M A S T E R A R B

Measuring trade-offs in valuing the benefits of autonomous technology to society

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Abstract
The change from conventional to highly automated vehicles is happening at a rapid pace. In addition to ongoing optimism among industries with the technologies that support such automation, various stakeholders have also highlighted concerns about this technology's plausible negative impacts on people's health and environment. Understanding users' market reaction towards the positive and negative impacts of the technology as well as its trade-offs is essential to facilitate anticipating market behaviour once the technology is deployed on the ground. This thesis addresses this issue, in particular linking individuals' behaviour with their personality traits, based on data from 1,000 Austrian participants collected via a stratified online questionnaire. This study takes a deeper look into different demographic clusters in its investigation of how different participants' values and behaviours influence their reaction towards the environmental and health impacts of an autonomous transport network. According to the results, the respondents exhibited individual-oriented reactions regarding environmental impacts while demonstrating more altruistic reactions in the case of health-related impacts. Also, a distinction can be made between age groups, as older generations aged between forty and sixty revealed more altruistic reactions than younger participants. In general, the respondents displayed strong support for the use of autonomous vehicles, with participants predominantly living in urban areas favouring autonomous structures. Despite an individualistic tendency towards environmental issues, when the respondents faced a choice between their own health and the common good, they prioritised the latter.

Keywords: autonomous vehicle, user acceptance, social value orientation, moral dilemma

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List of abbreviations

IoT .... Internet of Things

AVs .... Autonomous vehicles

ADAS .... *Advanced driver-assistance systems*

AI .... artificial intelligence

DM .... decision-maker

RQ .... research question

SQ... Sub question

SVO ....*Social Value Orientation*

V-C..Vehicle to Cloud

V-I................................*See* Vehicle to infrastructure

V-V................................*See* Vehicle to vehicle

1 Introduction

The following chapter serves as an introduction to this master's thesis. Establishing the context of the discussion begins by classifying the topic. The problem description provides an outline of the major research interest. After identifying the research gap, the research question is stated, followed by an explanation of the procedure.

1.1 Contextualisation

While digitisation continues to advance, such phenomena as big data, the Internet of Things (IoT) and artificial intelligence (AI) are already part of everyday life. Smartphones have become people's constant companions and have even been called an artificial expansion of the brain (Andelfinger V.P., 2015). Technological optimism is growing, and with it, innovations are expanding. The relationship between man and machine is becoming increasingly blurred. However, the IoT can be found in all areas of life and is not confined to telecommunication-capable devices. This development is also observable in the area of mobility. This thesis examines participants' social value orientation (SVO) and preference regarding the potential advantages and disadvantages of future technologies. As such, the investigation focuses on human behaviour and of objectives such innovations can bring to the decision-making process. Recognising human preferences and views is necessary before any disruptive invention, including autonomy, can be implemented. Restrictions and guidelines must be introduced in a careful political, economic and regulatory manner to ensure that these new technologies can be safely integrated into everyday life. With the help of connected infrastructures, transport infrastructure systems are becoming increasingly intelligent, offering the potential to lead to a "digital revolution of the car" (Johannig V., 2015). The change from conventional to highly automated vehicles is happening at a rapid pace. Potential advantages include decreased personal injury, increased traffic flow, sustainable and more efficient usage of resources, access to individual mobility for everyone, and gains in comfort and productivity (Proff & Fojcik, 2016). Such predictions conjure the vision of a utopia that was first hinted at around 1950, implying that humankind is heading towards the concept of a futuristic social individual. This thesis analyses the actual data, transcending media hype, and evaluates whether society is ready for a disruptive invention.

Figure 1: Glass-topped car rocketing to a futuristic city-centre (Sluis, 2018)

1.2 Presentation of problems

By replacing the driver, an autonomous transport network (ATN) will fundamentally change the current traffic system. Such a network comprises two primary components: (a) a self-navigating onboard sensor that detects the surroundings and can communicate with other vehicles and (b) the communication between the vehicle and the infrastructure. Such a sophisticated functional network already exists in test areas but implementing it into the existing transport system will require a few more years of research and development. Still, society is getting closer to this utopia in using increasingly automated vehicles that make travelling easier for the driver each year (Adnan et al., 2018).

The potential for greater road safety, greater comfort and integration through mobility for disabled and older adults promise opportunities in this area. Nevertheless, hardware and software failure that can lead to serious accidents or crime involving the manipulation of communication networks must be considered as risks 13/05/2021 09:20:00. The greatest threat involves the potential for severe damage to nature due to higher CO_2 emissions because of interconnection and an essential 5G network. Setting up and operating such a network on a global level requires massive energy resources, leading to an increase in greenhouse gases. Moreover, the continually growing data transfer, especially in the case of autonomous vehicles, requires steadily growing energy consumption (Bieser et al., 2020). Increasing travel distances could also lead to increased emissions (Brown, Repac, & Gonder, 2013).

Despite these concerns, people have high expectations of autonomous vehicles (AVs), drawn by the notion of being able to use their driving time more productively while thinking to cause an environmental contribution (Jing et al., 2020).

The so-called loss aversion effect plays a critical role in this instance. Kahneman describes this effect in his studies on behavioural economics as the tendency to prefer avoiding losses to gain equivalent benefits (Kahneman et al., 1991). Insurance companies rely on this concept, convincing people that they can avoid costly losses by making constant small payments to the insurance company (Eeckhoudt et al., 2018). As an example, in this context, the current transport network includes such negative parameters as CO_2 emissions, traffic accidents and congestion. The introduction of an ATN could lead to selling it as a possible solution without the backing of sufficient scientific research on possible outcomes. Research has already demonstrated some risks of an ATN (see the included literature review), but the question of how people would demand AVs in a market without having a regulated smooth conversion is of special interest. The significance of safety and ecological well-being in the participants' decision-making must be considered, along with the question regarding whether people simply decide on their own circumstances without referring to interconnections to other problems.

Making decisions solely based on individual benefit could have severe environmental consequences. Above all, implementing an ATN could trigger global resource problems and spur increasing pollution in supplying emerging countries (BMU, n.d.-a). The local pollution previously discussed bears mentioning again here.

Human acceptance of AVs depends on each individual's unique traits, including cognitive biases, that are influenced by individual attributes, like demographics, age, education and income. Thus, seeking a better understanding of such complex behavioural structures and tendencies in this new technology requires incorporating the most relevant influential factors into the survey. In the thesis, the scientific goal is to link people's social values and reactions to the impact of an autonomous transport network (ATN) on their well-being.

1.3 Research gap and research questions

Various studies and lectures have already discussed the multitude of advantages associated with autonomous vehicles and their interconnectedness (Uhlemann, 2018). Counter-arguments have been rare. Moreover, the human readiness for AV use was explored mostly in experimental terms and concerning mode-choice settings, involving no examination of public acceptance and readiness in a more general sense (Althoff, 2010, p. 129). This thesis focusses on Austrian residents and covers all generations from ages 18 to 60. The study facilitates drawing conclusions about the development and current tendency regarding an ATN using a regression analysis based on the demographic circumstances of the participants to better assess the future market and study the generation's behavioural preferences. The study also seeks to explore whether significant differences between generations can be measured. Thus, the investigation used Social Value Orientation (SVO) to identify these differences in the various subgroups. This approach allows tendencies in the various questions to be quantified and individualistic as well as altruistic decisions of the participants to be determined.

This work is of vast interest to futurologists, economists, behaviour psychologists, and social researchers. Furthermore, the study could provide prospects for possible business opportunities. That said, its primary intention is to raise awareness of autonomy and submit results to support thoughtful future decision-making. Accordingly, this investigation into human behaviour in decision-making processes provides insight into the future direction of the market and the environment. Current problems and possible solutions are introduced, which resonate with the implementation of an ATN. Making the present work easier to compare has necessitated the assumption that an ATN contains exclusively electrically powered vehicles. Therefore, the network only is compared to non-autonomous electric vehicles. Furthermore, energy use is considered sustainable, making the thesis more meaningful as it exclusively focuses on the autonomy aspect.

The following research question (RQ) undergirds this investigation of possible negative interactions in autonomous driving. This query should serve as a guide and is answered in the course of this work.

RQ: How will social value orientation influence environmental and health dilemmas in autonomous driving?

Approaching the question requires working out the underlying concepts separately. The following sub-questions (abbr. SQ) were formulated for this purpose to guide the research process and ensure the development of a fundamental understanding of the concept.

SQ1:	How does decision behaviour vary between social demographic indicators ?
SQ2:	Can society expect a shift of sustainability mindset over the generations?
SQ4:	How do attitudes relate to the advancement of technology in terms of a promising traffic system?
SQ5:	What is the current state of development of autonomous driving, and which factors speak for a transition to an autonomous transport network?

1.4 Approach and structure of the work

First, an overview of the current circumstances of autonomous vehicles will be provided to better assess participants' later decisions on autonomous vehicles. Thus, a detailed literature review of scientific publications on human decision-making and value orientation related to AVs offers an excellent starting place. Individual works from various scientific journals concerning basic economic science data are included. Due to the feasibility and topicality of the matter, articles from online journals are also used. After a detailed analysis of the literature, the methodology section discusses instrument selection to quantify the survey properly. The following graphic (Figure 2) is designed as a roadmap through the thesis to enhance the readers' understanding.

