., 68 % of people drive to work alone. This concept raises many concerns about logistics, car

infrastructure, environmental issues and sustainability. Aligned with that, Waymo introduced a car-sharing service that has already started to reshape the areas, transform the cities, prove safety in the technology and make autonomous vehicles more convenient and accessible (Krafcik, 2017).

In the European market, one of the main achievements was accomplished by truck manufacturer Scania in Sweden. Together with the law and regulations on autonomous vehicles of the European Union, Sweden approved three autonomous trucks that are being tested on a 300-kilometre route between Södertälje and Jönköping (Traton, 2022).

Another well-known example is Mercedes. Mercedes-Benz Groupe AG is a successful German company, leading a global supply of high-end vehicles. Besides being a great producer, Mercedes invests a lot of money into technology, research and development. In 2022 Mercedes-Benz started a close research collaboration with Bosch. In November 2022, the collaboration led to a green light for the commercial use of a highly automated parking function that presents an SAE Level 4 automation. Testing of the feature kicked off at the Stuttgart Airport in Germany, a busy and narrow parking garage, which was ideal for the feature. A simple app was developed where drivers would arrange parking information, while everything else would have been done for them, saving valuable time, reducing stressful moments and allowing people to focus on other priorities (Mercedes-Benz Group, 2023).

However, not everything is going smoothly in introducing and implementing automotive vehicles. A recent example is Tesla in the U.S. After a car crash in 2022, the National Highway Traffic Safety Administration (NHTSA) investigated the case, resulting in Tesla having issues with the autopilot function. This led to a recall of over 2 million Tesla vehicles. For car producers, this means that a large range of updates will need to be required and tested (Rapier, 2024). A similar incident occurred in China in April 2025, when a fatal accident involving Xiaomi's SU7 autonomous vehicle caused a scaling back of the promotion of autonomous driving features (The Financial Times, 2025).

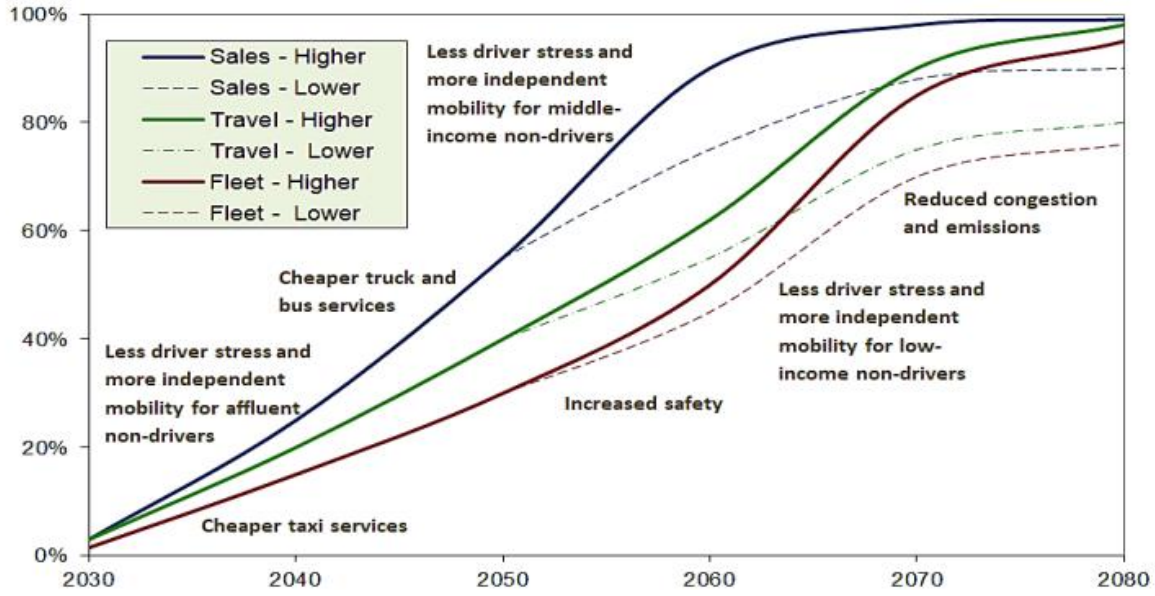
3.3 Driving factors in autonomous vehicle adoption

McKinsey’s research (Catlin et al., 2024) points out the optimistic industry view that, by 2030, almost every new vehicle will be connected, at least 15% of vehicles will reach the SAE Level 4 of automation and 33% of people will participate in car sharing. This trend will be accelerated by promoting MaaS, such as shared taxis and ride-sharing systems (Litman, 2024).

In Figure 7, we can examine the market projection of autonomous vehicle applications for several decades. The breakpoint is expected by 2050, when more than half of the vehicles on the market are expected to be autonomous, meaning featuring at least the SAE Level 4 of

autonomy. After this point, a faster market application will follow, which will start resulting in the full benefits of autonomous vehicles (Litman, 2024).

Figure 7: Future prediction of autonomous vehicles on the market



Source: Litman (2024).

However, the optimistic view overlooks some of the key factors and challenges. Namely, there are many significant obstacles that autonomous technology is bringing and should be considered carefully in the scope of the analysis. This features increased costs, uncertainties with the technology, and operating problems that will require years of testing and regulatory approvals before the idea will be widely available on the market (Litman, 2024).

Factors that are currently slowing down this process are, in the first place. affecting key original equipment manufacturers (OEM). In recent years, OEMs have been faced with technical obstacles, regulatory requirements and complex application processes (Litman, 2024). Namely, for successful market applications, OEMs need to make autonomous vehicles attractive to customers. Since this presents a long process, more and more businesses are focusing on the low level of automation, causing delays in market application (Catlin et al., 2024).

The uncertainties of bringing autonomous technology into the automotive industry show that the biggest concern is not the technology itself, but how to bring the technology closer to consumers, how to build trust and widespread acceptance in the market, and how to close the gap between the potential of technology and the slow adoption process on the market (Sandvik et al., 2024).

For an easier overview, some of the main facilitators and barriers of autonomous technology are gathered and further explained on the next pages.

3.3.1 Facilitators

Increased safety and social value. Human mistakes and errors in reaction time are often a cause of traffic accidents. The new emerging technology will reduce the risk of traffic accidents and make transportation more available, especially to the elderly and people with disabilities. As the ageing population is growing, this could be a potential solution, allowing a more convenient experience (Yurtsever et al., 2020).

Furthermore, people who spend a lot of time in a vehicle will benefit from having fewer worries about traffic, navigation and long-focused driving. Last but not least, the opportunity of new transportation models, such as autonomous MaaS, has the potential to reduce the stress and time needed to look for a parking spot, leading to better convenience and more efficient use of urban areas (Litman, 2024).

Time convenience. Autonomous vehicles will transform logistics and free up time used for driving. This could boost productivity significantly and reduce the stress caused by traffic congestion. With the high level of autonomous vehicles, people will be able to reclaim the time that was previously spent driving for other activities, such as working, sleeping, catching up with family, enjoying a meal, or simply relaxing, while the autonomous vehicle will take care of driving, navigation and safety for them (Litman, 2024).

Lower costs. Autonomous vehicles will lead to optimisation. This will be achieved through better fuel efficiency, lower parking costs, crash savings (Overtoom et al., 2020), increased car-sharing opportunities and more effective traffic flow due to connected vehicle systems. Shared rides will also lower service costs and increase convenience compared to taxis. While the advanced and complex technology used in autonomous vehicles could lead to expensive repair costs, it could also be drastically lower when combined with electric and connected vehicle systems (Litman, 2024).

The potential of existing technology on the market. One of the promising advantages of autonomous vehicles is the advanced integration of AI and machine learning. Smart vehicles, combined with the connected system, could even predict traffic better, help reduce the errors of the technology further and contribute to a more sustainable transport system (Catlin et al., 2024).

3.3.2 Barriers

The complexity of the technology and system failures. The hardware and software present in modern vehicles are shifting the automotive world. However, the technology in autonomous vehicles has its limitations. Some studies even show that the operation of an autonomous road-driven vehicle requires a more complex system than featuring autonomous technology in aircraft, Namely, there are more interactions with non- and low-predicting objects, causing a more challenging set-up, higher software complexity, better sensors

required, and more precise error control to achieve a safe experience (Litman, 2024). Furthermore, as the technology is changing rapidly due to AI and machine learning, any disruption could result in false activations (Catlin et al., 2024). An additional challenge is also the environment itself, as sensors and cameras have limited performance in heavy rainfall, snow, darkness and on an uneven road terrain (Litman, 2024).

Safety concerns. People are sceptical about the new emerging technology, its safety and the abuse of vulnerable information. Recent studies have also shared concerns about traffic accidents in mixed driving environments and high operational failure rates, especially in predicting non-connected factors such as human-driven vehicles, pedestrians and cyclists (Litman, 2024).

Increased costs. The costs of autonomous vehicles are expected to rise due to the advanced technology used. Another challenging aspect is infrastructure development, which requires time-consuming and costly updates (Alawadhi et al., 2020). However, this can vary widely, based on regulations and financial support (Litman, 2024).

Gap between acceptance, regulations and technology. Aligning advanced technology in an unpredictable environment is never easy, especially when handling a market with very specific requirements that demand high standards, precision and no room for mistakes (Sandvik et al., 2024).

Ethical and moral issues. There is a big concern about relying explicitly on the technology when it comes to safety, decision-making and data sharing. As the technology is based on the internet, there is also a risk of cyberattacks and abuse of the collected data (Alawadhi et al., 2020).

Legal issues. Legal guidelines are the basis for the successful implementation of autonomous vehicles. However, the regulations have so far not been set clearly, which is delaying the implementation process of highly autonomous vehicles (Alawadhi et al., 2020).

3.3.3 Dynamic factors

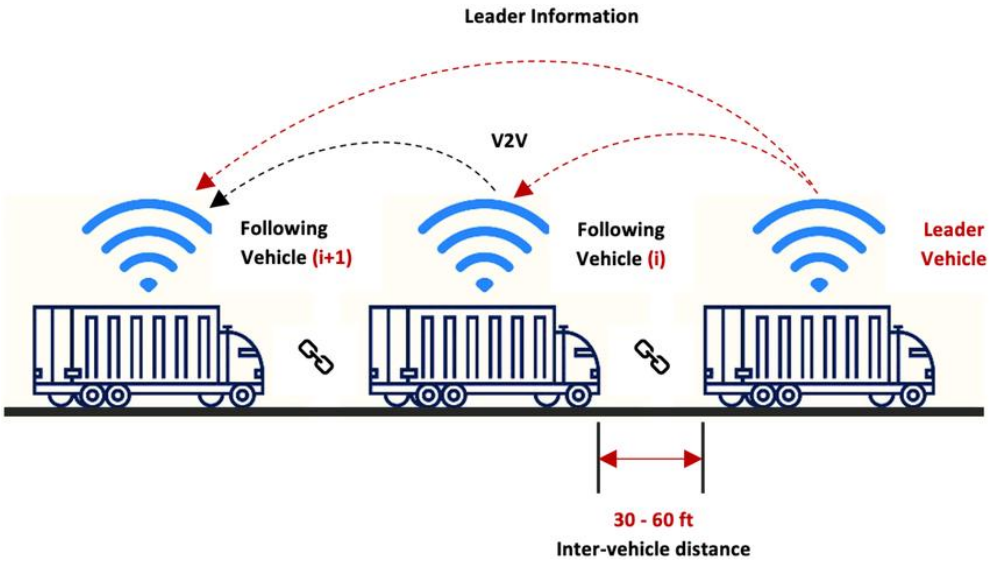
Traffic flow. One of the key concerns is how autonomous vehicles will affect the traffic flow. Will it lead to fewer vehicles on the road, or make traffic even more complex? It is promised that autonomous vehicles will optimise traffic flow, however, the overall picture remains unclear. Namely, a study shows that the urban traffic rate is likely to increase up to 30%, due to combined vehicles on the road and bigger demand for long-distance trips, which would require a better road management system (Litman, 2024).

Environmental impact and pollution. Autonomous technology has the potential to reduce fuel consumption by 60% with optimised acceleration and braking of the vehicles (Barabas et al., 2017), better fuel efficiency and a lower rate of emissions (Litman, 2024).

Autonomous vehicles also have the potential to reduce congestion, and therefore lower greenhouse gas emissions and fuel consumption and improve air quality, especially if compared with electric engines (Orieno et al., 2024).

Further optimisation of the emissions could also be achieved through the benefits of platooning. Platooning is a technique where a vehicle communicates a safety distance, adjusts the speed and follows a lead vehicle in a way that lowers the aerodynamic effect and improves traffic flow. It works based on the adaptive cruise control system. As illustrated in Figure 8, platooning operates with a Vehicle-to-Vehicle system (V2V) that provides back-and-forth communication, allowing the leading vehicles to adjust their speed based on the following vehicles (Khan et al., 2022). Platooning can also increase road safety and help achieve more sustainable mobility (Litman, 2024). However, it is hard to predict how many vehicles will be present on the road, how the technology will function, and whether self-driving vehicles will lead to share-driving or just additional vehicles present on the road (Litman, 2024).

Figure 8: Illustration of platooning



Source: Khan et al. (2022).

Future of insurance companies. Insurance will be highly impacted by fundamental changes in the automotive industry. In the future, these services will not only be responsible for human mistakes, but also for autonomous technology and crashes with connected vehicle systems. According to McKinsey's analysis (Catlin et al., 2024) by the end of 2030, the insurance industry will most likely experience substantial growth.

On the other hand, the insurance industry will also face many challenges connected to handling the data, cybersecurity issues and increased liability. Shifting the responsibility from humans to technology increases the complexity and leaves many open questions. In this area, proactive regulations are expected, such as tailored insurance and collaborations with OEMs and system providers of the technology (Catlin et al., 2024).

Game changer or only a modern trend. Lastly, research shows that autonomous vehicles may not end up as the biggest and long-awaited change in the vehicle market. While it will affect the future of transport, there are also other upcoming factors, such as electric cars and car-sharing systems (Litman, 2024).

To summarise the above, the adoption of autonomous vehicles is highly dependent on how people will perceive the innovation, interpret the benefits, accept the concept of technology and use the available functions. On the other hand, the industry will need to take the initiative to bring the technology closer to the consumers, deal with the concerns and ensure the overall safety of the technology, as this is the only way to outline any present concerns and barriers. Therefore, a close collaboration between governments, key industry players, researchers and developers is crucial.

3.4 Role of marketing in the adoption of high-technological products

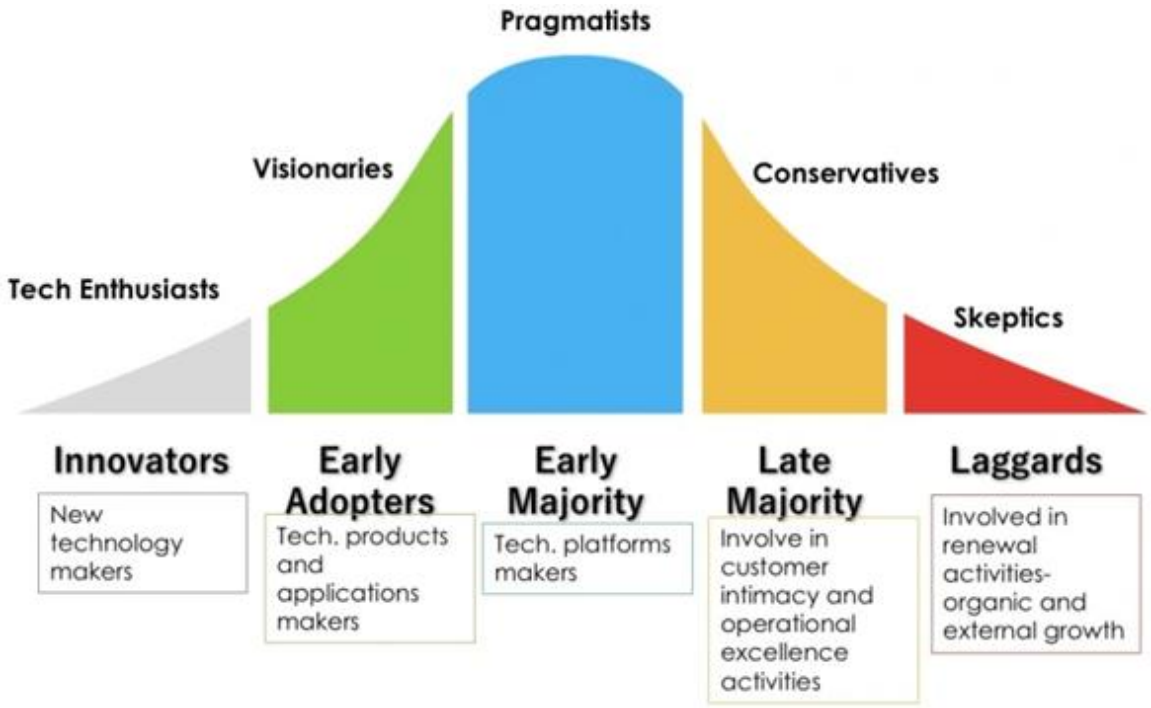
Various theoretical concepts and models have been introduced in the field of New Product Innovation and Adoption. Early work has been defined by Everett M. Rogers in the book *Diffusion of Innovation* (1962). His model defines five stages of the innovation process, typical for each individual in the process of new product adoption – knowledge, persuasion, decision, implementation and confirmation (Rogers, 1962):

- Knowledge – introducing the idea and potential benefits of the concept to the public with no or limited knowledge about the innovation.
- Persuasion – expanding the (positive or negative) desire to learn more about the idea and understand the overall concept of it better.
- Decision – the attitude of individuals and their effort to adopt the idea, consider the application or reject it.
- Implementation – being attracted by the idea, using it regularly, or at least a certain level of the available technology.
- Confirmation – the final stage of the adoption process, where users evaluate the decision, are satisfied with the outcome and continue to use it further.

Based on how individuals act when first hearing about a new product on the market, Rogers's model introduces five types of customers. In the ideal model, there are five categories – innovators, early adopters, early majority, late majority and laggards, presented in the adoption curve model (see Figure 9). Each group type can also be connected with a certain character. Innovators are people who are enthusiastic about the technology, early adopters are also known as visioners, the early majority usually adopts pragmatically, the late majority is represented by conservatives, and the last group presents sceptics or laggers of the adoption process (Rogers, 1962).

Following this theoretical model, autonomous vehicles are currently in the new market phase, where the technology is only being introduced to the market and impacts a small number of people known as technological enthusiasts. This could mean that there are either too many concerns for the rise of early adopters, or that the technology has so far not been introduced to the market successfully (Sandvik et al., 2024).

Figure 9: Roger's innovation adoption curve



Source: Al Dawood (2023).

Recent studies have shown that the adoption process of new products is highly affected by uncertain environments. A high level of uncertainty increases the difficulty of achieving the right timing, which is sometimes crucial for market implementation. Combining the adoption process with the Rogers curve model, research suggests that, especially in high-technology markets, the industry should focus on the *innovators* and *early adopters*, as their response shapes the reaction of others and determines the success of the innovation. This can be achieved by focusing on trust between businesses and potential users, targeting existing customers and positioning the product based on technological superiority (Eng & Quaia, 2009).

In general, disruptive technological innovations can develop into successful stories or end up as new product failures. However, it is also important to understand that the outcome of innovations is not necessarily the result of customer demand. Studies have shown that market orientation and marketing approaches can play an essential role in new product adoption. The right technique can lower customer resistance, broaden user knowledge and increase the critical role of understanding the new product or technology, resulting in customer interest and wider product acceptance (Eng & Quaia, 2009).

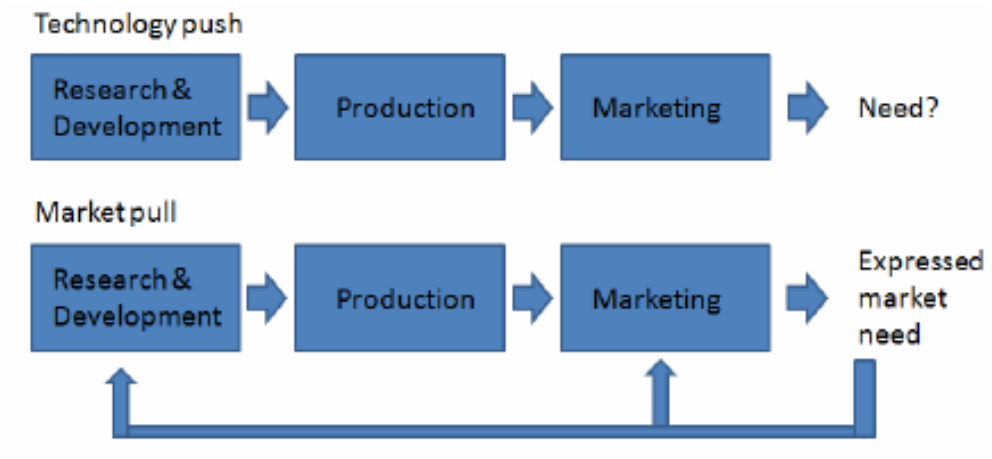
One of the key factors in improving new technology adoption in uncertain environments is continuous learning. Learning can bring advantages to both companies and customers. Through continuous learning, companies receive valuable feedback, and get to respond and adapt to a fast-changing environment. On the other hand, educating the customers reduces the perceived risk, anxiety and uncertainties of the innovation. This can be done by close product-customer interaction, offering pre-trials and training. The evidence shows that this approach can strengthen the relationship, speed up the learning curve process, and result in customer commitment, psychological attachment and behavioural loyalty to the new technology (Eng & Quaia, 2009).

