Residents’ perceptions of the impact of robotaxis on society, economy, and environment: The case of Zagreb

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Submitted to Prof. Dr. Horst Treiblmaier

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AFFIDAVIT

I hereby affirm that this Master's Thesis represents my own written work and that I have used no sources and aids other than those indicated. All passages quoted from publications or paraphrased from these sources are properly cited and attributed.

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ABSTRACT

Zagreb is expected to be one of the first cities worldwide to have robotaxis roaming the streets, as Rimac Automobili plans to introduce a fleet of robotaxis in 2024. Robotaxis have the potential to improve transportation significantly and can lead to significant benefits for the society, the economy, and the environment if implemented and regulated correctly. Otherwise, robotaxis could result in negative consequences. However, to gain all the benefits of robotaxis introduced in this study, it is important to reach a large-scale adoption. As the most significant barrier to large-scale adoption of robotaxis can be psychological rather than technological or regulatory, it is crucial to understand consumers' intention to use robotaxis.

Thus, this research aims at identifying the perception of the residents of Zagreb on the possible impacts of robotaxis on the economy, society, and environment and if the residents are acceptive of such a project. Moreover, it will try to identify any positive and negative relationships between the different impacts and factors with the behavioral intention to use robotaxis. The findings of the primary and secondary data will allow to provide recommendations to government officials, policymakers, and robotaxi developers on what should be done to ease the introduction and achieve large-scale adoption of robotaxis Zagreb. This study also includes a section briefly explaining robotaxis and autonomous vehicles and their functioning and thus contributes to raising the knowledge level of the residents on robotaxis and autonomous vehicles.

The research implemented a non-experimental fixed or quantitative strategy, and the data was collected using an online questionnaire. The analysis of the collected data was completed using Microsoft Excel, Microsoft Powerpoint, Miro, and PSPP. In total, 158 responses from residents of Zagreb were collected.

The findings indicated an extensive agreement from the residents with most of the statements and showed that *perceived usefulness* and *perceived ease of use* have a significant impact on the *behavioral intention* to use robotaxis. Furthermore, the findings showed that the higher the knowledge level, the likelier one is to use robotaxis. Therefore, some of the most relevant recommendations are: creating technological development skills and education programs to educate all stakeholders on autonomous vehicles and robotaxis and encourage their cooperation, raising knowledge and awareness of autonomous vehicles and robotaxis via formal and informal education, and promoting the benefits and usefulness of robotaxis and autonomous vehicles.

Key Words: Robotaxi, Autonomous Vehicle, Residents' perceptions

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LIST OF ABBREVIATIONS

5G – Fifth Generation (Standard for Broadband Cellular Networks)

AI – Artificial Intelligence

AV – Autonomous Vehicle

BI – Behavioral Intention

CAGR – Compound Annual Growth Rate

CAV – Connected Autonomous Vehicle

DARPA – Defense Advanced Research Projects Agency

DOI – Diffusion of Innovation Theory

DSRC – Dedicated Short-Range Communications

DSS – Dynamic Spectrum Sharing

EU – European Union

EV – Electric Vehicle

GHG – Greenhouse Gas Emissions

GPS – Global Positioning System

ICE – Internal Combustion Engine

ICT – Information and Communication Technology

IMU – Inertial Measurement Unit

IoT – Internet of Things

LIDAR – Light Detection and Ranging

OBU – On-Board Unit

PEU – Perceived Ease of Use

PPP – Public-Private Partnership

PT – Perceived Trust

PU – Perceived Usefulness

RADAR – Radio Detection and Ranging

RSU – Roadside Unit

SAE – Society of Automotive Engineers

SAV – Shared Autonomous Vehicle

SI – Social Influence

TAM – Technology Acceptance Model

TAR – Theory of Reasoned Action

TCO – Total Cost of Ownership

US – United States

UTAUT – Unified Theory of Acceptance and Use of Technology

VMT – Vehicle-Miles Traveled

VRU – Vulnerable Road Users

1 INTRODUCTION

1.1 Problem statement

Twenty years back, autonomous vehicles (AVs) and robotaxis were only seen as futuristic ideas or dreams often portrayed in sci-fi movies. However, technology has made significant advancements in recent years. Self-driving cars appear to be far closer to becoming an integral part of our daily lives and society than many anticipated. The European Union (EU) expects and aims toward fully autonomous vehicles roaming the streets of EU countries as soon as 2030. (*Self-Driving Cars in the EU*, 2019) The first attempts at developing autonomous vehicles were undertaken by Leonardo da Vinci as early as 1500. ("A Brief History of Autonomous Vehicle Technology," 2016) Today, many well-established and famous car manufacturers, such as Mercedes Benz, Ford, General Motors, BMW, and many more, are racing to deploy their solutions and gain a first-mover advantage. In addition, many new entrants with far more focus on the technological aspects of cars and far less experienced in the car manufacturing industry, such as Tesla, Google, Uber, Rimac, and many more, are intensifying the competition among AV developers and becoming key players in the market. Nowadays, almost every large car manufacturer has begun researching and developing self-driving vehicles.

The quick rise in the research and development of robotaxis and AVs can be attributed to the many benefits that robotaxis offer compared to conventional taxis. The robotaxi market is expected to grow to approximately 20.3 billion US dollars by 2028 and be worth 500 million US dollars in 2021 (*Global Robotaxi Market Flourishing*, 2022). The global robotaxi industry is expected to grow at a compound annual growth rate (CAGR) of 136.8%, from 617 units in 2021 to 1,445,822 units in 2030 (*Robotaxi Market*, 2021). These numbers may differ based on the source. However, all show significant growth in the CAGR and the market revenue size. In addition to the economic benefits and the substantial potential seen by large enterprises, robotaxis introduce several benefits to society and the environment and the battle against climate change. These are further discussed in chapter 2.5. Furthermore, there is a widespread perception in the automotive industry that the benefits of passive safety systems, such as seat belts and airbags, have reached a peak level. Thus, manufacturers are focusing on how to prevent accidents rather than survive them (Urmson & Whittaker, 2008). Robotaxis and autonomous vehicles, in general, are gaining significance with more and more benefits emerging over time and the economic value exponentially increasing. Croatia and its government have a great opportunity with the sister company Project 3 Mobility of Rimac Automobili planning to introduce autonomous robotaxis, which would roam the streets of Zagreb as early as 2024. This would be the first project of such kind in Europe and already has the support of the EU with a co-financing of 200 million Euros (*Ursula von Der Leyen Visits Rimac*, 2021). This project would not only show great economic value for Zagreb and Croatia. However, it would also bring many benefits to the residents of Zagreb and the protection of the environment by battling climate change and attracting car and/or technology enthusiasts to visit Zagreb to test out the robotaxis themselves.

In addition to the car manufacturing sector's rise in research and development, academic research on autonomous vehicles has significantly grown in the past decades (Mora et al., 2020). Nonetheless, there are only a few in-depth studies on robotaxis, especially ones discussing the resident's perception of robotaxis and its potential impacts. The majority of current research is focused on autonomous vehicles in general. If it is on robotaxis, it is usually based on other countries or cities than Croatia or Zagreb, with China being one of the more researched or explored countries. For instance, Liu et al. (2020) talk about the different perceptions of individuals on robotaxis and their behavioral intention to use them.

This study will focus on Zagreb and its residents, as Zagreb could become the first robotaxi hub for Europe or the Adriatic region. Moreover, this thesis will address the gap present in the literature. It will present and discuss the perception of the residents on the effects that they believe robotaxis will have on the economy, environment, and society. Doing so it will contribute to any further research done on robotaxis. It can serve as a starting point for Rimac and other companies looking into developing robotaxis, for future scientific research, for anyone trying to gain knowledge, and any government officials or policymakers trying to develop a set of policies or regulations while considering the perception of the residents themselves.

1.2 Purpose of the study

With robotaxis roaming the streets of Zagreb as early as 2024, the purpose of this study is to gain an understanding on the perception of the residents of Zagreb on the possible effects of robotaxis on the economy, society, and environment for the city of Zagreb. The study will specifically focus on the resident's perspective as to determine what they perceive could be the possible benefits as well as costs or problems once they are introduced. Nonetheless, it will not undermine the importance of other stakeholders involved in this topic, as some are affected as well by the impacts of robotaxis, such as business owners; taxi drivers; bus drivers etc., or can influence the impacts perceived, such as the government and policymakers.

With robotaxis roaming the streets of Zagreb as early as 2024 already, the purpose of this study is to understand the perception of the residents of Zagreb on the possible effects of robotaxis on the economy, society, and environment for the city of Zagreb. The study will hone in on the perspectives of residents to determine what they perceive to be the potential benefits, costs, or problems associated with their introduction. Nonetheless, it will not undermine the importance of other stakeholders involved in this topic, as some are affected by the impacts of robotaxis, such as business owners, taxi drivers, bus drivers, etc., or can influence the impacts perceived, such as the government and policymakers.

Croatians often show skepticism to change or innovations and scientific findings, regardless of the subject matter. For instance, only 36% of Croatians believe it is good to be a member state of the EU, but 63% believe they were able to gain many benefits from being an EU member state (Palokaj, 2018). A more up-to-date representation of the skepticism of Croatians can be seen in the COVID-19 vaccination rate in the country. With only 57% of the whole population fully vaccinated, Croatia is among the countries with the lowest vaccination rates in the EU, even though there is enough scientific research as well as proof that the vaccine protects from hospitalization and that it is not dangerous ("COVID-19 Vaccination Tracker," n.d.). This research should determine if residents are reluctant or skeptical of the project or if they accept it. This will not only allow to provide an idea if such a project would succeed in Zagreb, Croatia but would also provide additional data for anyone wanting to dive deeper into the skepticism present in the Croatian culture.

Furthermore, this research aims at creating awareness and educating people on the topic of robotaxis and AVs using secondary sources. Creating awareness and educating people will help them better understand the current situation of robotaxis globally and in Croatia, help them identify any new opportunities that robotaxis or AVs offer, and contribute significantly to the fast deployment of robotaxis (once the production starts).

Additionally, the researcher aims to provide a set of recommendations that take into regard the perception of the residents and will allow government officials or policymakers to adjust existing or new policies, regulations, and the legal frameworks to fit the needs or worries of the citizens as well as any future users. Regulations play a tremendous and influential role in adopting any new technology, and they can hinder the large-scale adoption of a technology or allow for it and innovations. It is essential for the right balance to be found, as too few regulations can result in negative consequences, such as the misuse of technology to cause harm, and too many regulations can hinder innovation. The recommendations can also be used by anyone working in the car manufacturing sector while developing AVs or robotaxis to create a product that will fit the consumer's needs. The recommendations will be developed using the survey's and literatures findings.

1.3 Research objectives

The research on this topic plays an utterly crucial role, as it will help advance the research on robotaxis, and the adoption of robotaxis in Zagreb and other cities, which can use this study to adjust existing regulations and policies or create new ones, while taking into consideration the perception of the residents. The objectives of this research follow the purpose of the study mentioned in chapter 1.2 and are the following:

- Identify which possible effects of robotaxis on the economy, society, and environment the residents perceive as beneficial and costly or challenging and compare the perceptions based on different independent variables, such as socio-demographic data of the participants.
- Identify if the residents of Zagreb, Croatia are acceptive or reluctant toward robotaxis roaming the streets of their city. The results will be compared to several variables and constructs to identify any relationships and possible predictors.
- Create awareness and educate people on robotaxis for everyone to make use of all the benefits offered and make the most use possible of these benefits.
- Provide a set of recommendations that will help government officials and policymakers adjust new or already existing regulations or policies while considering the residents' perceptions. The regulations or policies should allow for the large-scale adoption of robotaxis. Car manufacturers of AVs and robotaxis can also use these recommendations in the development process to fit the needs and address the consumer's worries.

1.4 Research questions

The research questions build on the purpose of the study and the research objectives. The study will look at three main research questions, and each one will include several sub-questions. The three main questions that will be researched and discussed are:

- How do the residents of Zagreb, Croatia, perceive the possible effects of robotaxis on the economy, society, and environment?

Before diving into all research questions, the available literature will be reviewed and presented comprehensively and detailed. Additionally, a survey will be developed. The survey's findings will help answer the research question and will focus on identifying what effects the residents of Zagreb perceive as beneficial, costly, or challenging. The survey findings can then be compared, for example, using different socio-demographic data. This question will lead the further research and other research questions.

- Are the residents ready to accept robotaxis?

As for the previous research question, this will be answered using the survey's findings. Followingly the results can be compared with the perception of the residents on the effects of robotaxis on the economy, society, and environment or with other independent variables, such as the socio-demographic data. This would allow to identify any relationships between the different variables and show if the independent variables or effects which cause reluctance or acceptance can be used to the benefit of increasing the acceptance.

- What should be considered when developing new or adjusting existing regulations and policies for AVs?

While the other research questions focus on contributing to the existing literature and filling in an existing gap in the robotaxi literature available, this question focuses on addressing the needs and worries of the residents obtained from the survey's findings. The needs and worries will be addressed by providing a set of recommendations to government officials, policymakers, and AV and robotaxi manufacturers. In doing so, the benefits will be increased for all stakeholder groups because they will be able to make use of all of them through their collaboration by meeting each other needs and addressing the worries at hand.

1.5 Structure of the thesis

The thesis will be divided into six large sections or chapters and many subsections or subchapters. The first section, "Introduction," introduces the topic and explains the purpose of the study, the research objectives, and the research questions. The second section, "Literature Review," will review the current landscape of AVs and robotaxis and the impactful potential of AVs for Croatia, will explain the core features of AVs and robotaxis and known limitations or challenges to the adoption of AVs or robotaxis in Zagreb, will discuss the triple bottom line impacts of AVs and robotaxis and will have a look at the theoretical framework for this research. The third section, "Hypothesis Development," develops the hypotheses for this research and explains each one individually. The fourth section, "Methodology," describes the research design and methods used, the data collection process, the development of the questionnaire, the population and study sample used, how the data was analyzed, and the research ethics used. The fifth section, "Results and Discussion," describes the results of the data collected, tests the hypotheses using various statistical tests, and discusses the findings while providing recommendations. The sixth and last section, "Conclusion," shortly summarizes the findings, explains how the research contributed to knowledge, describes the limitations of the research, and suggests what can be done for future research.

2 LITERATURE REVIEW

This chapter focuses on introducing AVs and robotaxis by looking at the possible applications, the current state, and potential globally and for Croatia. Additionally, the chapter explains the functioning of the individual components, gives a brief description of the workflow, introduces the different levels of automation, and looks at the challenges or limitations of introducing AVs or robotaxis in Zagreb. Most importantly, it introduces the expected impacts of AVs or robotaxis.

2.1 Introduction to AVs and robotaxis

Autonomous vehicles, also known as automated vehicles, driverless vehicles, self-driving vehicles, or robotic vehicles, are defined by the Society of Automotive Engineers (SAE) as a vehicle which has one or more automated tools capable of assisting the driver or entirely taking over driving and is capable of sensing its surroundings (Dekker, 2017; Zhu et al., 2020). Vehicles with automated tools assisting the driver are called semi-autonomous vehicles, and vehicles autonomously driving by themselves are fully autonomous vehicles (Krasniqi & Hajrizi, 2016). The SAE also created a commonly used classification standard for vehicle automation that identifies six degrees of automation, ranging from no driving automation to complete driving automation. The six levels of automation will be discussed in detail in chapter 2.4.1 and are displayed in Figure 5.

While there is no clear definition of robotaxis, they can be defined as self-driving vehicles or AVs without any human supervision, which operate as taxis and can be shared by several people at the same time. These robotaxis do not necessarily have to be electrically powered but can also be internal combustion engine (ICE) powered vehicles running on fuel.

There are several robotaxi and autonomous shuttle or bus projects globally, such as Waymo, Cruise, AutoX, Didi Chuxing, and many more (*The Self-Driving Car Companies Going The Distance*, 2021). However, none of these projects have reached a large scale yet. Even though the COVID-19 pandemic did not result in any new projects, it has helped and accelerated the transformation of the transportation system. People have started evaluating their mobility alternatives as a result of social distancing. In the US, one in every five individuals expresses more significant interest in AVs than before the outbreak (Motional, 2020, as cited in Souza & Castañon, 2021). During the COVID-19 outbreak, buses and subways were prohibited to prevent the virus spreading, forcing customers to consider alternate modes of transportation. Long-term impacts may persist; a sizable fraction of the population may remain fearful of crowded public transit, regardless of available universal vaccination (Wiseman, 2021, as cited in Souza & Castañon, 2021). Fear of additional viruses, diseases, and a lack of confidence in the vaccination may influence people's domestic travel patterns. As a result of the COVID-19 epidemic, the acceptance of AVs to provide public transportation services is predicted to increase (Souza & Castañon, 2021). COVID-19 is only the most recent driver of increased AV and robotaxi acceptance and usage, which has surged in the past decade. As the technology has matured, use cases of AVs and robotaxis are more well tested than ever before and have completed a significant number of kilometers to this day. Furthermore, an enlarged global market means that manufacturers can spread their research and development costs over many users.

2.2 Global AV and robotaxi landscape

Autonomous cars are slowly increasing their market share. While there were around 31 million vehicles with some degree of automation in operation globally in 2019, that number is predicted to exceed 54 million by 2024 (Placek, 2021a, 2021b, 2021c). As a result, the worldwide autonomous vehicle industry is expected to grow. Although the market size declined by roughly 3% in 2020 because of the economic downturn brought by the COVID-19 pandemic, it is expected to rebound and increase in 2021, reaching a value of more than 37 billion US dollars in 2023 (see Figure 1). Between 2019 and 2030, sales of autonomous cars are predicted to increase. Globally, around 1.4 million cars with at least Level 3 autonomy were sold in 2019. Global sales of these cars are expected to reach over 58 million units by 2030 (see Figure 2). During this year, total worldwide investment in autonomous car technology will exceed $200 billion, and that amount is expected to grow fast as competition grows. Simultaneously, nations worldwide are investing in infrastructure to ease AVs' development and adoption.

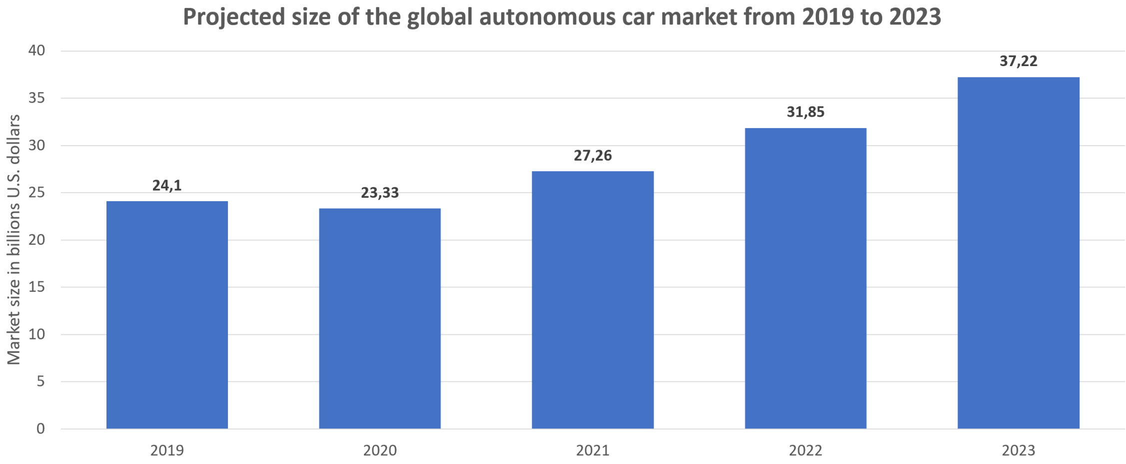

FIGURE 1 - PROJECTED SIZE OF THE GLOBAL AUTONOMOUS CAR MARKET FROM 2019 TO 2023 (PLACEK, 2021B)

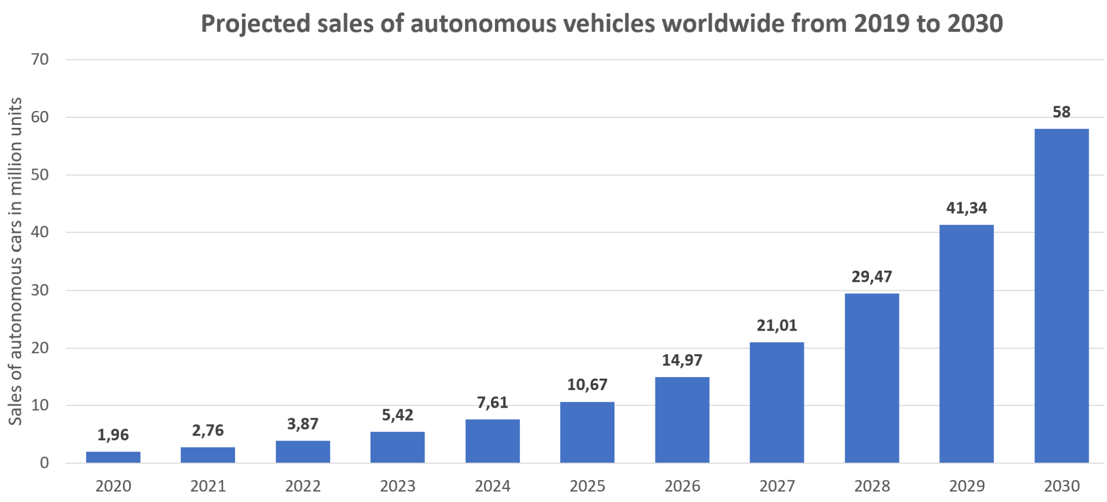

FIGURE 2 - PROJECTED SALES OF AUTONOMOUS VEHICLES WORLDWIDE FROM 2019 TO 2030 (PLACEK, 2021C)

The robotaxi industry is predicted to reach approximately 20.3 billion US dollars in revenue by 2028, increasing from 500 million US dollars in 2021 (*Global Robotaxi Market Flourishing*, 2022). The global robotaxi industry is expected to grow at a CAGR of 136.8%, from 617 units in 2021 to 1.445.822 units in 2030 (*Robotaxi Market*, 2021). These figures may vary according to the source. All, however, demonstrate a significant increase in both the CAGR and market revenue size.

The following section will look at five different regions worldwide and how they perform in adopting AVs and robotaxis.

Europe: Europe has established itself as one of the leading regions in developing and adopting AVs and robotaxis (*2020 Autonomous Vehicles Readiness Index*, 2020). Several countries have already started trials of AVs or robotaxis or are planning to do so shortly. As of 2019, Norway has introduced three driverless bus routes in Oslo. Furthermore, many countries have already developed a set of AV policies and regulations or regulation frameworks, such as the Automated and Electric Vehicles Act in the United Kingdom. In contrast, some have passed additional laws, such as France, which introduced a law that shifts the responsibility for accidents involving experimental AVs from the individual behind the wheel and onto the organization authorized to conduct the test. Moreover, many European countries can benefit from their existing Information and Communications Technology (ICT) and road infrastructure. According to KPMG, the Netherlands had the second-best quality of roads globally. In addition to that, Europe benefits significantly from its well-established and robust automotive industry, which can bring out innovations regularly due to the excellent talent pool that the region has.

North America: American technology firms and established automobile manufacturers dominate global AV and robotaxi development (*2020 Autonomous Vehicles Readiness Index*, 2020). Not only are car manufacturers making progressive steps in AV development, but technology giants and ride-hailing services, such as Apple, Uber, Google, and many more, are following right behind in their steps and are attracting several prominent investors. While other nations are upgrading their road infrastructure and incorporating autonomous cars into public transportation, the US lags and focuses more on private vehicles and taxis. The federal government's efforts to implement AVs are centered at the state and local levels, and thus, the US regulatory framework has not followed the pace of AV development. Canada is one of the nations rated top for both government-funded AV tests and public-private partnerships (PPPs). Additionally, the country's scope and diversity in the automotive components manufacturing industry, a diverse variety of urban and rural testing environments, and the political readiness to explore transportation legislation and policies represent additional strengths of the region.

Asia-Pacific: The Asian-Pacific region shows excellent potential for developing and introducing AVs and robotaxis, as the people in this region are very acceptive of AVs (Buchholz, 2020). Many countries in the Asia-Pacific region benefit greatly from having a well-developed ICT infrastructure and from their early introduction of fifth-generation (5G) broadband networks (2020 Autonomous Vehicles Readiness Index, 2020). The region is home to several AV and robotaxi developers and trials, which range from a small scale to a large scale, with Singapore and China leading the way. While China still lags in developing a regulatory framework for AVs, Singapore leads the way globally according to KPMGs readiness index. Australia is proving to be a top contender for the near future. The government has already introduced several laws and considers autonomy in future infrastructure projects and policies. The Asian-Pacific region does not lag in available talent and already has excellent experience with several technologies that can be found in AVs, such as the Internet of Things (IoT) or Artificial Intelligence (AI). As India has not yet established the use of electric vehicles (EV) and their infrastructure, it is setting its focus on them before looking at AVs.

Central & South America: The Central and South American region lags behind other regions. Besides some countries having the necessary infrastructure and 5G mobile broadband networks (*2020 Autonomous Vehicles Readiness Index*, 2020) no regulations or policies for AVs have been established thus far. Chile introduced the first AV pilot project in Latin America in January 2020.

Middle East & Africa: The African continent can not currently be seen as a potential region for AV development or the large-scale adoption of AVs. Most of the continent has no supporting infrastructure or stable or low latency mobile broadband networks. The continent will first have to address other (more urgent) issues before setting its focus on becoming a player in the global AV value chain. Some countries in the Middle East, such as the UAE and Israel, are working on developing and introducing AVs and robotaxis (*2020 Autonomous Vehicles Readiness Index*, 2020).

2.3 Impactful potential of AVs and robotaxis for Croatia

Croatia entered the AV scene later than many large countries, and thus not many applications of AVs can be found in Croatia. This is also supported by the fact that Tesla entered the Croatian market in December 2020 (Ivezić, 2021). Today, only one use case of AVs in Croatia is reported well in the available literature. The Plitvice lakes national park in Croatia used AVs to map the thirteen lakes as they are difficult to access and are often too shallow for a sonar installed on a boat (Kapetanović et al., 2020). The team developed a unique autonomous surface vehicle equipped with a multibeam sonar to map the lakes.

While this is one use case that has been reported well, Rimac Automobili's sister company, Project 3 Mobility, is working on developing and deploying robotaxis (*Ursula von Der Leyen Visits Rimac*, 2021). The project is part of the National Recovery and Resilience Plan of Croatia and, as such, received a co-financing of 200 million Euros from EU funds for the pre-commercial phase. The project has been in development since 2018 and has already received 450 million Euros in funding from foreign investors and shareholders, such as KIA Motors and Microsoft. The firm intends to create an urban mobility ecosystem in Zagreb integrated with public transportation (*Mate Rimac u Zagrebu gradi trg, park i mrežu robotaxija vrijednosti blizu 900 million KM*, 2021; *Ursula von Der Leyen Visits Rimac*, 2021; Spasić, 2021). The system will feature an autonomous electric vehicle of level five autonomy, which means that it is fully capable of driving without human intervention. The second phase of the project entails developing and building infrastructure that will maintain the robotaxis, which is supposed to be situated near the river Sava across the student dorm "Stjepan Radić." The infrastructure should be integrated into Zagreb's multimodal terminal. It will link the ecosystem to trams, buses, and suburban trains. The development of the robotaxis is ongoing, with a prototype already completed. The complete system will be tested in 2023 in Zagreb, and serial manufacturing of the driverless automobiles will begin as early as 2024. Infrastructure work is scheduled to begin this year and should be done by next year. While negotiations with around 20 cities throughout Europe and the Middle East continue, the firm and its CEO, Mate Rimac, aim for the service to launch in Zagreb first (*Ursula von Der Leyen Visits Rimac*, 2021). The objective is for cars and many components to be manufactured in Croatia, with tens of thousands of units exported annually to regions where the robotaxi services will be offered.

Considering that Croatia could be the first country in the EU to introduce robotaxis, it can be said that Croatia is somewhat lagging behind other countries in the EU in making amendments to the current legislation to address the arrival of autonomous vehicles and robotaxis at a large scale. The Croatian government showed the first steps towards developing a legal regulation for AVs and that they are aware of the complexity of AVs at the 10th annual meeting of the Croatian government on February 25th, 2022 (Čikeš, 2022; *10. saziv Hrvatskoga sabora*, n.d.). The government decided to accept the proposal to amend the Law on Road Traffic Safety, and introduced the term "fully automated vehicle" into the Croatian legislation. The government also accepted the proposal to introduce a monetary fine in the amount of 3.000 to 7.000 Croatian Kuna to drivers who use vehicles with built-in driver assistance systems in such a way that the driver does not sit in the driver's seat while driving or that the vehicle operates independently, and that the driver is unable to react in unforeseen situations. The government also noted the importance of road safety, civil liability and insurance, cyber security, intellectual property rights, data protection, data ownership, technical infrastructure, standardization, and employment. The Croatian government deems that the automation of anything that replaces human thought activity is very likely to require an independent legal regulation in the future, as the complexity of the topic far exceeds the possibility of merely making amendments to the existing legislation in these legal areas. Since AVs are not yet subject to a separate liability scheme, the responsibility for losses might be assigned to an owner or a manufacturer in line with the Civil Obligations Act's current civil liability standards for motor vehicles (Zrno Prošić & Sinožić, 2020).

While Croatia is lagging in developing the legal framework for AVs compared to other countries in the EU, Project 3 Mobility indicates an excellent opportunity for the city of Zagreb and Croatia and its citizens. Croatia will establish itself as a player in the global AV value chain and will play an essential role, as Rimac Automobili will supply several cities and other AV manufacturers with many components or robotaxis. This will further provide opportunities to retain the workforce which is migrating to find better economic opportunities or jobs in other countries. According to data from the Central Bureau of Statistics, around 260,000 individuals emigrated from Croatia between Croatia's accession into the EU until 2020 (*How Many People with Croatian Origin Live Outside Croatia?*, 2022). Since the company is intensely working with partners outside of Croatia, it can be expected that the company will be able to increase its employees' salaries and provide them with a better living standard. With the company investing over 200 million Euro into their new campus and opening offices in various cities worldwide, with a significant number in Croatia, the effect is already immense. With the completion of the campus, Rimac will have many new opportunities to create innovations and increase its production and thus employ more people (*Rimac Campus*, n.d.). With the number of autonomous vehicles and electric vehicles expected to grow significantly in the upcoming years and the company, being one of the early AV and AV component developers, it has an excellent opportunity to establish itself as one of the market leaders in the AV sector. With the global supply chain not being agile enough to withstand shocks, such as the COVID-19 pandemic or the Russo-Ukrainian war (Shih, 2020), the EU is expected to produce as many goods as possible inside the EU. This change can be seen in the European Chips Act to build a more resilient EU and numerous reshoring cases (Breton, 2021; *Reshoring Cases*, n.d.). Croatia has lower wage levels than several EU member countries (*Wages and Labour Costs*, n.d.), which can be seen in Figure 3. It also has the means to build AVs and components for them and other vehicles and is a growing and competitive technology hub with a large talent pool, with companies such as Infobip, PhotoMath, Gideon Brother, SofaScore, and many more. Therefore, a shift of production of some technological goods to Croatia could occur soon. The market for self-driving cars is predicted to increase tremendously in the following years, creating new employment and generating profits of up to €620 billion for the EU automotive sector by 2025 (*Self-Driving Cars in the EU*, 2019). In addition, Zagreb could experience tourism growth, as fans of new technologies or Rimac Automobili, and curious people will want to test ride the robotaxis after the commercialization of the robotaxis. If the service is expanded to other cities, an increase in tourism, predominantly domestic, can be expected. The impact of increased travel is further elaborated in detail in chapter 2.5.1.