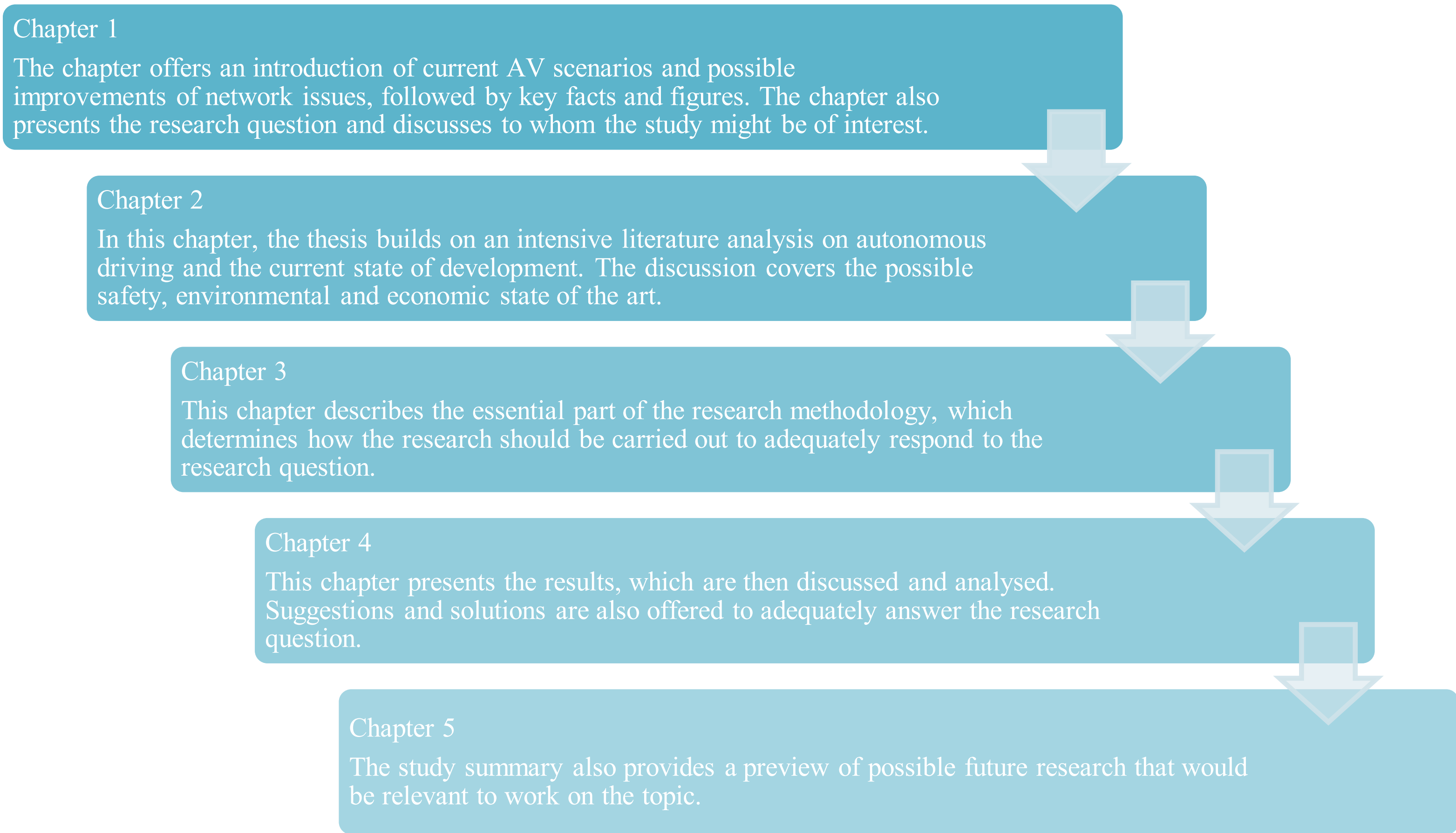

Figure 2: Thesis structure

2 Literature review

The following chapter reviews the relevant literature in the autonomy sector. The first part explains the current state of autonomous driving, technology development and its key terms. Next, human behaviour to AVs, including a comparative examination of tendencies in similar research studies are reviewed. Opportunities and challenges related to different concepts are considered when complementing the study. Relevant methods, theories, and concepts are chosen from the most relevant research to answer partial questions.

2.1 Definition of key terms

Autonomous driving describes the "independent, targeted driving of a vehicle in real traffic with onboard sensors, downstream software and maps stored in the vehicle for the detection of the vehicle environment" (Beiker, 2015). Both longitudinal guidance for speed control and lateral guidance to change position are involved. What is particularly relevant in this discussion is that this control takes place with no intervention by the driver (Glancy, 2015, p. 229). Assisted or partially automated driving can be used as a preliminary stage for autonomous driving. For some time now, advanced driver-assistance systems (ADAS) have been used to relieve the driver and improve road safety (Beiker, 2015).

2.1.1 Level of automation

In an international comparison between levels of automation, the development from assistance to autonomous driving is shown in five steps (see Figure 3).

The first stage, level 0, has no automatic functions. Vehicle control tasks, such as longitudinal guidance, require the driver to accelerate, hold and brake, and steer.

Assisted driving (level 1) can feature a function. If it involves longitudinal or lateral guidance, the driver directs while the other functions are improved.

In semi-automated driving, level 2, both longitudinal and lateral guidance in combination, are entirely taken over by the system in a specific application. However, monitoring by the driver remains imperative.

The difference in level 3, highly automated driving, according to the German Association of the Automotive Industry (VDA) and the Federal Highway Research Institute (BASt), is that the system can take over longitudinal and lateral guidance in a specific application and can also recognise system limits (Raposo et al., 2017). If necessary, the driver will be asked to take over. Full attention, as in level 2, is no longer necessary in this case.

From level 4 onward, fully automated driving is involved. In a specific application, this function requires no driver. The system copes with the individual situation independently.

With autonomous driving, level 5 in the description in Figure 3, no driver is required from start to finish. The vehicle is completely autonomous, taking over the driving function in all speed ranges, environmental conditions, and road types.

SAE Level	Name	Narrative Definition	Execution of Steering/ Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 3: Stages of autonomous driving; SAE International *(Engineers, 2015)*

As the SAE–classification is rather more descriptive than normative, the primary focus is more on a technical than regulatory definition.

Figure 4 shows how much human interaction is relevant in the described automatic stages and how the driving interaction shifts to the vehicle.

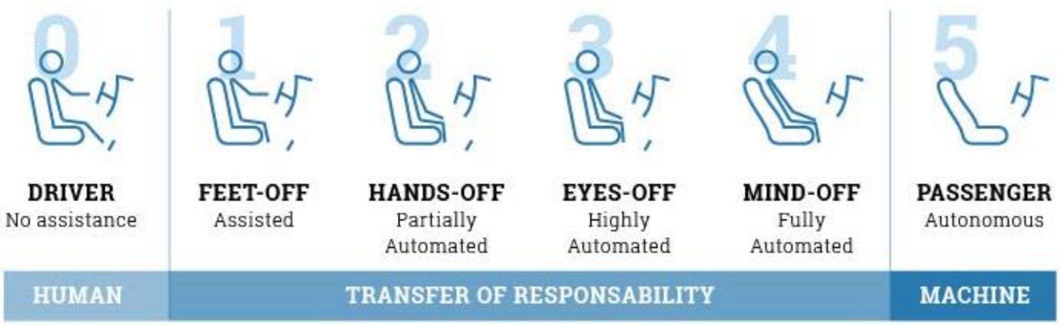

Figure 4: Human driving interaction from autonomy level 0-5 *(Calderazzo, 2019)*

As the figure illustrates, a smooth takeover by technology happens in stages. First, the driver can disengage the feet (cruise control level 1), then the hands (lane-keeping assistant and automatic lane change in level 2), and finally the mind. However, keep in mind that all the existing levels and their applicability depend on the traffic situation and the nature of the environment. Also, the driver retains full responsibility until level 4 autonomy, where supervising is the primary purpose. In the absence of interaction in a dangerous situation, the vehicle can choose the safest option, which is in most cases to reduce speed or stop. Level 5 autonomy takes place mainly in an urbanised area and in complex traffic situations, a utopian concept until now.

2.2 Level 5 - autonomy timeline

Since the idea of an AV was first presented at the New York World's Fair by General Motors in 1939, engineers have become obsessed with the idea of an electric chauffeur. The AV was an electric car that depicted the technological development in the industry potentially taking place in the next 20 years. At the beginning of the 1980s, Japanese engineers improved upon the idea and used cameras and processors to give the car an idea of its surrounding. The media and public were also motivated again by the cult television series *Knight Rider*, which made investors and engineers want to boost development further (Bartl, 2015).

The following figure by Bartl, published in *The Making-of Innovation* e-journal, claims that autonomy will be introduced into society in the near future, although the author does not distinguish between level 4 and 5 autonomy (Bartl, 2015). Observing the literature, the most used word regarding autonomy is "uncertainty" concerning timelines. Yet, looking at Waymo, Tesla or Google, AV progress cannot be compared with the much slower development in the 1980s. Progressive technological growth in recent years has also allowed the development of ATN to advance more rapidly.

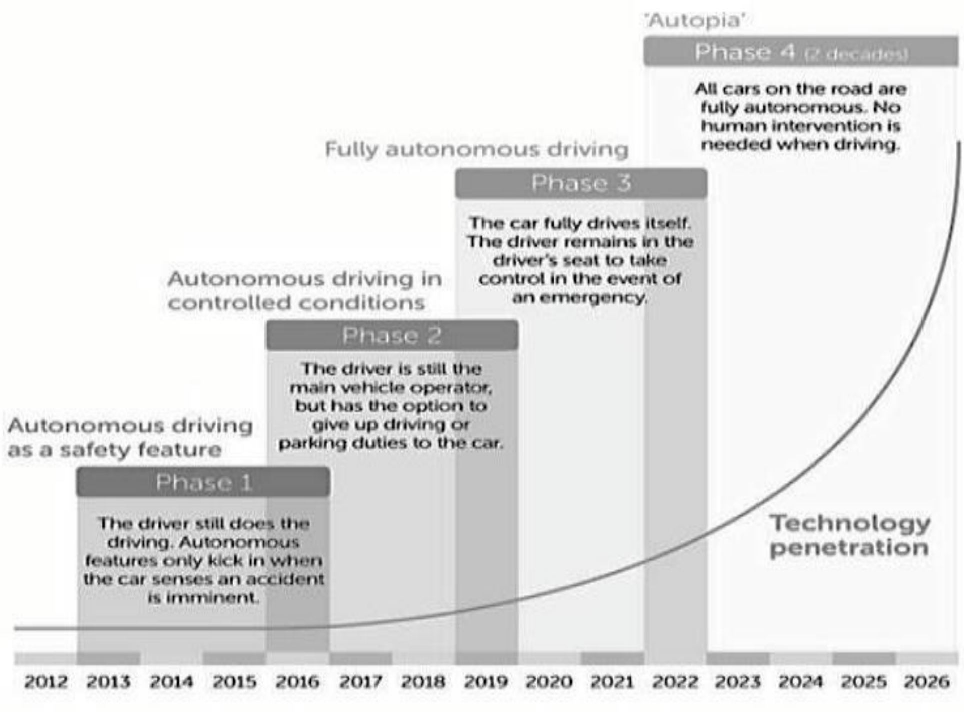

Figure 5: Timeline of autonomous driving (Bartl, 2015)

An interesting analysis by the Victoria Transport Policy Institute regarding autonomy suggests that by 2040, 75% of cars will drive autonomously in road traffic; moreover, manual driving could be banned in 2060 (Litman, 2017).

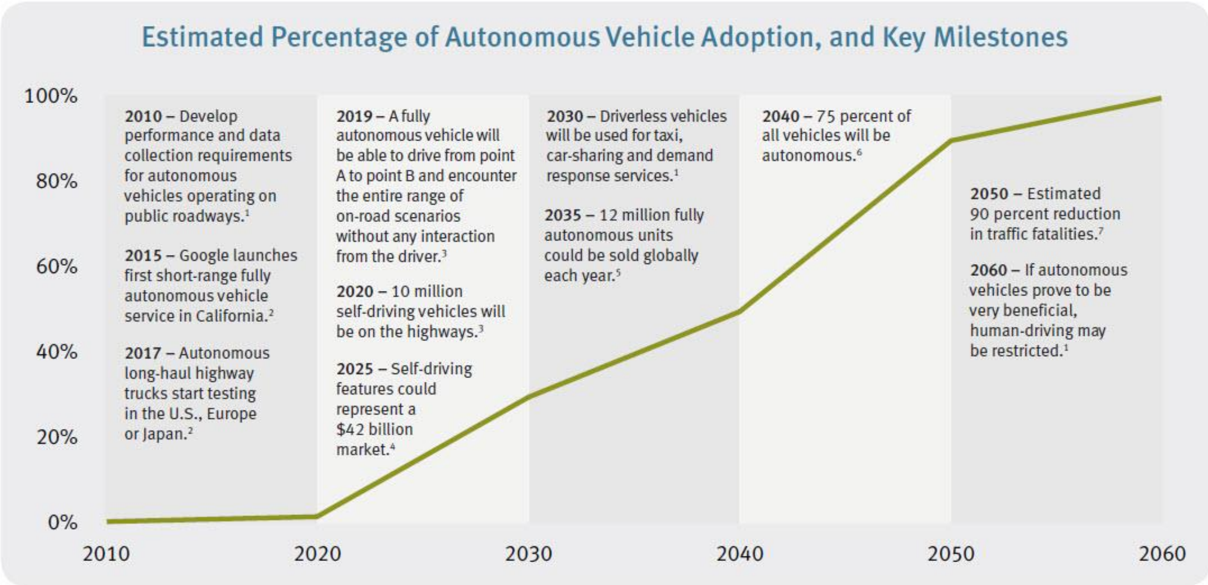

Figure 6: Estimated Percentage of AV Adoption, and Key Milestones (Litman, 2017)

Figures 5 and 6 reveal that neither transport institutes nor researchers – and least of all, the media – really know how far the development of autonomous driving has come and how far it is from being implemented in practical terms. Instead, the impression lingers that only younger generations will receive insight into this disruptive world, and older generations, according to the above-mentioned future statistics, can only hope to experience it.