Radical technology, such as autonomous vehicles, requires the power of marketing to support the adoption process (Alawadhi et al., 2020). However, the research shows that word-of-mouth communication and personal sources, mainly affect the adoption process only at the later stages of lowering the after-purchase uncertainty. At the beginning of the adoption process, impersonal sources have a higher impact on developing awareness of new products (Martilla, 1971), which confirms that the early adoption process should be focused on the learning process (Eng & Quaia, 2009).

The research also showed that environmental concern is a significant factor for customers. This means advertising sustainable transport, lower environmental impact and car-sharing could be an appealing way to gain user attention (Culiberg et al., 2022). In addition, the extension services can boost awareness, stimulate interest in the adoption process, and even educate users. The automotive industry has a high potential by providing remote vehicle diagnostics, software updates, educational programmes and customisations based on user preferences (Heiman, 2020).

Many industries use the technology-push and market-pull techniques to introduce the product or service to the market. The concept is presented in Figure 10 and further explained on the next page.

Figure 10: Technology-push and market-pull marketing approach



Source: Isoherranen & Kess (2011).

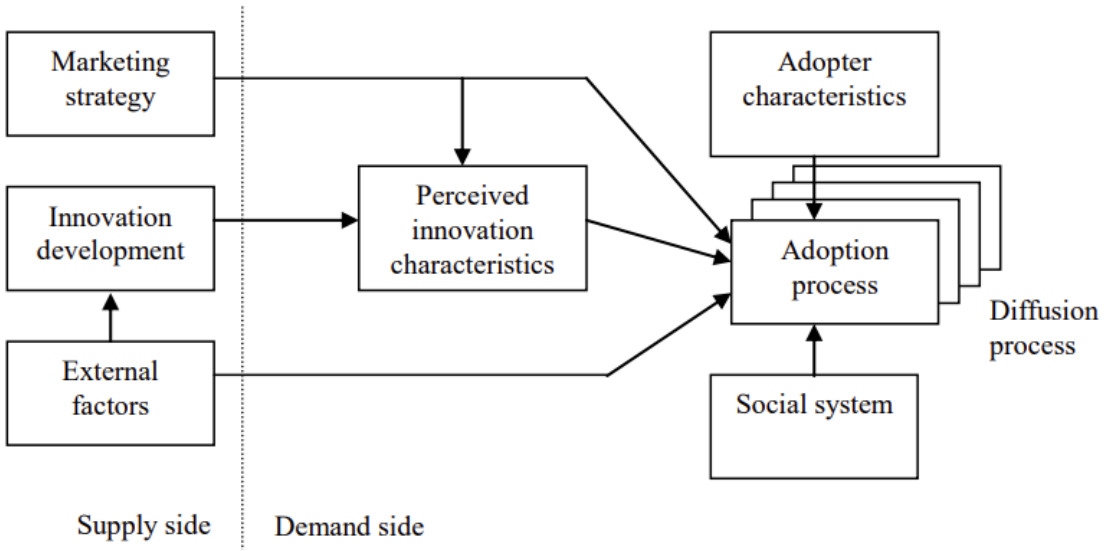
Technology-push means that the companies focus on manufacturing and internal development, whereas production pushes the marketing process. On the other hand, we have a market-pull model that uses a customer pain point and market need as a signal to introduce new ideas to the market (Isoherranen & Kess, 2011).

How we reach out to the market plays an important role and impacts the customers. Currently, autonomous car producers are approaching the market with a technology-push approach (Boyer & Kokosy, 2022). This thesis aims to evaluate the company's strategies and gain customer perception to better understand what role marketing plays in introducing and supporting the implementation of a new highly innovative product to the market.

Technology adoption is a process through which people or businesses learn about, accept and start using new technology. Key factors influencing technology adoption are the effort needed to adopt, the benefit of new technology, expected performance, conditions to use it and social influence (Lai, 2017). It is also crucial to understand that simply buying or acquiring an innovation does not lead to its adoption or effective use. This is a part of the adoption and diffusion theory, which predicts different speeds of adoption.

Even though innovation and diffusion present two different processes, there is an interrelation between them. Diffusion is a concept that focuses on how quickly the social system accepts innovation. As already mentioned, innovators present a group of people who adopt the product quickly, while laggers are more conservative and sceptical, and therefore their adoption process takes longer. In marketing, diffusion is driven by the innovation effect and the imitation effect. The innovation effect presents the speed of a small segment of early adopters, followed by other segments that copy and adopt the behaviour slowly (Driessen & Hillebrand, 2002). Factors that impact the adoption process are presented in Figure 11, with a more detailed description of the supply and demand factors explained on the next page.

Figure 11: Adoption and diffusion model



Source: Driessen & Hillebrand (2002).

The supply factors do not only impact the perception of potential adopters, but also the way people adopt the innovation. This means that a supplier needs to investigate and understand the adoption process already at the development stage of the innovation. The first step for potential buyers is being aware, and this is where marketing and communication play a critical role. Advertising, education and promotional activities boost influencing behaviour and can start the diffusion process. In addition, the adoption process is influenced by external factors, such as the competitive environment and regulations (Driessen & Hillebrand, 2002).

The adoption process follows five stages: awareness, conviction and decision, followed by implementation and confirmation. In the process of adoption, a person is triggered by the industry marketing strategy, external factors, social system and perceived innovation characteristics. The perceived innovation characteristics affect the speed of adoption, which is a result of relative advantages, compatibility, complexity, trialability, observability and the risk of uncertainty. Furthermore, each person and organisation have pre-set characteristics on how open and willing they are to trying new things (Driessen & Hillebrand, 2002).

4 EMPIRICAL STUDY ON THE MARKET ADOPTION OF AUTONOMOUS VEHICLES

Knowing the potential of the technology and realising how slow the adoption process is, opens the question of what the critical points in the market are. Namely, to date, only a limited number of studies have been conducted about the application of autonomous vehicles. This creates a limited view of the current market perception. Furthermore, there is a lack of studies on how marketing and communication strategies could support the adoption process, build trust in the technology and make the autonomous features more attractive (Sandvik et al., 2024).

To overcome the limitations mentioned above, this Master's thesis aims to explore the power of marketing and communication in making autonomous vehicles more attractive to the market. For the best results, the empirical research was divided into two parts: the first one focused on industry directions and the second on customer perception. The chosen research design, sampling strategy and data collection methods will be described further in the following subchapters.

The overall aim of the data collection was to:

- Investigate the current level of consumers' knowledge, awareness and interest.
- Identify opportunities for a smoother transition towards a safer environment and broader adoption in the market.
- Evaluate the ethical dilemmas and social concerns connected to autonomous technology and its impact on the adoption process.

- Investigate how marketing and communication can shape customer perception and acceptance of integrating autonomous technology into the transportation system.

The following research questions will be answered in the thesis:

1. How do potential users perceive autonomous technology in vehicles?
2. What are the key factors influencing consumers in using autonomous features in transportation systems?
3. Which limitations and challenges have the biggest impact on the autonomous vehicle industry?
4. In what ways can marketing and communication strategies support the adoption process of autonomous vehicles?

At the end of my Master's thesis, I will present the final results of the research aligned with the theoretical concepts and literature review. Based on that, I will provide recommendations and limitations for further research, including a marketing guideline to better support the adoption process of autonomous vehicles.

4.1 Qualitative study on industry directions

The main objective of the qualitative study was to gain insight into the strategic position and approach of the automotive industry. This was identified through in-depth interviews with diverse industry experts. The main focus of the research was to get more familiar with the current integration of autonomous technology, identify the main challenges of broad market application, and highlight the potential benefits of implementing autonomous vehicles in everyday transportation systems.

4.1.1 Purpose and goals of the qualitative study

The purpose of this qualitative research was to understand the industry of autonomous vehicles from different viewpoints. By examining the current challenges in the automobile sector, understanding the current implication process and potential market opportunities, this research aimed to develop practical guidance to support the adoption process.

The goal was to understand the industry viewpoint of the market adaptation process better. This includes clarifying the current market limitations, identifying potential solutions and focusing on how marketing and communication strategies can enhance the understanding of autonomous vehicles. The main aim was to highlight the benefits of this emerging technology, analyse the main concerns, and research the widespread implementation of autonomous vehicles.

4.1.2 Research methodology of the qualitative study

Research design. The reason for conducting in-depth interviews as a part of the qualitative research method was to gain a deep understanding of the current state of autonomous technology, identify the main challenges, and clarify how the broad-market application of autonomous vehicles is perceived by the industry. The interviews were semi-structured, to allow the consistency of the topics and leave room for the flexibility of different industry experts. The preparation included an interview guide that consisted short introduction about my research, a confidentiality statement and the main research questions. The questions were grouped into the following categories: background information, opening questions, transition questions, key research questions and closing part of the interview. The interview guide can be found in Appendix 2..

Based on the convenience and preferences of the candidates, the interviews took place online in the form of a video call, and were conducted either in the Slovene or English language. Before conducting the interviews, I informed the participants about the main objectives of the study. To achieve honest responses, the interviews were conducted with confidentiality and ensured that the answers would be used for academic purposes only. Based on the consent taken, the interviews were also recorded and stored for the purpose of the transcript, which is documented carefully in Appendix 3 and Appendix 4.

Sampling strategy. To gain comprehensive insights and ensure the best industry coverage, I included heterogeneous industry experts from cross-functional positions, different age groups and organisations. While selecting the companies and research institutions, my focus was to include organisations that had a major strategic impact on the vehicle market and were highly active in shaping the further steps in the autonomous vehicle market application.

For a more consistent overview, my research was based on the European market. The systematic sampling strategy was used for the best meaning that the members were identified based on the fit of their characteristics and experiences. The expected goal was to conduct at least two business interviews from different organisations, countries and backgrounds. The main criteria considered were to include only the European industry partners with well-established field experience.

The selection process was made based on the relevant positions and my available professional network. During the selection process, I contacted seven potential candidates. In the end, two of them agreed to participate in my research.

Sample analysis. As mentioned above, the qualitative study included two participants with more than ten years of in-field experience. Participant A was a male industry researcher based in Austria with a strong technical background. Participant B was an exclusive consultant of the luxury vehicle segment based in Germany.

More precisely, the first in-depth interview was conducted with a key researcher at the Institute of Automotive Engineering at the University of Technology in Graz, specialising in Advanced Driver Assistance Systems (ADAS). He has over ten years of in-field experience in active and passive vehicle safety at the worldwide automotive manufacturer Magna Steyr. In addition, since 2007, he has been the head of the Driver Assistance, Vehicle Dynamics and Suspensions Department at the Institute of Automotive Engineering, focusing on vehicle verification and validation, human-machine interaction and experimental research, involving simulations, testing, benchmarking and the education of people in driving schools. He is an active publisher and international reviewer of scientific articles in his field, with a deep passion for active vehicle safety. His institute supports industry partners with methods and tools to certify vehicles and help prove vehicle safety.

The second in-depth interview was conducted with an Exclusive Consultant who specialised in advising clients on luxury vehicles and high-assisted cars. He is based in Stuttgart, Germany. For the past 22 years, he has been employed by Mercedes-Benz, and is working directly with customers. His position allows him to be in direct contact with the customers of highly innovative vehicles. His job is to build and maintain a close relationship with the clients, help establish a strong brand identity and build trust with the customers. He is also highly involved with the personalisation requirements of the customers.

Data collection and analysis process. The data were collected through semi-structured online video-call interviews, taking between 50 to 80 minutes. To capture rich information, the effort was made to ensure comfortable and open conversations.

To analyse the qualitative data, I conducted a thematic analysis. This is a flexible and accessible qualitative data analysis that involves a detailed overview of the interview's transcript, identifying and coding the common topics, recognising patterns, and pointing out the main ideas and arguments directly from the data collected (Braun & Clarke, 2012). The deductive coding approach was used based on the main research topics (Fereday & Muir-Cochrane, 2006). The data were coded based on the already identified topics. All data gathered were analysed and discussed further.

As the interviews covered different areas of expertise in the field of the Automotive Industry, the viewpoints of the candidates were also compared where possible. In addition, the reflexive process allowed me to understand the complexity of industry viewpoints better, and ensure a good overview of both interviewees' backgrounds, more technical and business-oriented backgrounds. In addition, reliability was assured by creating and using a clear coding manual, including carefully all the data gained in the research analysis process.

4.1.3 Data analysis of industry directions

The following section, presented in Table 3: Overview of the main topics, shows the results of the thematic analysis conducted with two in-field experts, to explore the current position

of the autonomous vehicle industry and the view of the adoption process further. The data were collected through semi-structured in-depth interviews. Both participants have been interested in vehicles from a young age and have over ten years of extensive experience in the industry, and were selected by a systematic sampling strategy. To ease the differentiation between the participants and to put the emphasis on their expertise, Participant A will be described as a "researcher" and Participant B as a "consultant". The main topics identified in the data collection process are as follows: technology, market validation, market transition, European automobile regulations, concerns of adoption and understanding of the adoption process.

Table 3: Overview of the main topics analysed

Topic	**Sub-topics**
Technology	*Term "autonomous vehicles"*
	Harmonisation
	Technology limitations
Market validation	*Verification and certification*
	Combined traffic system
Market transition	*Market approach*
	Current view on the autonomous vehicle market
European automobile regulations	*European market*
	Most advanced European countries
	European legislation
	GDPR
Concerns of adoption	*Reliability of technology*
	Artificial Intelligence
	Ethical dilemma
	Environmental concerns
Understanding of the adoption process	*Types of technology enthusiasts*
	Motivation
	Education and training
	Timeline of the market adoption process
	Importance of market communication
	Sub-topics

Source: own work.

4.1.3.1 Technology

Term "autonomous vehicles". Both interviewees emphasised that full vehicle autonomy, meaning SAE Level 5, is unrealistic, as this would mean excluding humans from driving tasks completely and putting a machine system in full control of the decision-making process. Therefore, using the term autonomous vehicle can be unclear or misunderstood. The Researcher therefore suggested that, when the autonomous vehicle topic is discussed, we should take a step back and specify the level of vehicle autonomy with clear terminology.

More precisely, SAE Level 4, which stands for a driverless vehicle that operates in a certain environment and with predefined limitations where human intervention is needed.

Harmonisation. As identified by the Researcher, there is no role in harmonising the new technology used in autonomous vehicles. So far, every manufacturer has its own philosophy on how to incorporate it and we can already notice many variations. To ease the human-machine interaction and avoid potential problems and confusion, he recommended that industries should "somehow harmonise how the terminology is used, meaning how the systems are called and operated, how the human-machine interaction is done, and, last but not least, how people are educated about those driving assistance systems.". On the other hand, when talking with the Consultant, he has not yet identified this issue with his customers.

Technology limitations. The Researcher pointed out that the technology is lacking in safety testing, causing the so-called simulation-to-reality gap, which gets even more complicated with the difficulty of finding the right test cases. Not having the right test cases makes it harder to prove that the simulation is reliable and to classify the technology. This results in unapproved technology that cannot be used on the market. The additional limitation is the reliability of perception sensors in complex weather conditions, such as heavy rainfall, fog or snow, that limits or disables the sensors` operation completely. However, based on the conversation with the Consultant, the current technology does not appear to be a significant limitation for the use of autonomous vehicles.

4.1.3.2 Market validation

Verification and certification. In the eyes of the Researcher, the biggest limitations in the autonomous vehicle market are technology verification and certification. As technology and systems get more complex, testing gets more complicated as well. Statistically based methods becomes insufficient, and advanced methods, such as simulations, testing beaches, moving grounds and AI, present very costly and demanding operations. He described finding the right test cases to certify the vehicles as "finding a needle in a haystack". Due to its complexity, some people also call it a verification or certification trap.

To add on, certificates are hard to create, because technology keeps getting more advanced each day, due to the high-technology methods used in its system, and how should we classify something that will be further advanced tomorrow? The Researcher therefore believes that the lack of certification is a bigger problem than legislation, as legislation can be adopted, but the lack of documents and processes to certify the vehicles cannot be overlooked. The Consultant, however, believes that the technology testing and approvals rely mainly on the power of lobbies and interest groups that drive the main changes in the industry.

Combined traffic system. Both interviewees believe that mixed traffic will be harder to manage, and that our current road system is underdeveloped for incorporating combined

traffic. We also have a limited understanding of how human versus machine interaction will operate. It is hard to predict how people will interact with autonomous vehicles, meaning will they start pushing the boundaries and start behaving more carelessly? The researcher pointed out that some studies report that if we reach a certain number of automated vehicles on the road, the traffic flow could be influenced negatively. If this safe driving strategy of automated vehicles is overpowered, it could result in slower driving, with a bigger safety distance and a breakdown of the current transportation system.

4.1.3.3 Market transition

Market approach. The researcher pointed out two approaches to implementing autonomous vehicles in the everyday transportation system. The revolutionary and evolutionary approaches. An evolutionary approach means that the technology used in vehicles is approved stepwise, with small and simple steps. We can already see this with the step-by-step development of Level 2 vehicles, reaching Level 3 of assisted driving slowly. On the other hand, we have the revolutionary approach. This approach means taking out the human from the driving task directly, skipping Level 3 and reaching Level 4 directly. This would require excessive cost, an advanced traffic system and a high willingness to change the current driving patterns, making it rather unachievable at this moment in time. However, it would ease the complications of shared responsibility between the human and the robot-operated system during the transition period of Level 3 technology growth.

Building on this, the Consultant is involved more directly with everyday consumer interaction, and therefore aligns more closely with the evolutionary approach. In the interview, he highlighted that customer readiness and acceptance often depend on gradual exposure to the technology, as this makes it easier for people to build trust and adopt. This perspective underscores the importance of addressing customer concerns, and building trust incrementally to ensure a smoother integration into daily life.

Current view on the autonomous vehicle market. Current Level 3 vehicles have extremely exclusive prices, and are, therefore, only available to a limited people. However, as mentioned by the Consultant, there are also some technological constraints, such as the maximum allowed speed that limits when the autopilot mode can be used. For this reason, the Researcher predicted that Level 4 vehicles will only reach a broader market in the next five to ten years. Both interviewees also pointed out that the best way of adoption is in the commercial application. For example, attracting potential customers and technology enthusiasts with different business cases, such as robot taxis and car sharing.

Autonomous technology is also predicted to have a high success rate in logistics. Furthermore, as mentioned by the field expert, the research shows that the European Union is currently lacking truck drivers, and, in order to allow our supply chain to grow, we will potentially need to replace at least some of the drivers with the automated transportation system, to satisfy the market`s needs.

4.1.3.4 European automobile regulations

European market. The Researcher and Consultant see the European market as more conservative, especially compared to China or the U.S.. However, lagging behind could also be an advantage if we focus on proving vehicle safety and hardware development, instead of, as described by him "bringing the fast knowledge on the market for any price". However, the Consultant shared the fact that the European automotive industry is currently facing an economic crisis, which is already leaving its footprints on the automobile industry and slowing down the development and further investments into autonomous technology.

Most advanced European countries. A researcher believes that the main driver of innovation is Germany, with Mercedes-Benz S-Class vehicles, and Sweden, which puts a lot of focus on vehicle safety. And as stated by a consultant: "Within Europe, apart from Germany, I would point to France, Sweden, the United Kingdom, the Netherlands and Denmark", as he sees a big difference in their mindset and way of thinking.

European legislation. As confirmed by the Researcher and Consultant, European legislation has a complex structure. It all starts with international law, followed by the Vienna Convention on Road Traffic, which was adopted by European law, and, finally, we came to the binding law, which is the national legislation. One of the issues identified is that if you look closely at the Vienna Convention on Road Traffic, Level 4 should not be used on the roads. However, there is a loophole that presents a bit of a grey area. Due to these challenges, some European companies are establishing joint ventures with Chinese and U.S. companies, to ease the testing process.

The important realisation is, as believed by the interviewers, that the European automobile industry needs support and pressure from the European community if we want to see any real changes. Both interviewees also pointed out the importance of legal pressure, subversions and alignment with the lobbies as one of the most important factors for growth in the automobile market. More precisely, as stated by the Consultant: "What I miss is the support of the car industry in the form of subsidies so that we could compete better with our competitors". Due to the conservative mindset of most European countries, the existing legislation and guidelines are not enough to trigger the change. The Consultant believes that: "if there is no pressure from the European Community and legislation, nothing will happen". He also supported this argument with the example of the Anti-lock Braking System (ABS), which was made binding and mandatory for all new vehicles in the European Union and resulted in increased safety on the roads.