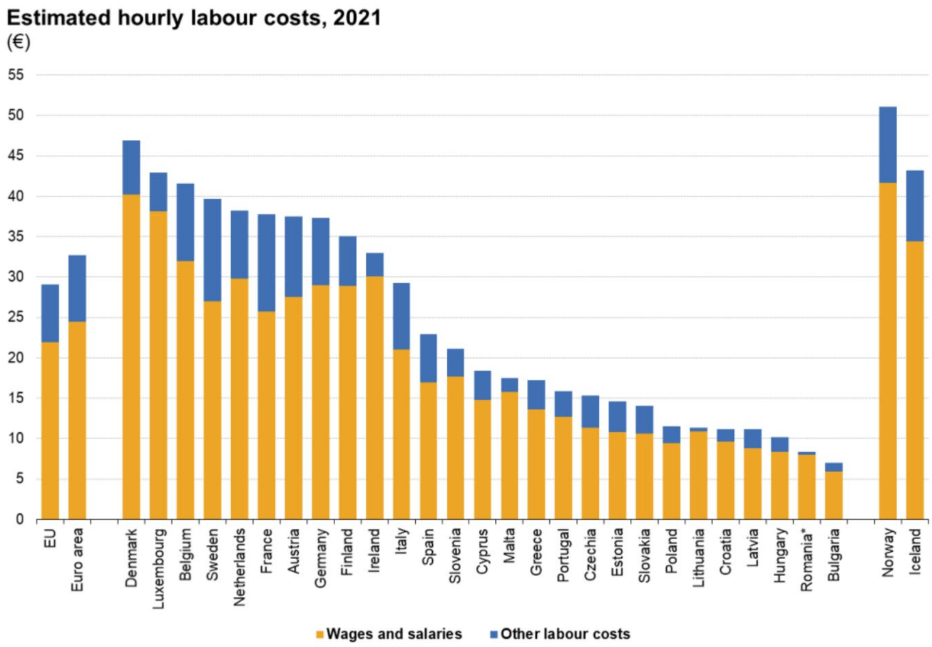

FIGURE 3 - ESTIMATED HOURLY LABOR COSTS IN 2021 (WAGES AND LABOUR COSTS, N.D.)

2.4 Autonomous vehicles and robotaxis

This section is divided into two larger subsections: the core features and the known limitations and challenges to adopting AVs or robotaxis in Croatia.

2.4.1 Core features

This subsection will focus on the core features of AVs, such as their applications, components, workflow, etc.

2.4.1.1 AV applications

Different industry verticals have different levels of potential in terms of AV impact. The verticals with the most potential are listed below:

Logistics and transportation: The adoption of AVs is likely to have a significant impact on the logistics and transportation sector. They will replace numerous driver professions, including truck, delivery, and taxi drivers, and create new services like robotaxis. AVs will also transform the logistics behind many supply chains as everything is increasingly automated. AVs will be safer and more efficient, especially under difficult working conditions, ensuring a more agile and reliable supply chain.

Heavy machinery: AVs have the potential to significantly transform the agriculture, mining, and construction industries by allowing machines to work longer and in various conditions, as well as by introducing numerous new features to the machines. For instance, this year, John Deere unveiled a production-ready autonomous tractor, while Caterpillar already has more than 282 autonomous trucks in operation (A World Leader in Autonomous Mining, 2020; John Deere Reveals Fully Autonomous Tractor at CES 2022, 2022).

Other industries that are expected to see significant transformations are the military, property, retail, media, and entertainment industries (Araya, 2019). Other industries are also expected to transform significantly, but time will only tell which ones will see the most significant change.

2.4.1.2 AV components and workflow

In principle, AVs follow a three-phase architecture called "sense-plan-act," which is the underlying principle of many robotic systems (Behere & Törngren, 2015; DiClemente et al., 2014; Siciliano & Khatib, 2008, as cited in Bagloee et al., 2016). Nonetheless, understanding and making sense of the complex and dynamic nature of the driving environment is a major challenge for AVs (Fagnant & Kockelman, 2015). Thus, AVs are equipped with various technologies, including sensors, radars, actuators, cameras, Global Positioning System (GPS), onboard units (OBUs), complex algorithms, and sophisticated software and artificial intelligence systems. (Pisarov & Mester, 2020). The functioning and use of some of these components are further explained in detail below.

Light Detection and Ranging (LIDAR) is a kind of remote sensing technology that uses a light beam to illuminate a target and analyzes the reflected light (Ondruš et al., 2020). The acquired data is fed into an onboard computer, which builds a precise three-dimensional map of the surroundings. The car makes use of the map to navigate around obstacles. It is positioned on the vehicle's roof in a rotating cylindrical body and comprises an emitter, a mirror, and a receiver.

Radio Detection and Ranging (RADAR) is a device that uses electromagnetic waves to determine the mutual velocity of an object and a vehicle (Šarkan et al., 2017, as cited in Ondruš et al., 2020). The radar systems are mounted on the vehicle's front and rear bumpers. The radar detects the surroundings, and the onboard computer merges this information with that obtained from the LIDAR system (Gestmair et al., 2019, as cited in Ondruš et al., 2020). The radar system is also applied for self-parking, blind spot recognition, lane-change assistance, adaptive cruise control, side-impact warning, and cross-traffic alert, among other tasks.

Ultrasonic sensors are placed on the car's sides to detect objects extremely close to the vehicle or to determine the location of other vehicles when parking or driving (Ondruš et al., 2020).

Cameras are mounted on the top of the front windshield as well as at the back and create real-time three-dimensional footage of the road ahead in real-time (Yun et al., 2019, as cited in Ondruš et al., 2020). These are used to identify traffic lights, traffic signs, marked crosswalks, and any other objects as well as animals or humans. Cameras aid in recognition of some actions that other sensors cannot interpret, such as hand waving or traffic cones.

Global Positioning System (GPS) is a satellite navigation system that gives current position and time information to users anywhere by feeding a map of the region into the central computer (Ondruš et al., 2020). With a precision of 30 cm, the GPS can maintain the car on its planned course.

Inertial Measurement Unit (IMU) is an electrical device that monitors and reports the vehicle's velocity, orientation, and gravitational forces (Yun et al., 2019, as cited in Ondruš et al., 2020). Accelerometers, gyroscopes, and magnetometers are used in the IMU. Because GPS data is often less precise than IMU data, the IMU supports the GPS by merging its outputs. The IMU also allows the GPS to work in places where there are no signals, such as tunnels, lousy weather, or electromagnetic interference.

The data collected from the AVs sensing technologies are sent to a central computer that would suggest suitable actions to be taken (Ondruš et al., 2020). The choice is made with the assistance of highly complex software and new technologies, such as AI. The AI can give tasks to electro-mechanical equipment, such as accelerating, changing lanes, overtaking, steering, and braking. The central computer is installed in the vehicle's interior. Figure 4 shows the placement of the components on Baidus "Apollo" robotaxi.

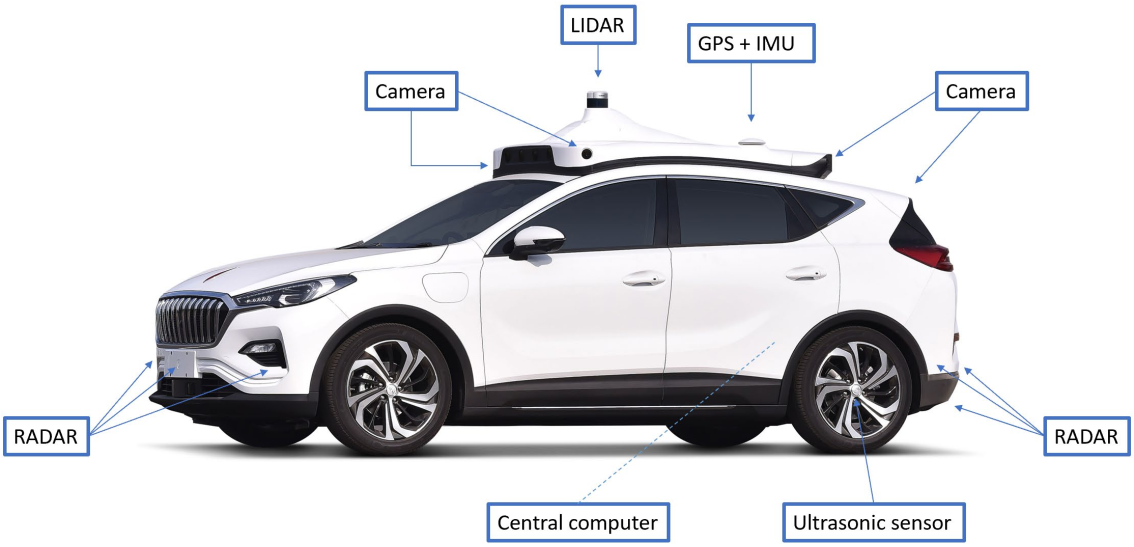

FIGURE 4 - SENSOR SCHEME (APOLLO, N.D.)

Furthermore, the car may enable the driver or vehicle to connect with other vehicles, road users, infrastructure, cloud and edge computing centers, and any other IoT devices (Pisarov & Mester, 2020). An AV that can communicate with infrastructure, vehicles, cloud, and edge computing centers, IoT devices, and road users in order to collect and share data or information as well as negotiate maneuvers is referred to as a connected autonomous vehicle (CAV) (Shladover, 2018, as cited in Faisal et al., 2019). To communicate, several wireless technologies can be used by CAVs, such as Wi-Fi, Bluetooth, Zigbee, 4G, etc. (Forbes, 2016, as cited in Krasniqi & Hajrizi, 2016). However, the two most suitable ones are dedicated short-range communications (DSRC) and 5G standard for broadband cellular networks, as a result of their low latency capabilities and faster download speeds, which will allow for faster transmission of data and thus faster reactions. Even lower latencies will be possible with 6G, which will allow IoT devices to be charged using energy gathered from their environments, such as vibrations, light, temperature, or radio waves. The ecosystem as a whole is dependent on the co-operation of OBUs (DSRC transceivers), roadside units (RSUs), and vulnerable road users (VRUs) (Vermesan et al., n.d.). While the proliferation of IoT devices has many advantages, such as increased safety and efficiency, it also poses new challenges, such as protecting these devices from malicious attacks. Thus, it is critical to approach the development of CAVs with care.

2.4.1.3 Levels of automation

In principle, an automated vehicle system may only be described as autonomous if it can perform all dynamic driving functions in all types of driving environments. However, in the literature, these degrees of autonomy are not rigorously defined, and any degree of autonomy is considered autonomous (Shladover, 2018, as cited in Faisal et al., 2019). There are six levels of driving automation ranging from level zero to level five. Figure 5 shows the different levels of automation with a short description for each level.

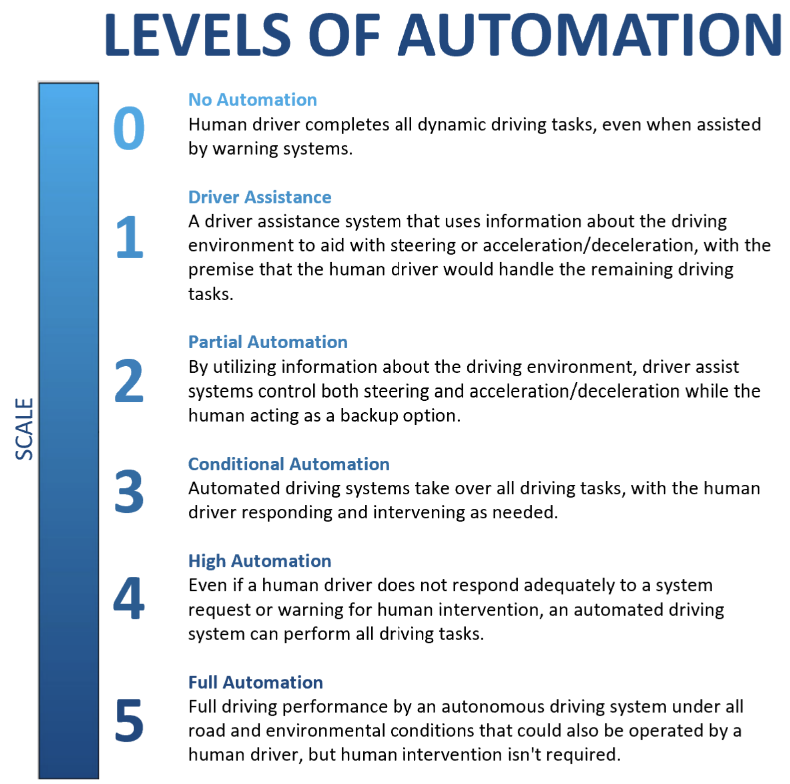

FIGURE 5 - THE SIX LEVELS OF DRIVING AUTOMATION ("A BRIEF HISTORY OF AUTONOMOUS VEHICLE TECHNOLOGY," 2016)

2.4.1.4 Historical development of AVs and future outlook of robotaxis

The idea and plan to develop self-driving objects already existed as early as 1500, when Leonardo da Vinci invented a cart that could travel without being pushed or dragged. ("A Brief History of Autonomous Vehicle Technology," 2016). In 1925, Houdina Radio Control debuted the "American Wonder," a remote-controlled car that drove up Broadway in New York City while being followed by an operator in another vehicle (Janai et al., 2020). In 1986, Ernst Dickmann and his team at the Bundeswehr University Munich in Germany developed a Mercedes Benz van that could drive by itself over a distance greater than 20 kilometers and with speeds of up to 96 kilometers per hour on a clear highway. By 1989, the van was capable of recognizing impediments, and by the 1990s, it was capable of performing lane changes (Weber, 2014, as cited in Davidson & Spinoulas, 2015). In 1995, Carnegie Mellon University's Navlab team, which assisted Dickmann's team in 1986, accomplished another significant milestone by driving from Washington, DC, to San Diego 98% autonomously (Janai et al., 2020). From 2004 to 2007, the Defense Advanced Research Projects Agency (DARPA) held several so-called Grand Challenges to accelerate the development of autonomous vehicle technology suitable for military applications. The 2005 and 2007 competitions resulted in AVs capable of navigating both desert terrain and urban streets (Pendleton et al., 2017; Shladover, 2018, as cited in Faisal et al., 2019). Google began its pursuit of full AVs in 2009 by creating its autonomous vehicle fleet, WAYMO (Faisal et al., 2019). In 2014, Mercedes-Benz introduced the S Class, while Tesla introduced the Autopilot ("Autopilot," 2014, as cited in Janai et al., 2020), both of which provide level 2 autonomy, including automated driving, lane keeping, accelerating, and braking on the highway. A year later, Uber started its own self-driving initiative ("Advanced technologies group," 2015, as cited in Janai et al., 2020). In addition to the already mentioned companies, large enterprises, such as Bosch, Baidu (Apollo), General Motors (Cruise), DiDi, etc., as well as newcomers, such as Rimac, are developing or have developed autonomous vehicles and robotaxis (*Apollo*, n.d.; *Autonomous Driving*, n.d.; Janai et al., 2020; Shepardson et al., 2022). Moreover, numerous cities worldwide are preparing to shift to an AV-based future.

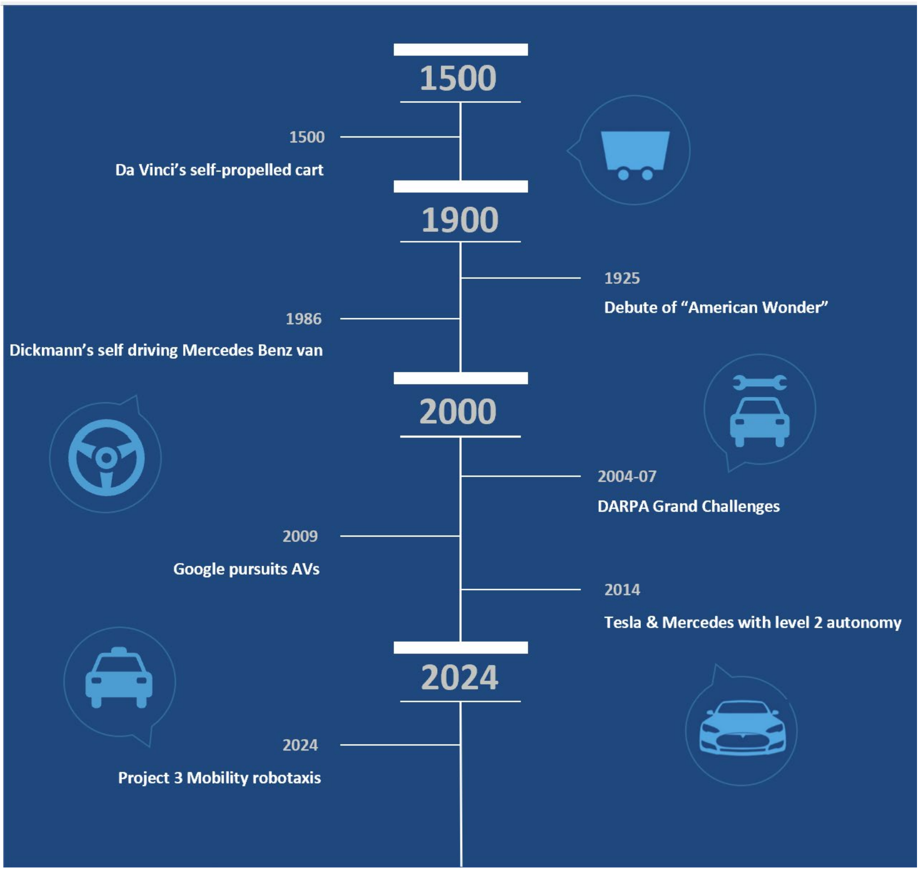

FIGURE 6 - TIMELINE

McKinsey expects robotaxis to evolve in three stages, as shown in Figure 7 (Ambadipudi et al., 2017). During the first deployment phase, robotaxis travel at low speeds on roads with clear lane lines, curbs, and little traffic. Later, robotaxis will be able to navigate busy streets and highways at any time of day or night. The final phase will allow robotaxis to navigate bad roads, unmapped and unclear in all weather conditions. Bigger markets, mainly city centers, are expected to see the first large-scale applications in 2026 or later, with China and the US dominating the market (Heineke et al., 2021). McKinsey expects level four use cases as early as 2024.

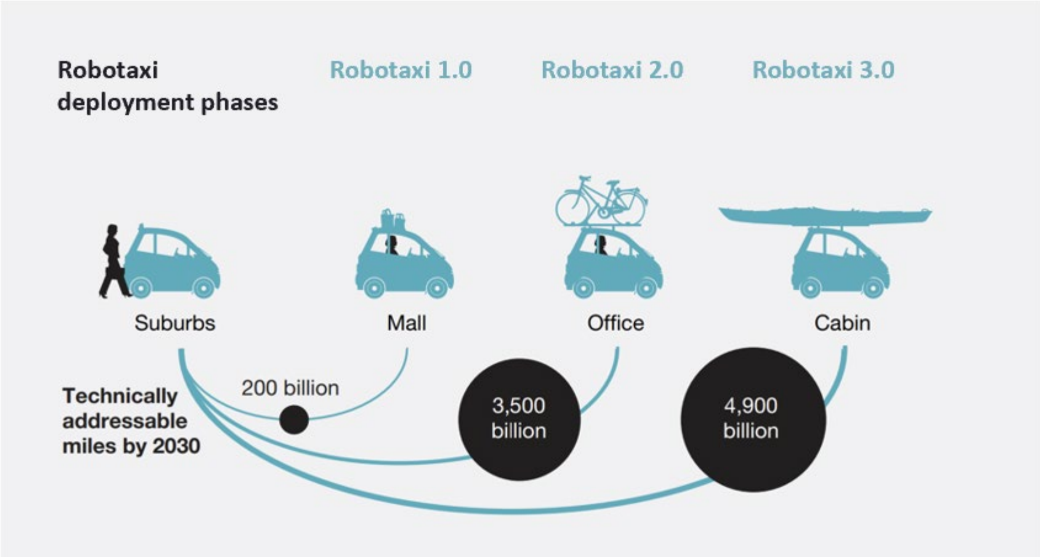

FIGURE 7 - ROBOTAXI DEPLOYMENT PHASES (AMBADIPUDI ET AL., 2017)

2.4.2 Known limitations or challenges to the adoption of AVs or robotaxis in Zagreb

Many factors influence the adoption of AVs or robotaxis. This subsection will look at a few of these challenges or limitations for Zagreb.

Technical & infrastructure challenges:

- **Network coverage:** Croatia has made 5G available to its citizens in October of 2020 (5G mreža u Hrvatskoj, n.d.) on the already existing 4G spectrum through dynamic spectrum sharing (DSS). (Lijović, 2020) However, compared to other countries globally, Croatia introduced 5G relatively late and thus could need more time to achieve full or sufficient 5G coverage for country-wide AV use. (Li & Park, 2019) This can also be seen in the map below, which shows where 5G is provided by the largest Croatian network provider (Hrvatski Telekom) in Zagreb. According to the National Plan for Broadband Development 2021 to 2027, Croatia's 5G networks should serve all major cities and villages and significant highways. (Broadband in Croatia, n.d.) Since robotaxis may be commercially available in Zagreb by the end of 2024, it is desired for 5G to be available throughout the city and the surrounding Zagreb County by then. 5Gs low latency, means that CAVs could react quicker, almost instantly, and drive much closer to each other.

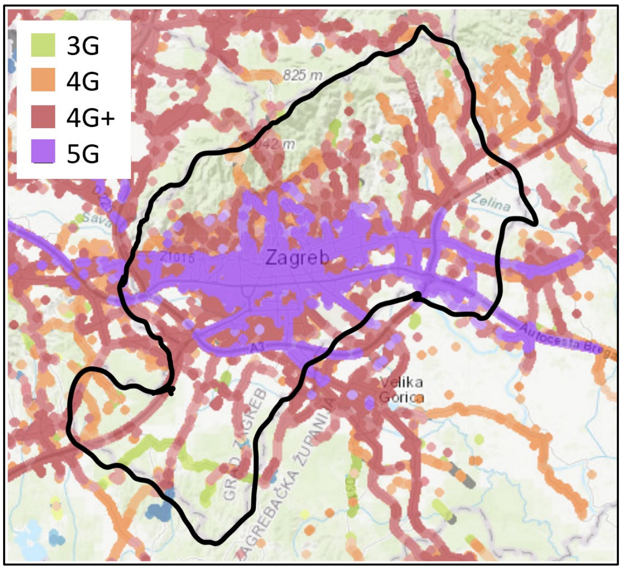

FIGURE 8 - T-MOBILE 3G, 4G, & 5G COVERAGE MAP OF ZAGREB (T-MOBILE 3G/4G/5G COVERAGE IN ZAGREB, CROATIA, N.D.)

- **Road infrastructure:** The Croatian or Zagreb road infrastructure is not ready for autonomous vehicles yet (Bičak, 2022). Road signs and markings must be maintained continuously and of higher quality than currently to allow robotaxis or autonomous vehicles to drive safely on roads. Standardizing them globally or continentally would also allow AVs or robotaxis to cross borders safely. To fully utilize the benefits of AVs and CAVs, Zagreb will need to introduce more smart or IoT devices throughout the city. Moreover, more EV charging stations will be required to accommodate robotaxis and other EVs. Currently, Croatia has 600 EV charging stations that can serve 2,000 cars.
- **Privacy and cybersecurity:** One of the critical challenges of AVs is their vulnerability to cyberattacks from cybercriminals (Pisarov & Mester, 2020). Hackers could take over the operating system and cause severe harm or even death to the user. The user can be financially or physically harmed by crashing the car or abducting the person. They can also obtain large amounts of sensitive data collected. Blockchain technology is prevailing as one of the possible solutions to the issue.
- **Interoperability and standards:** A lack of interoperability can result in several costs and risks, limiting the large-scale adoption of AVs and increasing security and privacy threats. A collaborative approach to overcome this hurdle is using open standards.

Regulations: Regulations are often viewed as the biggest challenge to the adoption of AVs (Heineke et al., 2021). Many may need to be revised to allow AVs or robotaxis to operate on public roads (Davidson & Spinoulas, 2015). So long as the driver is required to monitor and manage the vehicle constantly, AVs will not be fully realized. However, determining who is accountable and liable for accidents or injuries will be challenging. Vehicles without a driver face even greater legal challenges. Allowing unoccupied autonomous vehicles would have many benefits but will need substantial social, regulatory, and insurance changes.

Social dilemma: While the number of accidents involving AVs is likely to be significantly lower than it is now, they will undoubtedly occur. Bonnefon et al. (2016) discovered that, while respondents believe that utilitarian AVs that may sacrifice passengers to save others is the most moral, they would prefer not to ride in or purchase such vehicles. Thus, in addition to the technological and planning implications of AV adoption, we will face social and moral challenges as a society (Duarte & Ratti, 2018).

User acceptance: While all other challenges play an important role in easing or allowing the adoption of AVs, reaching a sufficient user acceptance is still the most crucial challenge present.

2.5 Triple bottom line impacts

This section will look at the different societal, economic, and environmental impacts of robotaxis or AVs. Figure 9 shows the different impacts summed up and the SDGs that are relevant to those impacts.

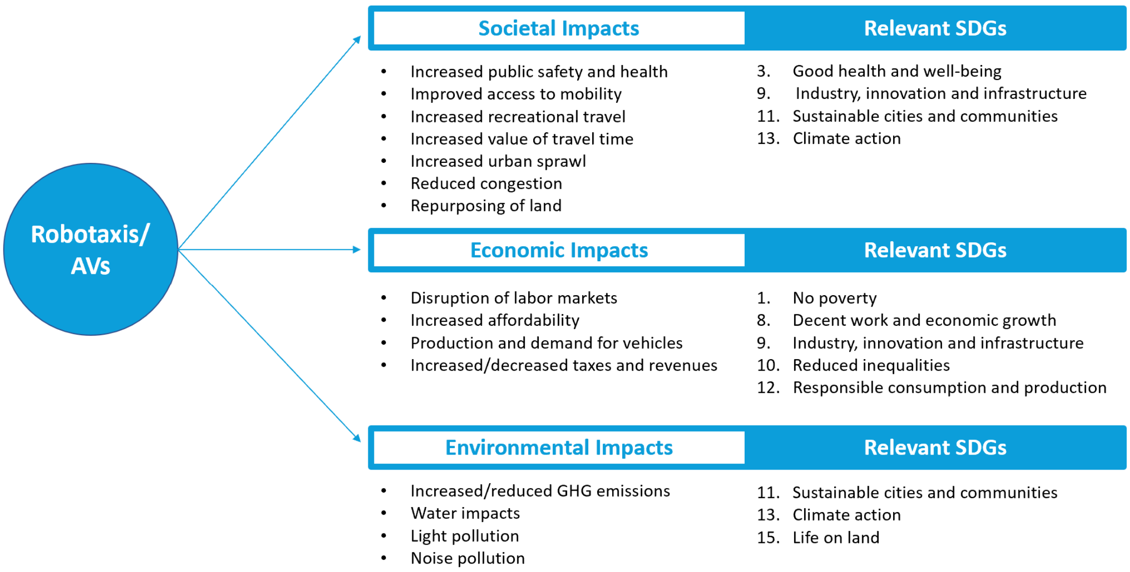

FIGURE 9 - TRIPPLE BOTTOM LINE IMPACTS AND RELEVANT SDGS

2.5.1 Societal impacts

This paper will first look at the numerous impacts that are expected to result from robotaxis or AVs.

2.5.1.1 Increased public safety and health

Approximately 1.3 million people are killed each year in automotive accidents globally, with over 90% of these crashes caused by human error (USDTO, 2015, as cited in Singleton et al., 2020). In 2019, 22.800 individuals lost their lives in the EU due to road-related accidents (Road Fatality Statistics in the EU, 2019). This number declined to 18.800 in 2020, while Europe's mortality toll decreased by 36% between 2010 and 2020. However, we must factor in decreased traffic in 2020 because of the COVID-19 pandemic. Most traffic fatalities in the EU occur on urban (38%) or rural (53%) roads; only a few occur on highways.

Traffic accidents are the leading cause of death from injuries among children and adolescents in Croatia (Nacionalni dan sigurnosti cestovnog prometa, 2021). Croatia ranks among the EU's worst countries in terms of road fatalities, with 7.95 fatalities per 100,000 inhabitants or 297 fatalities in 2019 (Global Health Estimates, n.d.). In 2020, this number dropped to 237 people as a result of people traveling less due to COVID-19 restrictions (Nacionalni dan sigurnosti cestovnog prometa, 2021). The majority (up to 57%) of severe traffic accidents in Croatia are caused by human error. Figure 10 illustrates the precise percentages attributed to each error.

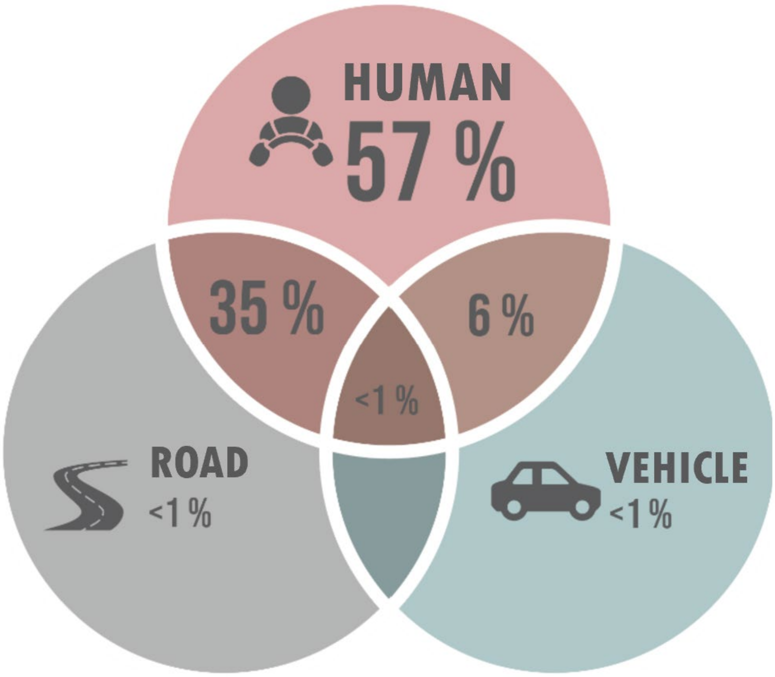

FIGURE 10 - REPRESENTATION OF THE PERCENTAGES ATTRIBUTED TO EACH ERROR

Traffic accidents constitute a public health and development issue, and it is critical to invest heavily in enhancing road safety at all levels (*Nacionalni dan sigurnosti cestovnog prometa*, 2021). Each person lost in a traffic accident imposes a high financial cost on the community and terrible social repercussions (Forrest & Konca, 2007). Their knowledge, labor power, and societal values are all lost due to automobile accidents. Even minor injuries have a significant financial impact, as treatment expenses are considerable and injured individuals cannot work for an extended length of time. The human costs associated with road accidents are illustrated in further detail in the block diagram depicted in Figure 11.

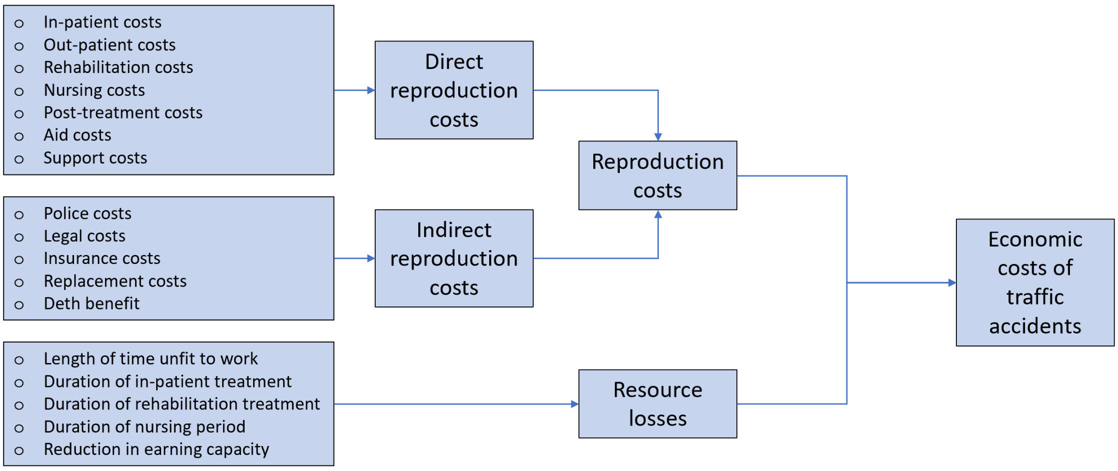

FIGURE 11 - HUMAN COSTS OF TRAFFIC ACCIDENTS (ABELE ET AL., 2005, AS CITED IN FORREST & KONCA, 2007)

Most frequently, AVs reduce traffic-related injuries and deaths (Dean et al., 2019; Pettigrew et al., 2018, as cited in Singleton et al., 2020). Because AVs are driven by computers rather than humans, they should be safer than current vehicles (USDOT, 2015, as cited in Singleton et al., 2020). If AVs could eliminate half of driver error-related crashes, the total number of crashes would drop by over 40%, reducing fatalities, injuries, and property damage (Nyquist, 2017, as cited in Saghir & Sands, 2020). Fully autonomous vehicles' computer vision systems are projected to improve collision avoidance, lane-keeping assistance, and other driving tasks. In contrast, connected vehicles or infrastructure will enable vehicle trajectories to be shared and safe in high-crash circumstances (e.g., queues, crossings) (Milakis et al., 2017, as cited in Singleton et al., 2020). Nonetheless, such safety gains may be limited until AV adoption is achieved on a large scale and AVs can operate fully autonomously without human assistance (Singleton et al., 2020).