2.3 State of development

Compared to automated air or rail traffic, a dynamically complex environment is the main road traffic obstacle. Automotive companies, software manufacturers, IT groups, and other industry competitors are trying to develop a smooth mobility solution by generating data in combination with detection software (Maurer et al., 2015, p. 107).

Presently, cars are already connected in many ways. The technology of self-driving cars uses an onboard sensor system that reacts to the environment in order to navigate to the destination without human intervention. (Adnan et al., 2018)

Vehicle to Cloud (V-C) services are also in use, making it possible to stream music playlists or find out about the current traffic situation. Vehicle to vehicle (V-V) automation is also already in use, enabling self-separable distance control from other vehicles. Moreover, this technology is not necessarily dependent on a telecommunication network. An ad-hoc system can be used, allowing cars in close proximity to communicate on the same frequency using a transmitter and a receiver. Hence, vehicles can also directly communicate. Vehicle to infrastructure (V-I) technology still needs to be improved for street access. For example, cars equipped with this capability can detect traffic signs, such as stop signs or traffic light systems. This interconnectedness can be imagined by means of a SIM card in the vehicle, which represents the data interface and provides it with information. Thus, the current development of the 5G network is contributing significantly to the progress of an ATN. According to development reports from telecommunication providers, a data flow of up to 10 gigabytes per second is possible in the foreseeable future (Herrmann et al., 2018).

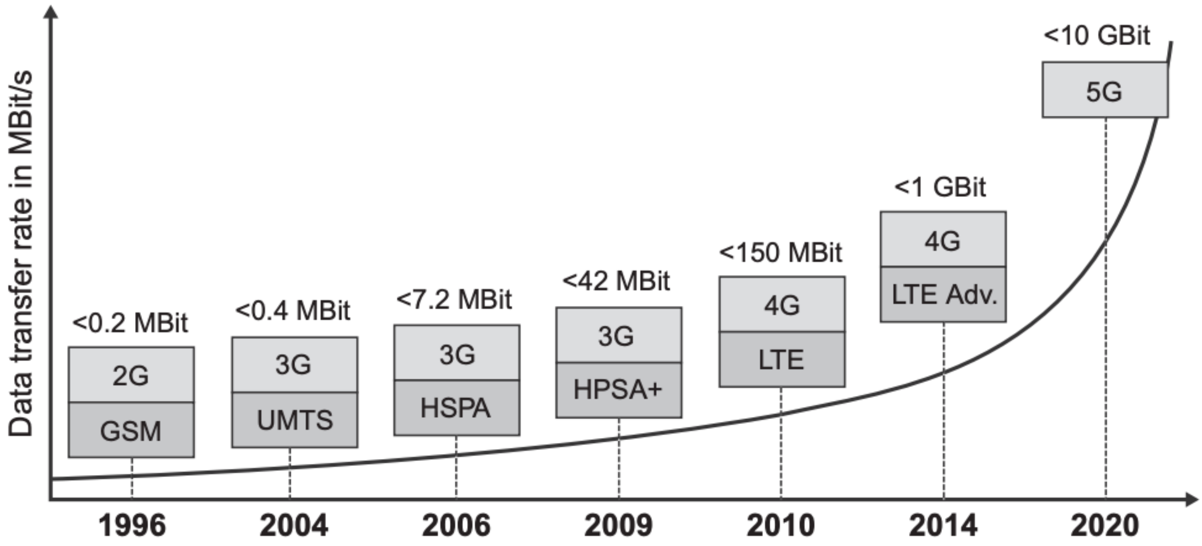

Figure 7: Data transfer rate in MBit/s (Herrmann et al., 2018)

Since all the systems that could make autonomous driving possible already exist, the question arises as to why society does not already use an ATN that has been implemented into the transportation network. On the one hand, the current state of affairs can be explained by the delay caused by the data exchange up to the final reaction of the vehicle. Until now, this delay has been one of the main risks, as a lag of even one second can have dramatic results, especially on high-speed roads. However, the already discussed 5G network can achieve a time delay of less than one millisecond (Herrmann et al., 2018). To put this number in context, human reaction time, which is comparable to the time delay, is on average one second.

Cybersecurity constitutes another reason for the difficulty in arriving at a smooth-functioning ATN. Data errors or intentional data manipulation can have devastating consequences for an ATN. Although data encryption can partly address this problem, this solution also extends the delay time.

Thus, close cooperation between mobile operators and car manufacturers is unavoidable to provide safe future technology for an autonomous transport network.

2.4 Effects of an ATN

While the expected positive effects that an ATN can have are praised to the skies, above all by car manufacturers and the media, this part of the work will present both the positive and the more dubious sides of this innovation.

The argument of greatest concern is the expansion of the 5G network, which is essential for a functioning ATN. However, studies reveal sobering consequences that the radiation from the high data traffic can have for human health (Kostoff et al., 2020).

Not only is human health affected, but the environment could also suffer significant damage. A Swiss study shows that the establishment and operation of the 5G network will produce additional emissions of 0.018 megatons of CO_2 equivalents per year by 2030. Of this number, 43% represents electricity and generation, and the remaining 57% is for providing the infrastructure (Bieser et al., 2020). The following advantages can be mentioned as positive aspects in this context: "Optimal driving cycle, optimal routing and dynamic eco-routing, less idling, reducing cold starts, trip smoothing and speed harmonization" (Heard et al., 2018). These factors would lead to lower CO_2 emissions. However, science is not entirely in agreement about which effect now predominates, as so-called rebound effects would have to be expected and are difficult to estimate. Risks for a rebound effect can include the following factors: access to vehicles by people who cannot drive (older adults, children) and a higher number of kilometres travelled because of lower opportunity costs (time use).

Hardware and software errors, which were briefly mentioned in the previous section, constitute a second major risk factor. A failed sensor, software problem, or a distorted signal can lead to disastrous consequences. Data misuse or malicious hacker attacks are also massive risk factors (Hashim & Omar, 2017).

Although an ATN is prone to errors, it is theoretically preferable as a safer variant. Nevertheless, this technology should not be confused with an injury-free option (Litman et al., 2020).

2.5 Presentation of relevant theories and concepts

In this section of the thesis, problems and the study's research questions will serve as the basis for preparing the theoretical framework. Answering the research objective will involve concentrating on the most relevant and recent methods and theories.

2.5.1 Anticipation of technological development

As already briefly shown in the discussion of the autonomy timeline, realistic anticipation of the technological development of such a disruptive technology is difficult to predict. Professor Glenn Lyons designed in his April 2020 report a framework to create a dialogue between four groups of evangelists, opponents, pragmatists and agnostics and asked various questions regarding opportunities, scenarios and necessities to spark discussion (Lyons, 2020). The six workshops' goal was to identify key issues and concerns about the future of autonomous transport. Regarding the report, it is crucial instead of glorifying AV's and thinking that they solve significant problems, to maximise benefits according to experts; thus, the public should face the subject with certain restraint. The correlations of AVs and society should be seen as a "wicked problem" instead of a solution. The idea is to expand the range to encompass different stakeholders, sparking discussion and raising awareness and information regarding ATN by questioning the technology critically. A significant bias in this context, which Professor Lyons also emphasises in his report, is the "Echo Chamber Effect" (Heard et al., 2018). In psychology, this phenomenon is also called confirmation bias, in which people only hear or interpret information that reinforces what they already know. Since most information exchange is now happening on the Internet, the technology industry also refers to information bubbles, which do not display data contrary to an individual image and only suggest information that encourages one's own opinion.

A critical aspect that has a significant impact on development is that progress is no longer only dependent on conventional car manufacturers. Technology giants like Google and network providers are also penetrating the vehicle market and influencing it significantly. Instead of concentrating on the critical aspects that make autonomous driving possible (5G, Edge AI), automakers are seeking to scale up advanced driver assistance systems until they reach a fully autonomous version (Bartl, 2015). Therefore, it is essential to differentiate between invention and innovation. The former is the creation of autonomy itself, and the latter means the understanding of the problem, the approach to the solution, and integrating disruptive technological progress in society. Moreover, invention does not guarantee innovation and vice versa. Along these lines, the research part of the present thesis determines on the one hand why autonomy is an invention and whether it represents sustainable innovation. The question also arises as to whether innovation differs from development since the former is often defined as follows: "innovation is a feasible, relevant offering such as a product, service, process or experience with a viable business model that is perceived as new and is adopted by customers" (Wulfen, 2012). The thesis's empirical part refers to the critical impacts to the environment, safety and pricing, and human behaviour when these columns are being juxtaposed.

2.5.2 Glorification and autonomy hype

Research and articles on autonomous driving are accumulating, and the further time goes, the more abstract the tangibility of this future type of technology becomes. However, a clear distinction exists between media newspaper articles or blogs and science. On the one hand, media should follow standards of professional journalism but are increasingly tainted with "media bias", which involves distorting information to gain a higher level of attention. In contrast, science distances itself from wild conjectures and uses data as its foundation (Entman, 2007). While print media is announcing that AVs will be introduced to the traffic network in the near future, experts like Linden and Fenn, analysts for Gartner consulting, or Dr Shladover, one of the lead researchers in the area of AVs at the University of California in Berkeley, express the opinion that, based on scientific research on technological development, autonomous driving can be expected in about 10 - 50 years, depending on the level of autonomy (Baltzarek, 2019; Linden & Fenn, 2003; Shladover, 2016). The hype cycle curve in the following figure illustrates media overenthusiasm through the period of disillusionment to an eventual understanding of the technology's relevance and role in the market (De Marez & Verleye, 2004). This concept is primarily supposed to observe development to analyse opportunities and investment risks regarding specific technology (Linden & Fenn, 2003). The gap between technological progress and public acceptance is worth noting and makes AVs a "showcase" for technology (Bartl, 2015).