GDPR. The Researcher pointed out that, when it comes to testing and the use of advanced technology methods in the systems, there is a clash with the role of GDPR, which says that personal data should not be stored. Namely, so far, the data have been stored for processing the captured environment. However, as stated by the Consultant, "Europe is already rather strict when it comes to privacy and data security, compared to the Asian market or the U.S.,

meaning there should be no worries for the customers. The companies are aware of the privacy policy, and respect it due to the ground base of privacy protection in Europe".

4.1.3.5 Concerns of adoption

Reliability of technology. The Researcher pointed out that different technology senses the environment differently, creating an unmatched view of the environment. This gets even more complex in the case of rain, snow, or fog. There is also a risk of misuse. Namely, the more complex the technical systems get, the bigger the possibility of manipulating them and using them in a way that was not intended. On the other hand, the Consultant showed a higher concern regarding the infrastructure development rather than the development of the technology itself.

Artificial Intelligence. The field expert believed that people can be extremely fast in adapting to new technologies, and, so far, as emphasised by the Consultant, most people do not show any concerns about it. As the concept is so new, we cannot know what the benefits and drawbacks of it will be in the future. However, in vehicles, we can already see that technological advancements are growing rapidly due to the use of AI. As said by the Consultant, "there are less than 4 % of people even considering the concerns about AI". However, the Consultant believes that we should remind ourselves that sharing our data and location might already be done through our mobile devices, which are always near us.

Ethical dilemma. To some extent, as said by the Researcher, the ethical dilemma of high-technology vehicles is still an open topic that has, so far, not been researched enough in the direct connection with autonomous vehicles. The main issue is that we all have our own ethical beliefs, which makes it harder to develop a unified system that would differentiate clearly between what is wrong and right, or make a general decision on who should be responsible for it. The Consultant also pointed out that very few people share the concern about the ethical dilemmas, and that, in his opinion, a partial reason for it is the strict guidelines on ethical topics that exist in Europe.

Environmental concerns. The Researcher believes that autonomous vehicles have the potential to reduce CO_2 emissions significantly through optimised driving and better fuel efficiency. However, he shares the doubts of consumers' unawareness of this topic. Aligned with this concern, the consultant of a high-end European car manufacturer also noticed that customers show little to no interest in environmental topics when making purchasing decisions.

4.1.3.6 Understanding of the adoption process

Types of technology enthusiasts. Both the Researcher and the Consultant discussed different types of people when it comes to adopting and using new technology. They

mentioned groups that adopt new technology easily, as well as the opposite group, which is more resistant to testing and trying new things. Since it is known that some people have a harder time trusting new technologies, they emphasised that different approaches should be used for each group based on their unique characteristics. Additionally, the Consultant pointed out that: "young people are more open and eager to change, no matter the technology limitations, which is also the only way we can make progress. After all, the old technology and concepts will one day simply be insufficient." Therefore, he believes that the focus should be put on the young generations that are more open to new ideas and innovations.

Motivation. One of the important topics highlighted by the Researcher is how to motivate people to use advanced technology in everyday transportation systems. As mentioned by the Researcher, "The European Union is lacking around 200,000 drivers, which will only worsen in the coming years, as young people are not willing to do this boring and stressful job of driving trucks. To keep our supply chain going, we need to replace at least some of the transportation systems to operate without a driver".

To raise motivation about this, the Researcher suggested emphasising the increased traffic safety, improved comfort of the drive, reduction of energy consumption and inclusive accessibility to all, including the elderly and people with disabilities. There is also economic motivation expected, which should be reached through commercial application.

Similar points were also highlighted by the Consultant, who revealed that, for his clients, "the first and foremost important factor is to ensure safety, and comfort comes second", which is quite often the reason his clients rethink choosing more advanced technology.

Education and training. The Researcher believes that "we need to educate people, explain to them the capability of the technology and train them to incorporate autonomous features", especially as there are no clear requirements on how people should be trained and educated about these modern technology systems. Namely, so far, the information only exists in the manuals, which are often left unread and are carried by car dealers who do not always take the time to explain it, or are even unaware of it themselves.

Additionally, the Consultant pointed out that the sales team should be more proactive in their approach by emphasising the interest, highlighting the benefits, increasing awareness, sharing best practice experience, encouraging testing and promoting change that will improve the current transportation system and create a more enjoyable drive.

Timeline of the market adoption process. When it comes to Level 4, it is currently only available for the purposes of testing, in logistics cases and for commercial testing. The Researcher pointed out that we will most likely not see private market implications in the next five to ten years. The Consultant also believes that the current market is not ready for such technology.

An additional issue is also the price, market alternatives and constraints of the technical system. As emphasised by both the Researcher and Consultant, Level 5 is unachievable. Furthermore, the adoption of Level 4 autonomous vehicles will depend heavily on how the government pushes this topic. Coming back to the current Level 3 offered to the market, the Consultant believes that: "commercial applications, such as robot-taxis, are a very good solution to make it more accessible to the wider community", and to make a transition to more automated features of the autonomous vehicles offered on the market.

Importance of market communication. The Researcher emphasised the importance of the correct channel used for communication. However, he believes that most communication nowadays can be missed due to bigger concerns in today's society, such as inflation, immigration, war and economic and climate crises. He stated that, no matter the effort, these topics will overrule the interest in autonomous vehicles, not only in terms of failing to reach a bigger segment, but also in losing the interest of people who would otherwise be interested in autonomous vehicles.

On the other hand, the Consultant once again pointed out the importance of sales and marketing departments in the automotive industry. He works with a lot of enthusiasm and passion, and believes that this should be the starting point for all car dealers. He believes that "every salesman must present to the customer what technology can bring. I always like to emphasise that the customer should try things out, and the fact is, that once self-testing the technology, most people end up being enthusiastic and open to innovations". Therefore, he concluded that, in most cases, sellers and marketers present the main contact to share the latest information about the technology, which makes it crucial that they are well educated and that they believe in the technology themselves, can promote its benefits and encourage other people to test it.

4.2 Quantitative study on consumer perceptions

The consumer research was based on the hypothesis developed in this thesis and investigated further through a consumer survey. A quantitative method was used to gain the broad views of consumers' perceptions, and help determine the cause-and-effect relationship of potential consumers. The main aim of the quantitative study was to research the level of consumer awareness and openness to autonomous technology, analyse the biggest concerns related to broad market implications, and clarify how marketing and communication could impact the adoption process. The focus of the research was to identify critical issues for the slow adoption process, and analyse whether the market gap could be the reason for poor business communication.

4.2.1 Research hypotheses

To gain a more comprehensive understanding of autonomous technology adoption on the market, it is essential to consider the perspectives of consumers. With this in mind, the following part was focused on investigating consumers' views on autonomous vehicles, their level of interest and their concerns about the technology.

All the hypotheses were built upon the theoretical framework included in this Master's thesis and aim to contribute further to the main research topic of how marketing approaches could support the adoption process of autonomous vehicles. The following hypotheses have been developed and evaluated to achieve these insights and address the gap between industry efforts and consumer perception.

The research shows that 84 % of responders would be willing to use autonomous vehicles as a part of everyday transportation systems (Du et al., 2021). There are also additional factors that could increase the interest level further. For example, reduced stress caused by driving in high traffic, and the higher inclusiveness of a wide range of people who would otherwise not be able to drive the vehicle themselves. This includes the elderly and people with special needs and disabilities (Litman, 2024). Based on these findings, I propose:

Hypothesis 1: Consumers show high interest in autonomous vehicles.

The studies show that the majority of people do not know that autonomous technology already exists or have low knowledge about the way it functions and the benefits it offers. Furthermore, only 30% of respondents included in the public survey claimed that they knew about the standard classification of autonomous vehicles, which represents the main terminology used (Alsalman et al., 2021). Reflecting on these findings, I suggest:

Hypothesis 2: There is a positive relationship between being familiar with autonomous vehicle classification (SEA Levels) and noticing autonomous vehicles on the roads.

Most people believe that advanced autonomous technology could lead to better and safer driving experiences compared to the current road system (Patel et al., 2022). Frequently highlighted features include maintaining a safe distance from other vehicles, an automatic emergency braking system in case of sudden obstacles, and a "lane assist" function, which helps vehicles to stay within the designated lanes (Ondruš et al., 2020). Bringing it all together to the proposal that:

Hypothesis 3: Consumers have a positive attitude towards autonomous vehicles.

Research shows that safety is a key concern in the driving context (Garidis et al., 2020), leading to scepticism and hesitation in trusting new technology when safety is not demonstrated or understood adequately (Sandvik et al., 2024). Therefore, I suggest:

Hypothesis 4: Safety is the biggest concern in choosing an autonomous vehicle.

Furthermore, the study by Feys et al. (2021) indicated that individuals who have experienced and tested an autonomous vehicle show greater interest, improved perception and higher trust in the autonomous vehicle`s features. Based on this finding, I suggest the following:

Hypothesis 5: Consumers agree that hands-on experiences, such as vehicle testing, car sharing and robot taxis, would help gain trust in autonomous vehicles.

Finally, based on my qualitative research, an industry Consultant and Researcher estimated that consumer awareness of advanced vehicles is low. They believe there is a lack of clarity in marketing strategy, not enough direct communication and insufficient effort in the sales process and training. As other key topics overpower today's media, the following hypothesis was created:

Hypothesis 6: Consumers feel uninformed about the latest advancements in the automobile industry, more specifically as regards the new technology available.

4.2.2 Purpose and goals of the quantitative study

The purpose of this quantitative research was to investigate the consumer's perspective on autonomous vehicles. Based on how consumers are exposed to information, their interests and their perception of the technology, this research aimed to provide a practical guideline for improved market implications. The main aim was to clarify consumer concerns, address gaps in understanding the technology, and identify the opportunities for a broader adoption process.

The goal of this research was to analyse consumer perception of autonomous vehicles. This involved understanding consumers' knowledge and openness to this emerging technology. By analysing these data, the research aimed to find the patterns in consumer behaviour, explore barriers to technology acceptance and help identify market opportunities.

4.2.3 Research methodology of the quantitative study

Research design. To gain consumer insights an online survey was conducted, using the online survey platform 1ka. This type of quantitative research brings a few advantages, such as improved generalisability due to a bigger representative sample, higher objectivity due to a standardised data collection process and higher effectiveness (Queirós et al., 2017) due to reaching a broader group of people from various countries in Europe. The main aim of the research was to collect consumers' thoughts, opinions and doubts about using and incorporating autonomous vehicles in everyday transportation systems. To achieve honest responses, a statement of confidentiality was added to the Introduction of the research, ensuring anonymous data collection and secured data storage, used for academic purposes only.

The survey consisted of 22 questions. For a smoother transition between the questions, the survey was divided into six different sections – Introduction, screening question, warm-up part, main section of the questions, social-demographic section and a final page - thank you note. A detailed overview of the survey can be found in Appendix 5.

Sampling strategy. To achieve consistency and comparability with the industry research, the customer questionnaire only targeted individuals who live or work in Europe and are actively involved in any type of transportation system, public or private. To ensure diversity across different demographic backgrounds, such as gender, age, education and geographical area, the participants were selected carefully.

The survey was distributed through multiple channels, including personal and professional networks, university groups, work colleagues, various interest communities, online platforms and across social media platforms – LinkedIn, Facebook and Instagram. Snowball sampling was usedl, to avoid the constraints of purposive sampling. To reach a broader audience and minimise potential sampling bias, all the participants were encouraged to share the survey further with their own network employing the snowball sampling technique.

Data collection process. The main aim of the online survey was to explore consumers' understanding, knowledge and perceptions of autonomous vehicles. To gain a deeper understanding of consumer openness to this technology and to identify key concerns regarding the broad market implication, the survey included different types of questions, including attitude-based questions, multiple-choice questions, Likert-scale questions, open-ended questions and hypothetical scenarios.

The survey followed a structured format, beginning with introductory questions and continuing with warm-up questions to the main section of the survey. The final part of the survey included socio-demographic questions and a thank-you note. Due to the specific nature of the research, the survey also included a screening question, which filtered out the respondents who did not use any type of transportation system or did not currently live or work in Europe.

Many of the key research questions were derived from established scientific literature, such as a question on consumer attitudes, which was taken from McCroskey & Richmond (1989), a question on the consumers' level of interest, which was derived from Xiao and Goulias (2021), and a question on knowledge which was summed from the Towne (2020) Doctoral Study.

The participants were informed about the main purpose of the Master's thesis, data usage and confidentiality on the Introduction page, before starting the survey. Before distributing the survey, the questionnaire was tested internally by seven participants. Their feedback, suggestions, and ideas were reviewed carefully and incorporated into the final version of the survey. I started the data collection process on 17th January and closed it after twelve days, on 29th January, 2025. Completing the survey took approximately 5-10 minutes.

As mentioned, the survey was created using the online survey platform 1ka. The data were collected by sharing the survey with my personal and professional network across Europe. All the participants were also asked to help distribute the survey further to their own connections, ensuring that the dataset was diverse, reliable and representative.

4.2.4 Data analysis

The aim of the quantitative analysis was to gain a deeper understanding of consumer perceptions about autonomous vehicles. The following sub-sections will outline the sample, present the survey analysis and discuss the hypothesis testing.

4.2.4.1 Sample description

A total of 562 invited participants opened the survey landing page, 209 participants began filling in the survey and 141 participants completed the questionnaire fully. Due to the initial screening questions, 6 participants who did not meet the eligibility criteria were excluded from the analysis.

As a result, the final sample consisted of 135 participants (n = 135), all of whom use either public or private transportation, are based in Europe and have responded fully to all the survey questions. In the following part, I will present a further detailed overview of the socio-demographic characteristics, such as gender, age, geographic location and highest level of education.

In Table 4 we can see that 53 % of the participants were male, 45 % female, and 2% identified as other (non-binary and agender).

Table 4: Gender of the participants

	Frequency	Percentage (%)
Male	71	53
Female	61	45
Other	3	2

Source: own work.

Looking into the participants` ages, we can notice that no participants were younger than 14 years old or older than 65 years old. A significant proportion of the respondents were between 25 and 34 years old (55 %), followed by 25 % of the participants who were between 15 and 24 years old, and 10 % were between 35 and 44 years old. The remaining part of participants were 45 years old or older (10 %). A detailed view of the gender structure is shown in Table 5.

Table 5: Age structure

	Frequency	Percentage (%)
15-24 years old	34	25
25-34 years old	75	55
35-44 years old	13	10
45-54 years old	9	7
55-64 years old	4	3

Source: own work.

The survey was distributed only to people who are currently living in Europe. Among all the participants, 64 % were from Slovenia, 9 % from Austria, 6 % from Germany, 6% from Croatia and 3 % from Spain. As presented in Table 6 , the remaining 12 % of the participants were from Belgium, the Czech Republic, Finland, France, Luxembourg, the Netherlands, Norway, the United Kingdom, Sweden and Switzerland.

Table 6: Geographic location of the participants

	Frequency	Percentage (%)
Slovenia	87	64
Austria	12	9
Germany	8	6
Croatia	8	6
Spain	4	3
Other countries	16	12

Source: own work.

Based on the highest level of education, the majority of participants had a Master's degree, more precisely, 43 %. 31 % of the participants have completed a Bachelor's degree, 21 % obtained a High school diploma or equivalent, and 5 % of the participants have completed a Doctoral degree. The results are presented in Table 7.

Table 7: Level of participants' highest education

	Frequency	Percentage (%)
High school diploma	28	21
Bachelor's degree	42	31
Master's degree	58	43
Doctoral degree	7	5

Source: own work.

4.2.4.2 Descriptive statistics

In addition to the socio-demographic questions, which were collected at the end of the questionnaire, the survey consisted of 18 questions, spread logically across several pages to enhance readability and maintain participant engagement.

The first two questions (Q1, Q2) served as screening questions, ensuring the main characteristics of the target group. Namely, the selection criteria were to focus only on European consumers who use at least one type of transportation system, either public or private. The following question (Q3) asked the participants about their years of driving experience. As seen in Table 8, the years of driving experience varied between 0 and 40 years. On average, the participants had 11 years of experience or more. The results were spread out widely, with a Standard Deviation of 9.8.

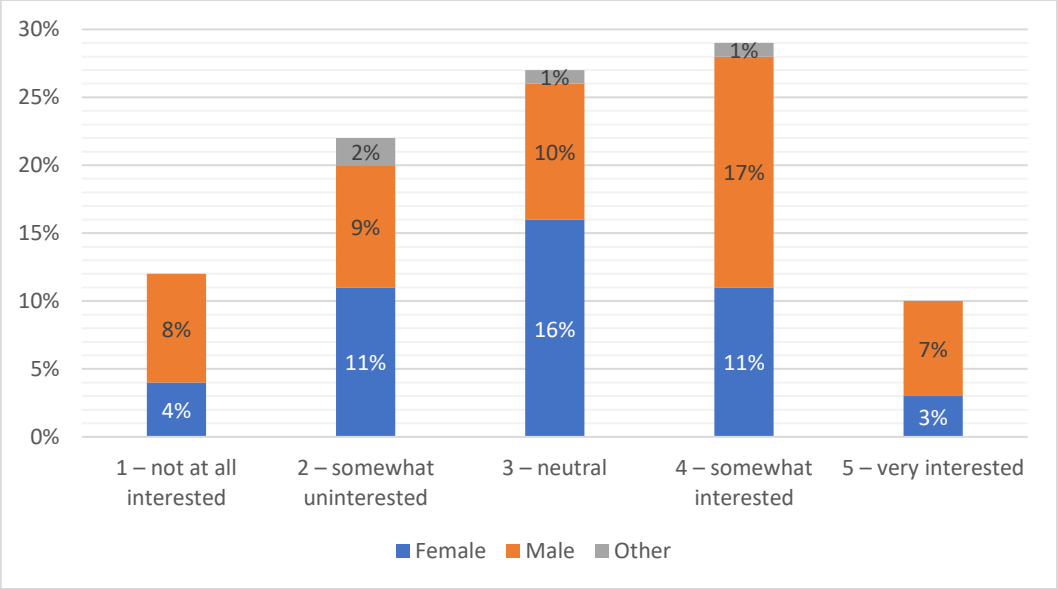
Table 8: Years of driving experience

	Frequency	Percentage (%)
0 years of experience	8	6
1-5 years of experience	31	23
6-15 years of experience	69	51
16+ years of experience	27	20

Source: own work.

With the following questions (Q4, Q5, Q6, Q7), I wanted to research the participants' level of interest, awareness and knowledge about autonomous vehicles. With Q4, I asked the participants directly about their interest in autonomous vehicles. The responses were collected with a 5-point Likert-type scale, ranging from 1 – not at all interested to 5 – very interested. As presented in Figure 12, 39 % of the participants claimed to be very interested to somewhat interested in the topic, 27 % were neutral, and 34 % were somewhat uninterested or not interested at all. The average score was 3.0, with a Standard Deviation of 1.3, indicating relatively divided opinions among the participants. However, a gender-based comparison revealed that males showed higher interest in autonomous vehicles compared to females.

Figure 12: Level of interest



Source: own work.

To better understand the interest in the autonomous features in the vehicle, the participants were also asked to select which (semi-)autonomous features (Adaptive Cruise Control, Lane Keep Assist, Automatic Emergency Braking, Self-Parking Function, Highway Assist, Autonomous Valet Parking) they wished to have in their next car. The results of Q5 showed that 50 % of the participants want to have at least one or more autonomous features, and only 13 % (17 out of 135) participants showed no interest in (semi-)autonomous technology used in vehicles. More precisely, 72 % of the participants wished to have an *Automatic Emergency Braking* system and/or 65 % *Adaptive Cruise Control* in their next vehicle. The lowest interest, 41 % of all the participants, was shown for *Autonomous Valet Parking*, which stands for fully autonomous parking, where a vehicle finds a space and parks itself without the driver being needed. 1 % of the participants selected the additional option *Other* – one participant responded with the desire for a self-charging car, which shows the misunderstanding of the topic as type of engine does not affect the autonomous technology.

The Q6 was "Have you noticed any examples of autonomous vehicles being used on the roads?". 36 % of the participants responded with *Yes*, 28 % with *No* and 36% with *Not sure*. Those participants who observed any examples were asked a follow-up question to name them. The majority of these participants (32%) mentioned Tesla as an example, while the remaining responses were Mercedes-Benz S Class, Audi A7, Waymo, a Verne robot-taxi in Zagreb, Porche, Ford, Audi, Polestars, Uber, a Volvo autonomous bus and delivery robots.