Improved travel satisfaction and spill-over effects: AVs are likely to improve driving experiences that negatively impact mental health and well-being. By reducing the need to drive, AVs may reduce the stress associated with urban traffic and congestion (Crayton and Meier, 2017; Curl et al., 2018; Dean et al., 2019; Richland et al., 2016, as cited in Singleton et al., 2020), hence enhancing mental and physical health. By allowing travelers to engage in more productive and rewarding activities while driving, AVs may also increase travel enjoyment and contentment, and satisfaction with the destination activity (Singleton et al., 2020).

However, these well-being benefits should not be overstated (Singleton, 2019, as cited in Singleton et al., 2020), as AVs may also adversely affect well-being. The increased possibility of successfully utilizing travel time produces psychological pressure, which reduces travel happiness and well-being (Pudane et al., 2019; Shaw et al., 2019, as cited in Singleton et al., 2020). Sharing and, specifically, pooling AVs removes one of their main advantages: a better travel experience and the ability to multitask (Singleton et al., 2020). Moreover, some people love driving and having a particular vehicle (Curl et al., 2018, as cited in Singleton et al., 2020).

Noise: Despite receiving less attention than the previous three issues, noise is recognized as a health hazard (WHO, 2018, as cited in Singleton et al., 2020). Noise can cause hearing loss and tinnitus. It also has adverse health effects, especially after prolonged exposure. Noise can disrupt sleep, harm the cardiovascular and psychophysiological systems, impair functioning, and cause anger reactions and social behavior changes (WHO, 2018, as cited in Singleton et al., 2020). The primary source of noise pollution in cities is traffic (EEA, 2014, 2018, as cited in Singleton et al., 2020). Over 70 million Europeans are estimated to be exposed to noise levels of over 55 dB during the day, evening, and night.

If AVs have electric engines mostly, the sound of a city will change dramatically. Nonetheless, the bulk of road noise is generated by tire and asphalt pavement interaction (Rochat and Reiter, 2016, as cited in Singleton et al., 2020), which would be reduced very little and may even be increased by higher traffic volumes and larger speeds (Sohrabi et al., 2020, as cited in Singleton et al., 2020).

Reduced transport-related physical activity: Reliance on motorized transport promotes physical inactivity. Inactivity increases the risk of obesity and is linked to several diseases (Khreis et al., 2016, as cited in Sohrabi et al., 2020). AVs are expected to reduce physical activity associated with transportation by displacing some modes of active transportation from walking, cycling, public transportation, and other modes of transit (Crayton and Meier, 2017; Curl et al., 2018; Milakis et al., 2017; Sohrabi et al., 2020; Soteropoulos et al., 2019, as cited in Singleton et al., 2020). While exact effects are unknown, AVs may help increase total physical activity. Being productive in AVs may allow more time for other physically active non-travel pursuits, or compensatory behavior may boost leisure-time physical activity (Crayton and Meier, 2017; Curl et al., 2018, as cited in Singleton et al., 2020). CAVs may increase road capacity, freeing up space for non-motorized infrastructure (Milakis et al., 2017; Soteropoulos et al., 2019, as cited in Singleton et al., 2020). Nonetheless, the benefits of mode shifts are unlikely to outweigh the disadvantages (Singleton et al., 2020). A decline in personal transportation-related physical activity is expected.

2.5.1.2 Improved access to mobility

A sizable portion of the population cannot travel or drive themselves at all or easily to and from everyday activities. This is particularly true for children, the elderly, and people with physical and intellectual disabilities (Bennett et al., 2019; Pettigrew et al., 2018, as cited in Singleton et al., 2020). AVs are expected to improve access for these people by eliminating the need for personal drivers and other costly transportation options. These groups are expected to drive AV travel demand (Krasniqi & Hajrizi, 2016; Harper et al., 2016, as cited in Singleton et al., 2020). Improved mobility may also aid rural residents in accessing hospitals and other services (Curl et al., 2018; Pettigrew, 2017; Richland et al., 2016, as cited in Singleton et al., 2020). AVs may also help reduce social isolation by promoting independent movement and access to opportunities like social activities and relationships with family and friends.

2.5.1.3 Increased recreational travel

Singleton et al. (2020) claim that the introduction of AVs will encourage people to travel longer distances or more frequently for everyday activities. However, increased vacation trips seem to be a more plausible outcome of AVs (LaMondia et al., 2016, as cited in Singleton et al., 2020). The third hypothesized cause is long-term changes in-home and/or work locations due to reduced travel opportunity costs, which would unintentionally result in urban sprawl (Heinrichs, 2016; Zakharenko, 2016, as cited in Singleton et al., 2020).

2.5.1.4 Increased value of travel time

Autonomous vehicles can significantly reduce a person's commute time, particularly in congested towns. Having the extra time for leisure activities improves our standard of living (Forrest & Konca, 2007). AVs will enable us to play cards or have lunch while traveling, but they will also let us undertake other productive and enjoyable tasks (Berg and Verhoef, 2016, as cited in Duarte & Ratti, 2018). Activities previously inaccessible via traditional automobiles would become accessible due to the ability to perform other tasks than driving during the trip (Meyer et al., 2017, as cited in Singleton et al., 2020). This means that former off-trip activities can be included within the trip, freeing up time for new or expanded off-trip activities (Mokhtarian, 2018; Pudane et al., 2018, as cited in Singleton et al., 2020).

Reduced wasted time also enables individuals to be more punctual and dynamic, resulting in a considerable increase in job efficiency (Forrest & Konca, 2007). CAVs might save over 2.7 billion hours of wasted time spent commuting to work and produce yearly savings of $447.1 billion in the United States alone. This is assuming that there is a 90% CAV penetration (Clements & Kockelman, 2017).

2.5.1.5 Increased urban sprawl

By alleviating stress associated with commuting and repurposing the time spent driving into productive or pleasurable activities, the distance between home and work becomes a secondary consideration when determining where to reside (Fagnant and Kockelman, 2015, as cited in Duarte & Ratti, 2018). Indeed, 10% AV market penetration may decrease traffic by 15%, and 90% market penetration can result in a 60% reduction in highway congestion, saving around 2,700 million hours saved and increasing vehicle-miles traveled (VMT) by 9%. As a result, urban sprawl is likely to increase (Duarte & Ratti, 2018).

On one hand, AVs may encourage people to move further away from cities, especially those who prefer single-family homes with large backyards and lots of natural space (Duarte & Ratti, 2018). On the other hand, people may be more inclined to return to or move to cities, since AVs virtually eliminate all car accidents and thus create a safer urban environment with less noise and pollution.

Due to shorter wait times, dense urban areas should attract more shared autonomous vehicles (SAVs) (Duarte & Ratti, 2018). Because commute time is a factor in where to live, cities (with more SAVs) may become more desirable than suburbs. The trade-offs between AVs and city infrastructure are unknown, and land use changes take years to manifest.

2.5.1.6 Reduced congestion

As mentioned shortly beforehand, AVs are expected to reduce or ease the current congestion levels greatly. While the socio-economic impacts have not yet been studied to a full extent, Frey (2017, as cited in Kim, 2018) was able to assert the following:

1. A fleet of 30.000 AVs can eliminate 50% of peak commuting traffic in a metropolis of 2 million people.
2. 30.000 AVs will meet almost all other transportation demands during off-peak hours.

2.5.1.7 Land use and repurposing

While cars sit idle for 96% of their lifetimes, AVs may operate at a rate upwards of 75%. ("If Autonomous Vehicles Rule the World," 2015, as cited in Duarte & Ratti, 2018). Thus, AVs may help cities reduce their reliance on parking spots, and infinite fluidity indicates a decrease in parking requirements. In the US, where 94.5% of the population drives, parking spaces cover 4.400 square kilometers, or 75 times the area of Manhattan (Ben-Joseph, 2012, as cited in Duarte & Ratti, 2018). With the sharing and pooling potential and AVs' ability to move continuously or self-drive to a remote and less expensive area, tens of thousands of parking spaces could be repurposed (Duarte & Ratti, 2018; Singleton et al., 2020).

The elimination of on-street parking places has already resulted in the establishment of public spaces, such as the 51 "parklets" constructed in San Francisco since 2010 and hundreds more internationally (Duarte & Ratti, 2018). Costs of development for all types of building and living in these regions might also decrease due to reduced parking needs (Clements & Kockelman, 2017). Along with fewer parking spaces, Anderson et al. (2014, as cited in Saghir & Sands, 2020) anticipate that broad use of AVs would likely result in denser urban centers and more buildings.

While researchers agree that there will be a reduced need for parking spaces, they seem to differ in their opinions if roads will have to be developed to fit AVs or if they could be repurposed. Duarte & Ratti (2018) claim that autonomous vehicles may necessitate modifications to the road infrastructure. Automating cars may eliminate the need for extra-wide lanes, guardrails, traffic control signals, and rumble strips (Clements & Kockelman, 2017). With enough market penetration, the government could forego investing in costly infrastructure safety measures. Platooning could save around $7.5 billion annually, according to KPMG (Silberg et al., 2013). The freed-up road space can be repurposed for transportation, pedestrian, and bicycle infrastructure (Singleton et al., 2020). This may result in more attractive, walkable urban areas, encouraging increased physical activity.

In their report "Urbane Mobilität und autonomes Fahren im Jahr 2035" (n.d.), Deloitte warns that more free parking spaces in cities could lead to new traffic. Increased traffic on residential streets may exacerbate the problem of urban street networks being less favorable to pedestrians and cyclists. Simultaneously, other regions may see an inflow of parked or circling empty AVs (Ostermeijer et al., 2019, as cited in Singleton et al., 2020).

2.5.2 Economic impacts

In addition to being expected to result in numerous societal impacts, robotaxis or AVs are expected to have various economic impacts. This section will introduce the economic impacts expected to occur.

2.5.2.1 Disruption of labor markets

In previous years, lower-skilled professions, which have been disproportionately impacted by automation, will continue to be disproportionately impacted by AV-related task automation (Marshall, 2017). AVs may replace many drivers in the public sector (Clark et al., 2017). Many of these positions require little education yet pay a decent income. However, many higher-education occupations may be more difficult to replace. Meanwhile, government employment growth is expected in information technology, data analytics, and other highly skilled industries. This discrepancy in educational achievement raises legitimate worries about equity in the public sector and across the economy.

The most significant shift in personal transportation due to CAVs will almost certainly be in the mode of short commutes (Clements & Kockelman, 2017). Companies may develop an on-demand taxi service using SAVs, eliminating the need for human drivers.

While the impact on long-distance transportation is uncertain, CAVs and SAVs will have the greatest impact on public transit and taxi services (Clements & Kockelman, 2017). The yearly income generated by public transit and taxi industries is $66 billion and $20 billion, respectively. The introduction of CAVs to ridesharing services would likely decline taxi revenue with a shift to ridesharing revenue.

AVs can devastate public transit support and finance, as those with the financial means can simply switch to fleet AVs (Clark et al., 2017; Saghir & Sands, 2020). With declining ridership and revenue, public transit may be restricted to those who cannot afford AV services. This may destabilize public transportation companies' budgets and result in service reductions that disproportionately affect the poor, widening the social gap. In this case, governments will almost certainly have to finance either access to AVs or the operation of their fleets.

Robotaxis, CAVs, or SAVs may also impact jobs in other transportation sectors or jobs related to transportation (Davidson & Spinoulas, 2015). Manufacturing, car rental, car financing, car retail, gas stations, and other on-road transportation industries may see significant job losses. When the expense of drivers is eliminated, the economics of transportation also shift. The trend toward bigger freight trucks can be reversed with a smaller, more focused end-to-end carriage. This would reduce road maintenance expenses and result in employment losses in wholesaling and storage. As road speed, capacity, and efficiency improve, the demand for transportation infrastructure is expected to decline, reducing employment in road construction, engineering, and transportation planning and modeling. Job losses are also expected in the aviation industry and rail industry, as people will be willing to commute longer distances using AVs, especially if the price difference is significant, the travel time is reduced, and the comfort, as well as privacy, are increased.

While many jobs will be destroyed, some will be created, especially since robotaxis will need to be produced and maintained. Moreover, roads will need to be maintained more frequently, and new services may arise.

2.5.2.2 Increased affordability

Robotaxis will likely change the dynamics of car ownership and public transit (*Gauging the Disruptive Power of Robotaxis in Autonomous Driving*, n.d.). They will alter how people think about transportation in urban contexts by lowering costs, increasing convenience, and increasing productivity. The cheap cost of robotaxis will make them a genuine game-changer, and economic considerations may persuade residents in cities to move to shared mobility. In other words, today's shared-mobility solutions cannot match the disruptive power of robotaxis because their total cost of ownership (TCO) is too close to those of private ownership's TCO.

Deloitte projects the robotaxi's per-kilometer cost will be 34 Euro cents in 2035 (*Urbane Mobilität und autonomes Fahren im Jahr 2035*, n.d.). This is less than one-eighth the cost of a traditional cab in Germany now, which is 2.60 euros per kilometer and 25% less than driving a mid-range vehicle today. For instance, the VW Golf costs 44 cents per kilometer. McKinsey predicts that the robotaxi's per-mile cost will be 1.2 US Dollars or 1.12 Euros in the lower range in 2030 (Heineke et al., 2022). Both are significantly lower than the current costs of taxis. Figure 12 and Figure 13 show the composition of prices for one kilometer or mile driven in a robotaxi or shuttle.

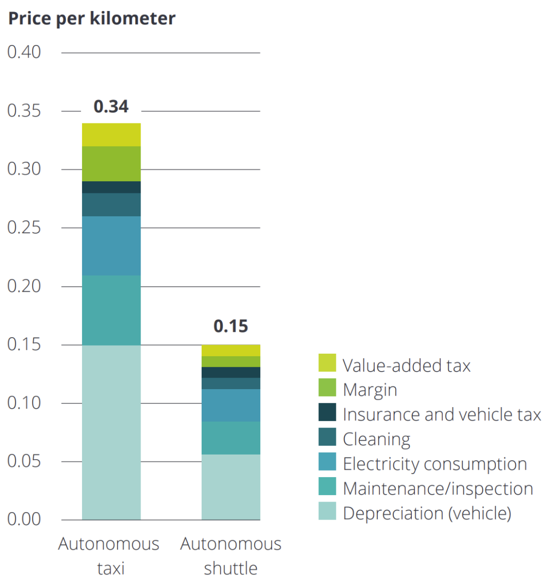

FIGURE 12 - COMPOSITION OF PRICES FOR ONE KILOMETER DRIVEN IN AN AUTONOMOUS TAXI/SHUTTLE (URBANE MOBILITÄT UND AUTONOMES FAHREN IM JAHR 2035, N.D.)

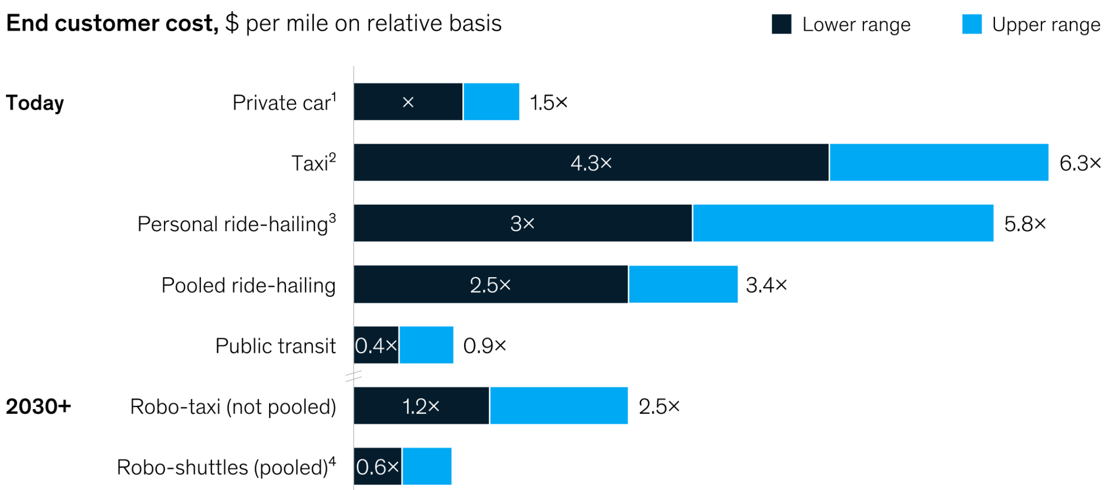

FIGURE 13 - MOBILITY COSTS TODAY AND IN 2030+

2.5.2.3 Production and demand for vehicles

CAVs could result in a drop in personal ownership, from 2.1 to 1.2 cars per household on average, reflecting a 43% decline in the average number of household vehicles while increasing the use of each vehicle and reducing empty VMT (Clements & Kockelman, 2017). With more people using autonomous cars, even those who currently take public transportation, walk, or cycle would dramatically increase trips (*Urbane Mobilität und autonomes Fahren im Jahr 2035*, n.d.). Today's urban resident travels 26.7 kilometers per day for work and leisure. Thanks to new autonomous car fleets, people will, on average, drive 32.9 kilometers per day by 2035.

With less frequent crashes, CAVs may have longer lifespans but lower car purchase rates. Clements & Kockelman (2017) estimate that overall passenger car production and sales will likely increase as demand for vehicle usage increases. While Goshen et al. (2019, as cited in Saghir & Sands, 2020) anticipate a decline in vehicle output as cars and trucks become more efficient.

Although the relative importance of demand-influencing factors is unknown, vehicle manufacturers would face a very different picture of demand, suppliers, and price (Clements & Kockelman, 2017). Businesses must proactively reposition themselves to respond to changing consumer demands. Once CAVs become widespread, the focus will shift from vehicle performance to software and digital media, forcing enterprises to specialize in certain areas.

2.5.2.4 Taxes and revenues

2.5.2.4.1 Property taxes and local revenue sources

Property taxes are the most apparent revenue source that could change. Parking is the single greatest land use in core cities (Shoup, 2005, as cited in Clark et al., 2017), accounting for between 14% and more than 25% of the area (Gardner, 2011; Chester; Fraser et al., 2015, as cited in Clark et al., 2017). With AVs, we will need up to 90% fewer parking places (International Transport Forum, 2015; Zhang, 2015, as cited in Clark et al., 2017). As a result, project density may grow as parking demand no longer limits the number of units built on a site (Clark et al., 2017). This would increase future property values and thus tax revenue associated with a specific site or development.

Parking-related revenues are not a significant revenue stream for most cities (Clark et al., 2017). However, Clark et al. (2017) would anticipate a decline in income from parking meters, parking garages, and fines issued for unlawful parking or expired meter fees when the demand for parking decreases significantly. The potential for AVs to expand urban sprawl and metropolitan footprints may raise property prices in cities farther from the city core but may devalue existing close-in suburbs.

2.5.2.4.2 Business taxes

These taxes are "sensitive to changes in the city's economic position" and are primarily influenced by employment and wages at the municipal level (City & County of San Francisco, 2016, as cited in Clark et al., 2017). These taxes generate more revenue as a city's population grows (Clark et al., 2017). Cities are expected to collect more revenue from this tax as a result of land-use changes, such as parking lots and spaces being converted into retail, commercial, industrial, or residential structures.

2.5.2.4.3 Sales taxes

Sales taxes on car sales are also expected to decline as more people opt for SAVs over private vehicles (Clark et al., 2017). A difficulty with the fleet car model is that it gives fleet owners the ability to argue for reduced sales tax rates on their purchases. Businesses may also use incorporation laws to purchase vehicles in states, countries, or jurisdictions with lower or no sales taxes and then transport them to their intended use areas. To protect sales tax revenues, governments would also want to resolve possible loopholes, such as "Like-Kind Exchanges".

2.5.2.4.4 Fees for services

Fees and user charges are unique to government products and services. As stated previously, cities are expected to enter the AV fleet market. They would provide fleets of autonomous vehicles similar to Bolt and Uber. This could be a significant revenue source or a significant expense. While public transportation is expected to lose some revenue, it may not look like it does today. It may be smaller cars with fewer people traveling in a more direct path (Clark et al., 2017). Numerous European countries and cities are already looking into AV integration into public transportation (Scott, 2017, as cited in Clark et al., 2017). Many countries' governments will push for EVs to reduce greenhouse gas (GHG) emissions (Clark et al., 2017). Charging stations may become a new revenue stream in the future of autonomous vehicles. While these may be privately offered, like gasoline, many cities already have public utilities that supply electricity, so charging electric cars may become a larger revenue stream. Nonetheless, the revenue effects remain unknown.

2.5.3 Environmental impacts

Additionally, to societal and economic impacts, many environmental impacts are expected to result from robotaxis. These are further explained in detail in this section.

2.5.3.1 GHG emissions

The EU's domestic transport emissions increased 0.8% in 2019. Early estimates show a 12.7% drop in 2020 due to the dramatic drop in transportation activities during the COVID-19 epidemic (see Figure 14) (*Greenhouse Gas Emissions from Transport in Europe*, n.d.).

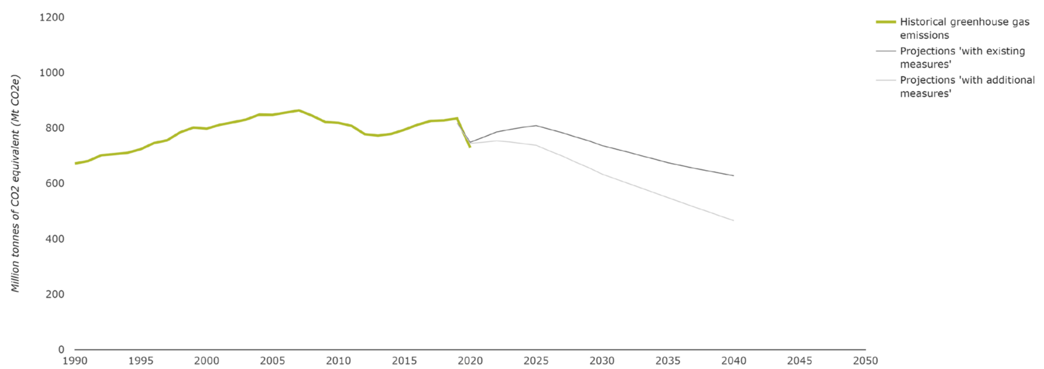

FIGURE 14 - GREENHOUSE GAS EMISSIONS FROM TRANSPORT IN EUROPE (GREENHOUSE GAS EMISSIONS FROM TRANSPORT IN EUROPE, N.D.)

Transportation accounts for a quarter of direct greenhouse gas emissions and a fifth of CO2 emissions in the European Union (EEA, 2018, as cited in Singleton et al., 2020). Transport emissions have increased by 33% in the EU since 1990, despite a 32% reduction in other sectors. In 2018, transport accounted for 29% of the EU's total greenhouse gas emissions. Figure 15 shows greenhouse gas emissions in the EU transport sector. This pie chart only includes emissions from direct transport; other emissions, such as fuel production, refining, and distribution, are included in the sum for other sectors.

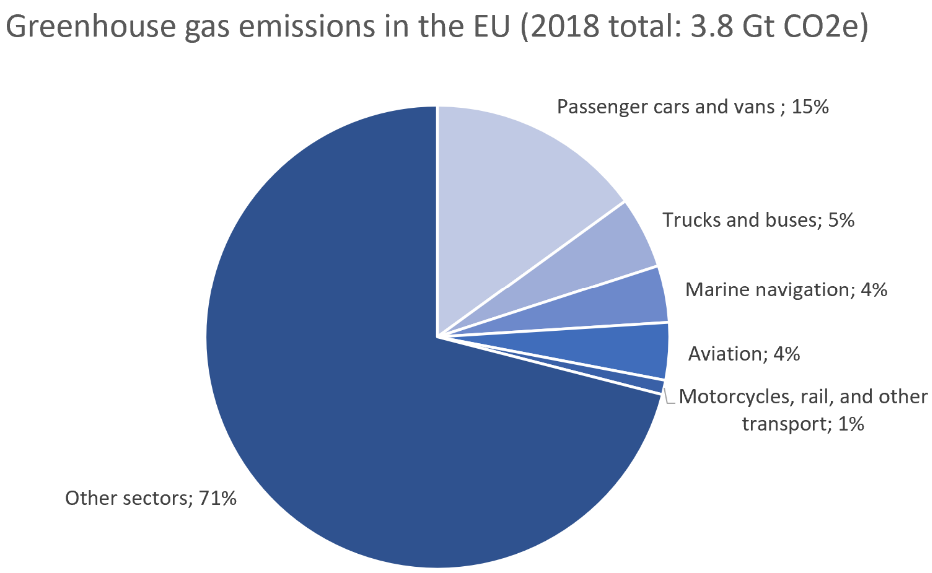

FIGURE 15 - GREENHOUSE GAS EMISSIONS IN THE EU (SINGLETON ET AL., 2020)

Croatia's overall emissions contributed 0.7% of EU total emissions in 2019 and decreased by 17% between 2005 and 2019. Transportation contributed the biggest share of Croatia's emissions in 2019. Between 2005 and 2019, transportation emissions climbed by 22%, increasing the sector's contribution to overall emissions from 18% to 27% (see Figure 16) (Liselotte, 2021).

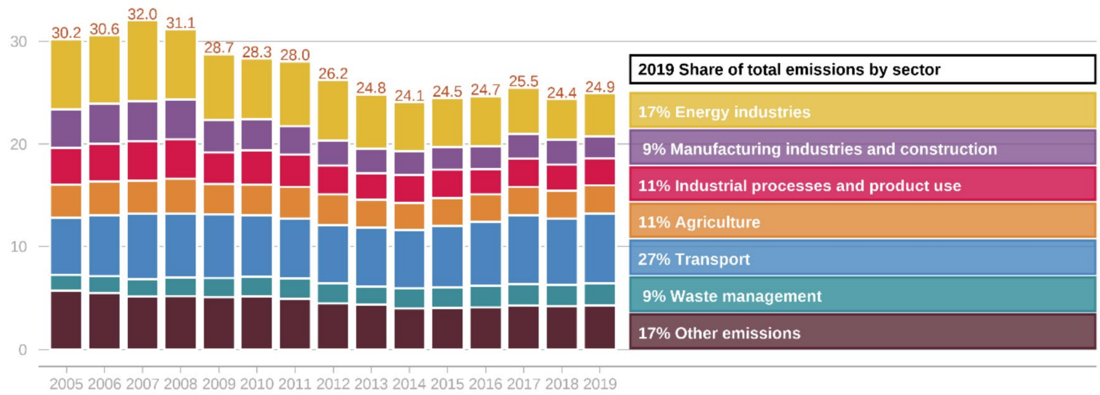

FIGURE 16 - 2019 TOTAL GHG EMISSIONS BY SECTOR IN CROATIA (MTCO2E)

Since many experts expect AVs to be electric, they will likely have many advantages over ICE vehicles (Pettigrew, 2017). Even without electrification, smoother driving operations, greater navigation, and fewer cold starts, particularly for SAVs, have the potential to reduce tailpipe emissions (Milakis et al., 2017).

2.5.3.1.1 Causes of reduced GHG emissions

Causes as to why AVs or robotaxis will reduce GHG emissions will be described further.

Easy parking: Guccione and Holland (2013, as cited in Massar et al., 2021) found that parking-seeking cars account for one-third of city traffic. Being on the road results in more gasoline used for the car itself, and because of greater traffic causes the other vehicle to use excessive fuel by being longer on the road. In addition, roadside parking contributes significantly to CO2 emissions. With the help of communication technologies, cars and infrastructure can communicate data, resulting in accurate parking information. Brown et al. (2014, as cited in Massar et al., 2021) calculated that up to 5% of emissions from a typical passenger automobile are due to parking searches. Fully autonomous cars may lower emissions by 5 to 11% due to less circulation for parking in cities. Additionally, partially autonomous cars might reduce emissions by improving their capacity to accurately detect available parking spaces (Massar et al., 2021). GHG emissions are expected to decrease by reducing vehicle idle time and searching for parking spaces.

Eco-driving: Eco-driving is the practice of driving as efficiently as possible by optimizing speed and acceleration. “Hypermiling” is a set of driving skills used by enthusiasts to maximize fuel efficiency by reducing braking-acceleration cycles (Barth & Boriboonsomsin, 2009; Torbert & Herrschaft, as cited in Massar et al., 2021).

Eco-driving may help with fuel efficiency (Barkenbus, 2010, as cited in Liu et al., 2019). According to Stephens et al. (2016, as cited in Liu et al., 2019), partial AVs save between 0% and 6.8% of fuel while fully autonomous vehicles save between 6.8% and 15.3%. Li and Gao (2013, as cited in Massar et al., 2021) concluded that after completing a series of microsimulation modeling tests to evaluate the effects of speed synchronization in a connected environment, such a setup might result in a 10% decrease in GHG emissions. Additionally, Barth and Boriboonsomsin used a traffic simulation model to assess the emissions associated with coordinated eco-driving (2009, as cited in Massar et al., 2021). They modeled a mixed fleet of cars on Southern California freeways and calculated that eco-driving could reduce CO2 emissions by 10% to 20%. However, as traffic becomes more free-flowing, emission reductions begin to wane. In similar research, Barth showed that a coordinated eco-driving system could reduce 5% to 10% emissions in congested traffic.

Eco traffic signal: AVs can communicate with infrastructure, such as traffic lights at intersections (Massar et al., 2021). This communication allows cars to alter their driving patterns, reducing the number of pauses at intersections. This is referred to as the eco traffic signal system. Li and Gao (2013, as cited in Massar et al., 2021) examined optimum signal management techniques for fuel efficiency in a connected vehicle environment. They demonstrated that such tactics might reduce fuel emissions by 10%. Rakha et al. calculated that vehicle-to-vehicle communication and signal coordination could reduce emissions by 8% to 23%, depending on the cars' driving characteristics (2011, as cited in Massar et al., 2021). AVs are equipped with various sophisticated sensors that communicate with the surrounding highway environment and can aid vehicles in adjusting their driving habits, minimizing pauses and speed variation (Massar et al., 2021). All of these elements reduce fuel consumption and thus vehicle emissions.

Collision avoidance: AVs' collision avoidance systems are meant to deliver critical information to the vehicle in advance of a collision (Massar et al., 2021). Both partial and complete automation include the collision avoidance feature, which reduces GHG emissions by avoiding and decreasing traffic jams and congestion that cause traffic accidents. According to Stephen et al. (2016, as cited in Liu et al., 2019) research partially autonomous vehicles could decrease fuel consumption by 0% to 0.95%, and fully autonomous vehicles could reduce fuel consumption by 0% to 1.95%.

Platooning: Vehicle platooning is the practice of many cars following closely behind one another to reduce aerodynamic drag and thus save energy and reduce emissions (Massar et al., 2021). Vehicle platooning can be done safely and effectively with automation and networking. This method is appealing because a large percentage of fuel consumption is due to aerodynamic resistance. According to Kasseris (2006, as cited in Massar et al., 2021), aerodynamic drag accounted for between 50% and 75% of the tractive energy required for highway driving. Because platooning benefits cars in the middle of the pack, average fuel savings increase with platoon size. With the assumption that 50% of tractive energy is used to overcome drag resistance, vehicle platooning could achieve a 22.5% to 27.5% reduction in emissions. Zabat et al. (1995, as cited in Massar et al., 2021) investigated the emission reduction potential of vehicle platooning using wind tunnel tests and numerical simulations. They discovered that the average reduction in emissions per vehicle ranged between 10% and 30% depending on platoon size, car count, and other factors. To achieve the best fuel economy, 15 vehicles have to travel six to eight meters apart in the platoon (Massar et al., 2021).

Vehicle right-sizing: Automation technologies allow for smaller cars to be produced without compromising safety (Wadud et al., 2016, as cited in Massar et al., 2021). Vehicle reduction might result in a considerable increase in fuel economy. In general, a 20% reduction in vehicle weight increases fuel efficiency by 20% (Joost, 2012, as cited in Massar et al., 2021). The engine power and fuel consumption needed for a journey are proportionate to the vehicle's size (Massar et al., 2021). With AVs technology in place, manufacturers may significantly reduce vehicle sizes or weight, resulting in significant energy and GHG emission savings.

Congestion mitigation and efficient routing: Cars in heavy traffic use more gasoline and thus generate more GHG than cars in light traffic due to frequent stop-and-go and idling (Massar et al., 2021). CAVs innovative vehicle communication capabilities may provide early warnings of impending traffic issues and unforeseen traffic. This enables cars to choose the most efficient routes and flow smoothly across the network, reducing GHG emissions.