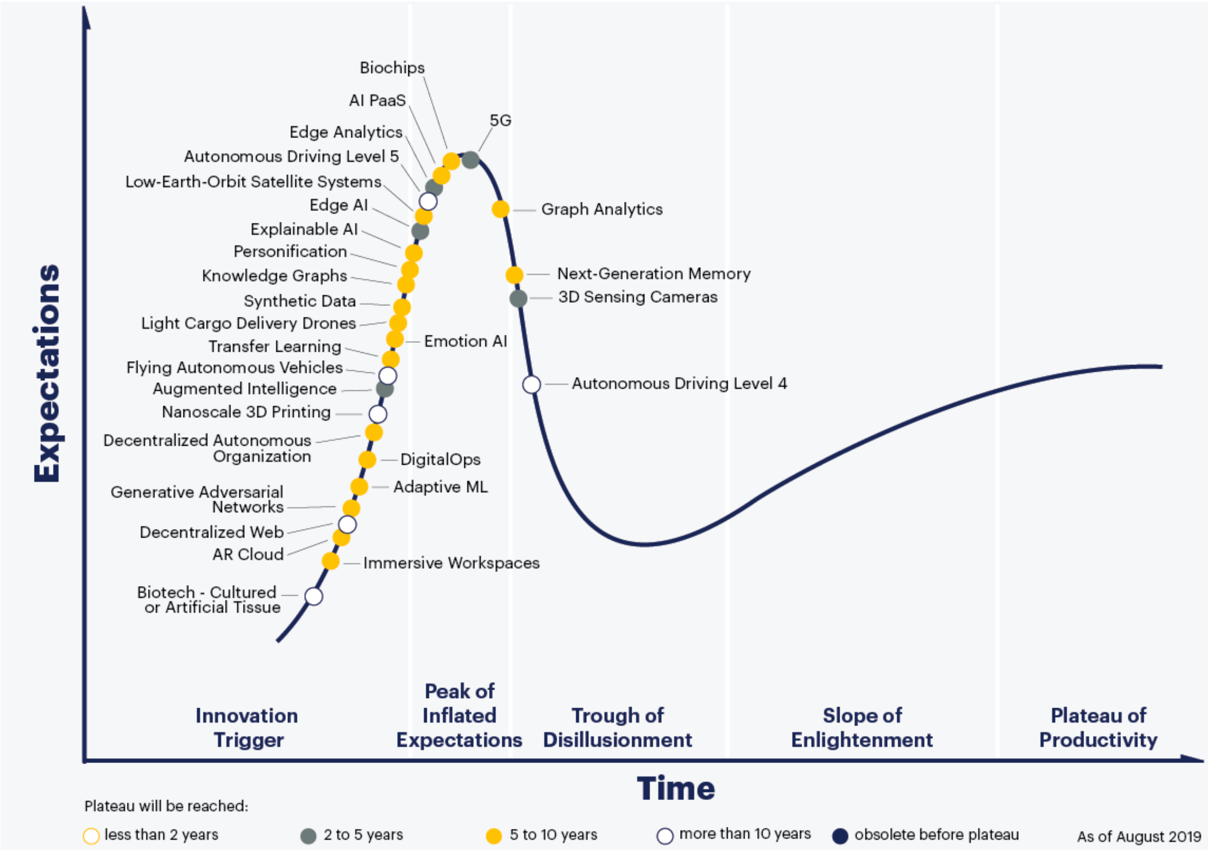

Figure 8: Gartner Hype Cycle for emerging technologies 2019

Making an objective future forecast is difficult. Of course, accuracy depends on the forecasters' setting and the point in time when the prediction is being made. Even if full technical implementation should become possible, adjusting the regulatory environment will be necessary. Thus, a long-term forecast can only be made very imprecisely, considering the number of unpredictable variables.

2.5.3 Social dilemmas

During the literature review, a frequently mentioned topic was the dilemma that autonomy creates. Especially in the traffic sector, reviewing the literature reveals the necessity that humans will face trade-offs when using AVs. For example, customers will be entirely dependent on the software programming of technology providers (Campbell et al., 2010). This dilemma makes it important to obtain psychological insight into human value orientation and discover which tendencies individual test subjects have when they are put into a forced choice that juxtaposes the monetary, environmental and safety factors of AVs. Even if requirements for morally and ethically correct behaviour are provided, most situations include decisions where a "right" judgement is almost indistinguishable from a "wrong decision", and its consequences might have a devastating impact (Lin, 2016). A prime example of this concept would be the so-called trolley problem, in which a decision must be made between several possible consequences of an accident. In the context of the present thesis, a more suitable example would have a more holistic approach, presenting participants with a trade-off between an increase in traffic safety and higher CO_2 emissions.

In a social dilemma situation, one's interest and the community interest conflict in terms of objectives. Thus, researchers apply the utilitarian approach, developed by John Stuart Mill, to morally justify right and wrong. Under this approach, the decision that brings the most "happiness" has the greatest value. Hence, according to Mill's philosophy, "an action is morally right if its consequences lead to happiness (absence of pain) and wrong if it ends in unhappiness (pain)" (Mill, 2009). In this view, the decision that avoids doing more harm is preferred to the other option.

The prisoner's dilemma is one of the most recognised dilemma situations in game theory (Morgan, 2001). This exercise portrays two suspects who commit a crime together and are interrogated separately. If the offender is convicted, the confidant hopes to be mitigated, while the accomplice should expect a higher sentence. The dilemma for the prisoners is to choose the best option to receive the mildest sentence. However, this solution is not possible because the individual puts his/her interests above the collective, leading to a shared confession and, thus, to a joint condemnation (Kreps et al., 1982).

As individual temptation exceeds the collective benefit and the fear of one-sided exploitation is higher than collective punishment, the dilemma leads to a noncooperative strategy. Furthermore, a problem that adds up to the one mentioned is that non-compliance with one commandment often leads to the violation of another. Such thought experiments describe ethical-moral decision-making situations that initiate various actions to solve the problem.

2.5.4 Social value orientation

In the past, researchers used descriptive behaviour theories for their studies to test social dilemma situations. Reviewing different case studies in the research literature to find a unified theory, reveals that a distinction is usually made between deontological and consequentialism theory. Additionally, the question then arises whether a utilitarian or a neo-mercantilistic approach, is being followed. The first approach takes into account the optimal holistic benefit, whereas the second pursues a capitalist individualistic benefit (Conti, 2018). Therefore, the SVO theory was used, also for the following reasons, to create a meaningful questionnaire that would provide relevant responses. The theory is used to explain how decisions are being made in a dilemma situation. Every player can choose to be egoistic and take decisions that have the most benefit for a single individual or have a more altruistic view and to choose benevolence as an alternative. Not only can social dilemmas create cognitive dissonance, but also upholding benevolence and acting morally responsible will not always make a correct decision clearly conceivable. Moreover, social psychology and behavioural economics have been seeking the interconnection between cooperative and prosocial behaviour with the individual characteristics of the decision-maker (DM; Fiedler, 2015).

The phenomenon of SVO is shown in a person's decision about a situation in which he/she makes an exit for himself dependent on him/her. Hence, SVO is used to investigate different motivators that lead people to their decisions in a social context (Harari, 2018).

SVO is usually quantified using simple distribution tasks (Aquino et al., 2009). This approach involves repeatedly giving people the choice of different ways to split money between themselves and another person (e.g. variant A: €85 for yourself and also €85 for any other person or variant B: €100 for yourself and €50 for the other person). Depending on the decision, the corresponding value orientation can be categorized from a more egocentric, via a cooperative to an altruistic attitude (Murphy, Ackermann, & Handgraaf, 2011). As an approach to precisely explaining differences in decisions, SVO is based on the rational model that assumes that people achieve benefits through individual ownership and fair distribution. This occurrence would explain cooperative behaviour, whereby the DM also considers others' "well-being" when weighing their decision (Murphy et al., 2011). These distribution situations can be compared to human decision-making in demanding traffic situations or environmental decisions when buying a vehicle. This concept will be theoretically examined in the discussion that follows to test its applicability for solving this dilemmatic problem.

2.5.5 Utilitarianism of AVs

Some utilitarian approaches can be executed in the thesis and imply a concept of solution. The most significant benefit of autonomous driving could be a safer traffic system with fewer traffic accidents (Trubia et al., 2017). The question arises as to what extent people embody a utilitarian attitude towards autonomous vehicles. Also, a more sustainable and environmentally friendly traffic network solution would have a tremendous positive impact. As a third pillar, economic affordability would be essential to make the effects mentioned scalable. The view of consequentialism, where the consequence gets judged, favours choosing for the benefit of the majority (Sinnott-Armstrong, 2009).

This thesis's important part is finding out if people's attitude shifts, in other words, if variables of the three columns of safety, environment, or economy increase or decrease to the benefit/detriment of one other pillar. For example: "How much more are people willing to pay for an AV to have a higher safety percentage?" Taking the environmental factor into account, this thesis assumes, based on the literature review, that individual interconnected autonomous level 5 vehicles are more environmentally harmful than conventional electric vehicles for various mentioned reasons, such as 5G, higher CO_2 emissions because of interconnectedness, and longer travel distances (Brown et al., 2013). Therefore, the safety factor is opposed to the environmental factor in determining which percentage is more important than the other.

3 Methodology

The following chapter describes the method used for data collection. First, the research method is presented, and its framework is determined. After discussing the measurement method, the instrument to quantify results is explained, followed by a brief description of the study's data collection and data analysis.

3.1 Research method

This master's thesis used the questionnaire method in the context of quantitative social research to collect data. Answering the research question of how SVO influences environmental and health dilemmas in autonomous driving involved testing participants on their SVO. Hence, the study employed a series of survey questions to work out a social tendency to test the hypotheses and adequately answer the research question.

The first part of the survey assessed the development and usability of participants' technological progress. The second part of the study aimed to determine the participants' SVO based on a division example, which will be explained in detail later. In this study, the link between individual behaviours and the participants' appreciation of the technology's impacts is primarily based on three pillars. The first pillar focuses on the individual's value orientation towards money. This pillar was chosen as it is one of the most influential and commonly used indicators in standard transport analyses; moreover, many behavioural studies also use the medium of money to research SVOs (Murphy et al., 2011).

The second pillar in this value orientation investigation is safety. Because of the discovered positive tendency participants had towards an ATN, the aim was to determine whether they placed their own safety above others and to what extent. So that this situation would be more quantifiable in the latter course of the work, participants had to distribute the probability of having an accident between them and a third unknown person. Only one person, the DM, could determine the distribution. Ensuring operational safety for users and the environment is one key point behind people choosing to use AVs. Nevertheless, traffic accidents caused by human failure cannot be ruled out. The implementation process will take time because conventional and automated vehicles will continue to operate in mixed traffic for many years to come (ADAC, 2019)(Fagnant & Kockelman, 2018).

The environmental pillar represents the third area of interest. Similar to the objects of investigation described above, this concept relates to environmental aspects. In the survey, the term can represent land area or unpolluted air, which needs to be distributed among participants.

Thus, if the DM claims a higher proportion on one pillar for him/herself, an individualistic behaviour can be attributed to him or her for the respective topic. An altruistic assessment would be based on a balanced distribution. The distribution of the three pillars allows conclusions about human behaviour, which are then related to an autonomous traffic network.

The last section of the study confronted participants with a conflicting situation in which their own safety was compared to the common use of nature. The object was to find out whether people would take back their well-being in the interest of the common good. Subsequently, social behaviour can be researched, and pillars are examined among themselves. The tested hypotheses include:

H1: Technological change in autonomy is strongly supported, and participants will spend more on AVs than on conventional vehicles.

H2: Although people are more aware of environmental problems that could severely affect future generations' lives, they will still choose economic affordability over environmental sustainability.

H3: People act in the interest of their personal advantage to the detriment of the common good.

These three hypotheses should serve as support to answer the research question precisely. This research aims to develop a tendency that relates to social values in connection with autonomous vehicles. Therefore, the study's data collection used a standardised questionnaire that examined ethical and moral issues related to level 5 autonomy vehicles. Claims and attitudes of participants were also considered in the interest of capturing the entire spectrum. The questionnaire also collected data reflecting the individuals' statements about their needs, expectations and attitudes towards autonomous vehicles concerning environmental, safety and economic issues.

The Google Forms platform was used to create the questionnaire. The examination of the collected data aimed to reveal introductory statements or tendencies about four different generations, gender, income classes, highest educational degree and place of residence (see appendix).

3.2 Research framework

The survey intended to find out about social tendencies between generations, gender, income classes, educational degree and place of residence. This experiment involved questioning over 1,000 people in specific distribution situations. Demographic restrictions within Austria were imposed when selecting the study participants. Since the literature review showed the population's significant uncertainty about the assumption of an autonomous transport network, assessing people's acceptance of this technology development was essential. The aim was to interview the respondents about autonomous transport networks, their attitude towards this interruptive technology and how that progress of development interacts with environmental, monetary and social relationships. First, the questionnaire was sent to a group of trial participants using social media and e-mail. The final survey was outsourced to a survey company hired using Fiver. The distribution among the 1,000 participants resembled the following table.