To get insights into respondents' technical knowledge and understanding, Q7 touched on the familiarity with the level of vehicle autonomy (SAE Level). 11 % of the participants (15 individuals) confirmed their understanding of the SAE classifications. To test the knowledge further, these participants were asked two additional sub-questions. In the first one, the participants had to explain the difference between SAE Level 3, Level 4 and Level 5, and in the second question, they had to indicate the current maximum SAE Level available on the broad European market. All the participants explained the meaning of SAE Levels correctly, however, only 20 % (3 individuals) answered the question about the highest SAE Level currently available on European roads correctly. The majority (53 %) thought that Level 4 was allowed. There were also 27 % of the participants who responded with *I do not know*. The detailed information is presented in Table 9.

Table 9: Participants' knowledge about the highest SAE Level available in Europe.

	Frequency	Percentage (%)
Level 0	0	0
Level 1	0	0
Level 2	3	20
Level 3	8	53
Level 4	0	0
Level 5	0	0
I do not know	15	27

Source: own work.

To ensure the correct understanding of the further analysis, the next page of the survey included an important explanation of what an SAE Level 4 vehicle is. The explanation was included as a subtext to all the questions mentioning SAE Level 4.

In the next section (Q8, Q9, Q10), the participants were asked about their thoughts on implementing Level 4 vehicles, key attributes, and their feelings and expectations on Level 4 autonomous vehicles.

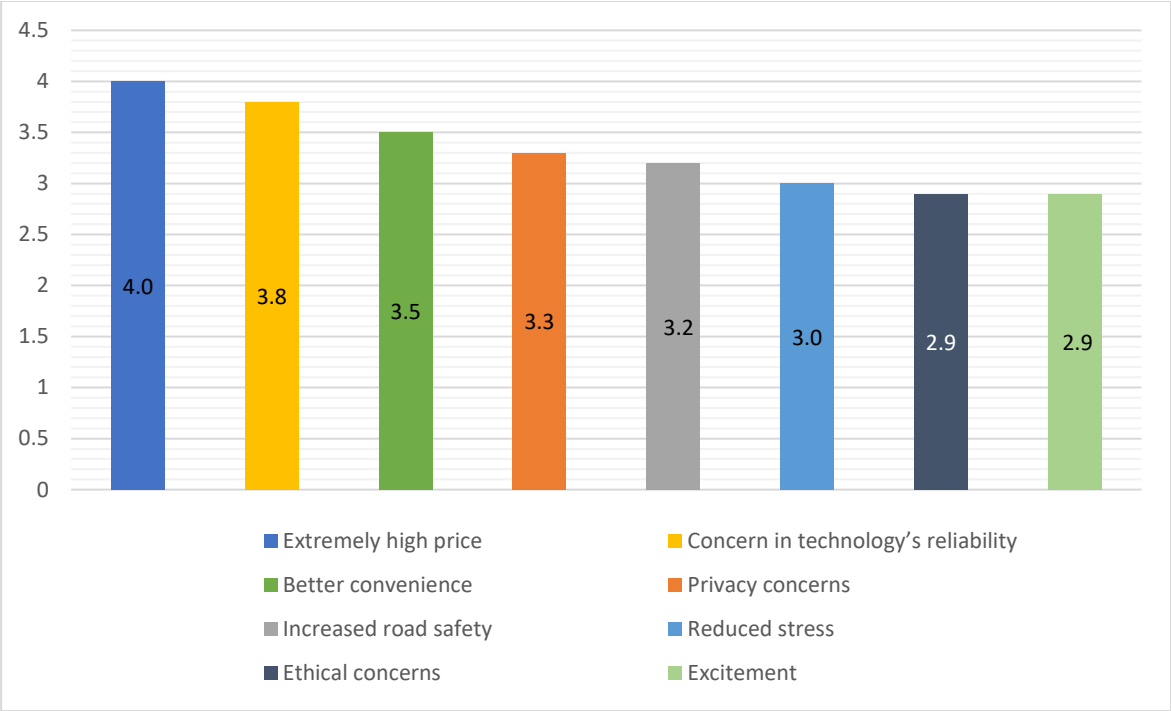
In Q8, I asked the participants to write their first thoughts on using and implementing Level 4 autonomous vehicles as a part of the everyday transportation system. To gain the most comprehensive insights, the question was designed as open-ended. All the responses were analysed carefully by categorising the positive, negative and neutral responses. The results showed that 35 % of the participants feel positive about the idea, 46 % are neutral or feel divided about the topic, and 15 % gave negative feedback about this idea. 4 % of the participants showed a misunderstanding about the topic. On a positive note, the participants highlighted that autonomous vehicles would create a safer and more enjoyable experience, make driving more accessible to people with disabilities and would help optimise traffic flow and limit congestion. On the other hand, the participants shared doubts about trusting the technology, abuses of the technology, reduced driving skills, safety concerns and feeling anxious about or scared of the advanced technology. The participants with mixed opinions expressed concerns about the current infrastructure, regulations, responsibility in the case of car crashes, limited human awareness about the technology, price, gap in technology testing, and performance in different weather conditions. Some participants also pointed out that they feel excited about the technology, but, at the same time, strange, or scared about its ability.

To understand the consumers' attitudes toward autonomous vehicles better, Q9 asked the participants to rate the selected attributes connected to autonomous (Level 4) on a 5-point scale. The question in the form of semantic differential included the following attributes: negative - positive (average = 3.3), wrong - right (average = 3.3), harmful - beneficial, (average = 3.4) unsafe - safe (average = 3.0), anxious - excited (average = 3.0) and unethical - ethical (average = 3.3). As presented in Table 12, the average score of all attributes was neutral or slightly positive, ranging from 3.0 to 3.4 with a Standard Deviation of 1.0. This indicates that the participants were, on average, rather neutral about the attributes.

In Question 10, the participants were asked to what extent they anticipate experiencing excitement, increased road safety, better convenience, reduced stress, extremely high prices, privacy concerns, ethical concerns and concerns about technology’s reliability when considering the implementation of Level 4 vehicles. They were responding on a 5-point Likert-type scale, ranging from 1 – not at all to 5 – to a great extent. The results of Q10 showed that the most notable, differences were observed regarding high price (average = 4.0), technology’s reliability (average = 3.8), improved convenience (average = 3.5) and privacy (average = 3.3), For the remaining factors, the average score was mostly neutral –

excitement (average = 2.9), increased road safety (average = 3.2), reduced stress (average = 3.0) and ethical concerns (average = 2.9), ranging from 3.2 to 2.9. The most positive response was given on improved convenience, and the biggest concern was noticed in rating the technology's reliability. The results are presented in Figure 13.

Figure 13: Anticipating key concerns (average scores)

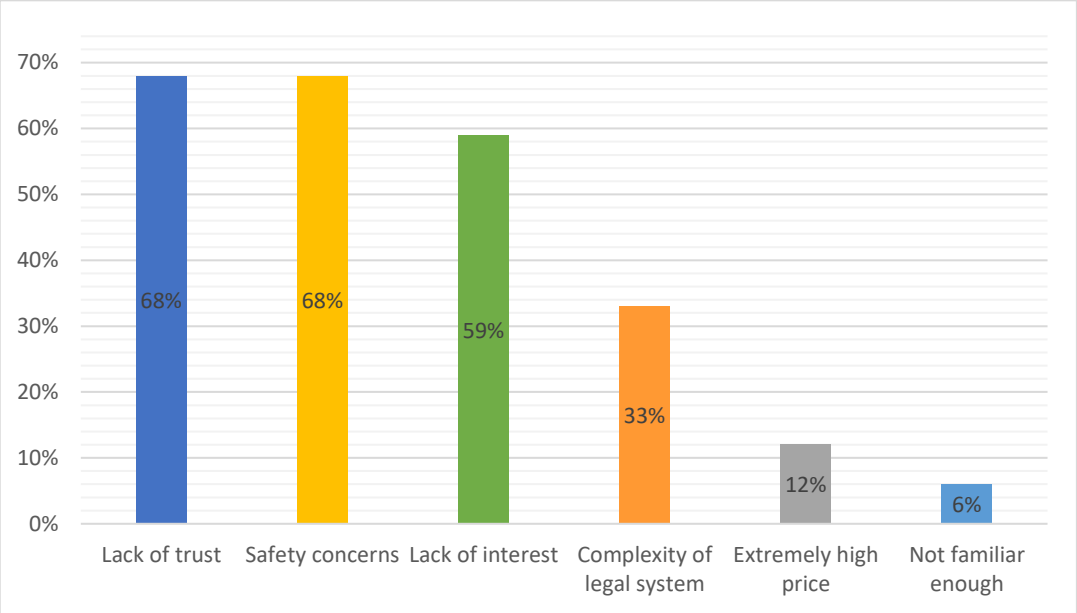


Source: own work.

The next section, (Q11, Q12, Q13, Q14, Q15), included questions on the main obstacles, the correlation between vehicle testing and gained trust in the technology, previous experiences and desire for testing autonomous vehicles, and a question to list the main source(s) of how participants were getting informed about new updates available in the automotive industry.

A closer look into the concerns (or obstacles for adoption) was researched with Q11: "What, in your opinion, are the biggest obstacles preventing consumers from adopting Level 4 autonomous vehicles?". The results showed that most of the participants identified a lack of trust (68 %) and safety (67 %) as the biggest concerns of autonomous technology, followed by extremely high prices (60 %). Followed by 59 % of participants pointing out on lack of interest and 33 % sharing doubts on the complexity of the legal system as one of the biggest reasons for consumer delay in adopting autonomous vehicles. Additionally, 7 % of the participants indicated that their lack of familiarity with the technology prevented them from answering this question. In further analysis, I also looked at how each age group responded to this question. The results showed that the participants aged 15-24, 25-34 and 35-44 believe that the biggest concern is safety, while the participants aged 45-54 and 55-64 mostly chose lack of trust as a reason for the slow adoption process.

Figure 14: Consumer perception on the biggest obstacles to adoption

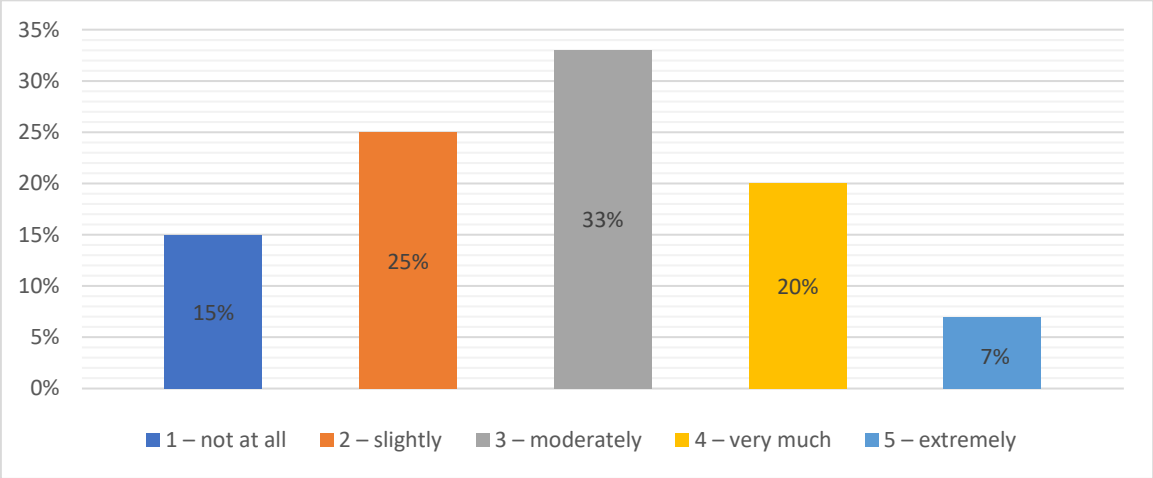


Source: own work.

In Q12, the respondents indicated to what extent they agreed with the statement "Hands-on experiences, such as vehicle testing, car sharing and robot-taxis, would help gain trust in autonomous vehicles" (from 1 – totally disagree to 5 – totally agree). Based on the sample included in the survey, the participants showed relatively high support for this statement, with 62 % of people agreeing with the statement, 28 % being neutral, and only 10 % of the respondents disagreeing with the statement. The average score was 3.6 with a Standard Deviation of 0.9.

The next question (Q13), asked about the previous experiences with Level 4 rides. Out of 135 participants, 7 % had already experienced a Level 4 test drive. Out of the 7 % of participants that had already experienced a Level 4 test drive, 2 % of the participants described it as a positive, nice and secure experience, and would recommend it further, 2 % felt some discomfort and expressed doubts about the technology development, and 3 % would not recommend it, as they experienced it as a slow, unpleasant and weird experience. This question was followed by Q14, asking to what extent the participants wanted to experience a Level 4 autonomous drive. The question was rated using a 5-point Likert-type scale, ranging from 1 – not at all to 5 – extremely. The average was 2.8 and the Standard Deviation was relatively moderate at a score of 1.1, indicating that most participants were neutral or slightly uninterested in testing Level 4 vehicles. For better representation, the results are shown in Figure 15.

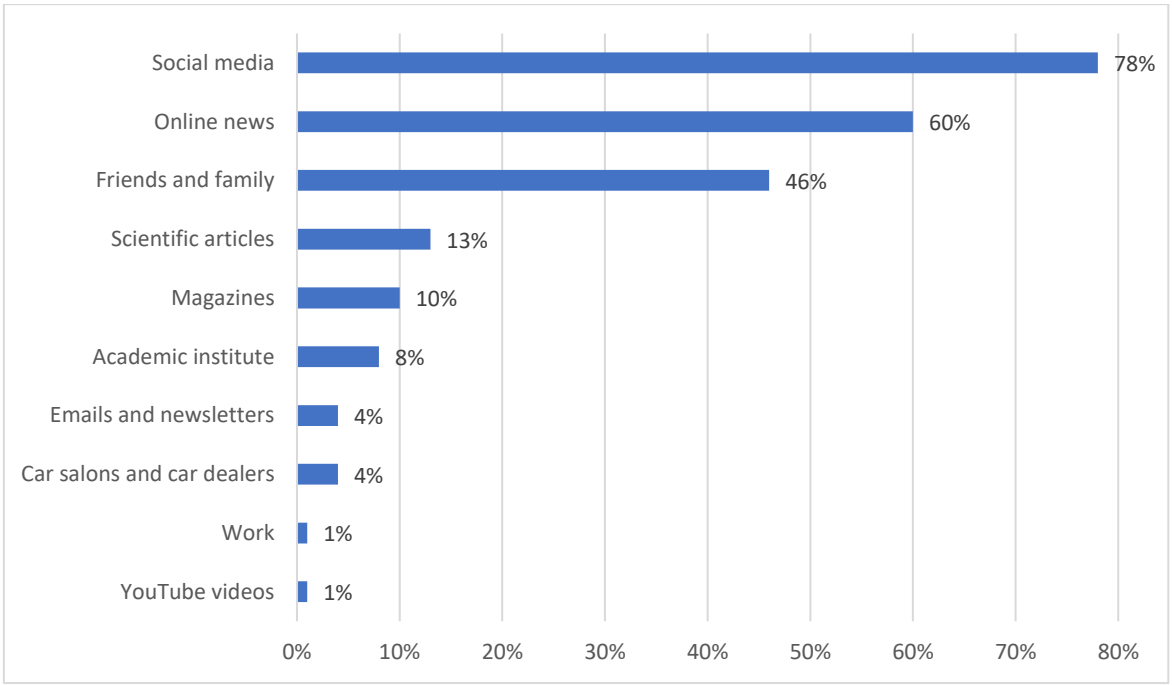
Figure 15: Desire to experience Level 4 autonomous driving



Source: own work.

The next question (Q15) was intended to capture where the respondents usually find out about the most recent technology updates and new technology features in the automotive industry. Multiple answers were possible. As seen in Figure 16, the analysis showed that 78 % of the participants research and learn about the most recent updates on the automotive industry through social media, 60 % through online news, and 46 % through friends and family. 13 % of the participants collect information by reading scientific articles and 10 % through magazines. Furthermore, 8 % of the participants learn about it at the academic institute, and 4 % or less receive the information by email, newsletters, personnel at car salons, and only 1 % via work and YouTube videos.

Figure 16: Source of information



Source: own work.

The final section before the social-demographic part focused on the subjective knowledge of the participants, their readiness to use a Level 4 vehicle, and the hypothetical question of whether they would be willing to accept a test ride (Q16, Q17, Q18).

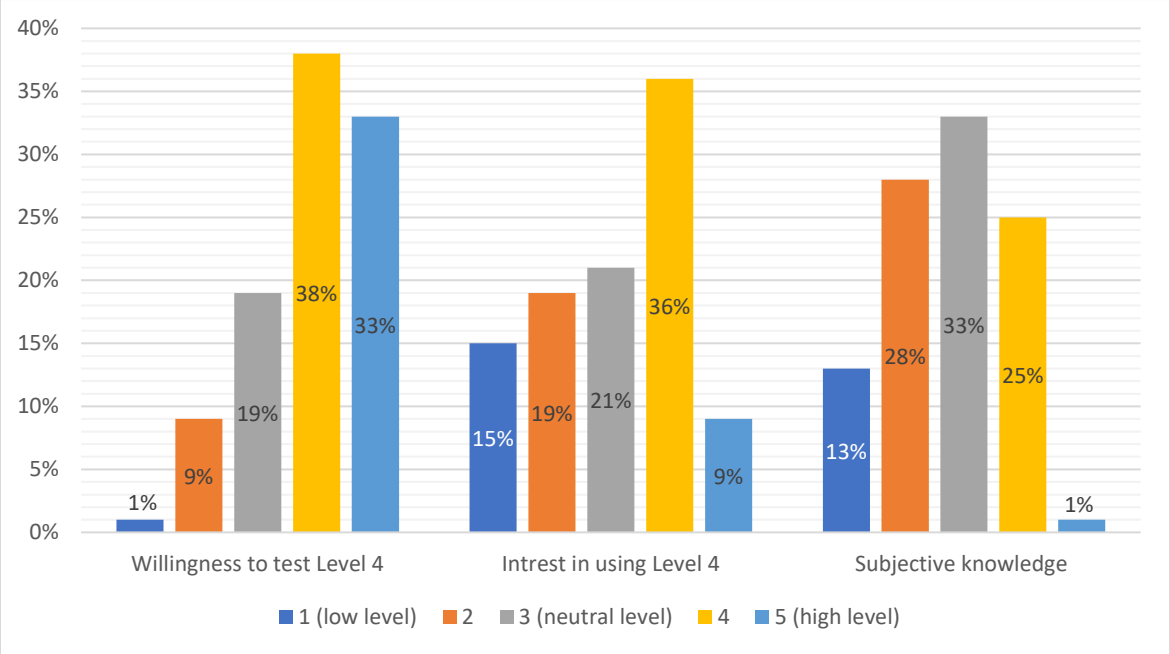
To test their subjective knowledge of the latest technology, the participants were asked to rate the statement "I feel well-informed about the latest technological advancements in the automotive industry" (Q16) on a scale from 1 – totally disagree to 5 – totally agree. The average score was 2.7 with a Standard Deviation of 1.0.

The participants were also asked to rate whether they would be willing to use Level 4 of autonomous vehicles as a part of the everyday transportation system (Q17). The answers were collected using a 5-point Likert-type scale (1 – not at all interested to 5 – very interested). The results of Q17 showed that 45 % were somewhat or very interested, 34 % were not interested at all or somewhat uninterested, and 21 % were neutral about it. The results had a moderate Standard Deviation of 1.0 and an average score close to neutral (2.7).

The final survey question (Q18), apart from the socio-demographic part, was put in the form of a hypothetical question: "If a car company invited you for a test ride with a Level 4 autonomous vehicle, how likely would you be to accept it?". The results were relatively positive, with an average of 3.9 on a 5-point scale (1 – not likely to 5 – very likely). More specifically, only 10 % claimed not to accept the offer, 19 % were neutral, and 61 % of the participants claimed to be interested in accepting the test drive opportunity.

The above three questions are presented in Figure 17, which shows that the participants are interested in testing the Level 4 autonomous vehicles.

Figure 17: Willingness to test Level 4, interest in using it and subjective knowledge



Source: own work.

4.2.4.3 Hypothesis testing

This chapter presents the results of the hypothesis testing. As mentioned in part 4.2.1, the main aim of the quantitative research was to examine the consumers' perceptions, subjective knowledge and attitudes toward autonomous vehicles. Each hypothesis (H1-H6) was analysed using a comprehensive approach conducted in Python. More precisely, different statistical methods were used, including a one-sample t-test, Fisher's exact test and descriptive analysis. The findings are presented in the following paragraphs.

H1: Consumers show high interest in autonomous vehicles.

H1 aimed to evaluate the overall interest in autonomous vehicles using a 5-point Likert-type scale (1 –not at all interested, 2 – somewhat uninterested, 3 – neutral, 4 – somewhat interested and 5 – very interested). The hypothesis was tested by performing a one-sample t-test analysis on Q4. The results presented in Table 10 show that there is no significant difference between the sample average (which was 3.0) and the test value of 3.0 as the p-value is higher than 0.05 ($p = 0.774$), indicating that there is not enough evidence to confirm the hypothesis.