Carpooling: The occupancy rate is critical in calculating the GHG emissions connected with present automobile trips (Massar et al., 2021). Less passenger capacity per car means more cars on the road, tripling emissions. For example, only 11% of Americans carpool to work, while 113.6 million commute alone (Shaheen et al., 2018, as cited in Massar et al., 2021). AVs have the potential to develop as a new business model that capitalizes on the benefits of ridesharing, resulting in a modal shift away from privately owned automobiles and toward shared mobility services (Massar et al., 2021). These changes should significantly reduce transit-related GHG emissions. Encouraging carpooling and ridesharing may help reduce GHG emissions by reducing automobile ownership and travel through less convenient means of transport.

Traffic law adherence: Iglinksi and Babiak (2017, as cited in Massar et al., 2021) anticipate that AVs would conform to traffic regulations more rigidly than human drivers. AVs will be more likely to adhere to set speed restrictions optimized for fuel economy, thereby lowering GHG emissions (Massar et al., 2021). Similarly, AVs will rigorously adhere to traffic signals, alleviating the inconvenience and congestion caused by human traffic.

2.5.3.1.2 Causes of increased GHG emissions

Causes as to why AVs or robotaxis will increase GHG emissions will be described further.

Easier travel: Travel demand is expected to increase as travel becomes more reliable, quicker, and less congested (Massar et al., 2021). Moreover, easier travel means more people will use

AVs, especially during traffic congestion. Increased demand and road capacity expansion will eventually result in increased GHG emissions.

Faster travel: With cutting-edge communication technology, CAVs can navigate and react faster than human drivers, allowing them to travel more safely at higher speeds (Massar et al., 2021). AVs may increase travel speeds, making travel more convenient and faster for passengers (F. Liu et al., 2019). Nevertheless, faster speeds mean more aerodynamic losses and thus more fuel consumption. The speed-fuel consumption relationship for a typical car predicted a 20% to 40% increase in highway GHG emissions (Berry, 2007, as cited in Massar et al., 2021). According to Liu et al. (2019), there will be a 0% to 3% rise in fuel consumption for partly autonomous vehicles and a 3% to 10% increase for completely autonomous vehicles. While Brown et al. anticipate a 40% or more increase in highway fuel consumption (2014, as cited in Massar et al., 2021). According to them, if individuals could travel more quickly, they would want to reside further away from their everyday destinations, hence promoting urban sprawl. Ultimately, this might result in a 50% rise in emissions.

Increased travel by underserved populations: While providing AV mobility assistance to the disabled and elderly appears to benefit society; it is likely to increase VMT (Massar et al., 2021). Due to a lack of reliable data on why some demographic groups travel less than others, forecasting future travel habits for people who are now underserved is challenging. According to MacKenzie et al. analysis of 2014 National Household Travel Survey data, VMT for persons over the age of 62 is significantly lower than those at the age of 42 (2014, as cited in Massar et al., 2021). They calculated that increased travel might result in a 2% to 10% rise in emissions. Non-drivers may operate AVs, those without driver's licenses, and individuals with special requirements will expand the road user population and hence daily vehicle journeys (Massar et al., 2021). While this may have several good implications, it projects GHG emissions to grow.

Mode shift: AVs may increase ridership by resolving first-mile or last-mile issues, thereby increasing GHG emissions. This would result in a shift of 56.5 billion miles (National Transit Database, 2013, as cited in Massar et al., 2021) and in a 2% rise in emissions. If city travel is believed to account for all emissions, it accounts for a 3.7% rise in city emissions (Massar et al., 2021). Considering that an estimated 79.8 billion passenger miles were traveled on domestic flights under 500 miles, it is a plausible scenario that all these passengers will shift to using (non-shared) AVs and thus result in a 2.9% increase in emissions exclusively on highways. With AVs operating at a cheaper cost per mile than other modes of transport, many people will be compelled to use them, resulting in increased GHG emissions.

Increased empty miles traveled: AVs enable car owners to send their AVs to the desired location in advance to decrease wait time and, in doing so, earn empty VMT (Massar et al., 2021). While empty, such vehicle idling may become the primary cause of increased VMT and associated emissions. Fagnant and Kockelman (2014, as cited in Massar et al., 2021) estimate a 5% to 11% rise in emissions due to vehicle repositioning.

Land use change: Many people are expected to move to locations that result in longer trips and simultaneously increased GHG emissions (Massar et al., 2021)

2.5.3.2 Water

Land-use changes play a significant role in the deterioration of water quality (Silva et al., 2022). Urbanization has a significant impact on hydrogeological systems for several reasons, such as increasing the severity and frequency of flooding, decreasing aquifer recharge, eliminating small surface water channels, altering the permeability of remaining natural terrain, and increasing the load of pollutants. At the same time, the demand for water and its services will increase as well.

2.5.3.3 Light pollution

Artificial light has been shown to negatively affect ecosystems (Gaston et al., 2015, as cited in Silva et al., 2022). Although street and road lighting are not just for driving purposes, Stone et al. (2019, as cited in Silva et al., 2022) think that AVs might be built to operate safely in low-light circumstances, reducing the need for additional lighting.

2.5.3.4 Noise pollution

Noise and air pollution are the two main risk factors for health in urban environments, accounting for more than 75% of illnesses caused by environmental factors (Hänninen et al., 2014, as cited in Silva et al., 2022), with road traffic being one of the primary sources of noise. Patella et al. (2019, as cited in Silva et al., 2022) estimate that if road traffic consisted of 100% AVs, inner-urban roadways would benefit from a 24% reduction in noise pollution due to a 5% reduction drop in traffic volume.

2.6 Theoretical framework

Given the complex and rapid advancement of technology, the rate at which customers embrace technologies relies on various factors. Several theories have been developed to explain individuals' intentions to accept or use new technology. This research will focus on two theories, the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT).

2.6.1 Technology Acceptance Model

The technology acceptance model is the most often used theory for determining a user's degree of acceptance and usage of a technology (Alotaibi & Wald, 2013; Lee et al., 2003). The

TAM was derived from the theory of reasoned action (TAR) and is based on two variables that are used to assess a user's desire to utilize a particular information system or technology: perceived ease of use (PEU) and perceived usefulness (PU). As the model had many limitations, Venkatesh and Davis developed the technology acceptance model 2 (TAM2). The new model proposes a variety of new variables which should provide more effective reasoning regarding any system or technology preference. The newly proposed variables are *the subjective norm, voluntariness, image, experience, job relevance, output quality, and result demonstrability*.

2.6.2 The Unified Theory of Acceptance and Use of Technology

The unified theory of acceptance and use of technology was developed by Venkatesh, Morris, Davis, and Davis in 2003 after reviewing eight models of IT acceptance, including the TAR, TAM, and Diffusion of Innovation (DOI) theory (Alotaibi & Wald, 2013; Nordhoff et al., 2021). The UTAUT claims that *performance expectancy*, *effort expectancy*, *social influence* (SI) (i.e., the extent to which a person believes others think he or she should utilize the new technology), and *facilitating conditions* influence the intention to use technology.

2.7 Conceptual framework

A conceptual framework has been developed to illustrate what is expected to be found out and how this is to be done. It greatly relies on the two theories mentioned and previous literature on the possible impacts of AVs or robotaxis. The research focuses on four constructs: PU, PEU, SI, and behavioral intention (BI), and tests their relationship. However, the two theories used do not address the fears or concerns the user might have regarding the technology, which decisively affects the behavioral intention (Mou et al., 2017; Gupta et al., 2016, as cited in Panagiotopoulos & Dimitrakopoulos, 2018). Thus, the construct of perceived trust (PT), which reflects how people trust a particular technological system, was added. Figure 17 shows each statement and the fitting construct, while Figure 18 shows the conceptual framework.

Robotaxis will result in ...					
Societal	**Construct**	**Economic**	**Construct**	**Environmental**	**Constrcuct**
Fewer accidents	PU	Disruption of labor markets	PU	Improved fuel efficiency	PU
Increased public safety and health	PU	Creation of new jobs	PU	Decreased GHG emissions	PU
Improved travel satisfaction	PU	Destruction of existing jobs	PU	Increased GHG emissions	PU
Improved access to mobility	PU	Increased affordability of taxi services	PU	Decreased quality of stream water	PU
Increased recreational travel	PU	Reduced demand for personal vehicles	PU	Decreased light pollution	PU
Reduced transport-related physical activity	PU	Reduced income from taxes	PU	Decreased noise pollution	PU
Reduced travel time	PU				
Increased value of travel time	PU				
Increased move to the city center from suburbs	PU				
Increased move to the suburbs from city centers	PU				
Reduced traffic congestion	PU				
Decreasing demand for parking spaces	PU				
Repurposing of parking spaces and road space	PU				

Acceptance Theories	**Construct**
Robotaxis will make me feel safer than normal vehicles	PU
It will be easy for me to learn to operate Robotaxis	PEU
I will be proud if people see me using a Robotaxi	SI
Robotaxis will increase my social status	SI
Using robotaxis will create cyber security and data privacy issues	PT
If robotaxis are cheaper I will prefer them over public transport	PU
I will be willing to share my robotaxi with others	PT
I find Robotaxis somewhat frightening	PT
Assuming Robotaxis come into use, I intend to use them	BI

FIGURE 17 – CONSTRUCTS

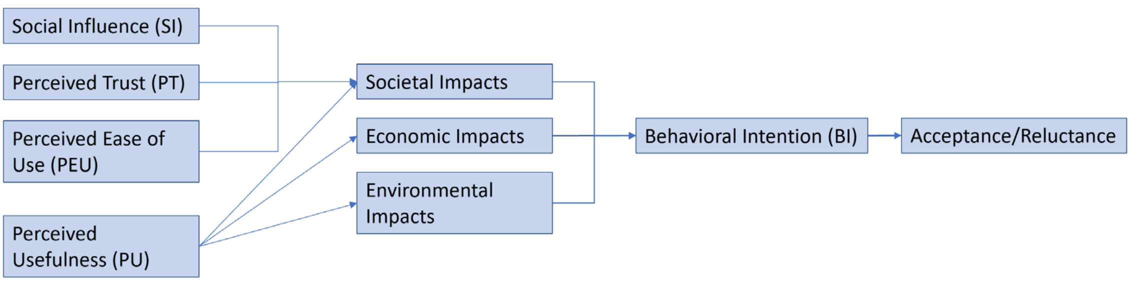

FIGURE 18 - CONCEPTUAL FRAMEWORK

3 HYPOTHESIS DEVELOPMENT

Quantitative hypotheses are statements made by the researcher on the outcomes of relationships between variables. A collection of statistical processes is used to test hypotheses, drawing conclusions about the population from a sample. A null hypothesis and an alternative hypothesis are two types of hypotheses. A null hypothesis states that the variables have no relationship or are not significantly different. The alternative hypothesis, on the other hand, anticipates a link between the phenomena or variables based on previous literature or study. The alternative hypothesis might be directional (one-sided) or non-directional (two-sided). This study investigates six hypotheses pertaining to the impact of robotaxis in Zagreb.

According to Forrest & Konca (2007) AVs are expected to reduce a persons commute time significantly and provide them with the opportunity to complete other productive or enjoyable activities during or after the trip (Berg and Verhoef, 2016, as cited in Duarte & Ratti, 2018). While both residents living close to the city center and far from it are projected to experience this impact, the people living far from the city center will most likely benefit from it more as they usually spend more time driving, especially in Zagreb where most of the company's offices and activities are in the city center. Thus, the researcher predicts that the residents living close to the city center will perceive the impact of increased value of travel time more negatively, as they do not have to travel far distances to and from work or activities. While the residents living far away from the city center will perceive the impact of increased value of travel time more positively, as they see it as an immediate benefit from the introduction of robotaxis.

Hypothesis one: There is a difference in the perception of travel time value between the residents living close to the city center and those living far from the city center.

According to Hohenberger et al. (2016), men and women differ in their willingness to use Avs, with women being less likely to use AVs than men. Thus, the researcher believes that there will be a difference between men and women and their intention to use robotaxis, with women being less likely to use robotaxis than men are.

Hypothesis two: There is a difference in the behavioral intention to use robotaxis between Zagreb's female and male residents.

Robotaxis are expected to result in the disruption of labor markets. Many individuals are predicted to lose their jobs, especially ones with lower-skilled professions (Marshall, 2017), employed in the transportation sector, or working jobs related to transportation. Thus, the researcher expects the residents working in the transportation sector and depending economically on it to perceive the impact of the disruption of labor markets differently from the residents not working in the transportation sector. The latter group is expected not to be as sure that robotaxis could disrupt labor markets.

Hypothesis three: There is a difference in the perception of the disruption of labor markets between the residents working in the transportation sector and those not working in it.

Thomas et al. (2020) showed that different age groups would have a different perception of AVs, including one impact, to be precise, the reduction of car crashes. Deka et al. (2021) also showed various perceptions of different age groups on the safety of AVs. Thus, the researcher believes that different age groups will have different perceptions of safety impacts. The elderly population (60+) is expected to be less likely to perceive robotaxis to reduce accidents and increase public health and safety, as a good part of that population is usually afraid of using new technologies (Raymundo & Santana, 2014).

Hypothesis four: There is a difference in the perception of the safety impacts of robotaxis depending on the age group.

A significant portion of the population cannot commute or drive themselves to routine activities, either at all or with relative ease. As pointed out by Bennett et al. and Pettigrew et al. (2019; 2018, as cited in Singleton et al., 2020), this is especially true for children, the elderly, and those with unique physical and intellectual disabilities. It is anticipated that autonomous vehicles would improve access for these individuals by removing the need for personal drivers and other expensive transit services. Thus, these two age groups are expected to mainly show an extensive agreement with the statement "Robotaxis will result in an improved access to mobility."

Hypothesis five: There is a difference in the perception of the impact of robotaxis on the access to mobility depending on the age group.

Robotaxis have recently emerged as a new phenomenon and are largely still in the research and development and testing phase (*The Self-Driving Car Companies Going The Distance*, 2021). The Croatian government has only recently added the definition of AVs in their legislature (*10. saziv Hrvatskoga sabora*, n.d.). With the technology and topic being very new, several people do not yet have extensive knowledge of the topic or are aware of all the possible impacts and consequences. Trust in the manufacturers, software developers, and others engaged in the technology's creation often influences acceptance (Ward et al., 2017). The greater a person's understanding of technology, the more correctly they may be able to assess it. Except for early adopters and technological aficionados, most individuals have little access to up-to-date information about AVs. The media focuses more on dangers than advantages, for instance, reporting on accidents and legal or ethical concerns. People are far less likely to accept a new technology if they see it as very dangerous, do not know much about it, and do not trust the organization that produces it. Ward et al. also confirmed that knowledge is related to the acceptance of automated driving in their study. Thus, the researcher believes there will be a difference between the different knowledge groups and their behavioral intention to use robotaxis.

Hypothesis six: There is a difference in the behavioral intention to use robotaxis depending on the residents' level of knowledge.

According to Liu et al. (2020), the PU, PEU, and SI have a significant positive effect on an individual's BI to use robotaxis. Zhu et al. (2020) also show a positive relationship between the PU and the BI to use AVs. Panagiotopoulos & Dimitrakopoulos (2018) show that the PU, PEU, SI, and PT have a positive effect on the BI to use AVs. Thus, the researcher believes that all the mentioned constructs will positively impact the BI of the residents of Zagreb to use robotaxis.

Hypothesis seven: Perceived usefulness, perceived ease of use, social influence, and perceived trust have a positive effect on the behavioral intention to use robotaxis.

4 METHODOLOGY

The methodology section is organized into four parts: research design and methods, data collection, questionnaire development, and research ethics. The methodology will describe the research design employed, how the data was acquired, why this form of data collection was chosen, and what ethical steps were taken.

4.1 Research design and methods used

For the research to be successful, it was essential to choose the right research design and approach. According to Creswell (2014), three different approaches can be used to research: a qualitative, quantitative, and mixed-methods approach. The qualitative approach focuses on the individual meaning, which people attach to things. Quantitative research applies its focus on the opposite. It tests the relationships among measurable variables, using survey instruments that produce numbered data and uses statistical analysis of data generated. The mixed-methods approach combines both quantitative and qualitative methods of collecting data.

The hypotheses developed in chapter 3 will need a sufficient amount of data collected on the perception of the residents of Zagreb to create a sample large enough to be able to retain or reject them. This research implemented a non-experimental fixed or quantitative strategy, which is best used to evaluate a theory or explanation, find the influencing variables of an outcome, or determine which variables best predict the outcomes (Creswell, 2014). The data was collected by a questionnaire survey, which provides a quantitative or numerical depiction of trends, attitudes, or opinions in a population by examining a population sample (Fowler, 2008, as cited in Creswell, 2014). The sample results are then generalized to the entire population (Creswell, 2014). The type of research used for the survey was explanatory research to investigate the causality between the variables or constructs specified in the hypotheses (Creswell, 2014; Veal, 2018). Throughout the research, the researcher used the postpositivist worldview to guide him. Postpositivists usually have a deterministic research ethic in which causes most likely dictate effects or outcomes (Creswell, 2014). As a result, the challenges explored by postpositivists reflect the necessity to identify and assess the causes that influence results.

4.2 Data collection

The data for this research was collected using primary sources. The survey instrument used to collect the data was an online questionnaire. The survey was conducted online for various reasons. The first one was that it was the easiest and quickest way of reaching a substantial amount of people to create a sample large enough to represent the population of Zagreb while being the cheaper option when conducting research. The second reason was that the researcher wanted to provide the participants with enough comfort for them to answer the questions honestly as well as to participate in the research by assuring them anonymity and eliminating the danger of contracting COVID-19 or any other diseases detrimental to their health, which is especially important for the elderly population. The third reason for conducting the survey online was that the product used provides the benefit of creating a custom survey design and viewing the results in real-time, and downloading them as descriptive statistics or graphed information ready for immediate analysis.

The data was solely collected using an online survey tool platform, which in this case was Google Forms. The survey was distributed via email, SMS, and various social media platforms. The survey was available from the 1st of May 2022 until the 10th of May 2022. During these ten days, the questionnaire could be accessed using the link provided.

In total, 158 responses were collected. No answers were excluded from the sample, as all participants provided the necessary data. The questionnaire survey can be found in Appendix 2 in English.

The secondary data, mainly used for the literature review, was obtained from Google Scholar, ScienceDirect, and other online databases or web pages. Additionally, the researcher used data provided by several governmental or national institutions and statistical organizations, such as the Croatian Institute for Public Health.

4.3 Development of the questionnaire

The questionnaire survey should have concluded how the residents of Zagreb perceive the possible impacts of robotaxis and if they are acceptive or reluctant of robotaxis roaming the streets of Zagreb. The questions in the survey were developed using secondary sources, which focused on the effects of robotaxis or AVs on the society, economy, and environment; acceptance theories, and already existing surveys on the perception of AVs or robotaxis by residents or their acceptance. To get a greater response rate and the majority of the participants speaking Croatian, the survey was made available in English and Croatian. However, only the Croatian version was analyzed, as all the answers from the English version could also be found in the Croatian version.

The questionnaire contains various closed questions because they are simpler to code, quicker to process, and may encourage participants to respond (Dawson, 2009). Those who wished to provide a longer response could do so in an additional concluding section of the questionnaire.

The first section of the questionnaire, which is also the most important one, introduced the participants to statements on the possible impacts of robotaxis. It was placed initially as the participants were more focused and not in a hurry to finish the survey. Using a five-point Likert scale (1= strongly disagree; 2= disagree; 3= neutral; 4= agree; 5= strongly agree), the survey participants could indicate to what level they agree or disagree with the statement made. This section was further divided into three smaller subsections: the societal, economic, and environmental impacts. The statements made in this section build on chapter 2.5, which can be found in the literature review.

The second section of the survey includes questions on the participant's attitude toward robotaxis. While these questions also provide data on the perception of impacts, they focus on different constructs from the previously mentioned acceptance theories. These questions will give an idea of how the residents feel towards robotaxis, including their concerns and if they intend to use robotaxis or not. This section explicitly addresses hypothesis six. The answers of this section can be of great use to determine any personal concerns that residents might have and which could be addressed by government officials or robotaxi manufacturers. The questions in this section build on the survey of M. Liu et al. (2020), Panagiotopoulos & Dimitrakopoulos (2018), and Zhu et al. (2020).

The third section focuses on collecting socio-demographic data, especially important to the first six hypotheses. The socio-demographic characteristics asked for included age, gender; distance from the city center; the highest level of education completed; working status; main mode of transportation, and many more. These will allow for other analyses in this research or any future research apart from the one necessary to address the hypotheses.

The fourth and last section provided the option to add any impacts that the participant might additionally expect to occur or any additional comments regarding this topic or the questionnaire itself.

The questionnaires in both languages can be found in Appendix 1 and 2.

4.4 Population and study sample

Sampling is a research strategy in which a researcher chooses a subset of a population to represent the entire population (Fowler, 2014). The researcher determines and measures the sample size. A sample can be chosen in a variety of ways. The distinction between probability or random sampling and non-probability sampling must be made first. Each individual, household, or other factor had the same chance of being selected via probability sampling. When a sample frame is not required, the non-probability sampling approach is utilized. Simple random sampling, stratified random sampling, systematic sampling, and multi-stage cluster sampling are all types of probability sampling. Non-probability sampling can be split into opportunistic, judgment, theoretical purpose, and snowball sampling.

The sampling methods selected for this research are snowball sampling, opportunistic sampling, and theoretical purpose sampling techniques. Snowball samples are obtained by creating a convenience sample and then asking these subjects to provide referrals to recruit new participants for the study. The first subjects act as so-called "seeds," via which new subjects are recruited. These are referred to as wave one participants by Etikan et al. (2016) and attract wave two subjects. The sample is supposed to grow like a snowball rolling down a hill continuously. The advantage of this technique is that the researcher does not have to explain to each participant how the survey works and what must be done or provide them with more information on the topic (Etikan et al., 2016). Thus, trust is established faster. Moreover, it is easier and quicker to find participants, as the initial sample will, in most cases, look for people with similar traits or, in this case, focus on the person just being from Zagreb. People who do not want to come forward and give their opinion might do so as they were asked by the person they already know well. Opportunistic sampling was used to select the most likely participants to answer the questionnaire (Fowler, 2014). At the same time, theoretical purpose sampling was used for various theoretical purposes, such as finding people who work in the transportation sector or have a disability that makes it harder for them to drive or does not allow them to drive. The first "wave" of participants selected for the study were close friends and family from Zagreb, which were then personally asked by the researcher to further spread the survey to their friends and acquaintances. In doing so, the bias of having many residents, not from Zagreb was reduced.

The population sample for this study consisted of individuals living in Zagreb, Croatia. When referring to Zagreb, we look at the population at a county level. This is also depicted in Figure 8, where the population of Zagreb considered for this research has been outlined. According to the census, Zagreb had 769.944 people in 2021 (*Popis'21*, n.d.). However, these were only the first estimates. The number might be larger since many people are registered in other cities but live in Zagreb.

However, because the survey was open to the public, it was not guaranteed that only the intended population would participate. To minimize bias, the researcher attempted to have as many people as possible complete the survey (Veal, 2018), personally invited residents of Zagreb to complete the survey, and explicitly asked people the first wave of participants only to forward it to other residents of Zagreb. The researcher made every effort to diversify the participants as much as possible, such as keeping a wide variety of ages to achieve age diversity or inviting residents with a disability to participate. However, the youngest participants were at least fifteen years old, as any younger participants would not have been able to provide an adequate viewpoint on this topic. Thus, the sampling frame excluded participants under fifteen and those who did not want to participate or could not be reached. As the sample must represent a city of almost one million residents, it was essential to collect a fair number of participants to represent the actual perceptions of these residents. While the research would benefit from more participants, the sample of 158 residents will suffice for this research.

4.5 Data analysis

The collected data has been transformed into useful information by employing various statistical methods and using several software and programs, including PSPP, Miro, Microsoft Excel, and Microsoft PowerPoint. In doing so, the researcher gained a better understanding of the data collected and was able to analyze and describe it due to a better understanding of the residents' responses and perceptions. Balnaves & Caputi (2001) assert that displaying data graphically is one of the essential tools for identifying and comprehending the patterns of the collected data and the various relationships between the variables. The graphs and charts make the written information easier to comprehend and remember (Balnaves & Caputi, 2001). Thus, several graphs and charts which visualize the data have been developed.

Before discussing any of the findings of the collected data, descriptive analyses are performed of the responses collected using the online survey. The descriptive analysis includes the description of the distribution of socio-demographic or personal information such as gender, age, and working status, among others. The process is then continued with an inferential statistical analysis, which involves more complicated testing and focuses on differences and relationships between specific variables. All of these studies are conducted to accept or reject the mentioned hypotheses. The following section examines the various socio-demographic groups in detail and compares their responses using the mean scores showing their agreement with a given statement or question. The conclusion of the quantitative analyses is the discussion of findings, in which the results are compared to prior research or surveys and evaluated accordingly. While the results are interpreted, the initial research questions and hypotheses are kept in mind.

4.6 Research ethics

No matter the type of research being conducted, research ethics are at the core of any research. The researcher must adhere to ethical standards when conducting research, especially when working with people (Fowler, 2014). The author took numerous ethical precautions and followed numerous ethical guidelines to ensure that none of the participants suffered negative consequences. The research was based on various moral principles, such as candor, prudence, confidentiality, etc.

Participation in the research was completely voluntary. To protect the anonymity of the participants, the author did not request their names or any other identifying information. In addition, the author provided participants with the option to withdraw from the research at any time and informed them of all the rules before they began the survey. In addition, the questions were selected with care, and sensitive ones were left as optional and were marked as so. A five-point Likert scale was provided to participants to allow them to indicate if they agreed or disagreed. The collected information was kept confidential and not shared with any third parties. Before participating in the survey, participants were informed that the data would be used exclusively for research purposes.

As for the collected secondary data, any data used was appropriately cited to prevent plagiarism and was not altered with in a way that would not keep the information in this study similar to that in the initial research article.

5 RESULTS AND DISCUSSION

This chapter will discuss the results and analyze the data collected from the online survey. Firstly, a general overview of the responses will be provided to understand better the data collected. This includes a sample profile and looking at how the participants answered the questions regarding the impacts. Secondly, the hypothesis mentioned in chapter will be analyzed. Lastly, further analysis will look at how different demographic groups answered different questions.

5.1 Sample profile

During the data collection process, 158 individuals, who are residents of Zagreb, participated in the survey. This section will look at the socio-demographic data of these participants or the sample at hand.

5.1.1 Gender

The survey participants were provided with three options when indicating their gender. The choices were “female” and “male”, and “I do not want to disclose”. None of the participants indicated that they did not want to disclose their gender. Thus, there are only two groups. Out of the 158 participants, 82 or 51.9% indicated female, and 76 or 48.1% indicated they were male. Figure 19 visualizes this distribution, which is relatively equal.

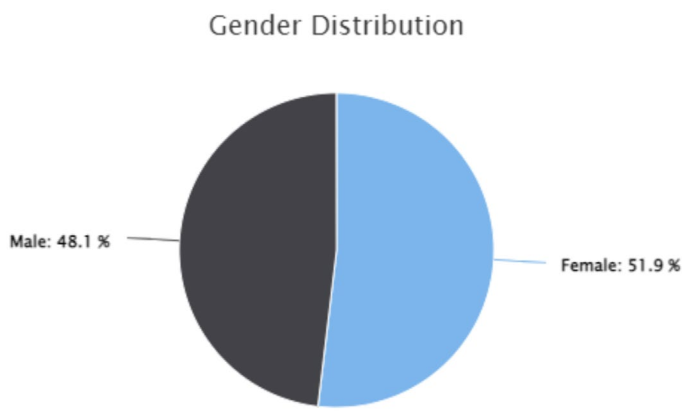

FIGURE 19 - GENDER DISTRIBUTION

5.1.2 Age

The 158 participants are divided into four age groups. The smallest age group includes three participants aged 15 to 18 years. The largest age group includes 89 participants aged 19 to 39 years, followed by the age group from 40 to 59 years, with 52 respondents. The age group, including participants above or 60, has 14 participants. Figure 20 shows a visualization of the groups in a pie chart. The average age among the participants is 37.1 years.

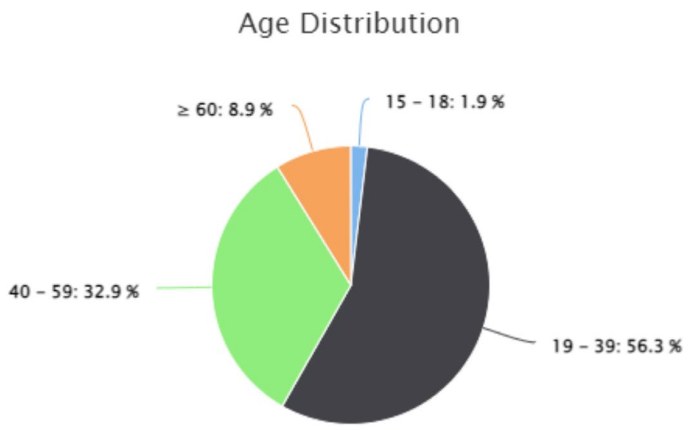

FIGURE 20 - AGE DISTRIBUTION

5.1.3 Highest degree obtained

Participants were given a choice between six options. The options include "no degree," "high school degree," "bachelor's degree," "master's degree," "doctorate degree," and "other degree". The largest group consisted of participants whose highest degree obtained was a high school degree with 51 respondents or 32.3%, followed closely by those whose highest degree obtained was a master's degree with 47 respondents or 29.7%. Forty-two respondents, or 26.6%, indicated that their highest degree obtained was a bachelor's degree. At the same time, seven respondents, or 4.4%, indicated that they had obtained a doctorate degree. Seven respondents also indicated that they have some other degree than the ones provided, while four indicated that they have no degree. Figure 21 shows a visualization of the groups in a pie chart.

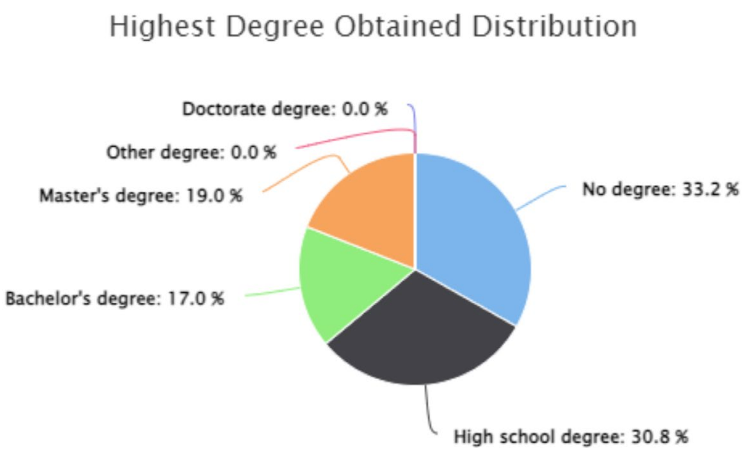

FIGURE 21 - HIGHEST DEGREE OBATINED DISTRIBUTION

5.1.4 Working status

Participants could choose between four options: "student," "unemployed," "employed," or "retired". The largest group consisted of respondents who indicated that they are employed (N= 100; 63.3%), followed by the group consisting of respondents who indicated that they are a student (N= 41; 25.9%). Eleven respondents (7%) indicated that they do not work, while six (3.8%) indicated that they are unemployed. Figure 22 shows a visualization of the groups in a pie chart.

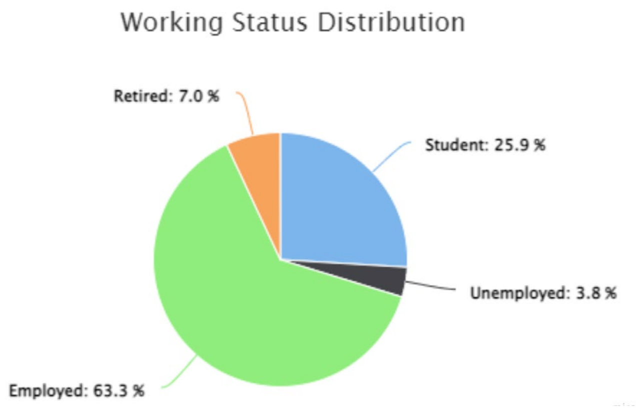

FIGURE 22 - WORKING STATUS DISTRIBUTION

5.1.5 Working in transportation sector

Out of the 158 participants, 146 or 92.4% indicated that they do not work in the transportation sector, while 12 or 7.6% indicated that they work in the transportation sector.

5.1.6 Distance from city center

Of the 158 participants, 81 or 51.3% live far from the city center (more than five kilometers), assuming that the Ban Jelačić square is the center, and 77 or 48.7% live close.