Table 1: Distribution of participants

Number of participants	n = 1,000
Male / Female participants ratio	50 / 50
Urban / Rural ratio	50 / 50
Generation Z (age 8 – 23)	20 – 30%
Generation Y (age 24 – 39)	20 – 30%
Generation X (age 40 – 55)	20 – 30%
Baby Boomers (age 56 – 75)	20 – 30%

The stated percentage distribution was chosen to achieve the most balanced distribution possible between all participants. More consistent conclusions can be made with these contingents since no single component should dominate the survey. Also, a relatively even distribution was created since the literature predicts the introduction of AV within a time horizon of 10 – 50 years. Therefore, all generations could still be affected. The study participants were also asked and categorised in the questionnaire concerning the following variable information to divide the targeted division into subpopulations in advance.

For participants not living in a rural area, name of their city
Income-level (Stages from €1k, €1.5k, €2k. €2.5k, €3k, €5k. >€5k)
Highest degree (Highschool, Bachelor, Master, PhD)
Gender

This type of stratified sampling divided study participants into different clusters to enable more precise statements to be made. After putting them into subpopulations (age), participants were split into an even deeper subgroup differentiated with variables such as income using systematic sampling. The results of this chosen method results are more representative and can be analysed more precisely using characteristics such as age, income or highest educational qualification.

3.3 Measuring instrument

The questionnaire was divided into three sections. The first was devoted to anticipating autonomous vehicles' technological progress and whether participants placed enough confidence in the new technology to give up any control. The participants chose answer options on a numerical scale (Likert scale) from 1 to 5, with a rating of 1 showing the least trust in technology and a rating of 5 representing full trust.

The second part quantified SVO based on Murphy et al. (2011). Trends and the participants' social attitudes were measured based on the accumulated pronouncements of six different scales offering a variety of nine decisions. Figure 9 depicts an example of one of the six scales in which the test subjects had to choose an amount they would claim against a third party unrelated to them (find the whole scale in appendix; Murphy et al., 2011).

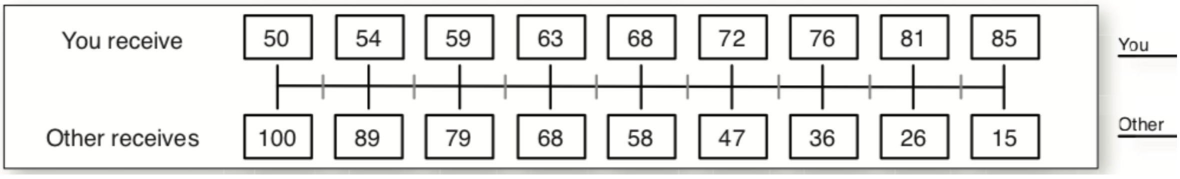

Figure 9: SVO Slider Items participants can choose

With this test, Murphy et al. could put participants' behaviour into the following four categories using a mathematical model called the "Slider Method," which calculates a decision's angle. The measurement consists of six decision options, each with nine secondary decision options. All have the same fence and differ in their resource allocation, based on which the DM can make his decision. Each decision includes a split payoff that is predetermined calculated from the participant's decision. For example, the DM chooses a value x between 50 and 100. The payoff for him would be x, whereas, for the third party, the payoff is 150 - x. The DM chooses his individual preference between the nine decision options and thus also determines the payoff a third party receives. The area of altruism in figure 9 extends somewhat beyond the first two decisions in which the independent received rights of 50 and contributed 100 to a third party. The aim of the altruistic thought is to determine the maximum amount paid to a third party. This selection contrasts with competitive behaviour at the other end of the scale, which takes a more selfish approach by trying to maximise the amount for itself. With the other two behaviours that tend towards the middle left (prosocial) to the middle right (individual), the aim is to minimise the amount paid out between them (Murphy et al., 2011). The categorization recorded can therefore be converted into a linear slope, which is recorded in Figure 10, on the basis of a formula which will be discussed in a subsequent period. This serves the purpose of initiating and connecting the following patterns of behaviors.

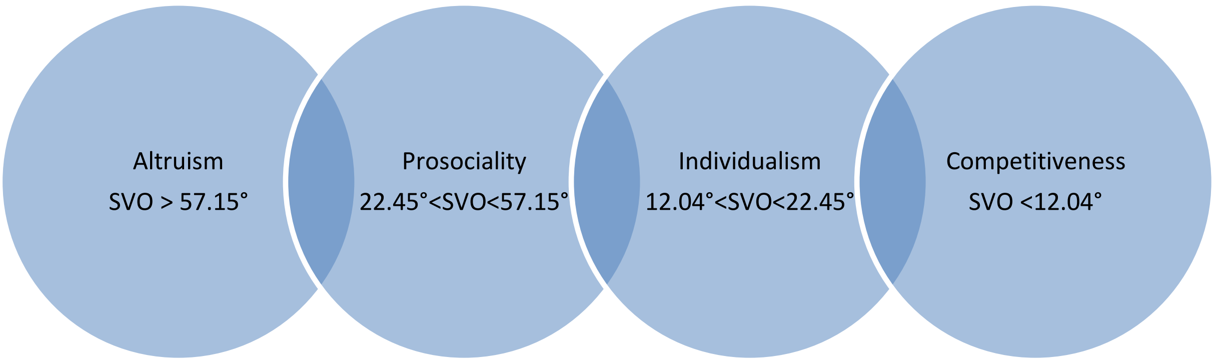

Figure 10: Social behavior categories

The third part of the questionnaire dealt with a concrete decision-making situation in which the study participant had to decide on a scale from 1 to 5 how he/she assessed his/her ethical tendency towards the environmental aspect while indicating how crucial the increase in safety was to him/her.

3.4 Questionnaire design

For the study, no incentives were planned. Before issuing the study, a pilot survey was conducted among 50 people. The survey was deployed for two weeks using the Google template and was available in German and English. About twenty minutes were required to answer the whole questionnaire, which was divided into three parts. Questions could be answered by ticking an answer box on a scale. Stratified random sampling was employed to capture variance between age, gender, and nationality behaviour. Only Austrian participants were included in this study. The core focus was to investigate different tendencies across generations, gender, rural and urban respondents, as well as tendencies between income classes. The survey was available from the middle of June until the end of August 2020 and could be filled out online. As most people were working from home or were home-schooling because of the current worldwide pandemic, a fast response rate was expected, and a scope of at least 1,000 participants was anticipated. The answers of the three levels of the survey could all be sub-categorised in a stated preference model specialised in the following variables.

Table 2: Questionnaire design categories

	Subcategory
Individual Attributes	Sociodemographic Status
Attitudes	Preferences Opinions
Satisfaction Aspects	Appeal Safety Price Environment

The first level of the analysis aimed to reveal respondents' previous knowledge in the area of AVs and rate them with easy-to-answer questions. Response options included a Likert scale from 1 - 5 (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree) as well as the choice between a closed yes-or-no question. Those traditional scales are commonly used for survey responses to show participants' tendency. The set of the four stated questions were formulated to help answer the first hypothesis, H1.

The second part used the SVO method by Murphy et al. Many social behaviour studies have based their investigations on that method to yield excellent results predicting actual behaviour (for more on that specific instrument, see point 3.3). The method was chosen to answer the second and third hypotheses, H2 and H3 to find out about value tendencies.

Next, part three directly confronted participants with a major ethical dilemma. The literature review revealed that a major conflict in this area is the environmental and technological mobility factor, meaning safety. Thus, the goal in this part was to determine participants' direct tendency between these issues using a 5-point scale. A rating of 1 represented an absolute preference for the safety factor and complete indifference to the environment. Participants who selected 2 would prefer the safety aspect but would not completely rule out the environmental factor. A rating of 3 classified the participant as indifferent to either circumstance. Selecting 4 meant the environment was preferred to safety (inverse to 2), and in 5, only the environmental factor was preferred, with the safety aspect unchanging at the current accident percentage. At the end of the questionnaire, the participants were asked about their gender, age, location and income to facilitate a cluster analysis.

After completing the data collection, the data record was downloaded. Using Google Forms enabled the data to be downloaded as an Excel document. The respondents' answers to the questions were each given a number assigning the value or their meaning using a variable key. Next, the individual questions were thematically combined into clusters to better test the results. SPSS was used to help with the categorisation and evaluation of the data, yielding results that should reflect the respondents' attitude towards autonomous vehicles, their ethical assessments and tendencies, and their SVO.

4 Results and analysis

First, a sample profile is presented for a better overview of the survey results. This descriptive statistic shows the numbers of participants and the categories and subcategories previously described in the methodology section. Descriptive statistics, bivariate and multivariable regression analysis were employed to provide a better understanding of the correlations of investigated behaviour patterns.

4.1 Results

As explained in the methods section, an attempt was made to achieve an even representation among different sociodemographic groups (see Table 3). This effort was mostly successful, as seen in the following table. Contingents were only set for the participation of the following variables.

As described in chapter 3, an equal distribution was targeted for several reasons. Distribution across gender (men vs women) and residential locations (rural vs urban) were distributed 50-50 to capture different behaviours that might have been caused by different background contexts (e.g. sociodemographic and built environment factors).

The survey output (as shown in Table 3 below) shows that the respondents were 47% female and 52% male. The age groups were distributed as follows: 18-20-year-olds (17%), 20-30 years (34%), 30-40 years (28%), 40-50 years (around 5%) and over-60 (only one participant; only 0.1%). In terms of geographical distribution, 59% of the participants were from rural areas, and around 40% were in urban areas. The variables in the distribution of income were distributed as follows: earnings under €1,500 (around 3%), up to €2.000 (approximately 12%), up to €2,500 (23.7%), €2.500-3.000 (33.5%), and up to €5.000 (17.5%). The last variable category involved respondents' level of education: high school graduates (around 29%), bachelor's degree (45%), master's degree (around 17%); meanwhile, PhD graduates accounted for only 3.6%.

Table 3: Sociodemographic profile of respondents

	Frequency	Per cent
Gender of respondents		
prefer not to tell	1.0	0.1
female	520.0	47.4
male	577.0	52.6
Total	1098.0	100.0
Age of respondents		
18-20	182.0	16.6
20-30	371.0	33.8
30-40	304.0	27.7
40-50	187.0	17.0
50-60	53.0	4.8
>60	1.0	0.1
Total	1098.0	100.0
Location of respondents		
Annweiler	1.0	0.1
Bruck an der Mur	1.0	0.1
Graz	53.0	4.8
Hinterglemm	1.0	0.1
Innsbruck	53.0	4.8
Linz	4.0	0.4
Lustenau	1.0	0.1
Rural	648.0	59.0
Salzburg	3.0	0.3
Vienna	331.0	30.1
Total	1096.0	100.0
Income of respondents		
N/A	7.0	0.6
to € 1,500	138.0	12.6
to € 2,000	133.0	12.1
to € 2,500	260.0	23.7
to € 3,000	368.0	33.5
to € 5,000	192.0	17.5
Total	1098.0	100.0
Highest degree of respondents		
N/A	66.0	6.0
High school	313.0	28.5
Bachelor’s	495.0	45.1
Master’s	184.0	16.8
PhD	40.0	3.6
Total	1098.0	100.0

Table 3 reveals a sparse percentage in the age group of >60 years. According to the commissioned company, it is challenging to include study participants over 60, as this age group often has no access to the Internet and is likely not computer literate. Data from 1,097 participants were recorded and analysed in the following sections.