Table 10: One-sample t-test for Hypothesis 1

Test value = 3					
Variable	**Mean**	**SD**	**t-value**	**p-value**	**95% CI**
Interest	3.0	1.2	0.2877	0.7740	[2.8 - 3.2]

Source: own work.

However, when I analysed the data by comparing the male and female respondents, I noticed that the level of interest was higher among male participants (3.11) compared to females (2.93). To check which statistical test should be used, I first conducted Levene's test to check for equal variances. As the p-value of the Levene's test was below 0.05, this indicated different variances in the two groups. Therefore, I continued using Welch's t-test, which showed no strong evidence of differences between males and females, as the p-value (0.331) was higher than 0.05. This means that we can conclude that gender does not play a major role in consumers' interest in autonomous vehicles.

H2: There is a positive relationship between being familiar with autonomous vehicle classification (SEA Levels) and noticing autonomous vehicles on the roads.

Through H2, I tried to analyse the relationship between consumers' subjective knowledge and awareness about autonomous vehicles. This was done by analysing Q6 ("Have you noticed any examples of autonomous vehicles being used on the roads?") and Q7 ("Are you familiar with different levels of vehicle autonomy (SAE Levels)?"). Using Fisher's extract test, I compared the expected frequencies of my categorical variables – awareness and subjective knowledge. The results showed that the odds ratio equalled 4.4138, which means that the chances for the event to occur in the "awareness" group are about 4.4 times higher

than in the “knowledge” group. Furthermore, as the p-value was lower than 0.05 (p-value < 0.001), the hypothesis H2 was confirmed statistically (the results are shown in Table 11). This finding confirms that (subjective) knowledge plays a significant role in shaping consumers' awareness of autonomous vehicles. Namely, the participants who were more familiar with the classification of autonomous vehicles were significantly more likely to notice and recognise autonomous vehicles on the road.

Table 11: Fisher’s extract test for Hypothesis 2

Variable	**Yes (in %)**	**No (in %)**	**Mean**	**SD**
Knowledge	36	64	2.0	0.8
Awareness	11	89	1.9	0.3
Ficher’s extract test			**p-value**	**Odds ratio**
			<0.0001	4.4138

Source: own work.

H3: Consumers have a positive attitude towards autonomous vehicles.

The H3 tested consumers' attitudes toward autonomous vehicles based on Q9, where the participants rated a set of six pairs of adjectives (measured on a 5-point scale by semantic differential). The average value across these six attributes was 3.22. The t-value for a positive attitude toward autonomous vehicles was 3.4703, and the p-value was below the significance level of 0.05 ($p < 0.001$), meaning we can confirm H3, as the hypothesis was statistically significant. This showcases that consumers are generally open to autonomous vehicle technology and show broad acceptance towards this technology.

Additional analysis of the factors right-wrong, beneficial-harmful and ethical-unethical supports the hypothesis further. However, attitude connected to safety and feeling anxious about the technology showed no significant difference between the sample average and 3.0. This suggests that, compared to other factors, safety and anxiety are observed with more neutral attitudes and should be addressed carefully in the implementation process. A detailed analysis of all the attributes is presented in Table 12.

Table 12: One-sample t-test for Hypothesis 3 and Question 9

Test value = 3					
Variable	**Mean**	**SD**	**t-value**	**p-value**	**95% CI**
Negative - Positive	3.3	1.0	3.4703	0.0007	[3.1 - 3.5]
Wrong - Right	3.3	1.0	4.0145	<0.0001	[3.2 - 3.5]
Harmful - Beneficial	3.4	1.0	4.1676	<0.0001	[3.2 - 3.5]
Unsafe - Safe	3.0	1.0	-0.1661	0.8684	[2.8 – 3.2]
Anxious - Excited	3.0	1.1	0.0776	0.9382	[2.8 – 3.2]
Unethical - Ethical	3.3	1.0	3.3906	<0.0001	[3.1 – 3.5]

Source: own work.

H4: Safety is the biggest concern in choosing an autonomous vehicle.

To analyse the consumers' biggest concern about autonomous vehicles, the participants were given a choice to select one or more factors that present the biggest risk to them (Q11). The results were analysed using descriptive analysis of the response frequencies and distribution. The H4 stated that safety is seen as the biggest limitation. However, the results showed quite similar scores for both, lack of trust (68 %) and safety concern (67 %). The third most frequently highlighted concern was the high price (60 %), followed by the complexity of the legal system (33 %) and lack of interest (13 %). Due to a similar perception of the lack of trust in technology and safety concerns, the hypothesis is only confirmed partly.

H5: Consumers agree that hands-on experiences, such as vehicle testing, car sharing and robot taxis, would help gain trust in autonomous vehicles.

To test the hypothesis on how hands-on experience would impact consumer trust, the participants were asked to rate a hypothetical question (Q12) on a 5-point Likert-type scale (1 – totally disagree to 5 – totally agree). The results were analysed using a one-sample t-test. Analysis showed that the average was 3.6, the t-value was 7.613, and the p-value was lower than 0.001. This confirms the H5 as that sample`s mean is statistically significantly different from test value 3. To interpret the results, the findings suggest that consumers show curiosity in hands-on experience, and connect hands-on experience with building consumers' trust in autonomous vehicle technology. This emphasises the importance of test drives, autonomous car-sharing opportunities and robot taxi services to enhance broader acceptance of the technology. The results can be found in Table 13.

Table 13: One-sample t-test for Hypothesis 5

Test value = 3					
Variable	**Mean**	**SD**	**t-value**	**p-value**	**95% CI**
Hands-on experience	3.6	0.9	7.6134	<0.0001	[3.5 - 3.8]

Source: own work.

H6: Consumers feel uninformed about the latest advancements in the automobile industry, more specifically as regards new technology available.

Finally, to test the level of subjective knowledge, I asked the participants to rate their agreement with the following statement: “I feel well-informed about the latest technological advancements in the automotive industry” (Q16). The statement was evaluated using a 5-point Likert-type scale, 1 – totally disagree to 5 – totally agree. The average value of the agreement was 2.7. The one-sample t-test analysis showed a t-value of -2.869 and a p-value of 0.005. Since the p-value was below 0.05, the result was statistically significant. Furthermore, a significantly lower t-value compared to the sample average confirmed the H6. This suggests that most participants feel uninformed about the latest developments in the automobile industry and lack awareness of the new autonomous technologies available,

which could be a sign of a communication gap between the industry and consumers. The detailed overview can be seen in Table 14.

Table 14: One-sample t-test for Hypothesis 6

Test value = 3					
Variable	**Mean**	**SD**	**t-value**	**p-value**	**95% CI**
Subjective knowledge	2.7	1.0	-2.8686	0.0048	[2.6 - 3.0]

Source: own work.

The summary of hypothesis testing is provided in Table 15.

Table 15: Summary of hypothesis testing

No.	**Hypothesis**	**Results**
H1	Consumers show high interest in autonomous vehicles.	Not confirmed
H2	There is a positive relationship between being familiar with autonomous vehicle classification (SEA Levels) and noticing autonomous vehicles on the roads.	Confirmed
H3	Consumers have a positive attitude toward autonomous vehicles.	Confirmed
H4	Safety is the biggest concern to choose an autonomous vehicle.	Partly confirmed
H5	Consumers agree that hands-on experiences, such as vehicle testing, car sharing and robot taxis, would help gain trust in autonomous vehicles.	Confirmed
H6	Consumers feel uninformed about the latest advancements in the automobile industry, more specifically as regards new technology available.	Confirmed

Source: own work.

5 DISCUSSION AND IMPLICATIONS

The main aim of the empirical part was to gain a better understanding of consumers' interests, knowledge and acceptance of the new technology, evaluate the biggest limitations in the industry, and help identify the opportunities for a smoother adoption of autonomous vehicles on the market. The results were interpreted based on the research questions. I also identified the main research gaps and provided market recommendations.

5.1 Interpretation of the findings

The results on how potential users perceive autonomous vehicle technology showed that participants showed rather low or neutral interest in this topic (H1), and only 11 % of the participants were familiar with the SAE classification of autonomous vehicles, showing a rather low consumer awareness. However, the overall attitude toward autonomous vehicles

in Europe seems to be positive (H3), which is comparable with the current trend and consumer perception in the U.S.(Du et al., 2021). In the hypothesis testing it was also noticed that there is a positive relationship between consumers who are familiar with the technical concepts of autonomous technology and the ones noticing the technology on the market (H2).

Taking a step back, the industry analysis shows that the timeline of bringing the technology to the market has been prolonged (Catlin et al., 2024). As believed by the interviewed industry researcher, the implementation of Level 4 "High Automation" vehicles will be a topic of the next 5 to 10 years, as the legal bases for having it on European roads are not set up yet. He even emphasised that, when it comes to Level 3 "Conditional Automation" vehicles, the adoption has not reached the broad market fully. Besides consumer concerns, some of the main reasons mentioned by him were the complexity of the certification process, technical concerns, operating only in a limited environment, high costs of owning such vehicles and little to no commercial opportunities.

Another aspect I aimed to analyse was understanding the key factors that influence consumers when considering autonomous features in transportation. The analysis showed that consumers see hands-on experience as a way to build trust in the technology (H5). Similar results were found in a study by Feys et al. (2021), which showed that people who experienced automated car rides had higher interest and trust in autonomous features. Additional factors identified in my quantitative research were the consumers' belief in an optimised traffic flow, a safer driving experience and more enjoyable drive.

On the other hand, in my study, the consumers identified trust and safety as the biggest concerns of autonomous vehicles (H4). There were also some doubts expressed on the price, reliability, responsibility in case of car crashes and potential misuse of the technology. What is interesting is, as Xiao and Goulias (2021) found out, that while the interest in autonomous vehicles has not grown in the past years, the concerns have increased over time. The growth of consumer concerns was also noticed by industry players. In the interviews I conducted, the key industry player highlighted the importance of addressing consumers' concerns and building trust as the crucial step of the technology adoption process.

As found in my qualitative study, a technical factor that seems to be limiting the current technology implementation is proving vehicle safety. Namely, due to the constantly evolving technology, complex environment and difficulty in finding the right test cases, it is hard to validate and classify the technology. This process was also described as "finding a needle in a haystack". The interviewed industry researcher and consultant also pointed out the risk of introducing autonomous vehicles in mixed traffic, complex legislation procedures, the dependency on governmental regulations and the interest of lobbies.

Last but not least, this thesis aimed to research how marketing and communication strategies could support the adoption process of autonomous vehicles. As shown through the analysis,

consumers feel rather uninterested in autonomous vehicles (H1) and uninformed about the latest advancements in the automobile industry (H6). However, what seems to have a positive impact on consumers' trust is hands-on experience, such as vehicle testing, car sharing and robot taxis (H5), which is aligned with the findings from a study by Feys et al. (2021). Additionally, based on everyday contact with the customers, the industry Consultant that I interviewed believes that consumers' readiness and acceptance depend on gradual exposure to the technology. He also noticed that step-by-step exposure makes it easier for consumers to build trust and adopt. The academic Researcher also pointed out that, besides promoting increased traffic safety, which is proven to be one of the most significant factors for consumers (H4), the industry should focus on communicating other benefits, such as better convenience and wider accessibility. Overall, both industry players also agreed on offering more commercial applications, such as shared autonomous vehicles and robot taxis.

Besides the analysis above, which was based on the research questions, I analysed the potential reasons for the non-confirmed hypothesis. As presented in the findings, the hypothesis about consumers' high interest in autonomous vehicles (H1) was not confirmed. This could be the result of consumers' lack of awareness, concerns about safety and technology reliability, cultural factors, such as scepticism and ongoing conflicts like war and economic uncertainties, which may have shifted the consumers' attention and priorities. As identified in Erskine et al.`s (2020) research, consumer attitude towards autonomous vehicles is affected strongly by social norms, perceived performance, ease of use and hedonic motivation. The above factors might be limiting the consumer's interest, shifting consumer priorities, and leading to consumers' low awareness of the autonomous vehicle topic.

5.2 Market potential and recommendations

The quantitative research showed that consumers feel uninformed about the latest developments in the auto industry and lack awareness of the new autonomous technologies available. To develop trust in emerging technology and bring the technology closer to the consumers, the automobile industry needs to take a more proactive approach. This could be done by interactive experiences, real-case applications and educational campaigns.

To add on, I identified that most consumers collect and receive information through social media, online news and magazines, which is an important indicator of how to approach the consumers. Based on the studies, I suggest using social media and online platforms as the main communication channel, while not forgetting about the power of word-of-mouth information (Dubey et al., 2022). It is also interesting that the interest in autonomous vehicles is slightly higher among males than females, but not statistically significant. In addition, Ágnes Hőgye-Nagy's research (2023) showed that personal beliefs, trust and openness to innovation, have a higher impact on autonomous vehicle acceptance compared to demographic factors.

Further, I identified a positive correlation between hands-on experience and gained trust in autonomous vehicles. This suggests that there is a need for more commercial implications and more hands-on experiences, such as robot taxis and shared vehicles. To achieve this, it is required to align the regulations with technological development, increase investments in smart city infrastructure, and build better governmental, financial and industry support, focused on offering a safer experience, and enhancing the broader acceptance of the technology. Namely, a safer experience was identified as a key benefit of autonomous technology, and one of the consumer's main pain points of this emerging technology.

Overall, as the knowledge of autonomous technology is not well-exchanged, the industry should get more involved and proactive in promoting the technology and encouraging people to experience it through commercial applications (Litman, 2024). This could also be supported by educational campaigns, to improve public attitude, perception and trust in autonomous vehicle safety further (Xiao & Goulias, 2021). This could potentially lead to continuous learning, resulting in valuable feedback, closer product-customer interaction and a faster learning curve and adoption process (Eng & Quaia, 2009).

To achieve a successful implementation of the above, the policymakers need to shape and support the mobility sector by supporting sustainable mobility models such as Mobility-as-a-Service, investing in smart-city development, adapting the existing laws and focusing on harmonised regulations for seamless integration that will be aligned and standardised for the broad European market. To kick off and test the infrastructure, the first attempts are suggested for logistic purposes, delivery services and public transportation, such as autonomous buses and robot taxis. There will also be a need for financial support and further research and testing. To raise awareness and increase public interest, the key role should also be played by car sellers, commercial services and marketing companies, which could be done through awareness campaigns, addressing customer concerns, building trust in the technology, promoting testing opportunities and educating, both the industry players and potential consumers. Supported by the Rogers curve model, it is especially important that the industry focus on the innovators and early adopters, as their response shapes the reaction of others and determines the success of the innovation (Eng & Quaia, 2009).

Research also shows that consumers are highly affected by social influence, expected performance, convenience and hedonic motivation (Erskine et al., 2020). This is why it is essential to create and promote safer, reliable, sustainable and future-oriented mobility supported by real-world applications, affordable business models and user-friendly experiences for consumers.

5.3 Research limitations and further research

The primary limitation of my empirical research was a non-probability sample that does not allow for generalisation. Most of the participants of my quantitative study were based in Slovenia, with less than 40 % represented by other European countries, and in my qualitative

research, there were only two participants involved, both living in Austria. This could present biased results, as the geographical background of the participants was not represented equally. Nevertheless, it is important to be critical of the possible subjectivity of participants and personal bias when interpreting the data. For more focused results, a further study could compare the differences between specific countries directly, and provide more direct business implications and a better overview of consumers' attitudes toward autonomous vehicles. It could also be interesting to conduct similar research in a region where autonomous vehicles are already implemented on the market. This would give a better understanding of how consumers accept the technology and respond to its adoption. Last but not least, another interesting topic would be to track the selling of highly autonomous features in vehicles and analyse if consumers end up using them, what their level of acceptance is, and which features they find most beneficial.

As another limitation, I would point out the focus on the European market. To ensure data accuracy, completeness and sample consistency in my quantitative research, I excluded the participants not based in Europe from my research. However, the results should not be generalised, as Europe presents a broad market with high diversity. The diversity which affects attitudes toward autonomous vehicles could vary significantly across regions. Different regulations, industrial priorities, openness to emerging technology and overall technological development, play a crucial role in shaping consumer interest and adoption rates across regions. Therefore, it would be interesting to perform a more detailed analysis between regions with higher vs lower innovation rates, or between the countries with more progressive vs restrictive policies, and compare the differences in how this affects the consumers` perceptions. For example, Slovenia, which scores high on Hofstede's uncertainty avoidance score, favouring stability and well-defined regulations, which could potentially lead to greater scepticism, compared to Germany, with a much lower uncertainty avoidance index, which might result in higher interest in technology and openness to autonomous vehicle adoption (The Culture Factor, 2025).

6 CONCLUSION

The current development and implementation of SAE Level 4 autonomous vehicles is at the experimental level, with an undefined timeframe for massive implementation (Hawkins, 2021). As identified in my Master's thesis, there is a lack of research on autonomous vehicle adaptation, particularly in the European market. The European automobile industry is highly fragmented due to complex legal frameworks, different National Regulations and diverse cultures. While some countries are more conservative and reserved towards new changes, others are more agile and open to innovations (Connell Garcia et al., 2020). Additionally, differences in economic development and urban environment affect consumer perception and their willingness to adopt new technology further (International Transport Forum, 2023).

As most existing studies on autonomous vehicles rely on simulations and low-scale pilot projects conducted primarily in the U.S., I focused on autonomous vehicle development and acceptance in Europe. The research showed relatively low interest in autonomous vehicles and limited awareness of the technology classification (SAE Levels). Besides safety concerns and lack of trust, consumers also identify a lack of interest as one of the main obstacles to autonomous vehicle adoption. However, surprisingly, consumers still show a positive attitude toward autonomous vehicles and believe that self-testing opportunities would help them gain trust in the technology.

On the other hand, some of the key challenges faced by the industry are a lack of governmental support, proving vehicle safety and ensuring reliable performance in a complex mixed traffic environment. Based on the research, the key industry players should focus on gradual exposure of the technology, commercial applications, and developing strategies to educate consumers and promote the benefits of autonomous vehicle technology, such as increased road safety, convenience and accessibility.

To summarise, the confirmed hypotheses were that there is a positive relationship between being familiar with autonomous vehicle classification and noticing autonomous vehicles on the roads (H2), that consumers have a positive attitude toward autonomous vehicles (H3), that consumers agree that hands-on experiences, such as vehicle testing, car sharing and robot taxis, would help gain trust in autonomous vehicles (H5) and that the consumers feel uninformed about the latest advancements in the automobile industry, more specifically regarding the new technology available (H6). It was also partly confirmed that safety, alongside lack of trust, is the biggest concern in choosing an autonomous vehicle (H4). And the non-confirmed hypothesis was that consumers show high interest in autonomous vehicles (H1).

To conclude, the implementation of advanced technology is a complex process that will require certain time and several steps before achieving full market integration. Therefore, it is important that consumers become familiar with the technology, gain interest and build trust in it. On the other hand, it is equally important that the industry recognises the different stages of the new technology adoption process and adapts accordingly.

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APPENDICES

Appendix 1: Summary in the Slovene language

Naslov: Trženjski pristopi k uvajanju avtonomnih vozil

Povzetek: Avtonomna vozila so pomembna tematika avtomobilske industrije, ki pa zaradi nejasnih predpisov, težav pri uvajanju tehnologije na trgu ter mešanega mnenja o njenem učinku ostaja negotova. Razvoj tehnologije namreč spremlja počasen proces uvajanja sprememb na trgu, ki odpira vprašanje ali je trg zrel za ta korak.

Ker večina obstoječih študij temelji na ameriškem trgu je bil cilj te magistrske naloge raziskati razvoj in sprejemanje avtonomnih vozil v Evropi. Posebnost Evropskega trga so namreč kompleksni zakoni in pestra raznolikost kultur, ki močno vplivajo na gospodarski razvoj držav, razvitost urbanega okolja ter dojemanje potrošnikov ter njihovo pripravljenost in dovzetnost k sprejemanju novih tehnologij.

V sklopu raziskave sem se dotaknila potrošniškega dojemanja avtonomne tehnologije, ključnih dejavnikov, ki vplivajo na potrošnike, glavnih omejitev in izzivov avtomobilne industrije ter trženjskih pristopov k uvajanju avtonomnih vozil na trg. Empirična raziskava je tako vključevala raziskavo industrije kot tudi potrošnikov in njihovega dojemanja.

Končni rezultati so pokazali relativno nizko zanimanje za avtonomna vozila ter omejeno poznavanje osnovne terminologije, ki opredeljuje stopno avtonomnosti vozil. Znotraj raziskave so uporabniki delili dvome o varnosti avtonomnih vozil in zaupanju v tehnologijo. Preverjanje hipotez pa je pokazalo tudi, da so potrošniki optimistično naravnani k temi avtonomnih vozil ter verjamejo, da bi testiranje pripomoglo k boljšemu zaupanju v tehnologijo.