5.1.7 Main mode of transportation

The participants were provided with a choice between five main modes of transportation. The choices provided were: "public transportation," "personal motor vehicle," "taxi or ridesharing services," "human-powered or motor-powered assisted vehicle," and "by foot". Participants using a personal motor vehicle as their main mode of transportation made up the largest group in the sample, with 105 respondents or 66.5%. Public transportation is used by 32 or 20.3% of the participants as their main mode of transportation. Taxi or ridesharing services are the main mode of transportation of 11 participants, or 7%, while four respondents, or 2.5%, use a human-powered or motor-powered assisted vehicle. Six participants, or 3.8%, indicated that they completed most of their trips on foot. Figure 23 shows a visualization of the groups in a pie chart.

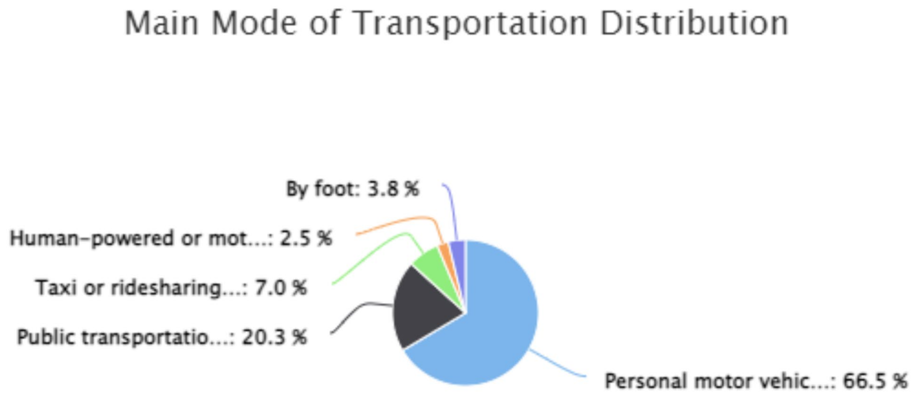

FIGURE 23 - MAIN MODE OF TRANSPORTATION DISTRIBUTION

5.1.8 Knowledge level about AVs

The participants were provided with a five-point Likert scale (1= not knowledgeable at all; 2= slightly knowledgeable; 3= somewhat knowledgeable; 4= moderately knowledgeable; 5= very knowledgeable) where they could indicate their level of knowledge they have on AVs. Most respondents, in this case, 54 or 34.2%, indicated that they are somewhat knowledgeable on AVs, followed by 36 respondents or 22.8% indicating that they are moderately knowledgeable. Twenty-eight respondents, or 17.7%, indicated slightly knowledgeable, and 24 respondents indicated that they are not knowledgeable at all about AVs. The lowest group consisted of very knowledgeable individuals about AVs, with 16 respondents or 10.1%. Figure 24 shows the distribution of the responses in a chart format. The average knowledge level among the participants is 2,95.

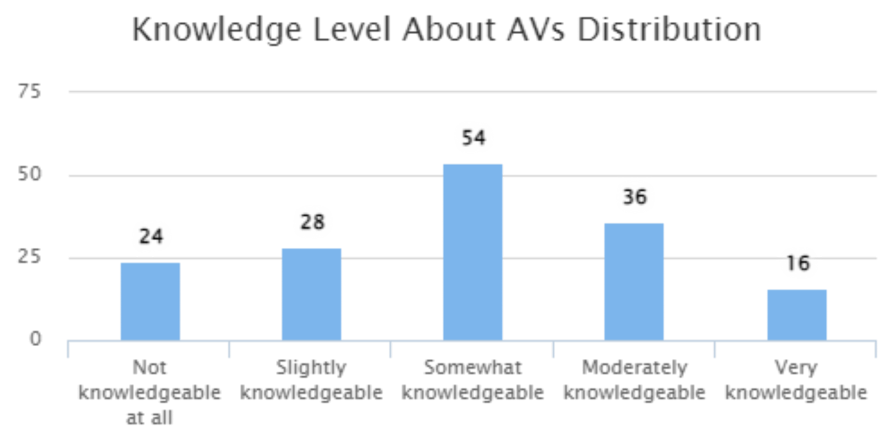

FIGURE 24 - KNOWLEDGE LEVEL ABOUT AVS DISTRIBUTION

5.1.9 Disability

Out of 158 participants, 153 or 96.8% indicated that they have no disability that prevents them or makes it difficult to drive, while five or 3.2% did.

5.1.10 Posses a vehicle with autonomous features

Out of the 158 participants, 86 or 54.4% indicated that they possess a vehicle with autonomous features, 45 or 28.5% indicated that they do not possess a vehicle with autonomous features, and 27 or 17.1% indicated that they do not own a vehicle. Figure 25 shows the distribution of the groups visually.

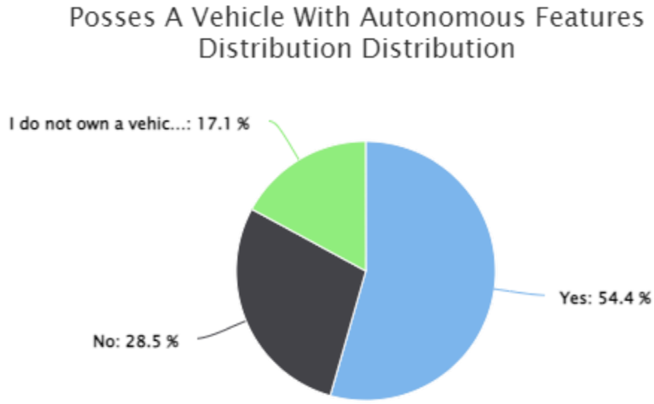

FIGURE 25 - POSSES A VEHICLE WITH AUTONOMOUS FEATURES DISTRIBUTION

5.1.11 Croatian citizen and lived abroad

Out of the 158 participants, 148 are Croatian citizens, and ten are of a different nationality, including Austrian, Bosnian, Filipino, German, and Serbian. Figure 26 shows the distribution of the different nationalities from this sample. Ninety-six of the participants, or 60.8%, have lived abroad, while 62, or 39.2%, have not lived abroad. Out of the 96 participants who have lived abroad, nine are not Croatian citizens.

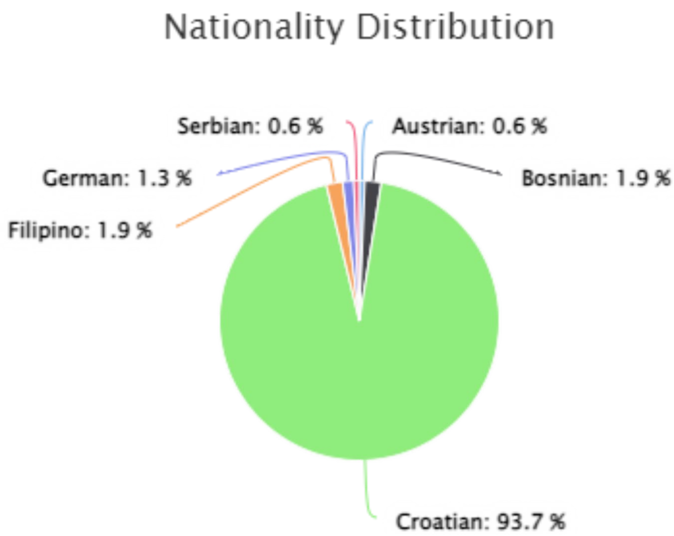

FIGURE 26 - NATIONALITY DISTRIBUTION

5.1.12 Introvert and extrovert

Out of all participants, 95 participants or 60.1% have indicated that they consider themselves an extrovert, while 63 participants or 39.9% have indicated that they consider themselves an introvert.

5.1.13 Past motor vehicle accident

This question was left as optional to be answered, as it might be sensitive to some participants. Thus, only 152 people indicated if they had or had not had a motor vehicle accident in the past. Out of the 152 people, 59.9% did not have a motor vehicle accident in the past, and 40.1% did have one. Figure 27 shows a pie chart displaying the distribution of the answers.

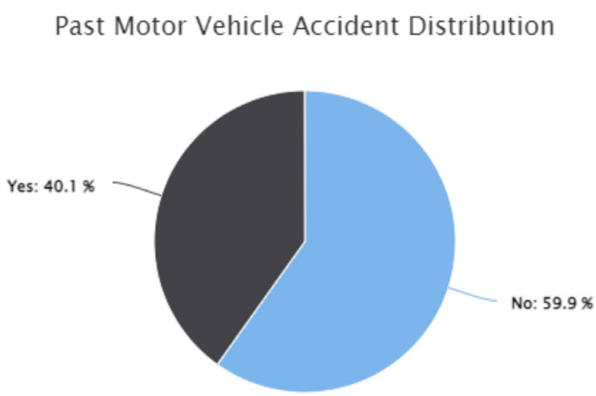

FIGURE 27 - PAST MOTOR VEHICLE ACCIDENT DISTRIBUTION

5.1.14 Monthly household income

Like the previous question, this question was also left optional to be answered, as it might be sensitive to some participants. Thus, only 128 participants indicated their monthly household income. Of the 128 participants, 60 respondents, or 46.9%, have a monthly household income of 1.001 to 3.000 Euros. Twenty-nine respondents, or 22.7%, indicated that they have an income of 0 to 1.000 Euros. The third-largest group is the respondents with a monthly household income of 3.001 to 5.000 Euros with 18 respondents or 14.1%, followed by the group with a monthly household income of 5.001 to 10.000 Euros with 11 respondents or 8.6%. The smallest group consisted of individuals with a monthly household income of 10.001 Euros or more, with ten respondents or 7.8%. Figure 28 shows the distribution of the groups visually.

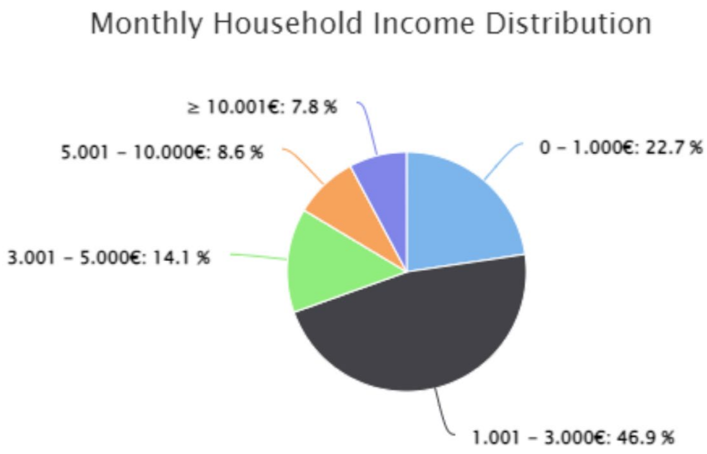

FIGURE 28 - MONTHLY HOUSEHOLD INCOME DISTRIBUTION

5.1.15 Monthly alcohol consumption when going out

This question was optional to be answered, as it might be sensitive to some participants. Thus, only 123 participants indicated their monthly alcohol consumption when going out. Out of the 123 respondents, 31 individuals, or 25.2%, indicated that they do not go out and consume alcohol. Seventy-seven respondents, or 62.6%, indicated that they go out and consume alcohol one to four times a month. With 77 individuals, this is also the largest group. The smallest group consisted of 15 individuals who indicated that they go out and consume alcohol five times or more. On average, the respondents go out and consume alcohol 2.10 times a month.

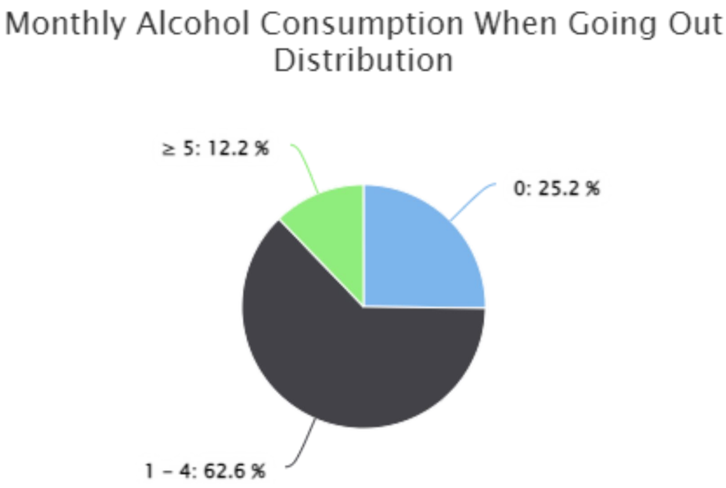

FIGURE 29 - MONTHLY ALCOHOL CONSUMPTION WHEN GOING OUT DISTRIBUTION

5.2 Perception of the residents on the impacts

This section will focus on displaying how the residents of Zagreb perceive the possible impacts of robotaxis on society, economy, and environment. Table 1 displays the possible impacts in the form of a statement on the left side and the mean score of the residents' agreement with that statement on the right side. The statement "Robotaxis will result in decreased demand for parking spaces" shows the highest agreement with a mean score of 4.11, followed closely by the statement "Robotaxis will result in improved access to mobility," which received a mean score of 4.09. The statements "Robotaxis will result in increased GHG emissions," "Robotaxis will result in decreased quality of stream water," "Robotaxis will result in an increased move to city centers from suburbs," and "Robotaxis will result in the creation of new jobs" indicate mean scores lower than three, meaning that the respondents least agree with these statements or possible impacts. The other impacts or statements showed mean scores higher than three but lower than four, with most of them being closer to a mean score of four rather than three. This indicates a significant agreement with most of the statements made. The statements which received a mean score closer to three are: "Robotaxis will result in an increased move to suburbs from the city centers," "Robotaxis will result in a reduced income from taxes," and "Robotaxis will result in decreased light pollution." This means that the participants or residents, in this case have a more neutral standpoint towards these questions or are unsure how to answer them.

Impacts	Mean Score
Societal	
Robotaxis will result in fewer accidents	3,68
Robotaxis will result in increased public safety and health	3,68
Robotaxis will result in improved travel satisfaction	3,78
Robotaxis will result in improved access to mobility	4,09
Robotaxis will result in increased recreational travel	3,58
Robotaxis will result in reduced transport-related physical activity	3,75
Robotaxis will result in reduced travel time	3,68
Robotaxis will result in an increased value of travel time	3,77
Robotaxis will result in an increased move to city centers from suburbs	2,78
Robotaxis will result in an increased move to suburbs from city centers	3,14
Robotaxis will result in reduced traffic congestion	3,58
Robotaxis will result in decreased demand for parking spaces	4,11
Robotaxis will result in repurposing of parking spaces and road space	3,73
Economic	
Robotaxis will result in the disruption of labor markets	3,54
Robotaxis will result in the creation of new jobs	2,90
Robotaxis will result in the destruction of existing jobs	3,66
Robotaxis will result in an increased affordability of taxi services	3,86
Robotaxis will result in a reduced demand for personal vehicles	3,53
Robotaxis will result in a reduced income from taxes	3,08
Environmental	
Robotaxis will result in improved fuel efficiency	3,68
Robotaxis will result in decreased greenhouse gas emissions	3,67
Robotaxis will result in increased greenhouse gas emissions	2,57
Robotaxis will result in decreased quality of stream water	2,71
Robotaxis will result in decreased light pollution	3,07
Robotaxis will result in decreased noise pollution	3,68

TABLE 1 - MEAN SCORES OF IMPACT STATEMENTS

Table 2 shows the personal attitudes of the residents of Zagreb towards robotaxis. While they fall under the societal impacts, they are separated in this Table, as these questions build on the acceptance theories. The statement "If robotaxis are cheaper, I will prefer them over public transport" received the highest agreement with a mean score of 4.32 in this Table. While the statement "Robotaxis will increase my social status" received the lowest agreement with a mean score of 2.43. The statements "I find robotaxis somewhat frightening" and "I will be proud if people see me using robotaxis" indicated mean scores lower than three. This means that most residents of Zagreb do not find robotaxis frightening and are not socially influenced to use robotaxis. The other statements received mean scores higher than three and lower than four, with the majority leaning towards a mean score of four besides the statements "Robotaxis will make me feel safer than normal vehicles" and "Using robotaxis will create cyber security and data privacy issues" which received mean scores closer to three and thus show that the residents have a neutral standpoint.

Acceptance theories	
Robotaxis will make me feel safer than normal vehicles	3,09
It will be easy for me to learn to operate robotaxis	3,82
I will be proud if people see me using a robotaxi	2,94
Robotaxis will increase my social status	2,43
Using robotaxis will create cyber security and data privacy issues	3,07
If robotaxis are cheaper I will prefer them over public transport	4,32
I will be willing to share my robotaxi with others	3,61
I find robotaxis somewhat frightening	2,87
Assuming robotaxis come into use, I intend to use them	3,88

TABLE 2 - MEAN SCORES OF PERSONAL ATTITUDE QUESTIONS

5.3 Hypotheses analysis

This section focuses on analyzing all the hypotheses mentioned in chapter 3.

5.3.1 Hypothesis one

Hypothesis one refers to the statement "Robotaxis will result in an increased value of travel time" in the questionnaire and looks at if there is a significant difference in the perception of the residents who live close and far to the city center on this impact. Hypothesis one reads as follows:

Hypothesis one: There is a significant difference in the perception of travel time value between the residents living close to the city center and those living far from the city center.

The hypothesis is tested by first creating a bar chart for each group or variable. The bar charts are used to identify whether the distribution is parametric or non-parametric and determine which test should be run after the visual inspection. A parametric test would assume that the sampled population is somewhat normally distributed. In contrast, a non-parametric test does not have any distributional assumptions. Since a comparison between two independent variables wants to be made, a choice has to be made between running a T-test and a Mann-Whitney U-Test. We know that the variables are independent as groups are compared. The test variable is the statement, and the two variables, or the residents living location from the city center, is the grouping variable. If the distribution of the bar chart is parametric, a T-test is run. If the distribution is non-parametric, a Mann-Whitney U-Test is run.

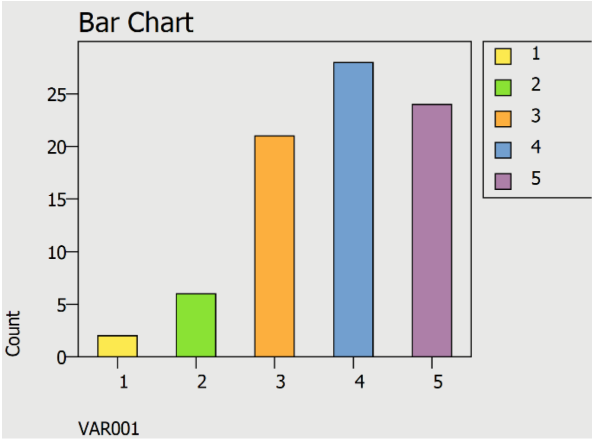

FIGURE 30 - HYPOTHESIS 1 DISTRIBUTION OF RESIDENTS LIVING FAR FROM THE CITY CENTER GROUP

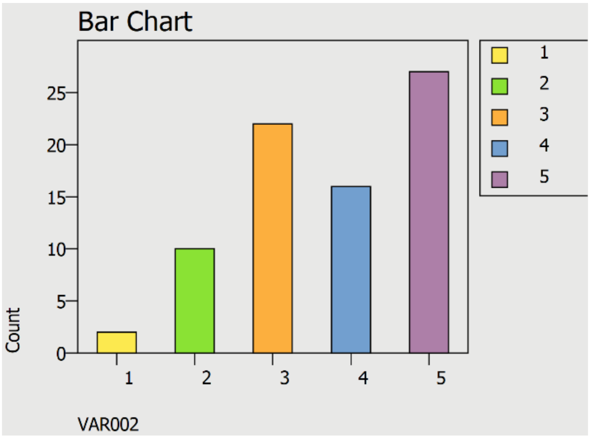

FIGURE 31 - HYPOTHESIS 1 DISTRIBUTION OF RESIDENTS LIVING CLOSE TO THE CITY CENTER GROUP

Both bar charts, which can be seen in Figure 30 and Figure 31, indicate no normal distribution. Since both bar charts visually indicate a non-parametric distribution, a Mann-Whitney U-Test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if both bar charts support the normality assumption and run a Kolmogorov-Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001
N		81
Normal Parameters	*Mean*	3.81
	Std. Deviation	1.03
Most Extreme Differences	*Absolute*	.21
	Positive	.14
	Negative	-.21
Kolmogorov-Smirnov Z		1.92
Asymp. Sig. (2-tailed)		.001

FIGURE 32 - HYPOTHESIS 1 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST RESIDENTS LIVING FAR FROM THE CITY CENTER

One-Sample Kolmogorov-Smirnov Test

		VAR002
N		77
Normal Parameters	Mean	3.73
	Std. Deviation	1.15
Most Extreme Differences	Absolute	.22
	Positive	.18
	Negative	-.22
Kolmogorov-Smirnov Z		1.89
Asymp. Sig. (2-tailed)		.001

FIGURE 33 - HYPOTHESIS 1 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST RESIDENTS LIVING CLOSE TO THE CITY CENTER

Both One-Sample Kolmogorov-Smirnov tests show a significant deviation, with the p-values being smaller than 0.05. In this case, both p-values are 0.001. Since a significant deviation exists, this also means that no normal distribution is present. Therefore, a Mann-Whitney U-Test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the residents living far from the city center is 3.81, while the mean score for the residents living close to the city center is 3.73. The residents living far from the city center of Zagreb indicate a somewhat larger agreement with the statement that robotaxis will result in an increased value of travel time than residents living close to the city center of Zagreb.

Ranks

	N			Mean Rank		Sum of Ranks	
	1	2	Total	1	2	1	2
VAR002	81.00	77.00	158.00	80.84	78.09	6548.00	6013.00

Test Statistics

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
VAR002	3010.00	6013.00	-.39	.695

FIGURE 34 – HYPOTHESIS 1 MANN-WHITNEY U-TEST

Figure 34 shows the Mann-Whitney U-Test, which indicates no significant difference with the p-value being larger than 0.05 or, as in this case, 0.695. Thus, the null hypothesis is accepted and the alternative hypothesis is rejected, which means that there is no significant difference in the perception of the residents living close to the city center and far away from the city center on the possible impact of increased value of travel time. This means that both groups agree with the statement that the value of travel time will increase once robotaxis are made use of. The group of residents living far from the city center indicates a mean rank of 80.84 (6548/81), and the group of residents living close to the city center indicates a mean rank of 78.09 (6013/77). This means that residents in Zagreb living far away from the city center agree more with the statement that robotaxis will increase travel time value than residents in Zagreb living close to the city center. However, one cannot generalize the results as the difference is small.

5.3.2 Hypothesis two

Hypothesis two refers to the statement "Assuming Robotaxis come into use, I intend to use them" in the questionnaire and looks at if there is a significant difference in the behavioral intention to use robotaxis between female and male residents from this sample. Hypothesis two reads as follows:

Hypothesis two: There is a significant difference in the behavioral intention to use robotaxis between Zagreb's female and male residents

Two bar charts are created first (one for each variable) and used to identify whether the distribution is parametric or non-parametric and determine which test should be run after the visual inspection. As two groups are being compared with one testing variable, we know that the variables are independent. Thus, a decision must be made between running a T-test or a Mann-Whitney U-Test. The test variable is the behavioral intention or statement, and the two variables, or gender, is the grouping variable. If the distribution of the bar chart is parametric, a T-test is run. If the distribution is non-parametric, a Mann-Whitney U-Test is run.

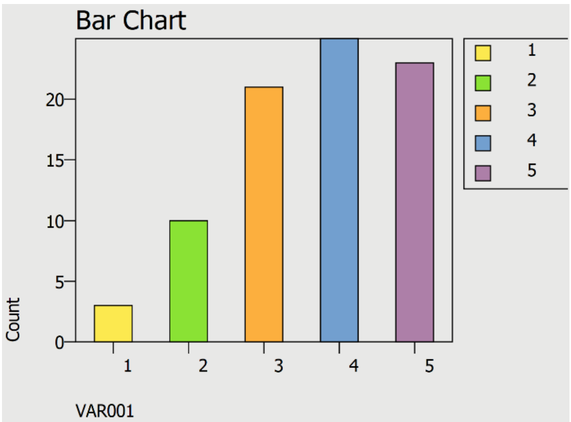

FIGURE 35 - HYPOTHESIS 2 DISTRIBUTION OF FEMALE GROUP

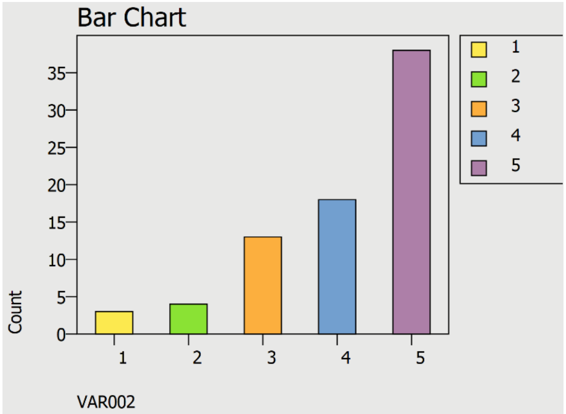

FIGURE 36 - HYPOTHESIS 2 DISTRIBUTION OF MALE GROUP

Both bar charts, seen in Figure 35 and Figure 36, indicate no normal distribution. Since both bar charts visually indicate a non-parametric distribution, a Mann-Whitney U-Test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if both bar charts support the normality assumption and run a Kolmogorov- Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001
N		82
Normal Parameters	Mean	3.67
	Std. Deviation	1.12
Most Extreme Differences	Absolute	.20
	Positive	.14
	Negative	-.20
Kolmogorov-Smirnov Z		1.82
Asymp. Sig. (2-tailed)		.001

FIGURE 37 - ONE-SAMPLE KOLMOGROV-SMIRNOV TEST FEMALE

One-Sample Kolmogorov-Smirnov Test

		VAR002
N		76
Normal Parameters	Mean	4.11
	Std. Deviation	1.11
Most Extreme Differences	Absolute	.29
	Positive	.21
	Negative	-.29
Kolmogorov-Smirnov Z		2.52
Asymp. Sig. (2-tailed)		.000

FIGURE 38 - ONE-SAMPLE KOLMOGROV SMIRNOV TEST MALE

Both One-Sample Kolmogorov-Smirnov tests show a significant deviation with both p-values smaller than 0.05. In this specific instance, the first p-value is 0.001, and the second one is 0.000. Since a significant deviation exists, this also means that no normal distribution is present. Therefore, a Mann-Whitney U-Test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the female residents is 3.67, while the mean score for the male residents is 4.11. The male residents of Zagreb from the sample indicate a somewhat larger intention to use robotaxis once they are available than the female residents of Zagreb from the sample.

Ranks

	N			Mean Rank		Sum of Ranks	
	1	2	Total	1	2	1	2
VAR002	82.00	76.00	158.00	70.45	89.26	5777.00	6784.00

Test Statistics

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
VAR002	2374.00	5777.00	-2.70	.007

FIGURE 39 - HYPOTHESIS 2 MANN-WHITNEY U-TEST

Figure 39 depicts the Mann-Whitney U-Test, which reveals that there is a statistically significant difference since the p-value is smaller than 0.05, or in this instance, 0.007. Thus, the null hypothesis is rejected, and the alternative hypothesis accepted, which means that there is a significant difference in the behavioral intention to use robotaxis between male and female residents of Zagreb. This means that both groups show a behavioral intention towards using robotaxis once they become available in Zagreb, with the male residents of Zagreb showing a greater behavioral intention to them. The female group of residents indicates a mean rank of 70.45 (5777/82), and the male group indicates a mean rank of 89.26 (6784/76).

5.3.3 Hypothesis three

Hypothesis three refers to the statement "Robotaxis will result in the disruption of labor markets" in the questionnaire and looks at if there is a significant difference in the perception of the residents who work in the transportation sector and the residents who do not work in the transportation sector on this impact. Hypothesis three reads as follows:

Hypothesis three: There is a significant difference in the perception of the disruption of labor markets between the residents working in the transportation sector and the residents not working in it in Zagreb.

The first step is to generate two bar charts, one for each variable. These bar charts are then used to establish if the distribution is parametric or non-parametric and which test should be carried out once the visual inspection has been completed. As two groups are being compared with one testing variable, we know that the variables are independent. Thus, a decision must be made between running a T-test or a Mann-Whitney U-Test. The test variable is the statement, and the two variables, or whether the resident works in the transportation sector, is the grouping variable. If the bar chart distribution is parametric, a T-test should be run. If the distribution is non-parametric, a Mann-Whitney U-Test should be run.

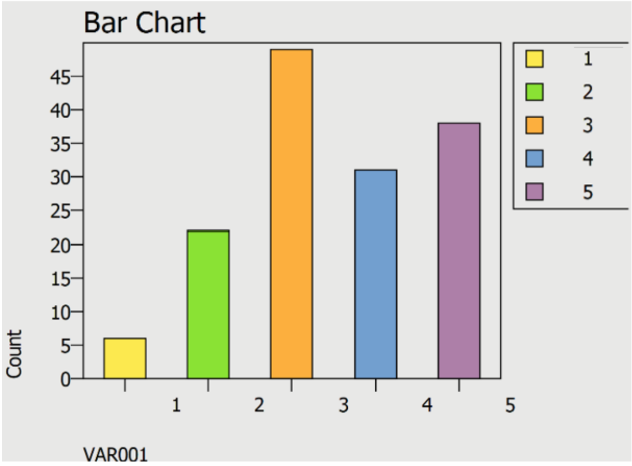

FIGURE 40 - HYPOTHESIS 3 DISTRIBUTION OF NOT WORKING IN TRANSPORTATION SECTOR GROUP

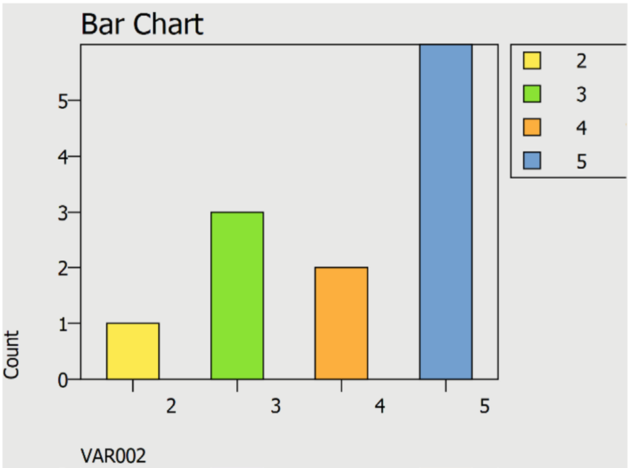

FIGURE 41 - HYPOTHESIS 3 DISTRIBUTION OF WORKING IN TRANSPORTATION SECTOR GROUP

Both bar charts, which can be seen in Figure 40 and Figure 41, show no normal distribution. Since both bar charts visually indicate a non-parametric distribution, a Mann-Whitney U-Test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if both bar charts support the normality assumption and run a Kolmogorov- Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001
N		146
Normal Parameters	Mean	3.50
	Std. Deviation	1.15
Most Extreme Differences	Absolute	.20
	Positive	.20
	Negative	-.16
Kolmogorov-Smirnov Z		2.36
Asymp. Sig. (2-tailed)		.000

FIGURE 42 - ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

One-Sample Kolmogorov-Smirnov Test

		VAR002
N		12
Normal Parameters	Mean	4.08
	Std. Deviation	1.08
Most Extreme Differences	Absolute	.30
	Positive	.20
	Negative	-.30
Kolmogorov-Smirnov Z		1.04
Asymp. Sig. (2-tailed)		.217

FIGURE 43 – HYPOTHESIS 3 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

The One-Sample Kolmogorov-Smirnov test for the part of the sample not working in the transportation sector shows a significant deviation, with a p-value of 0.000. In contrast, the second One-Sample Kolmogorov-Smirnov test shows no significant deviation with a p-value of 0.217. The p-value suggests no significant deviation present, although the bar chart certainly shows one. This is due to the Kolmogorov-Smirnov test's power for a small number of cases, which in this case is twelve. However, regardless of the different results, since only one group or variable indicates a p-value smaller than or equal to 0.05, a Mann-Whitney U-Test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the residents not working in the transportation sector is 3.50, while the mean score for the residents working in the transportation sector is 4.08. The residents of Zagreb working in the transportation sector indicate a larger agreement with the statement that robotaxis will disrupt labor markets than residents of Zagreb not working in the transportation sector.