4.1.1 Descriptive analysis

This section presents a descriptive analysis of the collected data. This method facilitates seeing how different values are distributed differently across different sociodemographic groups and context variables. In this section, bivariate descriptive analysis either shows single variables or maps the relationships between two variables. The distribution of respondents indicating their attitude on AVs is represented in Figure 11 which shows the yes / no answers given by the participants. Figure 11 reveals that the participants were confident about technological developments. According to the first chart in the table, over 90% would use an autonomous vehicle, and the majority would pay more for it. The last two results listed in the table show that around 80% expressed concern about relinquishing full control to an autonomous vehicle. Almost 70% were aware of the negative environmental effects of an autonomous network. Nevertheless, Figure 11 shows that people are relatively willing to invest more money in an autonomous vehicle.

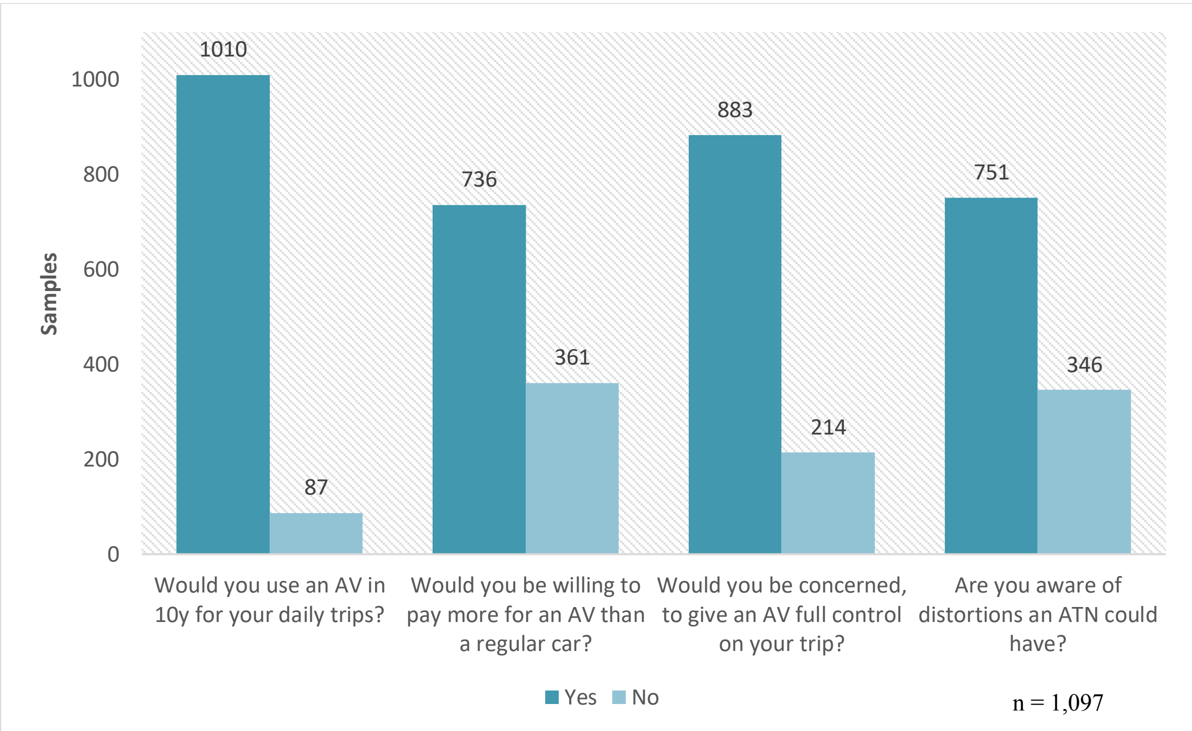

Figure 11: Possible attitudes towards autonomous vehicles

The first hypothesis that could be tested with this chart says that, despite a higher level of environmental awareness, economic affordability has higher importance to our respondents than environmental sustainability.

Next, an examination of different demographic variables provides more in-depth analytical insight.

An impressive result related to the second plot (Figure 12) deals with purchasing an autonomous vehicle and contrasts rural and urban participants. Respondents from rural and urban regions were asked whether they would invest more money in an autonomous vehicle compared to their own. All positive responses regarding the purchase of an AV are shown in the graph below (Figure 12. The figure shows that 84% of urban participants would buy an AV, whereas only 55% of rural respondents would invest in the new technology. The survey results recorded a potent buy mentality with a sum of 737 participants who were ready to invest in an AV. In comparison, we could note the greatest support was seen in urban areas.

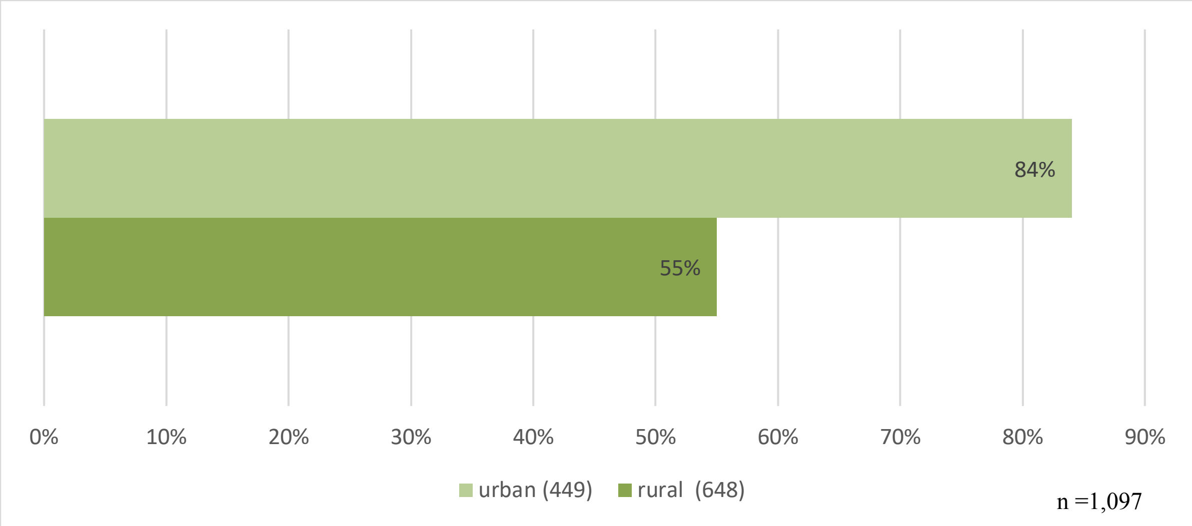

Figure 12: Difference between urban and rural, who would buy an AV

The next illustration (Figure 13) relates to how concerned participants were about using an autonomous vehicle. In more detail, the requirement was to give up full control and let the vehicle drive from point A to B without human interaction. The answers to this question were examined in connection with the participants' age. As shown in Figure 13, at least 90% of all age groups would be concerned in the scenario outlined here.

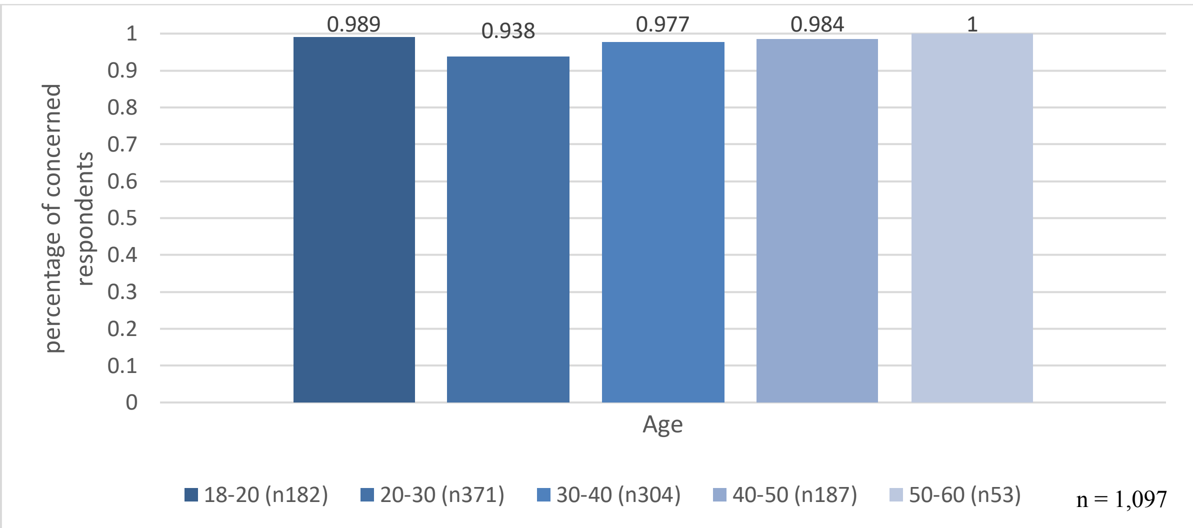

Figure 13: Percent concern about AV use of different age groups

4.1.2 Social value orientation (SVO)

The second part of the study focused on SVO, intended to show how people make decisions connected with an ATN. Some participants appear to make sensible decisions, but some decision results may not always be easy to understand. This analysis aims to understand and quantify respondents' value orientation. The so-called DM is responsible for the distribution between himself and a third party. The following explanation uses money to better illustrate the example. The respondent, who is also the DM, decided the amount he/she would claim for himself/herself and the amount he/she would distribute to a third party he/she did not know. Here are two examples of how the DM might have decided.

Option 1	Option 2
\$85 to the DM \$85 to another person	\$100 to the DM \$50 to another person

Figure 14: Example of options to choose for the DM (Murphy et al., 2011)

Option one represents a rational decision, whereas option two is considered an individualistic variant representing homo economics (maximum profit for oneself). So the DM would penalise the other person by \$35 to get an additional \$15. In this study, the monetary decision-making process for money distribution was examined along with value orientations of environment and safety. The last two pillars' units were defined by land area in square metres and a higher probability of survival in a traffic network. The calculation process for the three different SVOs was as follows (the example calculated the SVO for money, but the method was the same for the other two):
First, the respondents' distribution options were collected and subtracted by 50. Both the mean of the DM and the third party were determined, and the ratio of the two was calculated. The inverse tangent was then calculated from this result to determine a representative angle in the coordinate system. The following graphic describes the process using an equation.

$$\arctan\left(\frac{mean\ to\ self - 50 * scale}{mean\ to\ other - 50 * scale}\right)$$

SVO Equation (Murphy et al., 2011)

As already described in the methodology section, social forms of value orientation can be determined by calculating the different angles. These values are listed here again for further understanding.

$$\begin{aligned}
1 &= \text{Altruist} \Leftrightarrow \texttt{svo_angle} > 57.15,\\
2 &= \text{Prosocial} \Leftrightarrow 57.15 \geq \texttt{svo_angle} > 22.45,\\
3 &= \text{Individualist} \Leftrightarrow 22.45 \geq \texttt{svo_angle} > -12.04\\
4 &= \text{Competitive} \Leftrightarrow \texttt{svo_angle} \geq -12.04
\end{aligned}$$

Figure 15: Angles of SVO (Murphy et al., 2011)

For better understanding of the following graph, the study results are explained again, step by step, using the coordinate system in Figure 16. It can be seen that a low SVO angle leads to a competitive behaviour, and an angle that is closer to 60º is to be classified as more altruistic. In the evaluation of the 1,097 participants, the SVO shows 27º for money (ochre), 37º for health (red), and 28º for the environment (green). With these results, all three characteristics of the study contrast in prosocial value orientation. Concerning the initial question, the graph also shows a slight difference between money and environmental orientation, both of which border on individualism. In analysing these three pillars, the SVO of health is positioned much more altruistically, placing itself relatively precisely between the two orientations of the individualistic and prosocial forms. This outcome indicates the DMs were a lot more generous with their "fellow human beings" in the decision-making process regarding security (Murphy et al., 2011).