Raziskava industrije pa je na drugi strani pokazala, da so ključni izzivi predvsem v nezadostni pravni podpori, testiranju in klasificiranju varnosti vozil ter v zagotavljanju zanesljivega delovanja v slabih vremenskih razmerah ter skupaj z ostalimi prometnimi udeleženci. Ključna akterja sta tako predlagala postopno uvajanje tehnologije, izobraževanje uporabnikov in poudarjanje prednosti, ki jih ponuja avtonomna mobilnost kot storitev.

Ključne besede: avtonomna vozila, Evropa, mobilnost kot storitev (MaaS), družbeni vpliv, trajnostna mobilnost

Cilji trajnostnega razvoja:



Appendix 2: Interview guide (Qualitative study on industry approach)

Welcome!

First, I would like to thank you for taking the time to support my research. My name is Teja Koren, and I am a Master's student at the University of Ljubljana, Faculty of Economics and Business. My research topic is "**Marketing Approaches to the Adoption of Autonomous Vehicles**". The aim of my research is to analyse the power of marketing and education in supporting and boosting the adoption process of autonomous vehicles.

Confidentiality statement. The interview will be recorded for the purpose of transcription and analysis. Your responses will be kept confidential and used for academic purposes only.

Background information

1. Can you tell me a bit about yourself and the company you work for?
2. How long have you been involved in the automotive industry?
3. What initially drew you to the automotive industry and autonomous technology?

Opening questions

4. How do you perceive the current state of autonomous vehicles? [current level of autonomous vehicles, most significant breakthrough innovation, technology testing, market implementation]
5. What are your thoughts on the widespread use of autonomous vehicles in the market? [is the market ready, B2B or B2C use]
6. Which level of autonomous vehicles does your company currently offer to your consumers and do you plan any advancements in the near future?
7. How would you describe the current speed of the technology adoption process?
8. When do you expect the next big step in the adoption process of autonomous vehicles? [which steps are crucial to kick-off, are there any delays expected]

Transition questions

9. How effectively do current European guidance and regulations support the ongoing growth and innovation of your industry? [complexity of European law, most advanced countries and key players, support and challenges]
10. How familiar do you think the potential users are with autonomous vehicles, and how ready do you believe they are to adopt them? [awareness, interest, knowledge]
11. Which factors do you think are the most critical in the eyes of potential users? [technology, trust, cybersecurity, use of AI, social dilemma, ethical concerns]
12. Which positive benefit do you think has the biggest impact on customer perception of autonomous vehicles? [safety, level of advanced technology used, public opinion, regulations, trends, environmental impact, media coverage]

Key questions

13. What key initiatives is your company taking to bring the technology closer to the market and boost the adoption process?
14. What are the biggest challenges and limitations that you are currently facing?
15. How would you describe the current status of communicating and educating potential users about autonomous vehicles? [reaching out to B2B and B2C market, type of communication, channel, who should be responsible for it]
16. Would you say your company is on track with industry guidelines in terms of reaching the desired state?
17. What communication strategies do you expect to be most effective in promoting the adoption of autonomous vehicles?
18. How do you perceive the timeline of the next stages of autonomous vehicle application?

Conclusion

This concludes our conversation. Thank you for sharing your thoughts and insights. Would you like to add anything else on this topic? Otherwise, thank you for your participation.

Appendix 3: Transcript of the interview with Participant A

Participant A is a Head of the research area of Automated Driving and Advanced Driving Assistance Systems (ADAS) at the Institute of Automotive Engineering, Graz University of Technology (TU Graz).

Date and time: 29th August 2024, 10:00-11:20

Moderator: Welcome Participant A.

Participant A: Hi, I hope you are doing well.

Moderator: First, I would like to thank you for taking the time to support my research. Having a chance to interview such an expert for my thesis research truly means a lot. As you know already, I am a Master's student at the School of Economics and Business at the University of Ljubljana. My thesis topic is "Marketing Approaches to the Adoption of Autonomous Vehicles". I am researching the current state of adopting autonomous vehicles, and analysing the power of marketing, communication and education to support and boost the market application process.

If okay with you, the interview will be recorded for the purpose of transcription and analysis, and, of course, your responses will be kept confidential and used for academic purposes only.

Participant A: Sure, I am okay with it.

Moderator: Thank you. Now, let's get started. I will guide you through some questions, but please don't hesitate to jump in or add something. To begin with, I would like to ask you about your background. Could you tell me a bit about yourself and your research position?

Participant A: I am located at the University of Graz in Austria. I've been studying Mechanical Engineering at TU Graz, where I've also done my PhD on the topic of passive radio safety in biomechanics. Afterwards, I spent 10 years at Magna Steyer, an automotive supplier, developing different vehicle projects, focused mostly on the active and passive way of vehicle safety.

Since 2007, I have worked as an Associate Professor at the Institute of Automotive Engineering at TU Graz. My working group is called Assisted and Automated Driving (ADAS), where we focus on three things. One is vehicle verification and validation, aiming to develop methods and processes to test that automated vehicles are safe. This requires integrating various functions and developing innovative approaches. Second is experimental research on human-machine interaction, including detailed behavioural studies. Our third research interest is integrating sensors and developing advanced environment detection models. I am currently also working with five PhD students, several Master's and Bachelor's students, and around ten external PhD students who are collaborating with various companies.
Some of the things we do are simulations, test benches, driving simulators, and testing vehicles on the road. We work on human-machine interaction, benchmarking, testing, and checking how people interact with the technology. We educate and work with people in driving schools and perform driving simulations. We also monitor driving, using bio-signals. An important part of automated vehicles is perception, we are not investigating the hardware,

we are trying to set the process on how to incorporate perception sensors into the validation process, so mathematical moto sensors, implementation of sensors and test benches in test vehicles. We also work with data and training the AI.

So this is a short background of what we are doing, and, as you can see, I am also quite focused on academic research with about 200 citations per year. I hope this introduction was good enough.

Moderator: This was more than good, so thank you a lot for sharing this. If I may ask, what initially drew you to the automotive industry, more specifically in autonomous vehicle technology?

Participant A: I was already interested in vehicles as a child. Later, I chose this as my major and eventually got very interested in how to protect people. Therefore, I chose Vehicle Safety as the topic of my PhD. After finishing my PhD, I worked in the field for 10 years at Magna Steyr. More specifically, I was involved in passive vehicle verification safety. Afterwards, I realised we cannot always protect people with a certain level of passive safety, we need to avoid collisions. This brought my focus to active safety and investigating how, in the long run, to take away the human error that is the most frequently the reason for collisions. This sort of wraps up how I ended up in my current position. However, I would like to point out that I never use the term autonomous, because I think this is science fiction.

Moderator: Okay, can you tell me a bit more?

Participant A: So, I rather stick to the SAE Levels, as you might have noticed already, SAE Levels 0 to Level 5. What is usually considered autonomous would be equal to SAE Level 5. As this can often get mixed up, I prefer to specify the autonomous degree using the SAE classification. So, we have driving assistance, which is equal to SAE Level 2 and is already present on the current market. We can also notice SAE Level 3 vehicles, and we are doing research up to SAE Level 4, which means driverless cars in certain environments and with certain limitations.

I often point out to my students that Level 5, which we usually connect to fully autonomous vehicles, is science fiction, meaning it will never happen. Why? Because Level 5 says there are no limitations. Therefore, it is important to specify the environment and constraints in which driverless vehicles will operate clearly. For example, even robotaxis in China have pre-set limitations with the driverless mode.

One more thing I believe is critical for the term autonomous is, if you look it up in the dictionary, it says “it decides on its own”, which is not the intention of autonomous vehicles, meaning, it should decide on doing tasks without human input. If it would decide on a transportation task of its own, which is what the dictionary says about autonomous, then we would be at a level similar to the Transformers movies.

Moderator: I agree, the term autonomous can get misunderstood or misinterpreted.

Participant A: Indeed, it is a bit misleading. I know this team is used commonly and it's okay for me, but I would recommend taking a step back and rather specifying vehicle automation using the SAE Levels.

Moderator: Thank you for this. I agree. It is very important, especially when conducting research, to specify this term clearly and making sure it is not misunderstood. Coming back to my next interview question. What, in your opinion, is one of the most significant breakthrough innovations in the automotive industry, when it comes to autonomous technology?

Participant A: Artificial Intelligence, and I can explain why – because when we look back to simple systems like adaptive cruise control and ACC, we're able to define a driverless automated operation on the route-based level clearly. In Levels 3 and 4 the situations are so complex that you cannot figure out every situation, so you need to go back and use the same strategy as humans, meaning to learn. Also, all the technology above Level 2 is based on Artificial Intelligence. It might be the perception itself, or the driving strategy of the vehicles.

Moderator: And what are your thoughts on the widespread use of the vehicles in the future? For example, having this technology implemented in everyday transportation systems.

Participant A: Even in the literature you can notice two approaches to this topic. One approach is from Daimler, and it's called the evolutionary approach, which means the vehicles and the technology are approved step-wise, meaning taking small steps. For example, you introduce autonomous emergency braking into the system, then you add ACC, lane keeping, and so on, and if you look into advanced vehicles from Mercedes, Tesla or Volkswagen, you notice different technology coming from different steps, that somehow work together. This process I think will continue up to Level 3. This means people will be able to buy assisted driving. However, at the moment, I don't see a market for driverless technology for private use.

The second approach to this topic, from what is written in the literature, is the revolutionary approach. This means we take out the human driver. Up to Level 3, we always have a collaborative system between the human driver and the robot driver, that have to work together somehow. The advantage is that there is always someone in the vehicle who can take care if something goes wrong. Meaning, it includes Level 2, where we still have to observe and have our hands on the steering wheel, but it could also perform as Level 3, where we are allowed to do other things, as long as a person is in the driver's seat and ready to take over the control when the automation system requires it. I believe that this is a technology that will get widespread use. However, a driverless technology (Level 4) where we take away the driver, requires a lot of technology and a lot of costs, and it will therefore not be affordable to a big market – only for commercial applications. We can already see this type of application, such as robot taxis and other business cases, that provide a more affordable incorporation of automated vehicles.

Furthermore, in my opinion, in the next 10 years, there will be only a high level of driving assistance present in the broad market (Level 3+), and not driverless cars (Level 4), due to technology testing, road infrastructure, and so on. To sum up, for the commercial applications we can expect robotaxis and automated trucks, for which the business cases are rather clear – there will be no more drivers in the future. Last week there was also a documentary on the radio that the European Union is lacking around 200,000 drivers, which will only worsen in the next years, as young people are not willing to do this boring and stressful job of driving trucks. To keep our supply chain going we need to replace at least some of the transportation systems to operate without a driver. As business cases show, incorporating automated driving technology could be done easily on the motorway and

logistics, especially with loading and unloading trucks within the logistics site areas, but I am a bit sceptical about having it in the cities soon, because the technology is very complicated. So, coming back to my previous thought, it would be a big step already if we had driverless trucks in the logistics area and on the motorway, especially as there is a big market and demand for it.

Moderator: And what are some of the most crucial things that need to be done before the adoption of autonomous vehicles in the everyday transportation system?

Participant A: I like to use the example of the PhD thesis from one of my students. He elaborated on the idea of finding a needle in a haystack, which means when we speak about testing automated vehicles, the complexity is enormous. Some of the researchers call it a verification or certification trap. The more complex the system is, the more we have to test, and soon we reach a complexity of testing that we cannot handle anymore. What we need to do is find the right test cases, that can certify vehicle safety by statistical-based testing. For this we need advanced methods and the right test cases. This leads us to the high costs of the technology. To put this into more context - if you think of an average person who is not that rich, they can afford maybe a used car, in the range of approximately 10,000 euros. Also, in the next few years, we might have more electric-driven cars, that are even more expensive, and if we add up the costs for Level 4 technology, this will, most likely, not be affordable for most consumers.

So, returning to your question, I believe the main limitation is verification of the technology. This is why I focus on testing and verification methods, with simulations, test beaches, moving grounds, and so on. What makes the certification even more complicated is when we include Artificial Intelligence. Namely, if you certify a vehicle today, it might be more advanced tomorrow, and how can we ensure that this learning process will not be negative? We could train a vehicle, which is already certified, but it's a driving strategy that makes things worse, because how can we guarantee that it doesn't make things worse? One of the questions researchers often ask is, what is the testing effort to prove vehicle safety? One of the conclusions is that it would take around 500 years and from 300 to 400 autonomous vehicles that would operate 24/7, to prove statistically that driverless cars operate 20% better than human-driven vehicles, based on the failure rate that ends up with dead fatalities. However, when we think about the current Waymo vehicles in the U.S., which is testing around 100 vehicles, the conclusion is that statistical methods and many simulations are needed. To speed up this process, the majority of the test cases should be done in simulation, and only the remaining part should be done by testing real vehicles.

Moderator: And how would you describe the current speed of the technology adoption process?

Participant A: When I started my work in vehicle automation, it was 2005. Back then it was mainly about the drive assistance, meaning up to SEA Level 2. Later, around 2010, there was extreme hype on autonomous features, and many companies spent a lot of money to bring the technology closer to the market. As we can see, operating systems with testing robots already exist in China and the US, where technology is quite mature. However, we have a challenge to bring this prototype/demonstration into daily life operations, and since we are talking about mixed traffic (human and machine-driven vehicles), even more problems appear – how will people interact when automated vehicles will be present on the roads? If automated vehicles should be safe, they should probably have a defensive driving

style. For example. if the driving style of automated vehicles is defensive, people might use this. If people start overtaking and driving more carelessly, this could result in slower traffic flow and a more unstable and unsafe traffic system. Some studies even report that, if we reach a certain level of automated vehicles on the road, the traffic flow could be influenced negatively, because the automated vehicles would have a safe driving strategy, which means that the vehicles would drive slower and with bigger safety distances, which could result in a breakdown for some transportation systems.

There are also many more challenges, such as market penetration, and how the vehicles will interact with existing transportation systems. There is also the whole topic of legislation, which I would say is the easiest to achieve, as we can see in some countries already – such as China and the U.S. that have fewer concerns with the legislation. However, in Europe, we are quite conservative. If we look at Germany, Level 4 vehicles are allowed under some restrictions of the ODD, which restricts Level 4 operation to be defined clearly in the law. The fact is that, in Europe, we are lagging behind the other countries, which might however be an advantage. Namely, I think the European strategy is more about proving vehicle safety, rather than bringing the fast knowledge on the market for any price.

One more thing about which I would like to talk about is the ethical dilemma. I am curious if you heard about the moral machine before?

Moderator: Actually, I am not sure about it.

Participant A: I will explain it to you. When you write "moral machine" in Google, there is a survey carried out by MIT, about how to approach driverless cars ethically. You can later try it out on your own. So how it works is that the moral machine will ask you which scenario you find more moral when a failure accrues, namely, we all know that driverless vehicles will never be 100% safe. The simulations provide you with two scenarios of collusion, either staying in the line or changing the line, however, each will have a dead scenario. In the end, you will get the results of your assessment, and you will also be able to see how other people approach this ethical dilemma.

But behind this is an even bigger challenge. Namely, each of us has our own ethical guidelines, and we are free to decide if we should protect ourselves or others. If the decision was correct or not correct is later treated in a court case. For example, in the case of texting while driving, this would mean we are held responsible for the accident. But this is difficult for robot systems as it does not have the ethical background – we need to train the system. But how can you train robot systems on ethics? This is something that still remains an open question.

Moderator: Indeed, it is a complex topic, and we both know that deciding on who should be held responsible for failures remains a big question. Since you already touched a bit on the legal aspect, I would like to ask you how effective would you say the current European guidelines and regulations are in terms of supporting the autonomous auto industry?

Participant A: As I mentioned already, the European market is quite complex. It starts with international law, then we have the Vienna Convention on Road Traffic which gives some additional guidelines. These are somewhat adopted by European law, which provides further recommendations to European countries, and, finally, we have national legislation, which is, in the end, the only binding legislation, and it also varies from country to country. For

example, the Vienna Convention on Road Traffic is, at the moment, adapted to autonomous vehicles with some amendments, but if you read it carefully, Level 4 is not really allowed, and it presents a bit of a grey area. However, German legislation allowed Level 4 under certain limitations. I am not completely sure, but I think they are working on a new version of a Vienna Convention on Road Traffic, to get rid of this drawback. Another limitation is GDPR, which presents a problem for technology testing. Namely, to work with Artificial Intelligence, which is needed for vehicle testing, we need to collect data, and GDPR says that personal data are not allowed to be stored. So, we need to make changes to the data and clear them before we can use them for testing. For example, we need to remove number plates, faces, and so on.

When it comes to national laws, for example, in Austria, we have a special law that is built in a way that, if some institution or company wants to see a new technology in the market, they have to present their technology to the government, and then the government decides whether it can be taken to the law and market or not. More precisely, we have a parking assist function, which allows drivers to leave the parking task fully to the technology as a part of Level 3 technology that is allowed in Austria.

Some years ago Germany adopted Level 4 vehicles, but they are strict and limited ODDs, such as shuffle service automated vehicles in logistics and automated parking functions that require a remote operator. This means that, even if we don't have a driver, someone has to supervise the operation of the operated vehicle.

To sum it up, European law is making progress and German law is the most advanced in bringing automated vehicles on the market, but since there are no commercial implications at the moment, the legislation itself it's not the big problem. The issue is the certification of the vehicles. This presents a big and open topic, as we don't have established certification processes for Level 4 vehicles. We have it for Level 3; it is called regulation No. 157, which defines a use-case on automated line-keeping assistance strictly that is allowed for going up to 150 kilometres per hour, and it says that the vehicle can be operated without a driver on a highway, but the driver has to be on a driver seat and a person has to, on the request of the system, take over the control of the vehicle in case needed. This means my hands do not have to be on a steering wheel all the time and I can for example do other things, but if the system tells me that it requires my help, I need to take over immediately and do so. This is the only regulation which I know that has a certification process behind it, meaning that the manufacturer can pass this regulation and put such a car on the market. Seeing this, we can say that the technology goes in the direction of autonomous features, but more within a range of Level 3 vehicles. For example, the Mercedes S class has adopted this regulation that requires you to look at the road at least once every 30 seconds, which is a definition of SAE Level 3, meaning it requires a driver to monitor the vehicle regularly.
To conclude, we have a lack of certification, which I would say is a bigger problem than legislation. Namely, legislation can be adopted, but if we lack the documents and processes the certification will block the application process.

Moderator: Thank you for this detailed answer. You mentioned that Germany is the most advanced country when it comes to the most advanced automobile features. Which other countries, besides Germany, do you believe will lead the European autonomous market?

Participant A: At the moment, the main players of vehicle innovation are Germany and Sweden. Sweden has a big focus on vehicle safety. We can also notice the movement within

the whole European Union, that has set a goal of having zero fatalities by 2050. This motivates, and to some extent, pushes the technology in the direction of driverless operations, but, as far as I see it, the biggest countries researching this are definitely Germany and Sweden. What I also noticed is that German automakers are cooperating with Chinese and U.S. companies as joint ventures, and are moving testing efforts to outside countries rather than in Europe, most likely because of all the challenges of European Regulations and certifications that have been mentioned already.

Moderator: It is a massive step, so I agree that collaborations could be a good start to bring the technology closer to the market. However, if we focus now on consumers, how familiar do you think the potential users are with the technology, and how would you rate their level of interest and knowledge about this topic?

Participant A: This is something that we are also researching. I believe we need to educate people, explain to them the capability of the technology and train them to incorporate autonomous features. Namely, in the near future, this technology will, at least to some extent, be present in each vehicle. For example, we can already see commercial applications of driverless systems in China with robotaxis.

Moderator: What do you believe are the main limitations of the technology?

Participant A: One of them is driver acceptance, meaning how to motivate people to use advanced technology in vehicles. Another is raising the acceptance of vehicle automation. We already talked about safety validation and issues with certification or so-called searching for a needle in a haystack. We also already touched on moral topic, legal situation, high costs, the complexity of traffic systems and Artificial Intelligence, but to add on, to make technology trustworthy we need to perceive the environment very reliably. Here, the issue is that senses use different technologies, for example, a camera would detect a pedestrian very differently compared to a LiDAR or radar system, as each technology has its own drawbacks. So, how do we make the perception of the environment reliable? We would need a lot of sensors, to get enough information and present them all in the same way. But we all know this is very complex, and would lead to much higher costs. Another key limitation are the environmental conditions. So far, most tests have been conducted in U.S. cities, such as Phoenix, Arizona, Silicon Valley and California, and, do you know the song "*It Never Rains in California*"? Well, the weather in these cities is often dry, with no rain, snow or fog, but the reality elsewhere is often different. This creates big problems for perception sensors, resulting in much lower reliability.