Ranks

	N			Mean Rank		Sum of Ranks	
	1	2	Total	1	2	1	2
VAR002	146.00	12.00	158.00	77.82	99.96	11361.50	1199.50

Test Statistics

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
VAR002	630.50	11361.50	-1.67	.095

FIGURE 44 - HYPOTHESIS 3 MANN-WHITNEY U-TEST

Figure 44 shows the Mann-Whitney U-Test, which indicates that there is no significant difference with the p-value being larger than 0.05 or, as in this instance, 0.095. Thus, the null hypothesis is accepted, and the alternative hypothesis is rejected, which means that there is no significant difference in the perception of the residents working in the transportation sector and not working in the transportation sector on the possible impact of the disruption of the labor market. This means that both groups agree with the statement that robotaxis will result in the disruption of the labor markets. The group of residents not working in the transportation sector indicate a mean rank of 77.82 (11361.50/146), and the group of residents working in the transportation sector indicates a mean rank of 99.96 (1199.50/12). This means that residents in Zagreb working in the transportation sector agree more with the statement that robotaxis will disrupt the labor market than residents in Zagreb not working in the transportation sector.

5.3.4 Hypothesis four

Hypothesis four refers to the statements "Robotaxis will result in fewer accidents" and "Robotaxis will result in increased public safety and health" in the questionnaire and looks at if there is a significant difference in the perception of the different age groups of the residents in this sample on the possible safety impacts of robotaxis on the city of Zagreb. Hypothesis four reads as follows:

Hypothesis four: There is a significant difference in the perception of the safety impacts of robotaxis depending on the age group.

As there are two safety impacts, both will have to be tested and analyzed. The first analysis focuses on the possible safety impact "Robotaxis will result in in an increased public safety and health." Four bar charts are generated, one for each variable or, in this case, age group. These bar charts are then used to establish if the distribution is parametric or non-parametric and which test should be carried out once the visual inspection has been completed. As four groups are being compared with one testing variable, we know that the variables are independent. Thus, a decision must be made between running a Kruskal-Wallis H-test or an ANOVA test. The test variable is the statement, or the perception of the safety impacts, and the four variables or age groups are the grouping variable. If the bar chart distribution is parametric, an ANOVA test should be run. If the distribution is non-parametric, a Kruskal-Wallis H-test should be run.

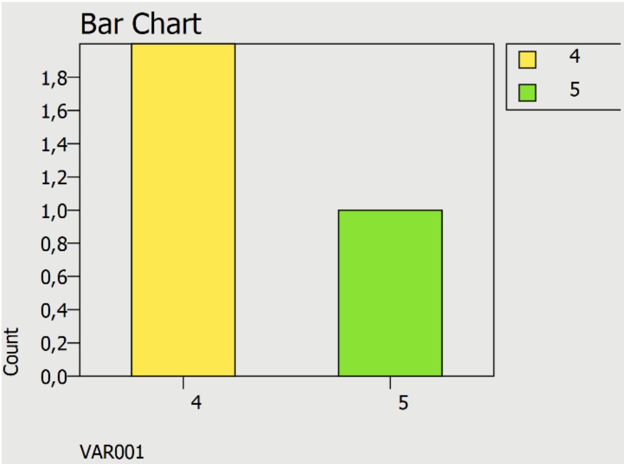

FIGURE 45 - HYPOTHESIS 4 DISTRIBUTION OF 15 TO 18 AGE GROUP

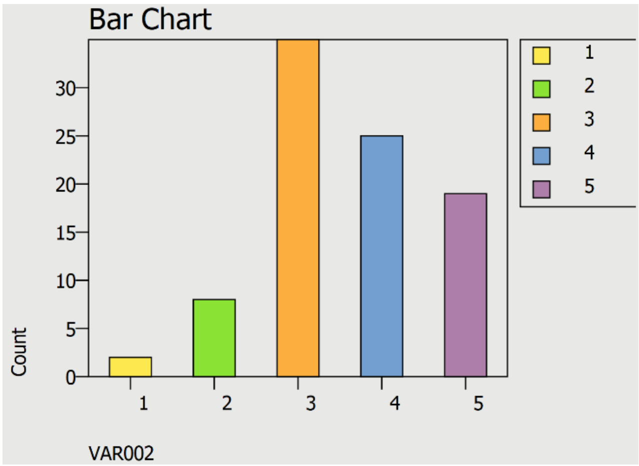

FIGURE 46 - HYPOTHESIS 4 DISTRIBUTION OF 19 TO 39 AGE GROUP

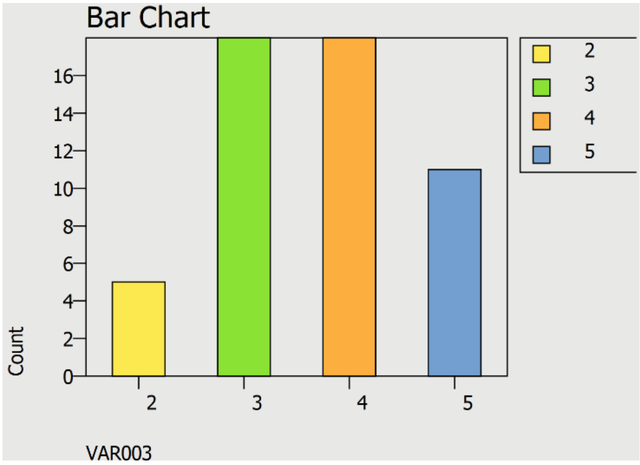

FIGURE 47 - HYPOTHESIS 4 DISTRIBUTION OF 40 TO 59 AGE GROUP

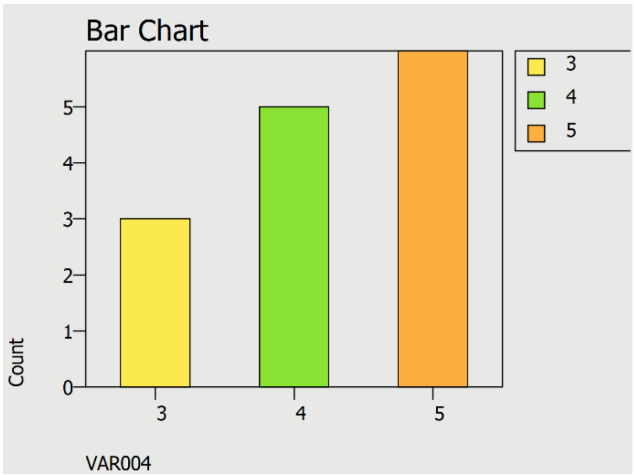

FIGURE 48 - HYPOTHESIS 4 DISTRIBUTION OF 60+ AGE GROUP

All four bar charts, which can be seen in Figure 45, Figure 46, Figure 47, and Figure 48, show no normal distribution. Since all four bar charts visually indicate a non-parametric distribution, a Kruskal-Wallis H-test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if all four bar charts support the normality assumption and run a Kolmogorov- Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001	VAR002	VAR003	VAR004
N		3	89	52	14
Normal Parameters	Mean	4.33	3.57	3.67	4.21
	Std. Deviation	.58	1.00	.92	.80
Most Extreme Differences	Absolute	.38	.22	.21	.27
	Positive	.38	.22	.21	.18
	Negative	-.28	-.17	-.20	-.27
Kolmogorov-Smirnov Z		.67	2.10	1.51	.99
Asymp. Sig. (2-tailed)		.766	.000	.014	.279

FIGURE 49 – HYPOTHESIS 4 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

The One-Sample Kolmogorov-Smirnov test seen in Figure 49 shows the results for all four variables. The One-Sample Kolmogorov-Smirnov test shows no significant deviation for the first and fourth variable or the age groups from 15 to 18 and 60 and above, with p-values of 0.766 0.279. The One-Sample Kolmogorov-Smirnov test shows a significant deviation present for the second and third variable or age group from 19 to 39 and 40 to 59 with p-values of 0.000 and 0.014. While the p-values for variables one and four suggest no significant deviation present, the bar chart certainly shows one. This is due to the Kolmogorov-Smirnov test's power for a small number of cases, which in this case is three and fourteen. However, regardless of the different results, since only two groups or variables indicate a p-value larger than or equal to 0.05, a Kruskal-Wallis H-test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the age group from 15 to 18 is 4.33, for the age group from 19 to 39 is 3.57, for the age group from 39 to 49 is 3.67 and for the age group from 60 and above is 4.21. The age group from 15 to 18 indicates the largest agreement with the statement that robotaxis will increase public safety and health, while the age group 60 and above follows right behind. The residents from 19 to 39 show the least agreement with the statement that robotaxis will result in increased public safety and health.

Ranks

	1	N	Mean Rank
Var0002	1	3	111.00
	2	89	74.94
	3	52	78.94
	4	14	103.79
	Total	158	

Test Statistics

	Var0002
Chi-Square	6.87
df	3
Asymp. Sig.	.076

FIGURE 50 - HYPOTHESIS 4 KRUSKAL-WALLIS H-TEST

Figure 50 shows the Kruskal-Wallis H-test, which indicates that there is no significant difference with the p-value being larger than 0.05 or, in this instance, 0.076. The age group from 15 to 18 indicates a mean rank of 111.00, the age group from 19 to 39 indicates a mean rank of 74.94, the age group from 40 to 59 indicates a mean rank of 78.94, and the age group from 60 and above indicates a mean rank of 103.79. This means that residents in Zagreb between the age of 15 to 18 agree most with the statement that robotaxis will result in increased public safety and health, followed by the 60 and above age group. The age group from 19 to 39 indicates the least agreement. However, from the mean (M= 3.57), it can be seen that they do not show disagreement but lean more towards agreeing with the possible impact. There is no need to run a post-hoc test, which in this case would be a Mann-Whitney Test for all pairs with Bonferroni Correction, as the p-value indicates no significant difference.

The second analysis focuses on the possible safety impact "Robotaxis will result in fewer accidents." The process is the same. Four bar charts are generated, one for each variable or, in this case, age group, which are then used to establish if the distribution is parametric or non-parametric and which test should be carried out once the visual inspection has been completed. The groups remain independent, and thus a choice has to be made between the Kruskal-Wallis H-test and ANOVA test.

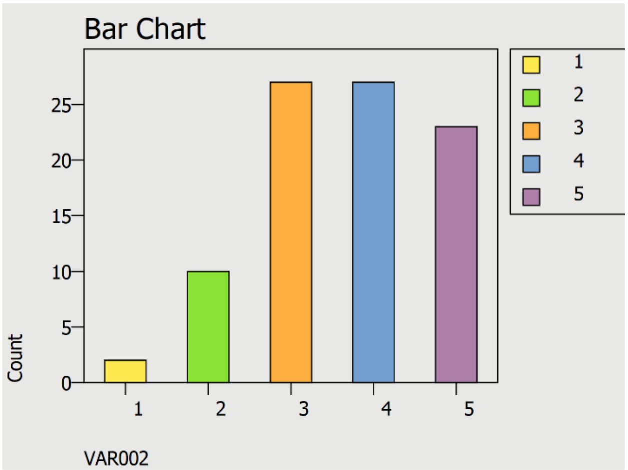

FIGURE 51 - HYPOTHESIS 4 DISTRIBUTION OF 19 TO 39 AGE GROUP

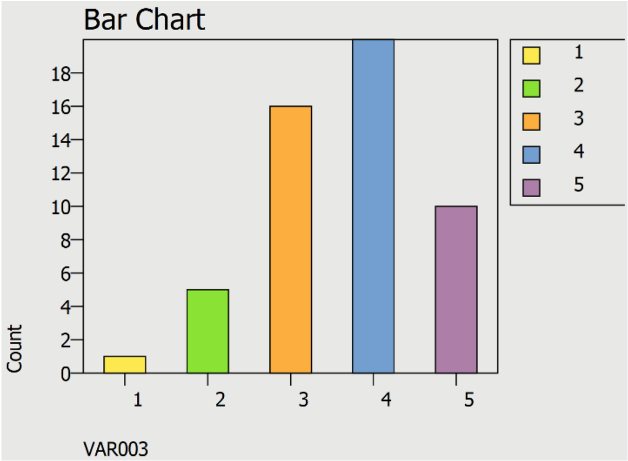

FIGURE 52 - HYPOTHESIS 4 DISTRIBUTION OF 40 TO 59 AGE GROUP

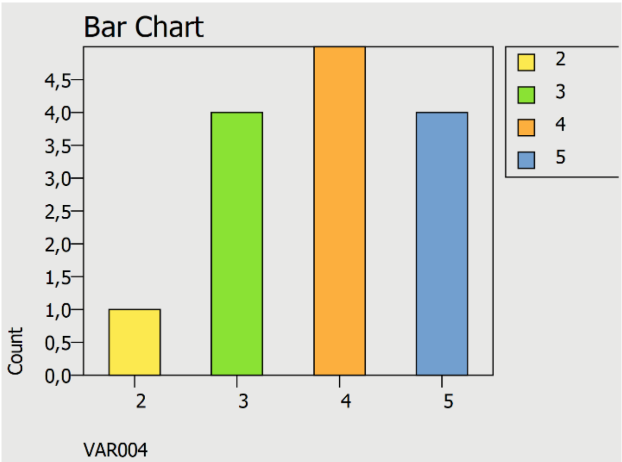

FIGURE 53 - HYPOTHESIS 4 DISTRIBUTION OF 60+ AGE GROUP

Only three bar charts can be generated, as the data for the age group from 15 to 18 years contains less than two distinct values for this statement. In this case, all participants indicated that they somewhat agreed with the statement. All remaining three bar charts, which can be seen in Figure 51, Figure 52, and Figure 53, show no normal distribution. Since all three bar charts visually indicate a non-parametric distribution, a Kruskal-Wallis H-test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if all three bar charts support the normality assumption and run a Kolmogorov- Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001	VAR002	VAR003	VAR004
N		3	89	52	14
Normal Parameters	Mean	4.00	3.66	3.63	3.86
	Std. Deviation	.00	1.05	.97	.95
Most Extreme Differences	Absolute	.	.19	.22	.20
	Positive	.	.17	.17	.17
	Negative	1.80E+308	-.19	-.22	-.20
Kolmogorov-Smirnov Z		-Infinity	1.77	1.61	.76
Asymp. Sig. (2-tailed)		1.000	.002	.007	.613

FIGURE 54 - HYPOTHESIS 4 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

The One-Sample Kolmogorov-Smirnov test seen in Figure 54 shows the results for all four variables. The One-Sample Kolmogorov-Smirnov test shows no significant deviation for the first and fourth variable or the age groups from 15 to 18 and 60 and above, with p-values of 1.000 and 0.613. The One-Sample Kolmogorov-Smirnov test shows a significant deviation for the second and third variable or age group from 19 to 39 and 40 to 59 with p-values of 0.002 and 0.007. While the p-values for variables one and four suggest no significant deviation is present, the bar chart certainly shows one. This is due to the Kolmogorov-Smirnov test's power for a small number of cases, which in this case is three and fourteen. However, regardless of the different results, since only two groups or variables indicate a p-value larger than or equal to 0.05, a Kruskal-Wallis H-test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the age group from 15 to 18 is 4.00, for the age group from 19 to 39 is 3.66, for the age group from 39 to 49 is 3.63 and for the age group from 60 and above is 3.86. The age group from 15 to 18 indicates the largest agreement with the statement that robotaxis will increase public safety and health, while the age group 60 and above follows right behind. The residents from the age of 40 to 59 show the least agreement with the statement that robotaxis will result in increased public safety and health.

Ranks

	VAR001	N	Mean Rank
VAR002	1	3	94.00
	2	89	79.08
	3	52	77.45
	4	14	86.68
	Total	158	

Test Statistics

	VAR002
Chi-Square	.83
df	3
Asymp. Sig.	.843

FIGURE 55 - HYPOTHESIS 4 KRUSKAL-WALLIS H-TEST

Figure 55 shows the Kruskal-Wallis H-test, which indicates no significant difference with the p-value being larger than 0.05 or, in this instance, 0.843. The age group from 15 to 18 indicates a mean rank of 94.00, the age group from 19 to 39 indicates a mean rank of 79.08, the age group from 40 to 59 indicates a mean rank of 77.45, and the age group from 60 and above indicates a mean rank of 88.68. This means that residents in Zagreb between the age of 15 to 18 agree most with the statement made that robotaxis will result in increased public safety and health, followed by the 60 and above age group. The age group from 40 to 59 indicates the least agreement. However, from the mean (M= 3.63), it can be seen that they do not show disagreement but lean more towards agreeing with the possible impact. There is no need to run a post-hoc test, which in this case would be a Mann-Whitney Test for all pairs with a Bonferroni Correction, as the p-value indicates no significant difference.

After completing the analysis for both safety impacts, the null hypothesis is accepted, and the alternative is rejected, which means that there is no significant difference in the perception of the different age groups on the possible safety impacts of robotaxis.

5.3.5 Hypothesis five

Hypothesis five refers to the statement "Robotaxis will result in an improved access to mobility" in the questionnaire and looks at if there is a significant difference in the perception of the different age groups on the possible impact of improved access to mobility as a result of robotaxis in the city of Zagreb. Hypothesis five reads as follows:

Hypothesis five: There is a significant difference in the perception of the impact of robotaxis on the access to mobility depending on the age group.

Four bar charts are created first (one for each variable) and used to identify whether the distribution is parametric or non-parametric and determine which test should be run after the visual inspection. As four groups are being compared with one testing variable, we know that the variables are independent. Thus, a decision must be made between running a Kruskal-Wallis H-test or an ANOVA test. The test variable is the statement, or the perception of the possible impact of robotaxis on the access to mobility, and the four variables or age groups is the grouping variable. If the bar chart distribution is parametric, an ANOVA test should be run. If the distribution is non-parametric, a Kruskal-Wallis H-test should be run.

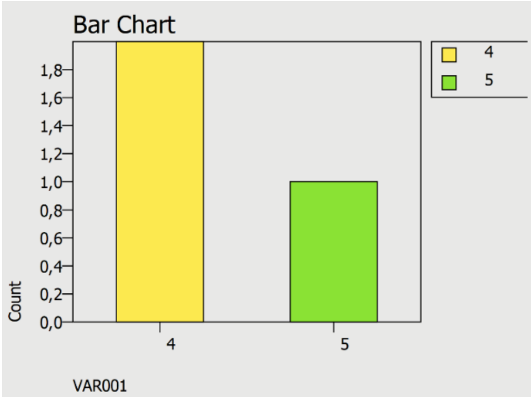

FIGURE 56 - HYPOTHESIS 4 DISTRIBUTION OF 15 TO 18 AGE GROUP

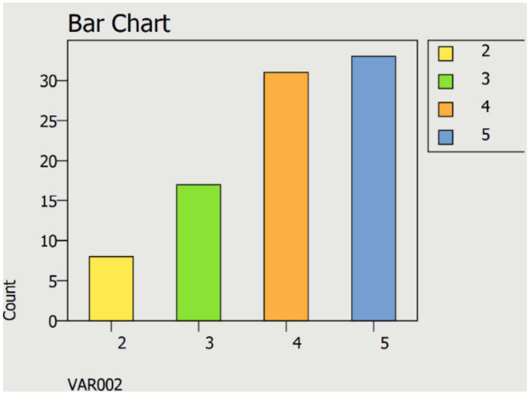

FIGURE 57 - HYPOTHESIS 5 DISTRIBUTION OF 19 TO 39 AGE GROUP

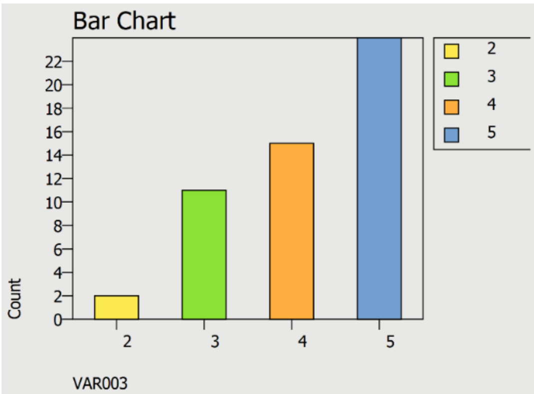

FIGURE 58 - HYPOTHESIS 5 DISTRIBUTION OF 39 TO 59 AGE GROUP

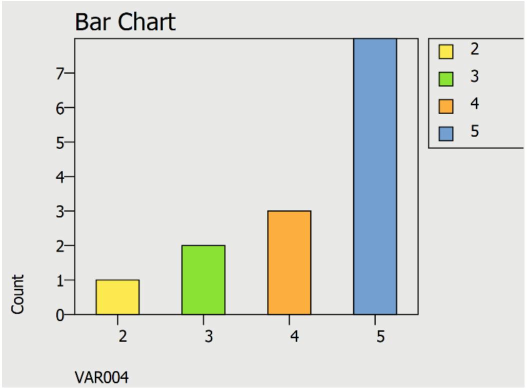

FIGURE 59 - HYPOTHESIS 5 DISTRIBUTION OF 60+ AGE GROUP

All four bar charts, which can be seen in Figure 56, Figure 57, Figure 58, and Figure 59, show no normal distribution. Since all four bar charts visually indicate a non-parametric distribution, a Kruskal-Wallis H-test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if all four bar charts support the normality assumption and run a Kolmogorov- Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001	VAR002	VAR003	VAR004
N		3	89	52	14
Normal Parameters	Mean	4.33	4.00	4.17	4.29
	Std. Deviation	.58	.97	.90	.99
Most Extreme Differences	Absolute	.38	.22	.28	.34
	Positive	.38	.15	.18	.24
	Negative	-.28	-.22	-.28	-.34
Kolmogorov-Smirnov Z		.67	2.08	2.03	1.25
Asymp. Sig. (2-tailed)		.766	.000	.000	.069

FIGURE 60 - HYPOTHESIS 5 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

The One-Sample Kolmogorov-Smirnov test seen in Figure 60 shows the results for all four variables. The One-Sample Kolmogorov-Smirnov test shows no significant deviation for the first and fourth variable or the age groups from 15 to 18 and 60 and above, with p-values of 0.766 and 0.069. The One-Sample Kolmogorov-Smirnov test shows a significant deviation present for the second and third variable or age group from 19 to 39 and 40 to 59 with p-values of 0.000 and 0.000. While the p-values for variables one and four suggest no significant deviation is present, the bar chart certainly shows one. This is due to the Kolmogorov-Smirnov test's power for a small number of cases, which in this case is three and fourteen. However, regardless of the different results, since only two groups or variables indicate a p-value larger than or equal to 0.05, a Kruskal-Wallis H-test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the age group from 15 to 18 is 4.33, for the age group from 19 to 39 is 4.00, for the age group from 39 to 49 is 4.17 and for the age group from 60 and above is 4.29. The age group from 15 to 18 indicates the largest agreement with the statement that robotaxis will improve mobility access. However, all other age groups follow closely with the age group 19 to 39, showing the lease agreement with the statement that robotaxis will improve mobility access. No age group shows disagreement with the statement.

Ranks

	VAR001	N	Mean Rank
VAR002	1	3	86.50
	2	89	75.47
	3	52	83.09
	4	14	90.29
	Total	158	

Test Statistics

	VAR002
Chi-Square	2.10
df	3
Asymp. Sig.	.553

Figure 61 - Hypothesis 5 Kruskal-Wallis H-test

Figure 61 shows the Kruskal-Wallis H-test, which indicates no significant difference with the p-value being larger than 0.05 or, in this instance, 0.553. Thus, the null hypothesis is accepted and the alternative hypothesis rejected, which means that there is no significant difference in the perception of the different age groups on the possible impact of robotaxis resulting in improved access to mobility. The age group from 15 to 18 indicates a mean rank of 86.50, the age group from 19 to 39 indicates a mean rank of 75.47, the age group from 40 to 59 indicates a mean rank of 83.09, and the age group from 60 and above indicates a mean rank of 90.29. This means that residents in Zagreb between the age of 60 and above agree most with the statement made that robotaxis will result in improved access to mobility, followed by the age group from 15 to 18. The age group from 19 to 39 indicates the least agreement. However, from the mean (M= 4.00), it can be seen that they do not show disagreement but lean to-wards agreeing with the possible impact. There is no need to run a post-hoc test, which in this case would be a Mann-Whitney Test for all pairs with a Bonferroni Correction, as the p-value indicates no significant difference.

5.3.6 Hypothesis six

Hypothesis six refers to the statement "Assuming Robotaxis come into use, I intend to use them" in the questionnaire and looks at if there is a significant difference in the behavioral intention to use robotaxis between the different knowledge level groups. Hypothesis six reads as follows:

Hypothesis six: There is a significant difference in the behavioral intention to use robotaxis depending on the residents' level of knowledge.

Five bar charts are created first (one for each variable) and used to approximately identify if the distribution is parametric or non-parametric and to determine which test should be run after the visual inspection. As five groups are being compared with one testing variable, we know that the variables are independent. Thus, a decision must be made between running a Kruskal-Wallis H-test or an ANOVA test. The test variable is the statement, or the perception of the possible impact of robotaxis on the behavioral intention to use robotaxis, and the five variables or knowledge level groups are the grouping variable. If the distribution of the bar chart is parametric, an ANOVA test should be run. If the distribution is non-parametric, a Kruskal-Wallis H-test should be run.

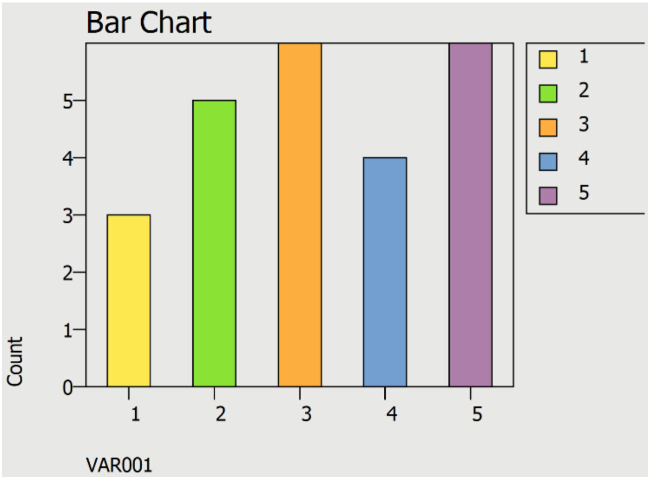

FIGURE 62 - HYPOTHESIS 6 DISTRIBUTION OF NOT KNOWLEDGEABLE AT ALL GROUP

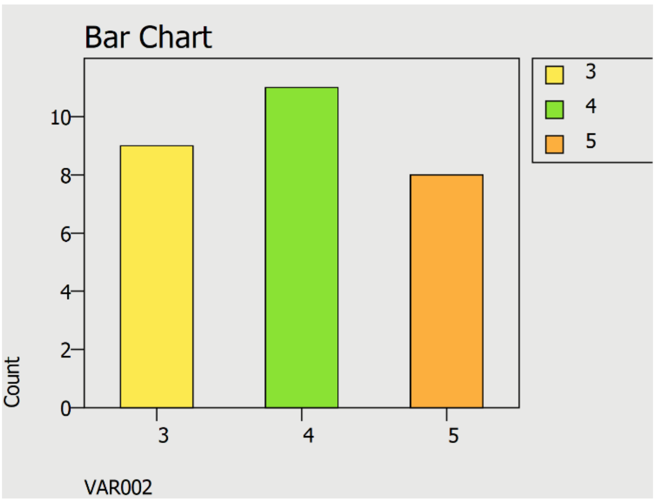

FIGURE 63 - HYPOTHESIS 6 DISTRIBUTION OF NOT KNOWLEDGEABLE GROUP

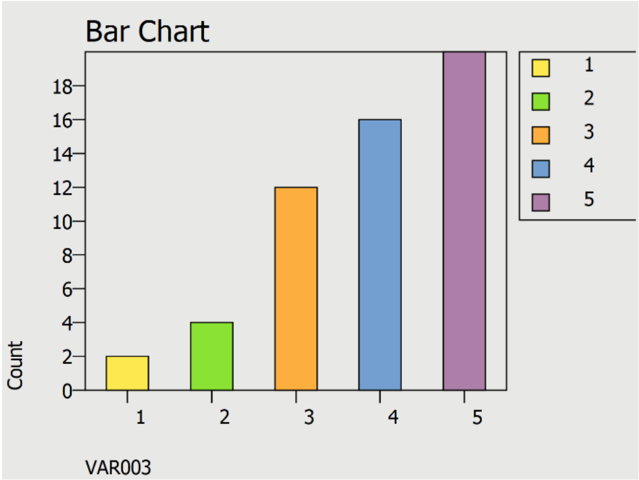

FIGURE 64 - HYPOTHESIS 6 DISTRIBUTION OF NEUTRAL GROUP

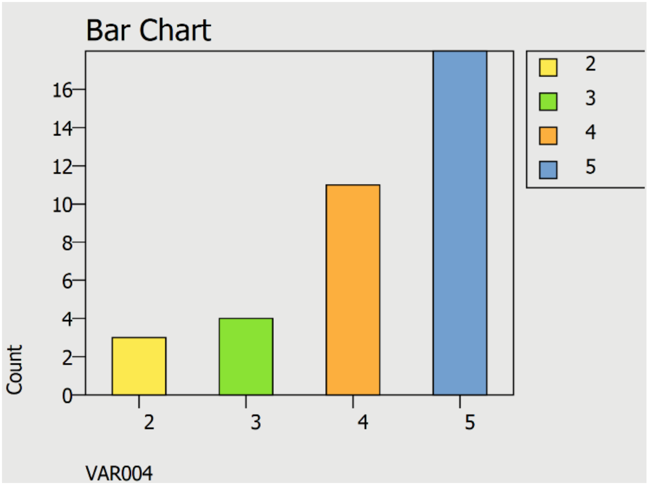

FIGURE 65 - HYPOTHESIS 6 DISTRIBUTION OF KNOWLEDGEABLE GROUP

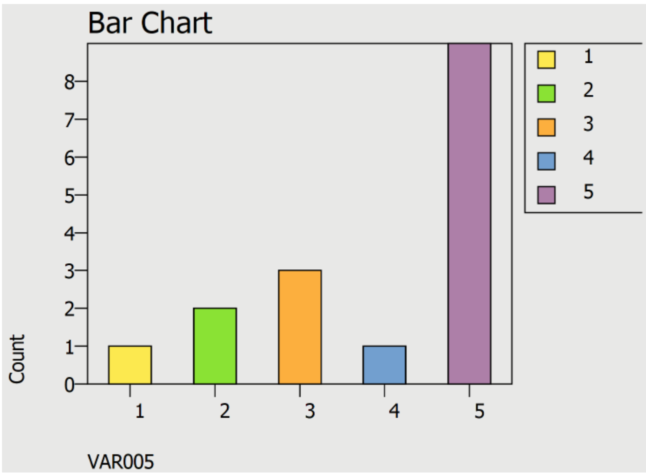

FIGURE 66 - HYPOTHESIS 6 DISTRIBUTION OF VERY KNOWLEDGEABLE GROUP

All five bar charts, which can be seen in Figure 62, Figure 63, Figure 64, Figure 65, and Figure 66, show no normal distribution. Since all five bar charts visually indicate a non-parametric distribution, a Kruskal-Wallis H-test should be run. However, to confirm or support this assumption, since we distrust our optical impression, we act as if all four bar charts support the normality assumption and run a Kolmogorov-Smirnov test.

One-Sample Kolmogorov-Smirnov Test

		VAR001	VAR002	VAR003	VAR004	VAR005
N		24	28	54	36	16
Normal Parameters	Mean	3.21	3.96	3.89	4.22	3.94
	Std. Deviation	1.38	.79	1.11	.96	1.39
Most Extreme Differences	Absolute	.15	.21	.21	.29	.34
	Positive	.14	.21	.16	.21	.22
	Negative	-.15	-.20	-.21	-.29	-.34
Kolmogorov-Smirnov Z		.75	1.11	1.56	1.75	1.36
Asymp. Sig. (2-tailed)		.632	.154	.010	.003	.036

FIGURE 67 - HYPOTHESIS 6 ONE-SAMPLE KOLMOGROV-SMIRNOV TEST

The One-Sample Kolmogorov-Smirnov test seen in Figure 67 shows the results for all five variables. The One-Sample Kolmogorov-Smirnov test shows that no significant deviation is present for the first and second variable or "not at all knowledgeable" and "slightly knowledgeable" roup, with p-values of 0.632 and 0.154. The One-Sample Kolmogorov-Smirnov test shows that there is a significant deviation present for the third, fourth, and fifth variables or "somewhat knowledgeable," "moderately knowledgeable," and "very knowledgeable" groups with p-values of 0.010, 0.003, and 0.036. While the p-values for variables one and two suggest that there is no significant deviation present, the bar chart certainly shows one. This might be due to the Kolmogorov-Smirnov test's power for a small number of cases. Nonetheless, since only two groups or variables indicate a p-value larger than or equal to 0.05, a Kruskal-Wallis H-test should be run. The One-Sample Kolmogorov-Smirnov tests show that the mean score for the "not knowledgeable at all" group is 3.21, for the "slightly knowledgeable" group is 3.96, for the "somewhat knowledgeable" group is 3.89, for the "moderately knowledgeable" group is 4.22 and for the "very knowledgeable" is 3.94. The "moderately knowledgeable" group indicates the greatest behavioral intention to use robotaxis once they become available, followed closely by the "slightly knowledgeable" and "very knowledgeable" groups. The "not knowledgeable at all" group shows the lowest behavioral intention to use robotaxis once they are available.