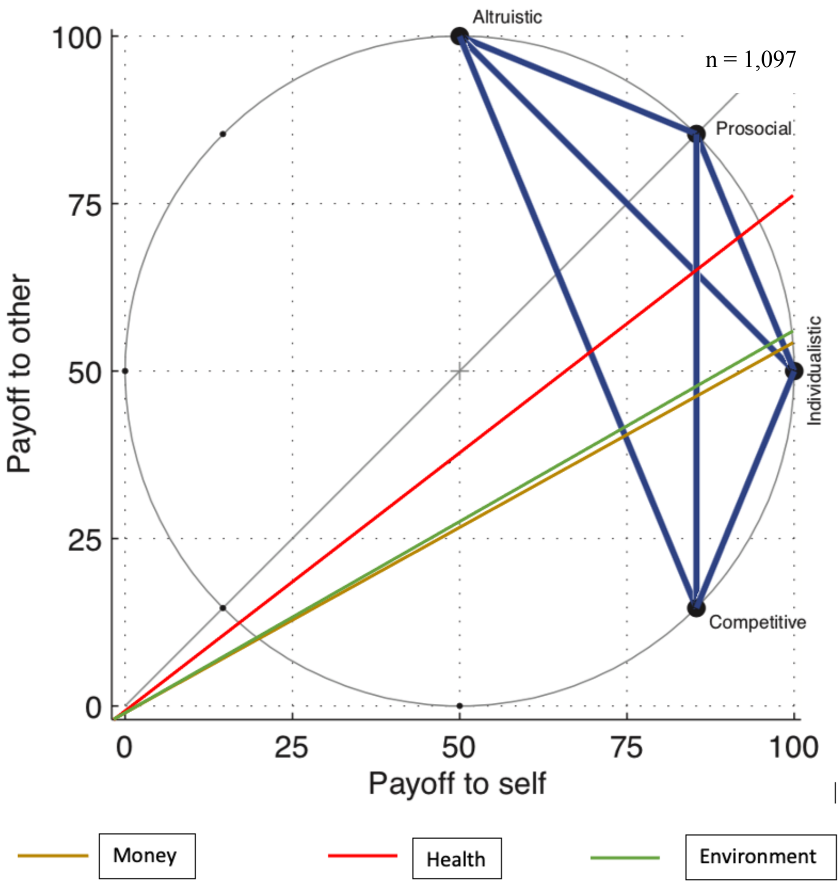

Figure 16: SVO results

The SVO results were next used to check the context of captured variables that contributed to the decisions shown in Figure 16 and were consequently processed, starting with the monetary value orientation.

One of the most prominent variables with a relatively powerful influence on monetary value orientation was gender. Figure 17 reveals a difference in the decision between male and female respondents of over five grade points. The calculated average of the survey resulted in a 27º SVO in money. This outcome means the female participants still fell within a pro-socialist range but came close to an individualistic orientation. However, men with a score above 30º (average black line in Figure 17) took a more altruistic direction.

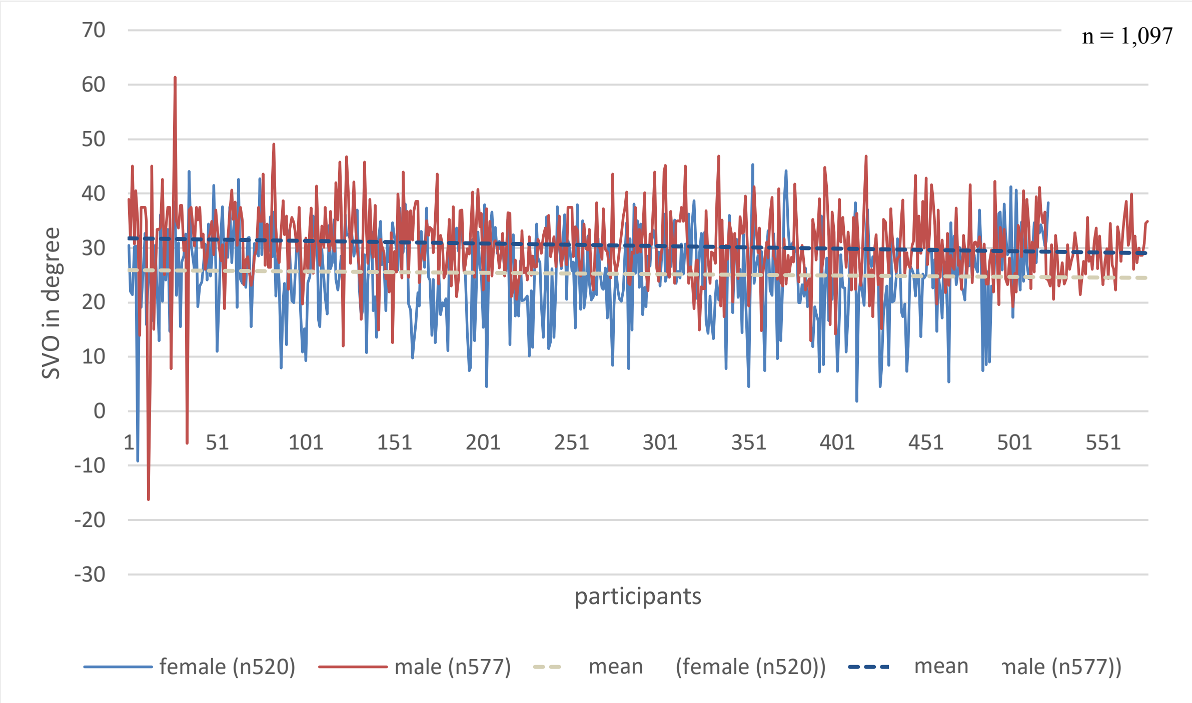

Figure 17: Monetary SVO on gender

Figure 18 presents a descriptive chart that allows a more detailed examination of the SVO of the environment for the variable of education level, ranging from high school to PhD. For this purpose, the test subjects were divided into subgroups determined by their level of education. The comparison between the highest educational qualifications also provides an exciting insight into the SVO environment. The figure demonstrates that respondents with a high degree have a rather egocentric attitude. A clear trend emerges along the spectrum from high school to PhD. participants, showing how relatively altruistic behaviour in high school develops into more individualistic behaviour as the level of education increases.

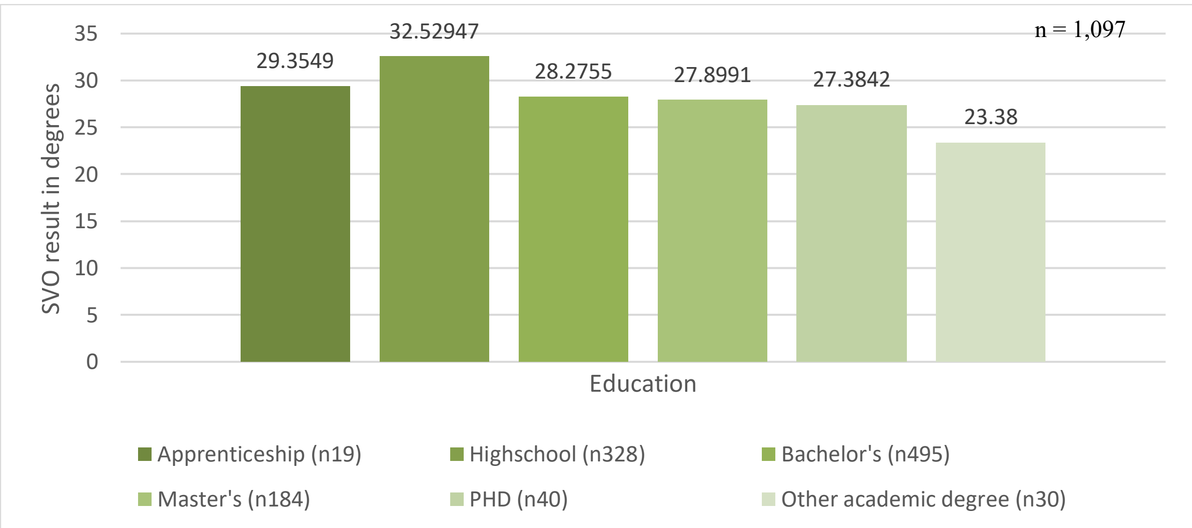

Figure 18: Environmental SVO on degree

The last section in the SVO in Figure 19 examines the pillar of safety in more detail. The most noticeable variable was income. The participants were divided into five different income classes to examine the SVO for security in terms of value orientation in the different classes. The descriptive analysis shows how an increase in income correlates with increasingly altruistic safety behaviour. The only exception to this trend is the highest income category of €5,000, which, after a sharp rise to over 36 ° in the previous category, falls back to 28º.

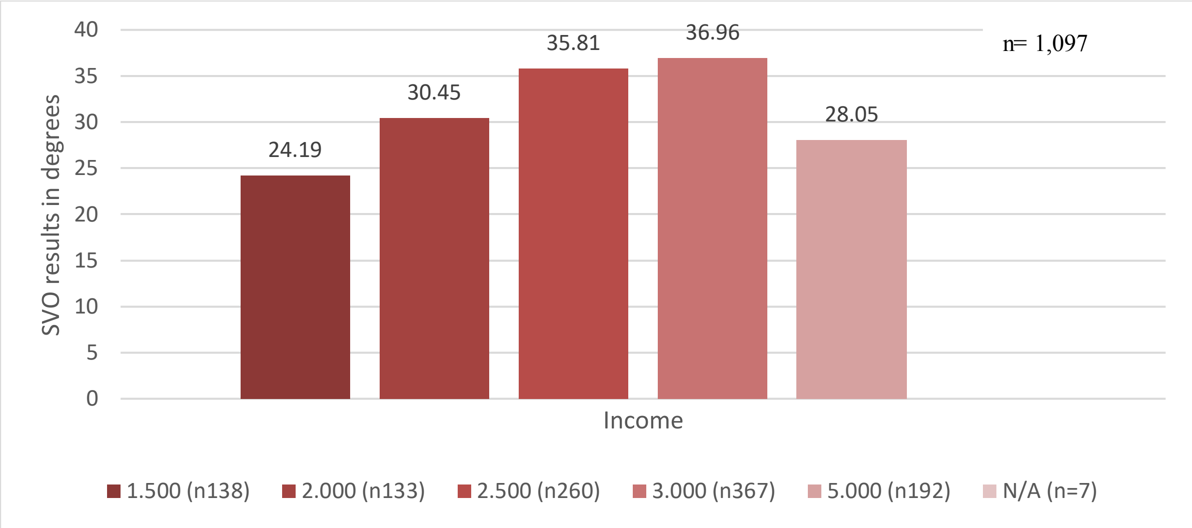

Figure 19: Safety SVO on income

In the last part of the study, the hypothesis explored assuming the existence of a selfish society that puts its safety above the environment's shared benefit. However, these investigations were against expectations considering hypothesis 2 and can be understood precisely in Figure 20. The participant's task was to choose between two outcomes: (a) cutting the chance of being hit by a car by half or (b) cutting CO_2 emissions by up to 200%. In the dilemma situation posed, each participant had five options to choose from. Possibility options 1 and 2 represented a preference for their safety, while options 4 and 5 represented an environmental preference. The graph demonstrates that participants decided with an overwhelming majority in favour of the environment, firmly placing this decision above their interest.