There is also a risk of manipulation or misuse, and the more complex the technical system gets, the bigger the possibility to manipulate and misuse it in a way which was not intended. People could even use it for terroristic attacks, for example, someone could put a bomb in the automated vehicle and drive it to the city or to the pedestrian area automatically. We also have this irony of automation, where one woman researcher said the following (I think 30-40 years ago, not related to automated vehicles). If you're introducing automation in the processes, a human being will come from a user to the operator, so he needs to supervise the automated system. The irony of automation is the more you automate, the more complex the system gets, and the more complex it is to supervise it. You can imagine a Boeing 777 aeroplane, where you need years of experience just to supervise the operation of the aeroplane. You train in a flight simulator, where you have to deal with difficult situations if something goes wrong. This means if we have a responsibile human, we have to educate

them on what to do in case something goes wrong. And this could be quite complicated, especially when you think about elderly people and handicapped people, how would they be able to deal with this?

We also have a topic of automation surprises, which means if I introduce automation to the system, it could lead, for example, to risk compensation. For example, if I put an electronic stability controller in a car, it can handle situations that a human driver cannot handle. So, the consequence could be that drivers take more risks and drive faster, because they would rely heavily on the technology.

Moderator: What would be your advice on how industries should reach out to potential users, educate them better and make them more interested and aware of the technology?

Participant A: This is something I cannot answer, but I would maybe like to point out five points of motivation. One of them is, of course, traffic safety, which is always one of the top priorities. However, it is also the most difficult one to reach, as we need to test the technology to be reliable enough to avoid collisions. As mentioned, this is called "searching for a needle in a haystack". Then, we have the need for comfort, which should be the easiest to achieve – for example, relieving people from boring tasks and giving them back the time to do other things. Meaning, to make a vehicle comfortable enough so people can do other things while driving on the road, such as eating, sleeping and reading, and you can sell comfort to customers. Another motivation is reduced energy consumption due to improved driving strategy, optimised traffic flow and fitting more cars on existing roads. Then we have the consideration of mobility, which includes people who are not able to drive anymore. As an old man, my eyesight will soon not be good enough, my reaction time will slow down, meaning I might soon need to give back my driving licence. But maybe with the automated vehicle or assisted driving, things would change. Last but not least, there is the economic motivation. Manufacturers and companies are already thinking of how to sell new business models, such as car sharing. So instead of selling directly to the people, which would be too costly for most of them at the moment, they are already shifting to a more future-oriented selling approach - how to sell mobility as a service.

Moderator: And could you tell me a bit about how your institute is currently supporting the industries and the adoption process?

Participant A: We are helping our industry partners with methods and tools to certify vehicles and with the simulation to help prove vehicle safety. For example, we build a digital twin of the environment and the automated vehicle, and, at the moment, we are trying to find the test cases and how to do the certification in a virtual manner. This is one of our biggest challenges – how can we prove that the simulation is good enough? This is the so-called simulation to reality gap and presents one of the challenges. At the moment we are focused on how to find the right test cases and doing it on the simulations or test benches. We should put the effort into on-road testing, which is done a lot these days to, let's say, move to smarter development processes. The other thing is human-vehicle interaction. We want to know how people interact with automated vehicles. For example, we have a project where we have a Level 3 vehicle in our simulator, that is able to drive on its own in traffic, and we are introducing other people who are driving carelessly. In that case, the automated vehicle cannot handle it by itself, and will tell the person in the car "please take over". Within this topic, we especially want to analyse how people answer and respond to this request. Another thing in this human-machine interaction is that, if we want to achieve Level 3, the legislation

will require that we know if the driver is able to take back the control. So, we need to monitor if the people are still able to do this, and one aspect is drowsiness. We have developed methods for how to classify the level of drowsiness of people. Finally, my additional point is, how can we prove the reliability of perception sensors? How do they perceive bad weather conditions? For example, in heavy rain, the line marks are not visible. To sum up, the three things are safety testing, human-machine interaction and the reliability of perception.

Moderator: What are the biggest limitations that you are currently facing, apart from time and costs?

Participant A: For safety, validation is finding the right test cases and proving that the simulation is reliable so that you can use it for certification. For the human-machine interaction it's how people who are not trained will interact with an automated system, will they be scared, and will they have failures?

Moderator: Would you say it is reasonable for people to have doubts about the technology, such as doubts about cybersecurity and the environment?

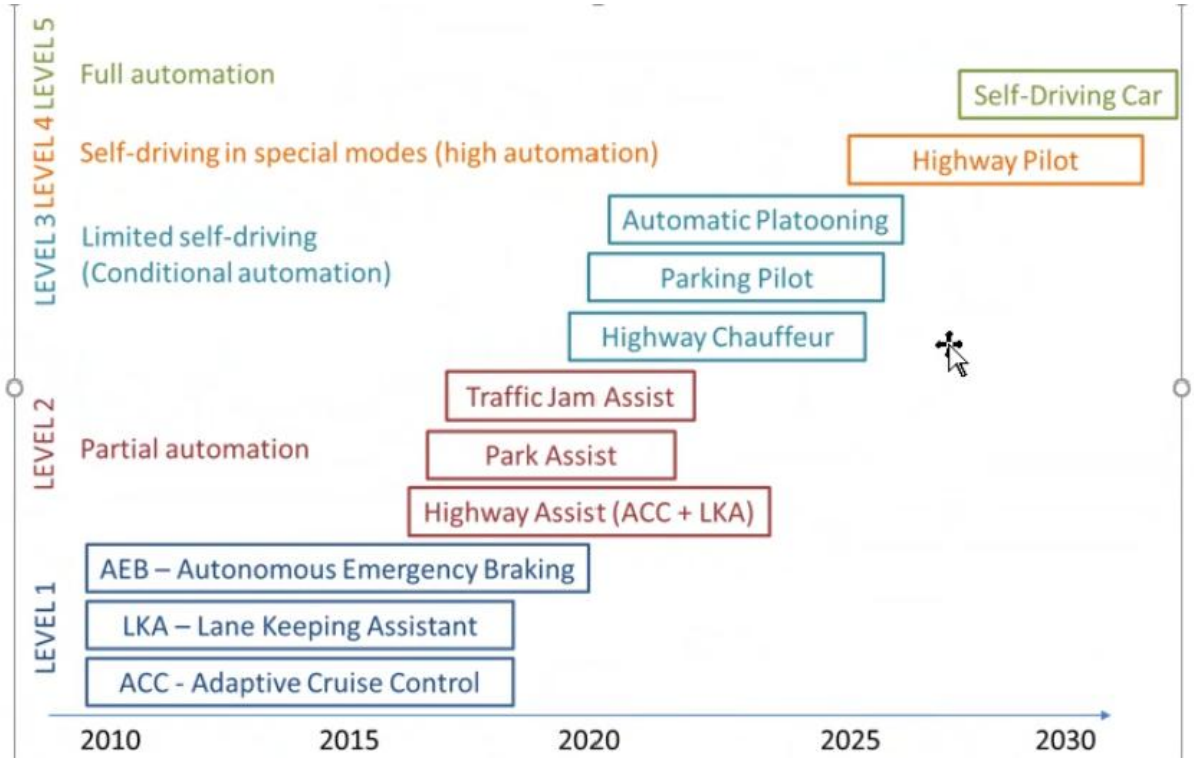
Participant A: My personal opinion, which is not based on any research, is that most people don't care about cybersecurity and data privacy. They are giving out the data to Google and Facebook freely, and seem really not to care about the data. d The industries like this a lot, as high-level automated vehicles gather data all the time, and nobody knows if the use of the data collected is done in the proper way or not. The only authorities that care about cybersecurity are governments and experts who are dealing with cybersecurity. But as I said, I think that the majority of people just don't care about cybersecurity and are not really aware of it, and this could be dangerous. Regarding CO_2 reduction, I personally believe that the majority of people do not care about the emission, or at least do not really understand its effect.

Moderator: How would you say it is with AI and machine learning?

Participant A: So far it looks like people adapt to AI very quickly. I figured out a lot of very fast progress. When ChatGPT came out, if I am not wrong this was around a year ago, and now, in just a year, we already have the first papers written on using ChatGPT in development. People use these large language models for programming new things, writing papers, analysing data, and so on, meaning, that people are extremely fast in adapting to new technologies. I would say that AI is adopted very, very quickly by the young generation, and the majority of people are not reflecting the consequences of it. I would not say whether this is good or bad. Also, at our university, we are currently collecting ideas on how to deal with AI in education, and how to ensure that a Master's thesis would not be created artificially. The concept is so new that we don't really know at the moment, what will the benefits and drawbacks of it be in our daily lives. In vehicles, we see that the speed of the technology is enormous with AI use, but, of course, if it's going to be used in the wrong way it could do harm. I don't really see an option to ensure and prove that the use of AI will only bring benefits and do no harm.

Moderator: As one of my last questions, based on your opinion, how do you see the timeline of the next stages in autonomous vehicle application?

Participant A: Interestingly, I have been dealing with this question in my lectures for the past 15 years, and I've never changed the slide I've created, because it seemed to be still a reasonable overview. It is not my picture, but it does present the process nicely. I will share it with you (see the picture below).



Moderator: Sure, thank you.

Participant A: We already have Level 1 automation on the market, with some elements already being prescribed by the law, such as an autonomous emergency braking system. We can also already see Level 2 features on the market, for example, lane keeping. And when it comes to Level 3, I remember that 10 years ago we were anticipating if we should bring Level 3 features to the market. Right now, we have something that is quite close to the predicted direction. We do not have automatic platooning, but we do have some capabilities of a parking pilot – even though the duration got prolonged.

However, we still don't see any Level 4 vehicles on a broad market, there are only commercial demonstrations, such as robotaxis. So, demonstrations-wise, there was some success, like robotaxis. However, Level 5, which is also mentioned in the picture, is, as I said already, utopic. I believe that even when there will be self-driving cars, there will always be some kind of limitation. This is why I don't like the words fully autonomous vehicles. At the moment, we are in the transition phase, between Level 2 and Level 3. An interesting fact is that some companies said that they will not bring Level 3 vehicles to the market. Once I heard Volvo announced this. They said they would skip Level 3 and go immediately from Level 2 to Level 4, without having this complicated interaction of shared responsibility between the human and the robot, and this could also be some consequence that there will be no real Level 3 vehicles on the market. We don't see it yet, as we currently have more something like Level 2+. Level 3 is close, but there is a very complicated collaboration between the humans and the machine, and we see now Level 3 over robotaxis and other applications such as automated trucks in logistics. This means that we can see some

examples, but no real commercial penetration on the market. I expect to have these robotaxis and robot trucks on the broader market in the next 5 to 10 years, and even with this estimation, I would say it truly depends on how our governments will pursue and push this topic. Does this answer your question?

Moderator: Yes, it does perfectly, thank you.

Participant A: Great.

Moderator: To wrap up the conversation slowly, how would you say that the technology is currently communicated to the market? Do you think people are educated enough, and is there enough awareness and interest in advanced vehicle technology?

Participant A: Actually, we did one research project together with psychologists, and we came to some conclusions that, at the moment, there is no clear requirement on how people should be trained and communicate with the new systems in the car. It is somewhere in the manuals, and some car dealers will, more or less, give you some instructions, but there is no clear requirement. Another problem that we see is that the systems on the market are very different. Every manufacturer has its own philosophy on how to operate it and how things are generated. For example, there are some requirements regarding how the icons should look, but even this is only at the beginning stage. All the systems have different names, for example, Volkswagen calls it “driver assistance”, and Tesla calls it “auto-pilot”, which, in my opinion, creates a lot of confusion for users as the systems are so different. We also know that some people adopt the technology quickly, however, some have more problems with adopting the technology.

I would recommend that we somehow harmonise how the terminology is used, meaning how the systems are called and operated, how the human-machine interaction is done, and, last but not least, how people are educated about those driving assistance systems.

Moderator: I definitely agree with this. I would also like to ask whether you notice any lack of communication in the market, or do you believe that the technology itself will bring out the interest.

Participant A: There is a lack of communication, but I think you also have to find the right channel to communicate it and the right way of communicating it. For example, it could be a specially tailored material when you buy a new car, it could be some sort of training and so on.
The main thing that I would recommend is that the manufacturers harmonise the system. It's really a mess if you think about it. If you think of car sharing in the future, you will need to change the vehicle quite often, and if every vehicle will have a different operating strategy, terminology and technology application, this would truly not be ideal.

However, if we are talking about broad-mass information, I am not completely sure about it. I would say that people have other problems, and there are other big topics like inflation, immigration crises, wars, climate crises, and so on. Therefore, I think the topic of new advanced technology used in cars is not so prominent. Technology enthusiasts and car lovers might catch the information. However, I believe mass communication will not reach most people, especially not at this moment in time.

So, from my perspective, I would emphasise the need to harmonise the systems and to try and find a way to educate people, train them and bring the technology closer to them by sharing the benefits with them.

Moderator: Thank you so much for these final words. I would truly like to thank you for all your thoughts and ideas. I appreciate that you shared all the information so openly. It means a lot.

Participant A: Of course! Good luck with your Master's thesis.

Moderator: Thank you for taking your time.

Participant A: It was my pleasure, and I would be happy if you send me your Mater thesis once you finish it. Maybe I could use some examples and learn from it, as I always try to.

Moderator: Of course, it is the least I can do. I will keep this in mind.

So, from my side, this would conclude our conversation, but if there is anything you would like to add, please feel free to do so.

Participant A: Good luck I would say.

Moderator: Thank you for participating. Bye.

Participant A: Bye.

Appendix 4: Transcript of the interview with Participant B

Participant B is an Exclusive Consultant specialised in advising clients on luxury vehicles and high assisted cars in Stuttgart, Germany. For the past 22 years, he has been employed by Mercedes-Benz, and is working directly with customers on a daily basis.

Date and time: 6th September 2024, 9:00-10:50

Moderatorka: Pozdravljeni.

Participant B: Zdravo. Upam, da si dobro. Če se strinjaš, bi te prosil, da me kar tikaš. Naj bo intervju čimbolj pristen, vprašaj kar želiš in potrudil se bom čimbolj pomagati z odgovori.

Moderatorka: Hvala in seveda. Najprej bi se ti rada zahvalila za tvoj čas in sodelovanje v moji raziskavi. Ta priložnost mi ogromno pomeni. Kot že veš, sem študentka na Ekonomski fakulteti v Ljubljani, smer marketing. Tema moje magistrske naloge pa je »Marketing Approaches to Adoption of Autonomous Vehicles«. Torej, moj glavni cilj raziskave je razviti trženjske koncepte, ki bi pomagali podpreti prehod avtonomnih vozil na trgu. V kolikor se strinjaš, se bo ta intervju snemal, za lažjo pripravo zapisnika. Tvoji odgovori pa se bodo uporabili zgolj in izključno samo za akademske namene.

Participant B: Seveda, brez problema.

Moderatorka: Skozi intervju te bom vodila čez različne sklope vprašanj. Če pa boš želel kadarkoli kaj dodati, pa me prosim prekini. Torej za začetek, ali bi mi lahko povedal kaj več o sebi, kdo si, s čim se ukvarjaš in kakšna je tvoja pozicija.

Participant B: Star sem 48 let in delam v Mercedes-Benz Group, kot ekskluzivni svetovalec, v Center of Excellence. Naša funkcija je, da strankam pokažemo naš brand, jim predstavimo našo dodano vrednost in jim predavamo pomembne informacije o naših vozilih. Dosti delam tudi na individualizaciji. Torej, če ima stranka željo za novo barvo, drugačno usnje, jim ponudimo tudi takšne stvari. Moja glavna služba pa je, da dam ljudem dober občutek o naši znamki, da gredo iz naše hiše zadovoljni in lahko rečejo to je moja znamka, ki bi jo želel imeti in peljati.

Moderatorka: Kako dolgo pa že delaš za Mercedes-Benz Group?

Participant B: Na trenutni poziciji sem pet let in pol. Na Mercedesu sem sicer začel delat že leta 2001. Še pred tem pa sem delal pri različnih privatnikih, ki so med drugim prodajali tudi znamko Mercedes. Skupno sem v avto industriji zaposlen že skoraj 30 let.

Moderatorka: Od kot pa izvira ta strast do avtomobilov, ali je bila prisotna že od majhnih nog?

Participant B: Drži, nad avtomobili sem navdušen že od majhnih nog. Bil sem rojen v družino, kjer se je vedno vse vrtelo okoli avtomobilov, sploh znamke Mercedes. Že starši so si, kot se reče, služili svoj kruh pri Mercedesu. Hkrati pa tudi ni najslabša znamka, zato me ne rabi biti sram, ko rečem, da delam za Mercedes.

Moderatorka: To je zelo pomembno, Kakšen pa je tvoj pogled na novo tehnologijo, torej na avtonomne funkcije pri avtomobilih in avtonomno vožnjo?

Participant B: Jaz osebno sem, kar se tega tiče, zelo odprt do nove tehnologije. Ne le kar se tiče avtomatizacije, ampak tudi glede elektro mobilnosti. Sam res uživam v avtomobilu, kot tudi v sami vožnji. Vendar, če grem na primer na dolgo pot in Nemčije v Slovenijo, je jasno, da bom pri konstantni vožnji 130 km/uro stisnil gumb in preprosto užival v tem, da me avtomobil sam avtomatično pelje po predpisani hitrosti. Sama zanesljivost mi veliko pomeni tudi, če sem na primer utrujen. Zato verjamem, da so avtomatske funkcije avtomobilov zelo pomembne in potrebne za prihodnost.

Moderatorka: Ali bi lahko izpostavil katero izmed funkcij avtonomne vožnje, ki jo sam najbolj ceniš? Oziroma jo morda najpogosteje opažaš pri željah svojih strank?

Participant B: Zame je najbolj ključna zanesljivst. Torej podpora avtomobila v primeru nenadnega zastoja, torej funkcija »emergency break«. Potem tudi »lane assistance«, torej avtomatsko spremljanje, da vožnja poteka znotraj voznega pasu. Torej v prvi vrsti predvsem zagotavljanje varnosti. V drugi vrsti pa mi je pomembno udobje. Na primer, ohranjane razdalje pred avtomobilom, ki vozi pred mano, omogočanje konstantne vožnje in podpora pri dosledni vožnji v primerih ko sem utrujen oziroma nimam tiste želje po vožnji. Podobne stvari pa opažam tudi pri svojih strankah.

Naslednja stopnja pa bi bila Level 3-4, torej da bi med vožnjo lahko gledal na telefon in opravljal druge stvari. Trenutno Level 3 že ponujamo in stranke so nad njim kar navdušene. Edino kar je potrebno še povečati, je sama hitrost, na kateri avtomobili delujejo s pomočjo avto pilota. Torej vsaj do 130 km/uro.

Moderatorka: Kako pa vidiš uporabo avtonomnih vozil na trgu, bolj v obliki zasebne ali komercialne uporabe, kot so na primer robo-taksiji in car sharing approach?

Participant B: To je verjetno stvar cene. Trenutno Level 3 vozilo stane okoli 150.000 do 200.000 EUR. Sam mislim, da je dosti ljudi, ki bi sploh v primerih konstantne vožnje, želeli imeti takšno vozilo. Vendar so za večino takšne cene nerealne.

To je žal realna slika začetne implementacije avtonomnih vozil na trgu, ki jo bo treba preživeti. Verjamem pa, da je ravno komercialna uporaba, kot so na primer robo-taksiji, zelo dobra rešitev za večjo dostopnost širši skupnosti. Na tem mestu bi definitivno rad izpostavil projekt Mate Rimaca v Zagrebu. Gre za izjemno ambiciozen projekt robo taksijev, poznanim pod imenom Verne. Ta projekt naj bi zaživel leta 2026. Sam pa vem, da če bo prišel takšen avtomobil do mene, bi plačal zanj, saj me avtomatsko pelje od vrat do vrat, brez potrebe po prestopanju in čakanju na različne mestne prevoze. In verjamem, da nisem edini. Edini limit je trenutno cena, ki bi morala biti sorazmerna alternativam, ki že obstajajo na tržišču. Ne smemo pa čisto prevzeti tudi tehničnih licitacij, ki se lahko pojavijo z večjim volumnom vozil.

Moderatorka: Ali bi rekel, da je vaše podjetje napredno v smislu razvoja avtonomnih vozil in kako bi ocenil razvojno hitrost v Evropi?

Participant B: Mislim, da je sam Mercedes, v primerjavi z Audijem in BMW-jem, ki so naši glavni konkurenti, zelo daleč. Tudi v primerjavi z Azijo menim, da nismo mi daleč zadaj.

Sploh pa ne v praksi. A v Evropi, kot tudi v našem podjetju je zelo pomembno, da smo v to prepričani. Ravno sem bil na izobraževanju v Frankfurtu, kjer so bila predstavljena kitajska vozila, kot so BYD in NIO. S temi vozili smo opravili tudi testno vožnjo. Sama vozila so cenovno zanimiva, imajo vgrajeno avtonomno tehnologijo, a dokazano je, da niso prepričljiva v praksi. Sami imamo bolj napreden hardware sistem, kar dokazuje, da imamo napredno tehnologijo. Opažam pa, da se konkurenca veliko bolj prikazuje s tem kakšno tehnologijo imajo. Če bi na primer nekoga vprašali: Kdo na svetu ima najbolj napredno tehnologijo v avtomobilih? Bi večina trdila, da Kitajci. A temu ni ravno tako. Gre za velik vpliv medijev, medtem ko je realnost drugačna.