Ranks

	VAR002	N	Mean Rank
VAR001	1	24	57.29
	2	28	78.48
	3	54	79.39
	4	36	92.51
	5	16	85.69
	Total	158	

Test Statistics

	VAR001
Chi-Square	9.73
df	4
Asymp. Sig.	.045

FIGURE 68 - HYPOTHESIS 6 KRUSKAL-WALLIS H-TEST

Figure 68 shows the Kruskal-Wallis H-test, which indicates a significant difference with the p-value being smaller than 0.05 or, as in this instance, 0.045. Thus, the alternative hypothesis is accepted, and null hypothesis is rejected, which means a significant difference in the behavioral intention to use robotaxis. The "not knowledgeable at all" indicates a mean rank of 57.29, the "slightly knowledgeable" group indicates a mean rank of 78.49, the "somewhat knowledgeable" group indicates a mean rank of 79.39, the "moderately knowledgeable" group indicates a mean rank of 92.51 and the "very knowledgeable" group indicates a mean rank of 85.69. This means that the residents who consider themselves knowledgeable about autonomous vehicles show the greatest behavioral intention to use robotaxis once they become available, followed by the very knowledgeable group of residents. The residents who do not consider themselves knowledgeable indicate the lowest behavioral attention to use robotaxis once they become available. However, from the mean (M= 3.21), it can be seen that they do not show disagreement but are more neutral towards using robotaxis.

There is a need to run a post-hoc test, which in this case would be a Mann-Whitney Test for all pairs with a Bonferroni Correction, as the p-value indicates a significant difference. The Bonferroni Correction is calculated as follows: 0.05/10 (tests)= 0.005. The new p-value is compared to all ten Mann-Whitney U-tests. Out of the ten tests, only one showed a significant p-value, as shown in Figure 69. The test shows a significant difference between the knowledge groups "not knowledgeable at all" and "moderately knowledgeable." Since the "moderately knowledgeable" group shows a higher mean rank, this group indicates a larger behavioral intention to use robotaxis.

Ranks

	N			Mean Rank		Sum of Ranks	
	1	4	Total	1	4	1	4
VAR001	24.00	36.00	60.00	22.90	35.57	549.50	1280.50

Test Statistics

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
VAR001	249.50	549.50	-2.88	.004

FIGURE 69 - HYPOTHESIS 6 MANN-WHITNEY U-TEST

5.3.7 Hypothesis seven

Hypothesis seven looks at whether there is a positive impact of perceived usefulness, perceived ease of use, social influence, and perceived trust on the behavioral intention to use robotaxis. Hypothesis seven reads as follows:

Hypothesis seven: Perceived usefulness, perceived ease of use, social influence, and perceived trust have a significant positive effect on the behavioral intention to use robotaxis.

In order to predict one dependent variable with one or multiple independent variables, a linear regression needs to be conducted. There is one dependent variable, the behavioral intention, and multiple independent variables, in this case, the PU, PEU, SI, and PT. Thus, a multiple linear regression should be run instead of a simple linear regression, which is used when there is only one independent variable. A multiple linear regression model using standardized coefficients has been developed to see if there is a positive impact of the PU, PEU, SI, and PT on the BI to use robotaxis.

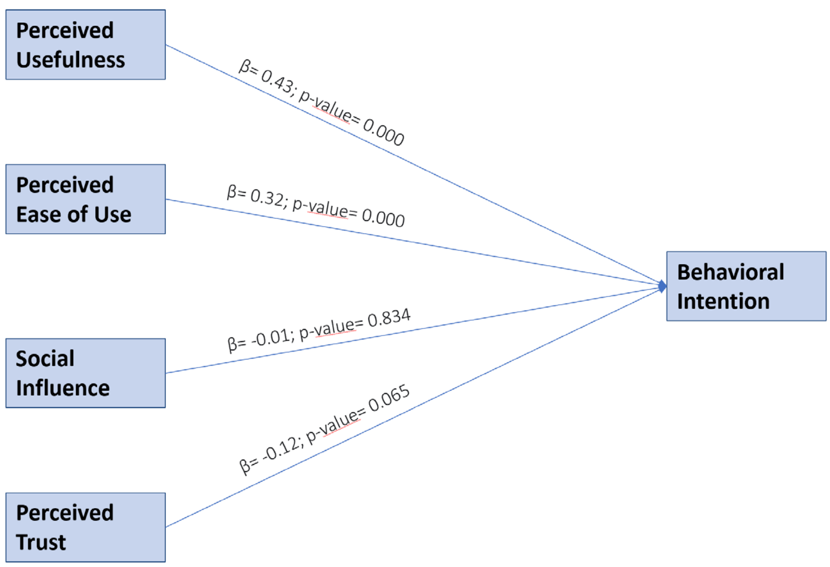

FIGURE 70 - RESULTS OF THE RELATIONSHIPS IN THE MODEL

The hypothesis testing results are shown in Figure 70. The p-values of the independent variables PU and PEU are lower than 0.05, and thus these independent variables can be used to predict the dependent variable behavioral intention. The remaining two variables, SI and PT, have p-values larger than 0.05, and thus the predictions are not entirely accurate. The analysis shows that the perceived usefulness has a positive effect on the behavioral intention to use the robotaxis (β= 0.43). That perceived ease of use also positively affects the behavioral intention to use robotaxis (β= 0.32). Social influence (β= -0.01) and perceived trust (β= -0.12) were shown to have a negative effect on the behavioral intention to use robotaxis. However, we have to keep in mind that both showed p-values that are not significant. Thus, the null hypothesis is accepted, and the alternative hypothesis is rejected. The impact is that perceived usefulness has the largest impact on behavioral intention to use robotaxis, followed by perceived ease of use, perceived trust, and social influence.

The findings revealed that PU, PEU, SI, and PT managed to explain 40% of the variance in BI (R^2= 0.40). This indicates that the model cannot account for all the variables influencing the BI to use robotaxis. Several other variables may be used to enhance predictions of the BI to use robotaxis.

Since the independent variables or constructs are a sum of multiple variables or statements, they do not show which specific statement has the largest effect on the behavioral intention to use robotaxis. Thus, multiple linear regression is run with each statement. The analysis indicates that multiple variables have a p-value that is not significant and only three significant variables: "Robotaxis will result in reduced travel time" (VAR010), "If robotaxis are cheaper, I will prefer them over public transport" (VAR027) and "I find Robotaxis somewhat frightening" (VAR033). These three variables also show the largest impacts on the behavioral intention to use robotaxis. The variable "If robotaxis are cheaper, I will prefer them over public transport" (β= 0.32) has the largest impact, followed by "Robotaxis will result in reduced travel time" (β= -0.17) and "I find Robotaxis somewhat frightening" (β= -0.15). Appendix 3 shows both multiple linear regression tests and the individual results.

5.4 Impacts as perceived by different socio-demographic groups

The previous section looked at how different socio-demographic groups answered one specific statement and if there was a significant difference in their responses or agreement. This section will look at what agreement different socio-demographic groups indicated for more than one statement and will compare them using the mean scores of the responses to be able to compare them to the previous literature or other surveys in chapter 2.5.

5.4.1 Gender

As shown in section 5.3.2, there was a significant difference in the behavioral intention to use robotaxis between male and female residents of Zagreb. The male group showed a greater intention to use robotaxis, which is also seen from the mean score in Table 3. Looking further at the mean score of the responses and comparing it between the male and female gender, several statements can be seen that indicate a large difference (larger than 0.5). The largest difference in the mean score can be seen in the statement, "I find robotaxis somewhat frightening." The male group (M= 3.49) indicated that they are less frightened by robotaxis than the female group (M= 2.2). A difference can also be seen in how easy the groups perceive it will be for them to learn to operate robotaxis and how much safer they will feel by robotaxis than they do currently by normal vehicles. The male group shows higher mean scores for both statements, as shown in Table 3. Meaning that they perceive that it will be easier for them to learn to operate robotaxis and that robotaxis will make them feel safer than normal vehicles. The Table shows that males also show greater agreement with the statement that robotaxis will result in improved fuel efficiency and an increased value of travel time.

Statement	Mean score Female	Male
Assuming robotaxis come into use, I intend to use them	3,67	4,11
I find robotaxis somewhat frightening	3,49	2,20
It will be easy for me to learn to operate robotaxis	3,56	4,09
Robotaxis will make me feel safer than normal vehicles	2,79	3,42
Improved fuel efficiency	3,44	3,93
Increased value of travel time	3,52	4,04

TABLE 3 - GENDER MEAN SCORES

5.4.2 Age

Comparing the mean score of the answers to age groups, differences can be seen. Overall for all questions, the age group 60 and above indicates the highest mean score (M= 3.74), followed by the age group from 39 to 59 (M= 3.56), the age group from 15 to 18 (M= 3.48), and the age group from 19 to 39 (M= 3.34). However, the results have to be looked at carefully, as the age group sample from 15 to 18 is relatively small, with three respondents. Table 4 shows the mean scores of each group's answers for a few statements which are of interest to this research. From the Table, the youngest and oldest age groups show the greatest intention to use robotaxis, followed by those between the ages of 40 to 59. The age group between 19 to 39 showed that they are most frightened by robotaxis, followed by the age group between 40 and 59 and the 60 and above age group. The age group from 15 to 18 showed the largest agreement with the statement "It will be easy for me to learn to operate robotaxis," while the 60 and above age group showed the least agreement. As shown in section 5.3.5, there is no significant difference in the perception of the different age groups on the possible impact of robotaxis resulting in improved access to mobility. However, the youngest group, followed closely by the oldest group, showed the highest mean scores in their answers to this statement. There is also no significant difference in the perception of the different age groups on the possible safety impacts of robotaxis, as shown in section 5.3.4. Nonetheless, the results can not be generalized due to the small sample size.

	Mean score			
Statement	15-18	19-39	40-59	60+
Assuming robotaxis come into use, I intend to use them	4,33	3,74	4,02	4,14
I find robotaxis somewhat frightening	2,00	3,00	2,83	2,36
It will be easy for me to learn to operate robotaxis	4,00	3,76	3,92	3,71
Improved access to mobility	4,33	4,00	4,17	4,29
Increased public safety and health	4,33	3,57	3,67	4,21
Fewer accidents	4,00	3,66	3,63	3,86

TABLE 4 - AGE MEAN SCORES

5.4.3 Highest degree obtained

When comparing the mean score of individuals' answers with different levels of education, numerous differences can be seen. Overall for all questions, the group of individuals with a master's degree indicated the lowest mean score (M= 3.32), followed by the group of individuals with a bachelor's degree (M= 3.45), the group of individuals with a high school degree (M= 3.47), the group of individuals with a doctorate degree (M= 3.53), the group of individuals with no degree (M= 3.76) and the group of individuals with another degree than the ones mentioned (M= 3.84). Individuals with a doctorate degree show the largest intention to use robotaxis, assuming they come into use, followed by those with a different degree than those mentioned. The individuals with a master's degree show the lowest intention to use robotaxis, assuming they come into use.

	Mean score					
Statement	No degree	Other	High school	Bachelor's	Master's	Doctorate
Assuming robotaxis come into use, I intend to use them	4,00	4,29	3,82	3,98	3,68	4,57

TABLE 5 - HIGHEST DEGREE OBTAINED MEAN SCORES

5.4.4 Working status

Numerous differences can be seen when comparing the mean score of the answers by different working statuses. Overall for all questions, students indicate the lowest mean score (M= 3.33), followed by unemployed (M= 3.37), employed (M= 3.47), and retired (M= 3.80). Table 6 shows the mean scores of each group's answers for a few statements which are of interest to this research. Out of the four groups, the retired residents of Zagreb showed the largest intention to use robotaxis assuming robotaxis come into use. In contrast, the other groups showed exactly the identical mean scores. They also showed the largest agreement (M= 4.73) with the statement "If robotaxis are cheaper, I will prefer them over public transport," while the unemployed residents showed the least agreement with a mean score of 4.00. The student group shows the largest mean score for the statements "Robotaxis will result in the disruption of labor markets," "Robotaxis will result in the creation of new jobs," and "Robotaxis will result in the destruction of existing jobs." The unemployed group shows the most skepticism towards robotaxis creating new jobs and robotaxis resulting in the disruption of labor markets.

In contrast, the retired group shows the least agreement with the statement, "Robotaxis will result in the destruction of existing jobs."

	Mean score			
Statement	Unemployed	Student	Employed	Retired
Assuming robotaxis come into use, I intend to use them	3,83	3,83	3,83	4,55
If robotaxis are cheaper I will prefer them over public transport	4,00	4,41	4,26	4,73
Destruction of existing jobs	3,67	4,15	3,51	3,27
Creation of new jobs	2,67	3,10	2,82	3,00
Disruption of labor markets	3,33	3,78	3,45	3,64

TABLE 6 - WORKING STATUS MEAN SCORES

5.4.5 Working in transportation sector

As shown in section 5.3.3, there is no significant difference in the perception of the disruption of labor markets impact among the residents working in the transportation sector and the residents not working in it in Zagreb. While the group of individuals working in the transportation sector showed a larger mean score for the destruction of jobs and the creation of new jobs, the difference in the mean score is small. However, the two groups showed great differences (larger than 0.5 in the mean score) in their intention to use robotaxis and their agreement with the statement "Robotaxis will increase my social status." The mean scores for both statements were larger for the group not working in the transportation sector, as shown in Table 7.

	Mean score	
Statement	Not working in transportation sector	Working in transportation sector
Assuming robotaxis come into use, I intend to use them	3,94	3,17
Robotaxis will increase my social status	2,51	1,50
Destruction of existing jobs	3,68	3,42
Creation of new jobs	2,91	2,75
Disruption of labor markets	3,50	4,08

TABLE 7 - WORKING IN TRASNPORTATION SECTOR MEAN SCORES

5.4.6 Distance from city center

As shown in section 5.3.1, there was no significant difference in the perception of the impact of increased value of travel time between the residents living close to the city center and living far from the city center. The two groups did not show any great differences in their perception of the remaining impacts or agreement with any other statements. Their intention to use robotaxis, assuming they come into use, shows a difference in the mean score of 0.11.

5.4.7 Main mode of transportation

Comparing the mean score of individuals' answers with different main modes of transportation, differences can be seen. However, the results have to be looked at carefully, as the sample of individuals who use human-powered and motor-powered assisted vehicles as their main mode of transportation and those who instead walk by foot is relatively small, with four and six respondents respectively. Table 8 shows the mean scores of each group's answers for a few statements which are of interest to this research. Overall for all questions, the group of individuals using personal motor vehicles as their main mode of transportation showed the highest mean score (M= 3.49), followed closely by the group of individuals using taxi or ridesharing services as their main mode of transportation (M= 3.42) and the group of individuals using human-powered and motor-powered assisted vehicles as their main mode of transportation (M= 3.40). The group of individuals using public transportation as their main mode of transportation showed a lower overall mean score (M= 3.37), followed closely by the group of individuals going by foot rather than using any of the transportation methods mentioned, which showed the lowest mean score out of all groups (M= 3.36). When looking at the mean scores of the answers shown in Table 8, the individuals using human-powered or motor-powered vehicles as their main mode of transportation showed the largest intention to use robotaxis out of the five groups. This group was followed by those using a taxi or ride ridesharing services as their main mode of transportation. The individuals using public transportation showed the lowest intention to use robotaxis. Nonetheless, they showed a large agreement (M= 4,19) with the statement "If robotaxis are cheaper I will prefer them over public transport." While this is true, the same group showed that they find robotaxis the most frightening, followed by the group of individuals who use taxi or ridesharing services as their main mode of transportation. Similarly, these two groups showed the lowest mean score for the statements "Robotaxis will make me feel safer than normal vehicles" and "Robotaxis will result in increased public safety and health." However, for the statement "Robotaxis will result in fewer accidents," the group of individuals using public transportation and individuals who rather walk showed the lowest mean scores. The individuals who use taxi or ridesharing services as their main mode of transportation show the highest mean scores for the statements "Robotaxis will result in reduced transport-related physical activity" and "I will be proud if people see me using a robotaxi." While the mean score of individuals who use taxi or ridesharing services as their main mode of transportation is 3.84 for the statement, all remaining groups showed mean scores lower than three.

	Mean score				
Statement	Walking	HP or MP vehicle	PM vehicle	PT	Taxi or RS
Assuming robotaxis come into use, I intend to use them	4,00	4,25	3,94	3,53	4,09
I find robotaxis somewhat frightening	2,67	2,00	2,72	3,34	3,27
If robotaxis are cheaper I will prefer them over public transport	4,00	4,25	4,40	4,19	4,18
I will be proud if people see me using a robotaxi	2,00	2,25	2,95	2,84	3,82
Robotaxis will make me feel safer than normal vehicles	3,17	3,75	3,13	2,94	2,91
Reduced transport-related physical activity	3,67	4,00	3,72	3,59	4,36
Increased public safety and health	3,83	4,00	3,74	3,47	3,45
Fewer accidents	3,33	4,00	3,80	3,28	3,73

TABLE 8 - MAIN MODE OF TRANSPORTATION MEAN SCORES

5.4.8 Knowledge level about AVs

When comparing the mean score of individuals' answers with different levels of knowledge on AVs, numerous differences can be seen. Overall, for all questions, the group "moderately knowledgeable" indicates the lowest mean score (M= 3.41), followed by "not knowledgeable at all" and "slightly knowledgeable" M= 3.42), and "somewhat knowledgeable" and "very knowledgeable" (M= 3.49). Table 9 shows the mean scores of each group's answers for a few statements which are of interest to this research. As shown in section 5.3.6, there is a significant difference between the groups in their intention to use robotaxis, assuming they come into use. To be specific, the difference is between the first and fourth group or "not knowledgeable at all" and "moderately knowledgeable" group, with the "moderately knowledgeable" group indicating a larger behavioral intention to use robotaxis. When paying attention to the statement "I find robotaxis somewhat frightening," a gradual decline in the agreement with the statement can be seen as the level of knowledge increases. This means that individuals with more knowledge showed less fear of robotaxis than individuals with less knowledge. A similar observation can be made for the statement "It will be easy for me to learn to operate robotaxis" with the group "not knowledgeable at all" indicating the lowest mean score (M= 3.42) and the "very knowledgeable" group indicating the largest mean score (M= 4.13). As the level of knowledge increases, so does the individual's perception of how easy it will be for them to learn to operate robotaxis. The statement "Using robotaxis will create cyber security and data privacy issues" shows a steady incline in the mean score from the "slightly knowledgeable" group to the "very knowledgeable" group. The "not knowledgeable at all" group shows a mean score of 3.00 and thus a higher mean score than the "slightly knowledgeable" group.

	Mean score				
Statement	1	2	3	4	5
Assuming robotaxis come into use, I intend to use them	3,21	3,96	3,89	4,22	3,94
I find robotaxis somewhat frightening	3,42	3,29	2,76	2,56	2,38
Using robotaxis will create cyber security and data privacy issues	3,00	2,79	3,04	3,28	3,31
It will be easy for me to learn to operate robotaxis	3,42	3,43	3,94	4,06	4,13

TABLE 9 - KNOWLEDGE ABOUT AVS MEAN SCORES

5.4.9 Disability

When comparing the mean scores of the answers of individuals who have a disability that prevents them from driving or makes it difficult for them to drive and those who do not have a disability that prevents them from driving or makes it difficult for them to drive, several differences can be seen. However, the results have to be looked at carefully. The sample of individuals who have a disability that prevents them from driving or makes it difficult for them to drive has only five respondents. The largest difference can be seen in the agreement with the statement "Robotaxis will result in an increased move to city centers from suburbs," as shown in Table 10. However, the most notable differences in the mean scores are for the statements

"Assuming robotaxis come into use, I intend to use them," and "Robotaxis will result in an improved access to mobility." As seen from Table 10, the individuals who have a disability that prevents them from driving or makes it difficult for them to drive show a greater intention to use robotaxis and show a larger agreement with the statement "Robotaxis will result in an improved access to mobility." Table 10 shows that the remaining statements also received larger agreement from the group of individuals with a disability that prevents them from driving or makes it difficult to drive.

	Mean score	
Statement	No disability	Disability
Assuming robotaxis come into use, I intend to use ther	3,86	4,40
It will be easy for me to learn to operate robotaxis	3,80	4,40
Robotaxis will make me feel safer than normal vehicles	3,08	3,60
Decreased noise pollution	3,65	4,80
Decreased light pollution	3,05	3,80
Decreased quality of stream water	2,69	3,20
Decreased greenhouse gas emissions	3,65	4,40
Improved fuel efficiency	3,64	4,80
Increased affordability of taxi services	3,84	4,40
Creation of new jobs	2,88	3,60
Repurposing of parking spaces and road space	3,70	4,60
Decreased demand for parking spaces	4,09	4,60
Increased move to suburbs from city centers	3,11	4,00
Increased move to city centers from suburbs	2,73	4,40
Increased value of travel time	3,75	4,60
Reduced transport-related physical activity	3,72	4,60
Increased recreational travel	3,56	4,20
Improved access to mobility	4,07	4,80
Increased public safety and health	3,65	4,40

TABLE 10 - DISABILITY MEAN SCORES

5.4.10 Posses a vehicle with autonomous features

Comparing the perception of the residents who own a vehicle with autonomous features, those who do not, and those who do not possess a vehicle, differences can be seen in the mean score of their answers for the statements shown in Table 11. Those who do not own a vehicle show the largest intention to use robotaxis, followed by those who own a vehicle with autonomous features and those who own a vehicle without autonomous features. The group of residents who do not own a vehicle with autonomous features show the largest agreement with the statement "I find robotaxis somewhat frightening," followed by those who do not own a vehicle and those who own a vehicle with autonomous features. Residents who own a vehicle with autonomous features show the largest agreement with the remaining three statements "Robotaxis will make me feel safer than normal vehicles," "Robotaxis will result in increased public safety and health," and "Robotaxis will result in fewer accidents." In contrast, those who do not own a vehicle show the lowest agreement. It could be said that those who are already familiar with autonomous features show a more positive standpoint towards robotaxis than those not familiar with them. However, the results can not be generalized as the sample size is not large enough.

	Mean score		
Statement	I do not own a vehicle	No	Yes
Assuming robotaxis come into use, I intend to use them	4,00	3,69	3,94
I find robotaxis somewhat frightening	2,94	3,18	2,69
Robotaxis will make me feel safer than normal vehicles	3,00	3,00	3,17
Increased public safety and health	3,37	3,60	3,81
Fewer accidents	3,19	3,64	3,85

TABLE 11 - POSSES A VEHICLE WITH AUTONOMOUS FEATURES MEAN SCORES

5.4.11 Croatian citizen

When comparing the answers of Croatian residents and those who are not, several differences can be seen when looking at the mean scores. However, the results have to be looked at carefully, as the sample of individuals who are not Croatian citizens has only ten respondents. The largest difference can be seen in the agreement with the statement "Robotaxis will result in increased recreational travel," as shown in Table 12. However, the most notable differences in the mean scores are for the statements: "Assuming robotaxis come into use, I intend to use them," "I find robotaxis somewhat frightening," "Robotaxis will increase my social status," and "It will be easy for me to learn to operate robotaxis." For all statements in Table 12 and the ones mentioned previously, Croatian citizens show lower mean scores or lower agreement than those who have another country's citizenship. This could mean that other countries' citizens have a more positive attitude towards robotaxis than Croatian citizens. However, the results cannot be generalized due to the small sample size.

	Mean score	
Statement	Other countries' citizen	Croatian citizen
Assuming robotaxis come into use, I intend to use them	4,30	3,85
I find robotaxis somewhat frightening	3,40	2,83
Using robotaxis will create cyber security and data privacy issues	3,70	3,03
Robotaxis will increase my social status	3,30	2,37
It will be easy for me to learn to operate robotaxis	4,40	3,78
Improved fuel efficiency	4,30	3,64
Increased move to suburbs from city centers	3,90	3,09
Increased value of travel time	4,40	3,73
Reduced travel time	4,30	3,64
Increased recreational travel	4,60	3,51
Increased public safety and health	4,30	3,64

TABLE 12 - CROATIAN CITIZEN MEAN SCORE

5.4.12 Lived abroad

When comparing the answers of individuals who have lived abroad and who have not, only one difference larger than 0.5 in the mean score can be noticed. The group of individuals who have lived abroad shows a higher mean score for the statement "Robotaxis will result in improved fuel efficiency" hat those who have not lived abroad. Both groups show a very similar intention to use robotaxis once they come into use, as shown in Table 13.

	Mean score	
Statement	Lived abroad	Have not lived abroad
Assuming robotaxis come into use, I intend to use them	3,90	3,86
Improved fuel efficiency	4,06	3,43

TABLE 13 - LIVED ABROAD MEAN SCORE

5.4.13 Introvert and extrovert

Individuals who consider themselves introverts and those who consider themselves extroverts did not show any great differences in their perception of the impacts or agreement with any other statements. Even in their willingness to share robotaxis with other people, the difference in the mean score of their answers was minimal.

5.4.14 Past motor vehicle accident

The group of residents who had a motor vehicle accident in the past and those who did not have a motor vehicle accident did not show any great differences in their perception of the impacts when comparing the mean scores of their responses.

5.4.15 Monthly household income

When comparing the mean score of individuals' answers with different monthly household incomes, several differences can be seen. However, the results have to be looked at carefully, as the sample of individuals with a household income of 5.001 to 10.000 Euros and 10.001 and more Euros is relatively small. Table 14 shows the mean scores of each group's answers for a few statements which are of interest to this research. Overall for all questions, the group of individuals who have a monthly household income of 5.001 to 10.000 Euros showed the highest mean score (M= 3.71), followed by the group of individuals who have a monthly household income of 10.001 Euros and more (M= 3.51), the group of individuals who have a monthly household income of 0 to 1.000 Euros (M= 3.48), the group of individuals who have a monthly household income of 3.001 to 5.000 Euros (M= 3.45) and the group of individuals who have a monthly household income of 1.001 to 3.000 Euros (M= 3.38). The group of individuals with a monthly household income of 5.001 to 10.000 Euros shows the greatest intention to use robotaxis, assuming they come into use. In comparison, the group of individuals with a monthly household income of 1.001 to 3.000 Euros shows the lowest intention to use robotaxis, assuming they come into use. The groups of individuals who have a monthly household income of 3.001 to 5.000 Euros and 10.001 Euros or more show the largest agreement with the statement "If robotaxis are cheaper, I will prefer them over public transport." In comparison, the group of individuals who have a monthly household income of 0 to 1.000 Euros shows the least agreement with this statement. However, the differences are minimal. The low agreement of the group of individuals who have a monthly household income of 0 to 1.000 Euros with the previous statement might result from the fact that the same group shows the least agreement with the statement "Robotaxis will result in an increased affordability of taxi services." The individuals who have a monthly household income of 5.001 to 10.000 Euros show the largest agreement with the statement. The statement "Robotaxis will result in the destruction of existing jobs" shows that the lower the household income group, the higher the mean score or agreement with the statement, with the group of individuals who have a monthly household income of 10.001 Euros and more being an outlier. As mentioned previously, this might be that the sample for this group is too small. A similar result can be seen in the statement "Robotaxis will result in the disruption of labor markets" in Table 14.

	Mean score				
Statement	0-1.000€	1.001-3.000€	3.001€-5.000€	5.001€-10.000€	10.001€+
Assuming robotaxis come into use, I intend to use them	3,83	3,82	4,00	4,45	4,10
If robotaxis are cheaper I will prefer them over public transport	4,24	4,25	4,50	4,36	4,50
Increased affordability of taxi services	3,55	4,02	4,06	4,45	3,90
Destruction of existing jobs	4,21	3,52	3,50	3,00	4,20
Creation of new jobs	3,10	2,90	2,78	2,82	2,40
Disruption of labor markets	3,86	3,35	3,72	3,00	3,90

TABLE 14 - MONTHLY HOUSEHOLD INCOME MEAN SCORE

5.4.16 Monthly alcohol consumption when going out

Differences can be seen when comparing the mean score of individuals' answers with different monthly alcohol consumption when going out. Table 15 shows the mean scores of each group's answers for a few statements which are of interest to this research. Overall for all questions, the group of individuals who do not consume alcohol when going out showed the highest mean score (M= 3.62), followed by the group of individuals who consume alcohol once to four times a month when going out and (M= 3.44) and the group of individuals who consume alcohol more than five times (M= 3.22). The individuals not consuming alcohol when going out showed the greatest intention to use robotaxis. However, the other two groups follow closely. The individuals not consuming alcohol when going out also showed the largest agreement with the statements "Robotaxis will make me feel safer than normal vehicles," "Robotaxis will result in increased public safety and health," and "Robotaxis will result in fewer accidents" when looking at the mean scores in Table 15. In contrast, the individuals consuming alcohol five or more times a month when going out showed the least agreement with all three statements.

	Mean score		
Statement	0	1 to 4	5+
Assuming robotaxis come into use, I intend to use them	4,03	3,86	4,00
Robotaxis will make me feel safer than normal vehicles	3,35	3,08	3,00
Increased public safety and health	3,94	3,65	3,38
Fewer accidents	3,71	3,73	3,25

TABLE 15 - MONTHLY ALCOHOL CONSUMPTION WHEN GOING OUT MEAN SCORE

5.5 Discussion of findings

The analysis in the previous chapter presented several interesting findings. This chapter will look at how these findings compare to previous literature and research.

This research had three main objectives. The first one was to identify how the residents perceive the possible effects of robotaxis on the economy, society, and environment and to what level they agree with the statements or questions. These should then further be compared with the different socio-demographic groups. The second objective was to identify what percentage of the residents of Zagreb, Croatia, are acceptive or reluctant toward robotaxis roaming the streets of their city. The third and last main objective was to help government officials and policymakers adjust new or already existing regulations or policies while considering the residents' perceptions. Automobile manufacturers of autonomous vehicles (AVs) and robotaxis may also utilize these factors to address customer concerns and meet their demands throughout the development phase.

The findings of the study indicated that the people of Zagreb agree with most of the statements made about the impacts, except "Robotaxis will result in the creation of new jobs," which showed a mean score of 2.90, "Robotaxis will result in increased greenhouse gas emissions," which showed a mean score of 2.57, and "Robotaxis will result in decreased quality of stream water," which showed a mean score of 2.71. The disagreement or skepticism with the statement that "Robotaxis will result in the creation of new jobs" is in line with the findings of Clark et al. (2017) and Marshall (2017), who point out that AVs will replace many lower-skilled professions as well as drivers in the public sector. However, to promote the use of robotaxis and leave a positive impression on the residents, the government needs to assure the individuals whose jobs are affected or destroyed by robotaxis will receive an opportunity to work another job or upskill or reskill themselves. For instance, many current taxi drivers, which will be affected the most, could upskill themselves to become car mechanics or an engineer. However, the process from one job to another has to be made as easy as possible and with the government's full support. The robotaxi manufacturers can also play a significant role by providing these individuals with new jobs in their companies.

Taking a further look at the questions asking about the residents' attitudes, the residents have a neutral standpoint towards robotaxis, making them feel safer than normal vehicles and robotaxis creating cyber security and data privacy issues. These results are similar to the findings made by M. Liu et al. (2020), which showed that Chinese residents think that robotaxis will make them feel safer than normal vehicles, with a mean score of 3.52. Panagiotopoulos & Dimitrakopoulos (2018) also showed that 44% of the respondents will feel safer on their driving trips and that 31% have concerns about AVs' system security and data privacy. While the residents of Zagreb believe that it will be easy for them to learn to operate robotaxis, the Chinese residents perceive that it will be somewhat easier for them to learn to operate robotaxis with a mean score of 4.04 (M. Liu et al., 2020). While the residents of Zagreb disagree that they will be proud if people see them using robotaxis, Chinese residents indicate that they would feel proud if they see them using a robotaxi (M= 3.56) (M. Liu et al., 2020). While the residents of Zagreb indicate that they intend to use robotaxis, the Chinese residents show a higher mean score of 4.18 in their intention to use robotaxis. However, it has to be considered that China has made great steps towards introducing and developing robotaxis. The residents of China most likely have more knowledge of AVs than the residents of Zagreb, as the topic is more talked about. The distribution of the knowledge levels about AVs can be seen in Figure 23, which shows that only 16 individuals are very knowledgeable about AVs and 24 believe that they have no knowledge at all about AVs. As can be seen from Figure 23, as well as the mean score of the knowledge level about AVs, which is 2.95 and thus lower than the average, there is a clear need to educate the residents of Zagreb on AVs and robotaxis; as for them to gain the most benefits from AVs and robotaxis and become more acceptive towards robotaxis roaming the streets of Zagreb. This is also confirmed in section 5.3.6, which shows a significant difference in the behavioral intention to use robotaxis, assuming they come into use, between the different knowledge groups. There was a significant difference between the knowledge groups "not knowledgeable at all" and "moderately knowledgeable." The very knowledgeable group did not indicate any significant difference. However, this might be due to the small sample size of 16 respondents. These findings are in line with those of Ward et al. (2017), who suggested that people are far less likely to accept a new technology if they see it as very dangerous, do not know much about it, and do not trust the organization that produces it. Regardless of the behavioral intention to use robotaxis of the residents of Zagreb being lower than the one of Chinese residents, the residents of Zagreb still showed an intention to use robotaxis, which was not expected as Croatians were shown to be skeptical of new things very often, as previously discussed in chapter 1.2. An interesting finding was that the price greatly affected the choice of transportation, which can also be seen in Table 1 by looking at the mean score. This would mean that if robotaxis are genuinely more affordable than public transport as many anticipate (*Urbane Mobilität und autonomes Fahren im Jahr 2035*, n.d.), the residents of Zagreb may prefer using robotaxis over public transportation. This would mean that public transit will lose great revenue and that public transportation may look different than it does today, especially with the residents of Zagreb indicating that they are willing to share their robotaxi with others. Thus, it is of great importance for the government to follow the development and the prices of robotaxis closely to gain a new source of revenue, replacing that of public transportation, if necessary. While the residents of Zagreb indicate that they do not feel frightened by robotaxis, the issue of a large number of people being frightened might arise once the topic becomes more up to date and closer to the introduction of robotaxis in Zagreb, as the media tends to focus on the dangers and disadvantages rather than on the advantages. If this happens, or better said, when this happens, the government needs to be ready to calm down the residents and assure them that they are not being put in danger nor are robotaxis only going to lead to disadvantages. Thus, it is of great importance to address known challenges as soon as possible, such as the cyber security and data privacy issues present at the moment.

When analyzing the responses of the residents by the various socio-demographic groups, some noteworthy observations can be made. The different socio-demographic groups will be looked at individually and compared.

There was a significant difference in the behavioral intention to use robotaxis between male and female residents of Zagreb, with the male group showing a greater intention to use robotaxis. The male group also believes that it will be easier for them to learn to operate robotaxis than the female group does. The male group indicates that they are less frightened of robotaxis than females. The findings align with those of Hohenberger et al. (2016), who claimed that women and men differ in their willingness to use AVs. The male group might find it easier to operate robotaxis and are less frightened of them, possibly because men traditionally tend to be more interested in cars than women are (Cresswell, 2016).

The age groups showed no large differences in their intention to use robotaxis. However, it can be seen that the higher the mean score for the statement "I "find robotaxis somewhat frightening" the lower the behavioral intention to use robotaxis. While one would believe that an individual having more knowledge about AVs would mean that he is less frightened (Ward et al., 2017), this correlation can not be seen when looking at the different knowledge levels of the age groups. In fact, the higher the knowledge level mean score of an age group, the more the age group is frightened of robotaxis or, the lower the intention to use them. Out of all age groups, the residents of Zagreb who are 60 and above showed the lowest mean score for the statement "It will be easy for me to learn to operate robotaxis" and thus the most concern, which is in line with Thomas et al. (2020) findings, which showed that the older age groups were more concerned with learning to use the vehicles. As shown in section 5.3.4, there is no significant difference in the perception of the safety impacts of robotaxis on the city of Zagreb among the residents' different age groups, as suggested by Thomas et al. (2020). Moreover, there is no significant difference in the perception of the impact of robotaxis on the access to mobility in the city of Zagreb among the residents of different age groups. However, the youngest and oldest age groups show the largest agreement, which could mean that they see this as one of the benefits of their daily life, as suggested by Bennett et al. and Pettigrew et al. (2019; 2018, as cited in Singleton et al., 2020).

While the working status did not show many differences between the groups, some interesting observations can be made, such as the retired group indicating the largest intention to use robotaxis, while all other three groups show a very similar intention to use robotaxis. Another interesting observation is that the unemployed individuals show the least agreement with the statement "If robotaxis are cheaper, I will prefer them over public transport," even though it would be expected that they will look for the cheapest option available, especially since the 83.33% do not have a household income higher than 3.000 Euros and the group not indicating that they are frightened by robotaxis.

Robotaxis is expected to greatly affect the transportation sector and any jobs related to transportation (Davidson & Spinoulas, 2015). The greatest impacts are expected to be seen on public transit and taxi services, as many drivers will be replaced with AVs, and many individuals will be changing their transportation habits (Clark et al., 2017; Clements & Kockelman, 2017). The findings indicate that those working in the transportation sector agree with the statement "Robotaxis will result in the disruption of labor markets" and are more skeptical of robotaxis creating new jobs. However, when running the significance test, no significant difference in their perception of the disruption of labor markets impact could be seen.

AVs are expected to increase urban sprawl, as those who want to move further away from cities but do not want to lose out on valuable time can do so now, with robotaxis or AVs expected to increase the value of travel time considerably. However, some individuals may also be inclined to return to or move to city centers with AVs or robotaxis being expected to create a safer urban environment with less noise and pollution. Nonetheless, as the travel time for those living further from the city center tends to be longer for everyday activities, it was expected that they would show a larger agreement with the statement "Robotaxis will result in an increased value of travel time." While the residents living far away from the city center showed a larger agreement, there was no significant difference in their responses. This means that both groups perceive that they could greatly benefit from an increased value of travel time.

When comparing the different main modes of transportation groups, several interesting findings can be observed. Even though the individuals using public transportation indicate that they are somewhat frightened by robotaxis, they show a willingness to change their main mode of transportation if robotaxis were cheaper. Clark et al. (2017) and Clements & Kockelman (2017) pointed out that people might change their transportation habits or that public transportation, the way we know it today, may look different in the future. Thus, it will be of great importance for the government to develop several plans for any possible scenario from the introduction of robotaxis. Individuals using taxis or ridesharing services as their main mode of transportation showed that they would be the proudest if people see them using robotaxis out of all groups and showed the least agreement with the statement "Robotaxis will make me feel safer than normal vehicles," followed by the group of individuals using personal motor vehicles as their main mode of transportation.

According to Ward et al. (2017), the greater a person's understanding of technology, the more correctly they may be able to assess it. If people see technology as very dangerous, do not know much about it, and do not trust the organization that produces it, they are less likely to accept it. The findings of the analysis confirm this. The higher the knowledge level was, the higher the intention to use robotaxis, except for the "very knowledgeable" group, which shows a somewhat smaller mean score than the "moderately knowledgeable" group. Furthermore, the higher the knowledge level, the less frightened one is, and the easier it will be to learn to operate robotaxis. Furthermore, from the data collected, it can be seen that the individuals who own a car vehicle with autonomous features show a higher degree of knowledge (M= 3.22) than those who do not own a vehicle with autonomous features (M= 2.56) and those who do not own a vehicle at all (M= 2.74). Thus, the individuals who own a vehicle with autonomous features and are somewhat familiar with some level of autonomy show that they are the least frightened by robotaxis and believe that robotaxis will make them feel safer than the other groups do. They also show the largest agreement with the statements "Robotaxis will result in increased public safety and health" and "Robotaxis will result in fewer accidents." Nonetheless, those who do not own a vehicle show a greater intention to use robotaxis.

As already mentioned previously, Bennet et al. and Pettigrew et al. (2019; 2018, as cited in Singleton et al. (2020) showed that children, the elderly, and people with specific physical and intellectual disabilities would greatly benefit from improved access to mobility as a result of robotaxis. The findings show that individuals who have a disability that prevents them or makes it difficult for them to drive show a larger agreement with the statement "Robotaxis will result in an improved access to mobility." Thus, it can be said that these findings are in line with the expected impact shown in the previous literature.

As stated at the beginning of this study, Croatians tend to view new concepts with skepticism; therefore, it was anticipated that they would show reluctance to the introduction of robotaxis. While this expectation was proved wrong, Croatians showed less intention to use robotaxis than other countries' citizens. Similar results can also be seen for those who have lived abroad and those who have not, with those who have lived abroad indicating a slightly greater intention to use robotaxis.

The comparisons between extroverts and introverts, those who had a motor vehicle accident in the past and those who did not the different monthly household income groups, and the different monthly alcohol consumption when going outgroups did not allow for any conclusions to be drawn, as there were no patterns observable in the data. However, this might be due to the sample size being smaller for these questions than for the research as a whole.

This study showed that PU and PEU have a significant impact on individuals to use robotaxis once they become available. PU had a significant positive impact on the BI to use robotaxis, and its impact was stronger than that of any other construct. This suggested that those who feel robotaxis will be useful are more likely to show acceptance. These results are in line with the findings of M. Liu et al. (2020), Panagiotopoulos & Dimitrakopoulos (2018), and Zhu et al. (2020). Therefore, government officials can focus on promoting the benefits or the usefulness of robotaxis to achieve a larger acceptance or BI to use them. PEU also had a significant positive impact on the BI to use robotaxis, but with a smaller influence than PU; therefore, this result is in line with the findings of M. Liu et al. (2020) and Panagiotopoulos & Dimitrakopoulos (2018). Therefore, robotaxi and AV manufacturers should focus on producing robotaxis or AVs that are easy to use. While PT and SI were shown not to be significant to the model, they indicate a negative impact on the BI to use robotaxis. The results are not in line with the findings of M. Liu et al. (2020) and Panagiotopoulos & Dimitrakopoulos (2018). Moreover, when looking at every variable's relationship with the BI individually, three variables show to have a significant impact on the BI to use robotaxis. In this instance, these were "Robotaxis will result in reduced travel time" and "I find robotaxis somewhat frightening," which showed a significant negative impact on the BI to use robotaxis, and "If robotaxis are cheaper, I will prefer them over public transport," which showed a significant positive impact on the BI to use robotaxis. This means that the government and car manufacturers together need to reassure and comfort the residents of the harmlessness and safety of robotaxis and avoid using the benefit of reduced travel time to promote the use of robotaxis. While the statement "If robotaxis are cheaper I will prefer them over public transport" showed a positive impact on the BI, the government needs to be very careful with promoting this benefit, as this could greatly affect the use of public transportation as mentioned previously.

5.5.1 Recommendations for the development of AV strategies in Croatia

After conducting primary and secondary research, a set of recommendations are provided, which can be used by government officials or policymakers to ease the adoption of robotaxis or AVs and achieve a large-scale implementation and acceptance.

5.5.1.1 Recommendation 1: National AV plan

Develop a national plan for autonomous vehicles consistent with broader economic strategies that include physical goods and services. To develop a national plan, it is essential that all stakeholders be considered and involved. The national strategy should clearly articulate the goals and vision for AVs and include specific objectives, initiatives, roles, and timeframes. Among the measures a government might take are the following:

- Create technological development skills and education programs to educate all stakeholders on AVs and robotaxis and encourage cooperation.
- Raise knowledge and awareness of AVs via formal and informal education.
- Promote the benefits and usefulness of robotaxis and AVs.
- Identify current AV and robotaxi projects and initiatives. If they are sustainable or strategically and economically intelligent, aid them in achieving their objectives with available funds or by providing testbeds.
- Create policies and regulations and apply standards to foster innovation, attract new investors to improve capital inflows, and support domestic markets.
- Develop regulations that determine who is accountable and liable for accidents or injuries and make the respective insurance changes necessary.
- Increase government investment in private sector initiatives to enhance government and private sector collaboration. Whereas the private sector increases its budget for innovation and transformation.
- Provide individuals affected by job losses with the opportunity to reskill themselves and employ themselves elsewhere.
- Help residents who cannot afford AV services at first by either financing access to AVs or operating their fleet. Owning a fleet of robotaxis would be immensely beneficial for the government, as there is a real possibility that public transportation revenues and usage will plummet.

5.5.1.2 Recommendation 2: Connectivity

Increase network coverage and connectivity, and promote the development of mobile broadband networks. If the latency is not sufficiently low, connectivity issues may become one of the major challenges to the adoption and functioning of AVs and robotaxis. Thus, it would be good to introduce 5G everywhere and 6G once it becomes available.

5.5.1.3 Recommendation 3: Taxation

The government should provide stable and transparent taxation systems that reduce uncertainty and risk without discouraging investment and using robotaxis or AVs. For instance, instead of taxing autonomous vehicle usage per mile due to improved fuel efficiency, develop and invest in electric charging stations. If AV or robotaxi usage were to be taxed, this would only create larger social inequalities, as not everyone will be able to afford this service anymore.

5.5.1.4 Recommendation 4: Data protection and privacy

Implement mandatory data protection and privacy laws and ensure that these are used. The rules governing the collection, storage, and transfer of data must be appropriate to increase AV and robotaxi adoption. The Croatian personal data protection agency, the courts, and the police should be responsible for enforcing the laws. To make the potential users of robotaxis less frightened, they should be provided with the information as to where their data is stored, what it is used for, and by whom it is used.

5.5.1.5 Recommendation 5: Infrastructure

The Croatian or Zagreb road infrastructure is not ready for autonomous vehicles yet (Bičak, 2022). Some steps that should be taken are listed below:

- Maintain road signs and markings continuously and of higher quality than currently.
- Introduce more smart or IoT devices throughout the city to fully utilize the benefits of AVs and CAVs.
- Build more EV charging stations to accommodate robotaxis and other EVs. If owned by the government, this will also serve as a new source of revenue.
- Develeop a plan on how to repurpose the newly made available space sustainably. Preferably, create more green areas, which will promote public health by encouraging physical activity and reducing GHG emissions.

6 CONCLUSION

6.1 Summary

Autonomous technologies have the potential to improve transportation significantly. As the most significant barrier to the large-scale adoption of robotaxis can be psychological rather than technological or regulatory, it is crucial to understand consumers' intention to use robotaxis. This study employed a theoretical framework based on the TAM and the UTAUT to discover if consumers plan to use robotaxis once they come into use and identify the primary variables and constructs that influence their acceptance. The study also looks at how the perceptions of different socio-demographic groups differ on these influencing variables to determine if any significant differences have to be paid attention to. These variables included statements on the possible societal, economic, and environmental impacts of robotaxis and personal attitudes toward robotaxis. The findings indicated that the male residents of Zagreb show a greater intention to use robotaxis than the female residents of Zagreb. Furthermore, the findings showed a significant difference in the behavioral intention to use robotaxis based on the knowledge level. There is a significant difference between the knowledge groups "not knowledgeable at all" and "moderately knowledgeable." The findings also showed that PU and PEU have a significant impact on the BI to use robotaxis, with PU having the strongest impact. SI and PT were shown not to have a significant impact. Based on the findings, some recommendations were provided to reach a large-scale adoption and acceptance of AVs and robotaxis. Some of the more relevant recommendations included: creating technological development skills and education programs to educate all stakeholders on AVs and robotaxis and encourage their cooperation, raising knowledge and awareness of AVs via formal and informal education, and promoting the benefits and usefulness of robotaxis and AVs. Educating people on AVs and robotaxis would result in a larger acceptance and give more accurate and educated answers. This study's results may serve as a strong basis for future research and give valuable insight into developing and promoting robotaxis and AVs.

6.2 Contribution to knowledge

This research contributed significantly to AV and robotaxi research or, specifically, research looking at how residents perceive the possible impacts of robotaxis. It provided a view into the perception of the residents of Zagreb and indicated with which statement they show agreement and with which one's disagreement, and to what level they do so. It also showed the personal attributes of the residents towards some statements or questions, which build on the TAM and UTAUT theories. Moreover, it was able to show if the residents were acceptive or reluctant to robotaxis and as to which variables or constructs influenced the acceptivness. While doing all of this, it also compared the different socio-demographic groups' answers. Finally, the research introduced a set of recommendations for government officials on how they can achieve the large-scale adoption of robotaxis or AVs and what they need to consider. Additionally, the research initially provides a few short sections, which the readers or any other individual can use to inform and educate themselves on robotaxis or AVs.

6.3 Limitations

Despite the thesis contributing to existing robotaxi and AV research, limitations are present. Even though the sample of 158 individuals is representative of the population of the city of Zagreb, the sample size for some groups was relatively small, i.e., there were only three residents between the age of 15 and 18, 14 above, or the age of 60, four residents with no degree, seven with a doctorate degree, seven with another degree, six who are unemployed, 12 working in the transportation sector, four who use a human-powered or motor-powered assisted vehicle as their main mode of transportation, six walking as their main mode of transportation, ten foreign citizens, 11 with a monthly household income of 5.001 to 10.000 Euros, ten with a monthly household income above 10.001 Euros, 16 with a knowledge level of five, and 15 who consume alcohol more than or five times when going out every month. Thus, some bias in the results might exist, which could reduce the generalizability of the findings. Moreover, another limitation of this study was that the online survey was published on a national public holiday, the 1st of May or the "International Workers' Day." Thus many of the first wave of potential respondents either did not respond because they were too occupied with other activities, or they responded but did not share the survey with their friends and family. The research findings indicated that PU, PEU, PT, and SI only explained 40% of the variance in the BI. This means that the model cannot capture all variables or constructs that impact the BI to use robotaxis. Therefore, additional constructs or variables could be used to improve the predictions of the BI, for example, experience, voluntariness, etc.

6.4 Future research

The previous chapter looked at the limitations of this research. When discussing future research, there is still plenty to be researched regarding robotaxis or AVs, as both have not been researched enough to this point in time, especially when considering the perception of the residents. In order to advance this research, a similar study could be conducted that addresses the limitations of this research. In this case, this could be a study with a larger sample size to identify different relationships between various variables and to show research with fewer biases due to small sample sizes of particular groups. Furthermore, this research could be repeated after a particular time to see if the perceptions have changed once robotaxis are very close to being introduced and once they are introduced. If the perceptions have changed, it could be further researched as to what led to this change. Another possibility would be to conduct this or a similar study in a different city or country and compare it to the findings of this one. While the previous ideas focus on conducting the same research at a different time or place or with a larger sample, the possibility to look at new impacts, additional attitudes, or constructs also exists and may show relevant findings. These findings could then be used to create a set of new recommendations. For instance, one could test the relationship between knowledge and the behavioral intention to use robotaxis. As can be seen, there are many opportunities for how future research can be conducted. This is mainly because there are still many unknowns about AVs and robotaxis.

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APPENDICES

Appendix 1: Online questionnaire (Croatian version)

Percepcije stanovnika o utjecaju robotaksija na društvo, ekonomiju i okoliš: slučaj Zagreba

Poštovani sudionici ankete,

U ovoj anketi, koja je dio moga magistarskog rada na Modul University Vienna, istražujem percepciju Zagrepčana o mogućim utjecajima robotaksija (autonomnih ili automatiziranih taksija) na društvo, ekonomiju i okoliš.
Svrha ovog istraživanja je steći razumijevanje mogućih učinaka robotaksija.

Molimo vas da uzmete u obzir da je ova anketa namijenjena ispunjavanju samo stanovnicima Zagreba. Sudjelovanje u ovom istraživanju je dobrovoljno i povjerljivo. Međutim, ako se ne osjećate ugodno odgovoriti na bilo koje od pitanja, slobodno ih preskočite. Pitanja koja nisu obavezna su označena kao takva. Anketa će biti anonimna i neće prikupljati nikakve osobne podatke koji bi omogućili povezivanje s vama. Za dovršetak će biti potrebno otprilike pet minuta.

Zahvaljujem se na sudjelovanju!

* Required

Pitanja o mogućim utjecajima

Ovaj odjeljak će vas upoznati s nizom pitanja o mogućim utjecajima robotaksija. Morate ukazati slažete li se ili ne slažete s mogućim utjecajem. Pitanje treba zamisliti na sljedeći način: vjerujem da će robotaksiji rezultirati u
...

1. Manje nesreća *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

2. Povećanoj javnoj sigurnosti i zdravlju *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

3. Poboljšanom zadovoljstvu s putovanjem *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

4. Poboljšanom pristupu mobilnosti *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

5. Povećanim rekreativnim putovanjima *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

6. Smanjenoj tjelesnoj aktivnosti povezanoj s transportom *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

7. Smanjenom vremenu putovanja *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

8. Povećanoj vrijednosti vremena putovanja *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

9. Povećanoj selidbi u gradska središta iz predgrađa *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

10. Povećanoj selidbi u predgrađa iz gradskih središta *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

11. Smanjenju prometnih gužvi *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

12. Smanjenoj potražnji za parkirnim mjestima *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

13. Prenamjeni parkirnih mjesta i prometnog prostora *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

14. Narušavanju tržišta rada *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

15. Stvaranju novih radnih mjesta *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

16. Uništavanju postojećih radnih mjesta *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

17. Povećanoj priuštivosti taksi usluga *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

18. Smanjenoj potražnji za osobnim vozilima *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

19. Smanjenim prihodima od poreza *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

20. Poboljšanoj učinkovitost goriva *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

21. Smanjenim emisijama stakleničkih plinova *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

22. Povećanim emisijama stakleničkih plinova *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

23. Smanjenoj kvaliteti podzemnih voda *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

24. Smanjenom svjetlosnom onečišćenju (suvišno korištenje umjetne svjetlosti) *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

25. Smanjenom onečišćenju bukom (redovito izlaganje glasnim zvukovima koji mogu naštetiti ljudima ili drugim živim organizmima) *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

Sljedeća pitanja odnose se na vaše osobne stavove prema robotaksijima

26. Robotaksiji će učiniti da se osjećam sigurnije nego normalna vozila *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

27. Bit će mi lako naučiti upravljati robotaksijima *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

28. Bit ću ponosan ako me ljudi vide kako koristim robotaksi *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

29. Robotaksiji će povećati moj društveni status *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

30. Korištenje robotaksija stvorit će probleme s kibernetičkom sigurnošću i privatnošću podataka *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	◯	◯	◯	◯	◯	U potpunosti se slažem

31. Ako su robotaksiju jeftiniji, radije ću ih koristiti od javnog prijevoza *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

32. Bit ću spreman dijeliti robotaksi s drugima *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

33. Smatram da su robotaksiji pomalo zastrašujući *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

34. Pod pretpostavkom da robotaksi dođe u upotrebu, namjeravam ih koristiti *

Mark only one oval.

	1	2	3	4	5	
U potpunosti se ne slažem	⬭	⬭	⬭	⬭	⬭	U potpunosti se slažem

Demografska informativna pitanja

35. Kojeg ste spola? *

Mark only one oval.

- Žensko
- Muško
- Radije ne bih otkrio

36. Koja je vaša dob? (napišite svoju dob kao broj, npr. 30; 31; ...) *

37. Navedite svoj najviši stupanj završenog obrazovanja *

Mark only one oval.

- Bez diplome
- Matura
- Sveučilišni prvostupnik
- Magisterij
- Doktorat
- Ostalo

38. Navedite svoj radni status *

Mark only one oval.

- Student/ Učenik
- Nezaposlen
- Zaposlen
- Umirovljen

39. Radite li u sektoru transporta? *

Mark only one oval.

- Da
- Ne

40. Koliki je vaš mjesečni prihod kućanstva? (Neobavezno)

Mark only one oval.

- 0-1.000€
- 1.001-3.000€
- 3.001€-5.000€
- 5.001€-10.000€
- 10.000€+

41. Koliko živite od centra grada (pod pretpostavkom da je centar grada Trg bana Josipa Jelačića)? *

Mark only one oval.

- Blizu (5 kilometara ili manje)
- Daleko (više od 5 kilometara)

42. Navedite svoj glavni način prijevoza *

Mark only one oval.

- Javni prijevoz
- Osobno motorno vozilo
- Taksi usluge ili usluge dijeljenja vožnje (npr. Uber)
- Vozilo na ljudski ili motorni pogon (npr. bicikl; električni skuter, ...)
- Pješke

43. Koliko ste upućeni u automatizirana vozila? *

Mark only one oval.

	1	2	3	4	5	
Uopće nisam upućen	◯	◯	◯	◯	◯	Vrlo upućen

44. Imate li invaliditet koji vam onemogućuje ili otežava vožnju? *

Mark only one oval.

◯ Da
◯ Ne

45. Posjedujete li vozilo s autonomnim značajkama (npr. tempomat, sustav pomoći * za održavanje vozne trake, pomoć pri parkiranju itd.)

Mark only one oval.

◯ Da
◯ Ne
◯ Ne posjedujem vozilo

46. Jeste li u prošlosti imali prometnu nesreću? (Neobavezno)

Mark only one oval.

◯ Da
◯ Ne

47. Jeste li hrvatski državljanin? *

Mark only one oval.

- Da
- Ne

48. Ako ste na prethodno pitanje odgovorili "Ne", ovdje navedite svoju nacionalnost.

____

49. Jeste li ikada živjeli u inozemstvu? *

Mark only one oval.

- Da
- Ne

50. Smatrate li se introvertom ili ekstrovertom? *

Mark only one oval.

- Introvert
- Ekstrovert

51. Koliko puta mjesečno izlazite i konzumirate alkohol? (napišite broj, npr. 2; 3; ...) (Neobavezno)

____

52. Ako očekujete bilo kakve druge utjecaje ili ako želite dati dodatne komentare, slobodno to učinite ovdje.

Appendix 2: Online questionnaire (English version)

Residents’ perceptions of the impact of robotaxis on society, economy and environment: The case of Zagreb

Dear Survey Participants,

In this survey, which is part of my Master thesis at Modul University Vienna, I investigate the perception of the residents of Zagreb on the possible impacts of robotaxis on the society, the economy and the environment.
The purpose of this study is to gain an understanding of the possible effects of robotaxis.

Please consider that this survey is only meant to be filled out by residents of Zagreb. Participation in this study is voluntary and confidential. However, if you do not feel comfortable answering any of the questions feel free to skip them. Questions which are optional are indicated as such. The survey will be anonymous and will not collect any personal information that makes it possible to link it to you. It will approximately take five minutes to complete.

Thank you for your participation!

* Required

Questions on the possible impacts

This section will introduce you to a set of questions on the possible impacts of robotaxis. You have to indicate if you agree or disagree with the possible impact. The question is to be thought of as following: I believe robotaxis will result in ...

1. Fewer accidents *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

2. Increased public safety and health *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree						Strongly agree

3. Improved travel satisfaction *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

4. Improved access to mobility *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

5. Increased recreational travel *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

6. Reduced transport-related physical activity *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

7. Reduced travel time *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

8. Increased value of travel time *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

9. Increased move to city centers from suburbs *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

10. Increased move to suburbs from city centers *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

11. Reduced traffic congestion *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

12. Decreased demand for parking spaces *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

13. Repurposing of parking spaces and road space *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

14. Disruption of labor markets *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

15. Creation of new jobs *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

16. Destruction of existing jobs *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

17. Increased affordability of taxi services *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

18. Reduced demand for personal vehicles *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

19. Reduced income from taxes *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

20. Improved fuel efficiency *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

21. Decreased greenhouse gas emissions *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

22. Increased greenhouse gas emissions *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

23. Decreased quality of stream water *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

24. Decreased light pollution (excessive or inefficient use of artificial outdoor light) *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

25. Decreased noise pollution (continuous exposure to high sound levels that may cause harm to humans or other living organisms) *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

The following questions are about your personal attitudes toward robotaxis

26. Robotaxis will make me feel safer than normal vehicles *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

27. It will be easy for me to learn to operate robotaxis *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

28. I will be proud if people see me using a robotaxi *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

29. Robotaxis will increase my social status *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

30. Using robotaxis will create cyber security and data privacy issues *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

31. If robotaxis are cheaper I will prefer them over public transport *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

32. I will be willing to share my robotaxi with others *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

33. I find robotaxis somewhat frightening *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

34. Assuming Robotaxis come into use, I intend to use them *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Demographic Information Questions

35. What is your gender? *

Mark only one oval.

- Female
- Male
- Do not want to disclose

36. How old are you? (write your age as a number e.g., 30; 31; ...) *

37. Indicate your highest level of education completed *

Mark only one oval.

- No degree
- High school degree
- Bachelor's degree
- Master's degree
- Doctorate degree
- Other

38. Indicate your working status *

Mark only one oval.

- Student
- Unemployed
- Employed
- Retired
- Other: ____________

39. Are you working in the transportation sector? *

Mark only one oval.

- Yes
- No

40. What is your monthly household income? (Optional)

Mark only one oval.

- 0-1.000€
- 1.001-3.000€
- 3.001-5.000€
- 5.001-10.000€
- 10.000€+

41. How far do you live from the city center (assuming that the city center is Ban Jelačić square)? *

Mark only one oval.

- Close (5 kilometers or less)
- Far (more than 5 kilometers)

42. Indicate your main mode of transportation *

Mark only one oval.

- Public transportation
- Personal motor vehicle
- Taxi or ridesharing services (e.g., Uber)
- Human-powered or motor-powered assisted vehicle (e.g., bicycle; electric scooter, ...)
- By foot

43. How knowledgeable are you about automated vehicles? *

Mark only one oval.

	1	2	3	4	5	
Not knowledgeable at all	◯	◯	◯	◯	◯	Very knowledgeable

44. Do you have a disability that prevents you or makes it difficult to drive? *

Mark only one oval.

- ◯ Yes
- ◯ No

45. Do you possess a vehicle with autonomous features (e.g., cruise control; lane keeping system; park assist; etc.) *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I do not own a vehicle

46. Did you have an motor vehicle accident in the past? (Optional)

Mark only one oval.

- ◯ Yes
- ◯ No

47. Are you a Croatian citizen? *

Mark only one oval.

- ◯ Yes
- ◯ No

48. If you answered the previous question "No" indicate your nationality here.

____

49. Have you ever lived abroad? *

Mark only one oval.

- Yes
- No

50. Do you consider yourself an introvert or an extrovert? *

Mark only one oval.

- Introvert
- Extrovert

51. How many times a month do you go out and consume alcohol? (write a number e.g, 2; 3; ...) (Optional)

____

52. If you expect any other impacts or if you would you like to add any further comments feel free to do so here.

____
____
____
____
____

Appendix 3: Multiple linear regression tests

Model Summary (VAR034)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.63	.40	.38	.89

ANOVA (VAR034)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	80.45	4	20.11	25.17	.000
Residual	122.27	153	.80		
Total	202.72	157			

Coefficients (VAR034)

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-.20	.61	.00	-.32	.746
VAR028	.34	.07	.32	4.61	.000
PU	.04	.01	.43	5.89	.000
SI	-.01	.03	-.01	-.21	.834
PT	-.06	.03	-.12	-1.86	.065

Model Summary (VAR034)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.81	.65	.56	.75

ANOVA (VAR034)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	132.23	33	4.01	7.05	.000
Residual	70.49	124	.57		
Total	202.72	157			

Coefficients (VAR034)

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-.16	.64	.00	-.24	.809
VAR001	.10	.08	.09	1.23	.221
VAR002	-.04	.10	-.04	-.42	.678
VAR003	.07	.09	.06	.74	.459
VAR004	-.09	.10	-.07	-.92	.362
VAR005	.00	.09	.00	.04	.972
VAR006	.03	.07	.02	.35	.728
VAR007	.08	.07	.08	1.14	.255
VAR008	.00	.08	.00	.05	.959
VAR009	-.05	.07	-.05	-.65	.515
VAR010	-.16	.07	-.17	-2.39	.018
VAR011	.13	.08	.14	1.65	.102
VAR012	-.08	.09	-.07	-.92	.360
VAR013	.13	.08	.12	1.58	.116
VAR014	.03	.08	.03	.36	.723
VAR015	.02	.06	.02	.29	.773
VAR016	.09	.08	.09	1.17	.245
VAR017	.13	.08	.11	1.67	.098
VAR018	.13	.07	.13	1.91	.059
VAR019	-.10	.08	-.09	-1.37	.172
VAR020	.04	.08	.03	.44	.660
VAR021	.01	.08	.01	.15	.884
VAR022	-.02	.08	-.01	-.20	.843
VAR023	-.03	.09	-.03	-.39	.699
VAR024	-.07	.08	-.06	-.90	.368
VAR025	.10	.08	.09	1.28	.201
VAR026	.11	.08	.12	1.39	.167
VAR027	.36	.09	.31	4.09	.000
VAR028	.12	.08	.11	1.57	.118
VAR029	.01	.08	.01	.11	.910
VAR030	.00	.07	.00	.05	.962
VAR031	-.05	.07	-.05	-.70	.483
VAR032	.08	.05	.09	1.40	.163
VAR033	-.12	.06	-.15	-2.06	.042