Moderatorka: Kakšen pa je tvoj pogled na pravno podporo s strani Evropske unije. Bi rekel da je za spremembe ključna zakonodaja, ali je industrija tista sila, ki kroji napredek?

Participant B: Drži dejstvo, da je Evropska zakonodaja zelo kompleksna, kar se kaže v tem, da kdaj stvari niso najhitrejše ali najbolj konkretno določene. A dejstvo je, kot se vidi tudi v avto industriji, če ni pretiska s strani Evropske skupnosti in zakonodaje se nič ne zgodi. Lep primer je CO2. Zato menim, da Evropska unija ima svojo moč in nas ne ovira pri napredku. Torej imamo kar konkretno zakonodajo, podane smernice in potreben pritisk. Pogrešam pa, podporo avtomobilske industrije v obliki subvencij, da bomo lahko bolje konkurirali proti Kitajski.

Lep primer, zakaj je zakonodaja nujno potrebna za povod sprememb, je Tesla. Namreč, ko je Tesla prišla na naše tržišče, smo imeli masivne probleme, nad tem kar so Američani mislili, da je dovoljeno na Evropskem trgu, in našim, bolj konservativnim pogledom na položaj. Zaradi česar so za določene stvari sledile tudi prepovedi. Sam razlog pa je bila predvsem potreba po zanesljivosti.

Moderatorka: Kaj pa v primeru strank. Glede na tvoj stik z njimi, kako bi ocenil njihovo zanimanje in odprtost do nove tehnologije?

Participant B: Imamo stranke, ki so popolnoma zainteresirane za tehnologijo in pa seveda tudi tiste, ki so zelo konservativne in odrivajo pomoč tehnologije. Obe skrajnosti obstajata. Ampak ravno tu nastopimo mi kot prodajalci. Na nas je odgovornost, da stranke navdušimo. Ne le, da verjamemo v svoje podjetje in svoje produkte, ampak da stranki približamo tudi samo tehnologijo. Za to smo plačani, in zato tudi menim, da je vsak prodajalec dolžan stranki predstaviti, kaj tehnologija lahko doprinese. Sam zmeraj rad poudarim, naj stranka preizkusi stvari. In reči moram, da je večina ljudi na koncu navdušenih in odprtih za novosti. Namreč marsikdo bo na prvo žogo rekel, da ne vidi potrebe po dodatni tehnologiji. A ko stranki predstaviš, kako lahko s preprosto asistenco povečaš varnost in preprečiš prometno nesrečo, vsak premisli svojo izbiro. Torej v veliko primerih ne gre le za tip strank, ampak predvsem za klasičen postopek prodaje. Potrebno pa je tudi poudariti, da je naša znamka prepoznavna po novostih, zato se toliko bolj srečujemo s strankami, ki so željne novosti in ne toliko s strankami, ki bi se novostim izmikale.

Moderatorka: Torej, če povzamem, zanimanje je. Ozko grlo pa so med drugim tudi nekateri prodajalci, ki morda prednosti tehnologije ne izpostavijo dovolj dobro, da bi stranke prepričali o nakupu.

Participant B: V mojem primeru je to nekoliko lažje. Na primer, moji stranki je vseeno, ali bo za novo vozilo odštela 180.000 ali 189.000 EUR. Vem, da se to veliko sliši, sploh za

normalne ljudi, kot sem tudi jaz privatno. Ampak ja, takšnim strankam je, že če ponudiš nekaj, kar morda niti nima boljše funkcije, vendar le lepše zgleda, jo bo kupila. Zato še enkrat poudarjam, trenuten problem je predvsem cena avtonomnih vozil. Zato je predvsem na nas, velikih podjetjih, da začnemo bolj aktivno sodelovati pri prodaji avtonomnih vozil. Namreč večja bo masa, bolj se bo cena lahko spustila. Morda prvotno ne na trgu samem, ampak skozi komercialno uporabo.

Moderatorka: Kako pa ocenjuješ strankin pogled na umetno inteligenco v avtomobilih in kibernetsko varnost, torej pogled na znane socialne in etnične dileme?

Participant B: Vedno mi je smešno, ko si nekdo želi tehnološko napredno vozilo in me nato vpraša, kje lahko izključi nevarnost, da bi ga kdo izsledil. Tem strankam vedno postavim vprašanje, ali imajo pri sebi mobilni telefon. Ko pritrdijo, jim rečem le, da njihove podatke že deli njihova mobilna naprava. Torej ja, stranke kdaj kaj preberejo in povprašajo po njihovi varnosti, a gre morda le za okoli 3 % strank, ki o tem sploh razmišljajo. Je pa to morda tista bistvena razlika v primerjavi z ameriškim in azijskim trgom, kajti Evropa je, kar se tiče varstva osebnih podatkov, zelo stroga. Dosti stvari, ki jih želimo razviti, ne zaživijo, prav iz razloga zanesljivosti. Če stvari niso pravilno izvedene in zavarovane lahko sledijo obupne kazni. Zato ne vem, koliko je tematika in dilema o varstvu podatkov v Evropi sploh aktualna. Drži pa, da se bodo vedno našle kakšne stranke, ki bodo občutljive na te podrobnosti.

Moderatorka: Kakšna pa je tvoja izkušnja z zanimanjem strank po okoljski varnosti? Kot so zmanjšanje CO_2 izpustov in manjši vpliv na okolje.

Participant B: Strank to ne zanima, oziroma to sploh ni tematika ob nakupu. Je pa jasno, da vsak, ki se ukvarja z elektroniko, ve kakšna masa podatkov je potrebna, da zadeva funkcionira, in s tem tudi koliko energije je za to potrebne. Kar se pa tiče samega CO_2, gre za grozno stvar, na katero vsi kdaj pozabimo. In v večini primerov nihče ne želi o tem preveč vedeti oziroma slišati.

Moderatorka: Kakšen pa je tvoj pogled, na tehnologijo, ki jo ponuja Mercedes-Benz? Ali se obeta kakšen večji tehnološki napredek?

Participant B: Torej kot je že znano trenutno Mercedes-Benz ponuja avtonomna vozila na nivoju Level 3. In sicer v avtomobilih S-Class in EQS Sedan model. Obeta pa se, da bodo Level 3 vozila delovala avtomatično vse do hitrosti 130 km/uro, kar bo dalo ljudem še več udobja med vožnjo. Kar se pa tiče Level 4, mislim, da trenutno kupci v Nemčiji še niso pripravljeni na to tehnologijo. Level 5 pa, kot vozilo brez volana, menim da nima nobene realne možnosti, sploh pa ne s trenutnim mišljenjem prebivalstva ali v trenutnih prometnih situacijah.

Obeta se pa žal tudi kriza, ki pričakujemo, da bo še dodatno upočasnila prehod na novo tehnologijo. A to je morda druga tema. Lahko pa povem, da je že za Mercedes-Benz, ki služi velike prihodke, zmanjšal izmene dela, iz treh izmen, ki so delovale s polno paro na eno samo izmeno. In to se je zgodilo kar preko noči, nekje pred dvema mesecema. In kako torej brez visokih čistih dobičkov investirati še ogromne vsote, ki so potrebne za naložbe? Žal le do določene meje, in ne v obsegu, kot bi si to morda želeli oziroma vsaj ne z načrtovano hitrostjo.

Dodaten problem pa predstavlja tudi samo električno omrežje, ki še ni pripravljeno na tako velik preskok in predstavlja kompleksen problem.

Moderatorka: Kaj pa tehnološki izziv? Omenil si že, da je cilj Mercedesovih Level 3 vozil doseči avtomatsko vožnjo pri hitrosti 130 km/uro. Kdaj se lahko to pričakuje?

Participant B: Sama tehnologija v avtomobilih že premore to funkcijo. Gre le za oviro s strani zakonodaje. Torej, kar je dovoljeno na tržišču in kaj ne. Sama zadeva se zelo razlikuje tudi v primerjavi med Evropo in Ameriko, kjer je sprejemanje zakonodaje nekoliko lažje. Zato težko podam oceno. Veliko vlogo pa imajo tudi lobiji in pa seveda cena ter širši politični interes.

Lep primer pa so električna vozila. Tehnologija je preizkušena in koncept je poznan, a še vedno ni širše uporabe. Za tem seveda stojijo različni problemi. Na primer, različne interesne skupine, kot so naftni lobiji, na eni strani in zelene stranke na drugi. Hkrati pa imamo tudi države, ki imajo drugačen »mindset«, na primer Norveška, kjer je več električnih vozil kot klasičnih. In spet sva nazaj pri infrastrukturi, ki jo ljudje pogosto izpostavljajo, kot omejitev tehnologije. Vendar sam menim, da to ne drži. Gre le za pogost izgovor. Namreč infrastruktura in omrežje sta le stvar investicije. Vsak lahko izbere napredek in postane eden izmed vodilnih pri uvajanju nove tehnologije. To kaže na pogosto dilemo in konservativnost Evrope, ki sedaj kaže na to, da se ljudje ne želimo spremeniti.

Moderatorka: In če se ponovno vrneva nazaj na temo komunikacij, ali bi si upal trditi, da je večina ljudi dovolj informiranih o avtomobilskem napredku.

Participant B: Menim, da ja. Seveda pa ponovno govoriva o dveh skupinah ljudi. Tisti, ki novosti ne poznajo, se zanje seveda ne zanimajo. Zato morata v igro vstopiti marketing in klasična prodaja. Je pa jasno, da je takšno tehnologijo potrebno proaktivno poudarjati in prikazati njene prednosti. Je pa opcije tudi, če bi Evropska unija sprejela novo zakonodajo, na primer od leta XY naprej, je Level 3 obvezen standard v avtomobilih zaradi politike »nič mrtvih na cestah«. To se je za določene funkcije, kot je med drugim tudi ABS sistem, že zgodilo.

Moderatorka: In če ni skrivnost, s katerih držav prihaja večina tvojih strank, oziroma katere stranke kažejo največji interes za Level 3 vozila?

Participant B: Ob Evropi bi seveda definitivno izpostavil ZDA, Japonsko in Kitajsko. A kitajski trg je nekaj povsem drugačnega, kajti tam stranke, ki kupujejo luksuzna vozila niso vozniki, ampak imajo najete šoferje. Zato je povpraševanje tam, vsaj kar se tiče prodaje naših vozil, povsem drugačna. Imajo pa Kitajci, v primerjavi z drugimi, izredno velik interes po napredni tehnologiji, ter so veliko bolj navdušeni nad digitalizacijo v avtomobilih.

Znotraj Evrope pa bi zraven Nemčije izpostavil še Francijo, Švedsko, Veliko Britanijo, Nizozemsko in Dansko. Razlika se pogosto opazi že v sami miselnosti in razmišljanju teh kultur. A žal gre tukaj med drugim tudi za skrb za okolje. Zato bi bilo nujno potrebno drugače razmišljati. Niti ne toliko zaradi mene, ampak zaradi generacije, kot je tvoja. Zato mi ni jasno, kako lahko toliko ljudi reče, da jim je vseeno, kaj bo za njimi. Namreč prvi korak za spremembo smo mi sami. In tega se moramo začeti zavedati.

Moderatorka: Ali bi za konec dodal še kako tvoja položaj v podjetju doprinaša k boljšemu jutri?

Participant B: Moja osrednja naloga je, da strankam na preprost in jasen način pokažem kaj jim lahko ponudimo, kakšne so prednosti ter tudi kakšna je cena takšnega izdelka. Glavni cilj pa je, da stranko navdušim in prepričam. In na tem mestu bi si želel, da imajo vsi tržniki na podobnih pozicijah zagon za novo tehnologijo. Kajti če že mi sami nismo prepričani v napredno tehnologijo, tudi ne bomo mogli nikogar prepričati o njenih prednostih in koristih. To bo na dolgi rok pomagalo tudi pri boljšem mindsetu strank.

Želim si tudi izboljšano regulacijo, kajti Evropa žal funkcionira le na tak način. Torej, da bodo ljudje prisiljeni narediti korak naprej, ter se privaditi na spremembo.

Zavedam pa se tudi, da bo za širšo uporabo potreben tudi padec cen, povod za katerega bo tudi komercialna uporaba, kot že omenjeni robo taksiji ter car sharing.

Izid takšnih sprememb pa bo večji užitek, večja varnost ter manjši vpliv na okolje. In verjamem, da je to za današnje čase nujno potrebna sprememba. Dejstvo je, da je potrebno, da so mladi odprti in željni sprememb, tudi če z nekaj napakami, kajti le tako lahko pričakujemo napredek. Namreč stara tehnologija in koncepti bodo nekega dne preprosto nezadostni.

Moderatorka: Menim, da je bil to res zelo dober zaključek, tako da iz moje strani nimam več nobenih dodatnih vprašanj. Hvala ti za vse odgovore in za čas. V kolikor pa bi rad še kaj dodal ali izpostavil, pa seveda z veseljem.

Participant B: Tudi meni je bilo v veselje in upam, da ti bodo dogovori čim bolje pomagali. Če pa boš imela še kakšno dodatno vprašanje zame, pa sem ti na voljo. Želim ti dosti uspeha.

Moderatorka: Najlepša hvala še enkrat, in prijeten konec tedna želim.

Appendix 5: Consumer survey (Quantitative study of consumer perception)

Introduction

Welcome,

My name is Teja Koren, and I am a Master's student at the School of Economics and Business at the University of Ljubljana, Slovenia. For my thesis, I am conducting research on "Marketing Approaches to the Adoption of Autonomous Vehicles". The main aim of my research is to gain important insights into the current autonomous vehicle market.

Your answers are crucial to this research, and will help me understand consumer perspective on autonomous vehicles better.

The survey is anonymous and will take approximately 5-8 minutes to complete. All the responses will be kept confidential and used for research purposes only.

Thank you for your time and cooperation,

Teja Koren

Introduction questions

1. Do you use any type of transportation system (private or public)? *
   ☐ Yes
   ☐ No

* If an answer to one of the above questions is "No", the participant will not be able to continue with the questionnaire and will be redirected to the final page of the survey – thank you note.

2. Are you currently living or working in one of the countries within Europe?
   ☐ Yes
   ☐ No

3. How many years of driving experience do you have? (in years)
   _____ years of driving experience

The main part of the survey

(Hypothesis 1: Consumers show high interest in autonomous vehicles.)

4. What is your level of interest in autonomous cars?

1 – not at all interested
2 – somewhat uninterested
3 – neutral
4 – somewhat interested
5 – very interested

5. Which (semi-)autonomous features do you wish to have in your next car? (multiple answers are possible)
   ☐ **Adaptive Cruise Control** – a system that adjusts the speed actively to maintain a safe distance from the vehicle ahead.
   ☐ **Lane Keep Assist** – actively ensuring your vehicle stays within the lane by small steering corrections.
   ☐ **Automatic Emergency Braking** –activating the brakes automatically in case of a potential crash or sudden obstacle appearing.
   ☐ **Self-Parking Function** – automated manouver to park your vehicle, controlling your steering wheel, acceleration and braking.
   ☐ **Highway Assist** – maintaining speed, following the lanes and adjusting to the curves with minimal driver input.
   ☐ **Autonomous Valet Parking** – fully autonomous parking where the vehicle finds a space and parks itself without the driver being needed.
   ☐ Other: (specify) _____
   ☐ I am not interested in the technology used in vehicles.

(Hypothesis 2: There is a positive relationship between being familiar with autonomous vehicle classification (SEA Levels) and noticing autonomous vehicles on the roads.)

6. Have you noticed any examples of autonomous vehicles being used on the roads?
   ☐ Yes – If yes, please name the example(s): _____
   ☐ No
   ☐ Not sure

7. Are you familiar with different levels of vehicle autonomy (SAE Levels)?
   ☐ Yes *
   ☐ No (jump to Question 9)

   * Explain (using your own words) the difference between SAE Level 3, Level 4 and Level 5:
   _____

* What is the current maximum SAE Level available on the broad market in Europe?

☐ Level 0
☐ Level 1
☐ Level 2
☐ Level 3
☐ Level 4
☐ Level 5
☐ I do not know.

Explanation:
An SAE Level 4 autonomous vehicle is a self-driving vehicle that can operate without human intervention in a predefined environment and under certain constraints, such as a maximum speed allowed in self-driving mode. Unlike fully autonomous vehicles (Level 5), the Level 4 system allows the driver to take control of the vehicle manually if desired or needed. An example of this technology is Waymo.

8. What are your first thoughts on using and implementing Level 4 of autonomous vehicles in everyday transportation systems? Write a sentence or two. (open question) _____

(Hypothesis 3: Consumers have a positive attitude toward autonomous vehicles.)

9. On a scale from 1 – 5, how do you feel about the following attributes connected to autonomous (Level 4) vehicles?
   Negative (1 – 2 – 3 – 4 – 5) Positive
   Wrong (1 – 2 – 3 – 4 – 5) Right
   Harmful (1 – 2 – 3 – 4 – 5) Beneficial
   Unsafe (1 – 2 – 3 – 4 – 5) Safe
   Anxious (1 – 2 – 3 – 4 – 5) Excited
   Unethical (1 – 2 – 3 – 4 – 5) Ethical

10. When considering the implementation of Level 4 autonomous vehicles, to what extent do you anticipate experiencing the following? (1 – not at all, 2 – slightly, 3 – moderately, 4 – very much, 5 – to a great extent, 0 – do not have an opinion)

	1	2	3	4	5	0
Excitement						
Increased road safety						
Better convenience						
Reduced stress						
Extremely high price						
Privacy concerns						
Ethical concerns						

Concern in the technology's reliability						

(Hypothesis 4: Safety is the biggest concern to choose an autonomous vehicle.)

11. What, in your opinion, are the biggest obstacles preventing consumers from adopting Level 4 autonomous vehicles?
    ☐ Extremely high price
    ☐ Safety concerns
    ☐ Complexity of the legal system
    ☐ Lack of trust
    ☐ Lack of interest
    ☐ I am not familiar enough with the technology to be able to answer this question.

(Hypothesis 5: Consumers agree that hands-on experiences, such as vehicle testing, car sharing and robot taxis, would help gain trust in autonomous vehicles)

12. Would you agree with the following statement: "Hands-on experience, such as vehicle testing, car sharing and robot-taxis, would help gain trust in autonomous vehicles."
    1 – totally disagree
    2 – disagree
    3 – neutral
    4 – agree
    5 – totally agree

13. Have you ever experienced Level 4 of an autonomous vehicle ride (through a test drive, robotic taxi or car-sharing)?
    ☐ Yes *
    ☐ No
    *If yes, describe your experience (how did you feel, what was the experience, did your perception of the autonomous vehicles change afterwards and would you recommend it to a friend?): _____

14. To what extent do you wish to experience Level 4 of autonomous driving?
    1 – not at all
    2 – slightly
    3 – moderately
    4 – very much
    5 – extremely

15. How do you usually find out about the most recent technology updates and new technology features in the automotive industry? (multiple answers are possible)
    - ☐ Social media
    - ☐ Online news
    - ☐ Emails/newsletters
    - ☐ Magazines
    - ☐ Car salons and/or car dealers
    - ☐ Friends and/or family
    - ☐ Academic institute
    - ☐ Scientific articles
    - ☐ Other: _____
    - ☐ Not following this topic

(Hypothesis 6: Consumers feel uninformed about the latest advancements in the automobile industry, more specifically as regards the new technology available.)

16. Would you agree with the following statement: "I feel well-informed about the latest technological advancements in the automotive industry."
    1 – totally disagree
    2 – disagree
    3 – neutral
    4 – agree
    5 – totally agree

17. Would you be willing to use Level 4 of autonomous vehicles as a part of the everyday transportation system?
    1 – not at all interested
    2 – somewhat uninterested
    3 – neutral
    4 – somewhat interested
    5 – very interested

18. If a car company invited you for a test ride with a Level 4 autonomous vehicle, how likely would you be to accept it?
    1 – not likely at all
    2 – unlikely
    3 – neutral
    4 – likely
    5 – very likely

Social-demographic questions

19. Age group (in years):
    - ☐ 14 or below
    - ☐ 15-24
    - ☐ 25-34
    - ☐ 35-44
    - ☐ 45-54
    - ☐ 55-64
    - ☐ 65 or more

20. Gender:
    - ☐ Female
    - ☐ Male
    - ☐ Non-binary
    - ☐ Prefer not to say
    - ☐ Other

21. Currently living in: (name the country)
    _____

22. Highest level of education:
    - ☐ High school diploma or equivalent
    - ☐ Bachelor's degree
    - ☐ Master's degree
    - ☐ Doctoral degree
    - ☐ No formal education

Thank-you note

You reached the end of the survey. Thank you for your cooperation and willingness to contribute to this research.