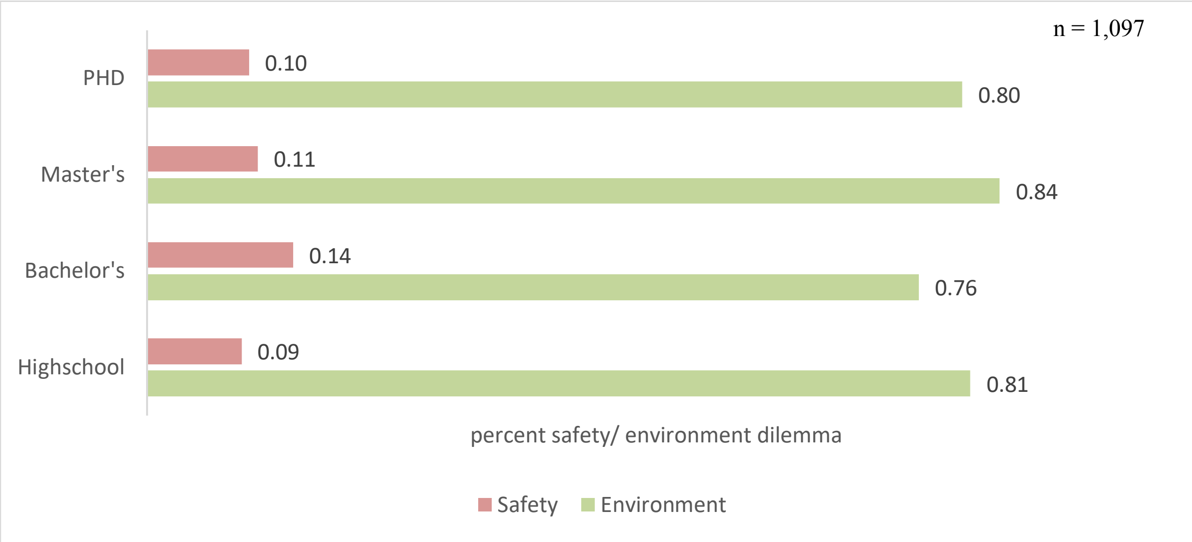

Figure 20: Social Dilemma results Safety / Environment in per cent

The next part of the analysis explores other analytical relationships and examines their model strengths.

4.1.3 Multivariate-regression modelling

Multivariate analyses were carried out to better analyse the variable influences and clarify relationships. In this part, some regression models showed the interactions of variables on the SVO. This approach facilitates subsequently determining which variables influence and which can be ignored in further analysis. The coefficient is the average increase in the dependent variable in the regression, while the other explanatory variables remain the same. The following equation depicts how the regression is calculated.

$$y = \beta 0 + \beta 1X1 + \ldots + \beta nXn + \varepsilon$$

y shows the dependent variable's value, where ß0 is the constant value when all other values are 0. The value ß1 is the estimated coefficient of dependent variable 1, showing the magnitude of influence that dependent variable X1 has on y.

The table for the coefficients provides information about the size, the sign of the constant (plus or minus), and the significance of the explanatory variable's effect on the dependent variable. The effect's significance is represented by alpha, which shows the probability of the study rejecting its hypothesis if true.

The standardised coefficient (B) is calculated, which compares the strength of each variable's effect with the dependent variable. Therefore, the larger the value of beta, the greater the effect. In brief, an example of how the model works is as follows, where the model involves how the level of education affects income. To compare these two variables, they must be standardised. Suppose the level of education has a standardised beta coefficient of 0.4, and the income level has a value of 0.23. Then the model shows that, with each increase of a unit of standard deviation formation, the variable of education increases by a factor of 0.4. The variable of income remains constant here.

Conversely, if the standard deviation of income increases by one unit, this variable will grow by 0.4. The standardised beta coefficient is calculated by subtracting the mean value from the variable and dividing it by the standard deviation. This process yields comparable units of the variable.

The last tool used to describe the strength of the correlation in the model is r^2, which has a value between 0 and 1 and shows how much the variation of the model's data can be accurately mapped. However, no conclusions can be drawn about future prognoses.

The independent variables' regression statements are broken down as follows and are always checked for the same independent variable.

Dependent variables	Independent variables
• Most concerned participants	• Male / Female
• Participants buying an AV	• Rural / Urban
• SVO result money	• Age
• SVO result environment	• Income
• SVO result safety	• Degree

The first hypothesis to be tested with the regression analysis mentions that technological change is supported. The following results, in Table 4, reveal the level of how concerned people are when giving full control to the AV. Compared to the non-standardised regressions, the standardised is not intuitive and shows a change of one unit of the variable "being a female" to a unit. Here, an amendment of 1.032 is seen in the concern to leave control to an AV. Since the variable "being a female" is also significant, it can be concluded that a higher proportion of female participants would lead to a more severe concern towards autonomous vehicles. However, the non-standard coefficient is interpreted intuitively and can only conclude a negative or positive context since the units of the variables do not match.

The level of education demonstrates a significant correlation with the change in concern as well. Respondents with a master's degree, who represent a positive correlation with increasing AV concerns, are strong outliers in a relative negative trend, with a significant standardised value of 0.333 (see Table 4). Furthermore, a trend in the level of concern regarding income can be observed. It turns out that the group above the income limit of €2.500 income, shows a positive correlation with concerns about autonomous vehicles. Compared with income groups lower than €2.500, the level of concern remains relatively low. The rural factor also represents a negative correlation, indicating that participants in urban areas are slightly more concerned about giving full control to an AV. That said, the results for that specific variable are not significant.

Table 4: Regression models to examine the influence of sociodemographic factors to the level of concern towards an ATN

	Change in concern		
	B	Beta	Sig.
(Constant)	0.834		0
Being female	0.363	1.032	0

Rural	-0.013	-0.035	0.414
Age 18-20	0.002	0.005	0.875
Age 20-30	-0.037	-0.098	0.005
Age 30-40	-0.019	-0.049	0.16
Income 2,000€	0.003	0.005	0.904
Income 2,500€	-0.053	-0.127	0.012
Income 3,000€	0.183	0.492	0
Income 5,000€	0.165	0.357	0
Bachelor's	-0.175	-0.496	0
Master's	0.333	0.309	0
PhD	-0.337	-0.468	0
R	.462a		
R Square	0.213		

Table 5 relates to those participants who would most likely be willing to purchase an autonomous vehicle. In the second line of the table, it is immediately apparent that female respondents are significantly less willing to buy an autonomous vehicle than male participants. The cost of one's vehicle was used as a comparison value. The table also shows significant values in income. Observably, beginning with a salary of €2,500, there is a positive correlation towards the acquisition of an AV. This means that participants who have a salary below €2,000 are less interested in a purchase. The respondents' academic degree also reveals significant figures and notes a negative correlation to the master's degree, whereby participants with a PhD degree are more likely to invest in an autonomous vehicle with a significant standardised coefficient of 0.226. Notably, in this case, r's value is higher than the other regression models' values. Compared to the other tables, the informative value of the relationship between the variables in this model is far greater.

Table 5: Regression model to investigate the influence of sociodemographic factors to the probability of one would buy an AV

	Change in the purchase of an AV		
	B	Beta	Sig.
(Constant)	0.932		0
Being female	-0.461	-0.49	0
Rural	-0.101	-0.105	0
Age 18-20	0.031	0.025	0.235
Age 20-30	-0.02	-0.02	0.364
Age 30-40	-0.018	-0.018	0.426
Income 2,000€	-0.205	-0.143	0
Income 2,500€	0.181	0.164	0
Income 3,000€	0.142	0.142	0.008
Income 5,000€	0.087	0.071	0.113
Bachelor's	-0.158	-0.167	0.016
Master's	-0.503	-0.175	0
PhD	0.435	0.226	0
R	.829a		
R Square	0.688		

The next regression model in Table 6 analyses different monetary value behaviours. The participation of rural respondents shows a strong positive correlation in contrast to the urban comparison group. A value of 0.141 of the standardised beta coefficient means a 0.14% increase in social monetary value orientation for each additional rural candidate. Furthermore, alpha has a value of 0.001, which represents a rather low risk of taking a wrong decision and therefore is also significant. Another significant value in this regression table can be seen in income of up to €2,500 and €5,000. Both reveal prosocial monetary behaviour compared to the odds and would increase SVO by around 17% when increased by another respondent in that income range. Most noticeable in the table is that bachelor's degree graduates have a significantly strong negative correlation in monetary behaviour.

Table 6: Changes in SVO money

	Change in monetary SVO		
	B	Beta	Sig.
(Constant)	27.733		0
Being female	-2.389	-0.152	0.093
Rural	2.24	0.141	0.001
Age 18-20	0.423	0.02	0.548
Age 20-30	1.448	0.087	0.015
Age 30-40	0.583	0.033	0.347
Income 2,000€	0.61	0.025	0.546
Income 2,500€	3.483	0.189	0
Income 3,000€	-0.248	-0.015	0.862
Income 5,000€	3.256	0.158	0.028
Bachelor's	-4.6	-0.292	0.009
Master's	-1.839	-0.038	0.43
PhD	1.251	0.039	0.496
R	.438a		
R Square	0.192		

Table 7 describes the social value behaviour connected with environmental resources in contrast to the previous discussion. Here, the significant influence that rural participants have becomes evident. With a Betha coefficient of 2.88, this variable has one of the most significant positive influences on social-environmental behaviour. With an increase of one rural participant, the environmental SVO will also increase by around 17%. However, the highest positive significant value has the income class up to €2,500 with a Betha coefficient of 4.129. Also noteworthy is that the salary variables listed here all have a positive correlation with environmental behaviour. Finally, as observed in the previous table, a strongly negative correlation of bachelor's graduates is also displayed in Table 7, even if the impact of alpha does not represent significance here. However, the strength of the regressive environmental model is rather low, with a value of R=0.32 compared to the other models shown above.

Table 7: Changes in SVO environment

	Change in environmental SVO		
	B	Beta	Sig.
(Constant)	27.339		0
Being female	-0.968	-0.057	0.548
Rural	2.88	0.168	0
Age 18-20	-0.693	-0.031	0.383
Age 20-30	1.114	0.062	0.097
Age 30-40	0.442	0.023	0.529
Income 2,000€	3.132	0.121	0.006
Income 2,500€	4.129	0.208	0
Income 3,000€	1.407	0.079	0.382
Income 5,000€	0.75	0.034	0.654
Bachelor's	-3.416	-0.202	0.085
Master's	3.423	0.066	0.194
PhD	-0.067	-0.002	0.974
R	.328a		
R Square	0.108		

The last regression analysis describes the SVO in terms of health. As can be observed in Table 8, none of the values is significant except for income. All income classes listed have a powerful positive correlation compared to those below €2,000 and above €5,000. Thus, the conclusion can be drawn that in the income brackets of €2,000 to €5,000, a strongly positive trend towards an altruistic value orientation can be seen. The table records a steady increase from €2,000 to €3,000 in the SVO, consequently dropping from a beta value of 15 to 7 when income reaches €5,000. Although the described model has fewer significant independent variables, its variables have a higher correlation than in the previous graph. Here, it has a value of R being approximately 0.43.

Table 8: Changes in SVO safety

	Change in safety SVO		
	B	Beta	Sig.
(Constant)	21.149		0
Being female	-0.058	-0.003	0.977
Rural	0.712	0.031	0.474
Age 18-20	-1.168	-0.039	0.245
Age 20-30	0.176	0.007	0.835
Age 30-40	0.519	0.021	0.558
Income 2,000€	5.806	0.17	0
Income 2,500€	11.701	0.447	0
Income 3,000€	15.066	0.638	0
Income 5,000€	7.472	0.255	0
Bachelor's	2.855	0.128	0.254
Master's	5.344	0.078	0.109
PhD	-2.106	-0.046	0.422
R	.428a		

R Square	0.184

In summary, relationships between variables can be well-represented here, even if the strength of some models (r^2) fluctuates somewhat in the lower range of the representative models. Another crucial observation is that the difference between the generations usually has no significant influence on the dependent variables. In contrast, all other variables, such as income, gender, place of residence or education, influence the dependent variables to a higher level of significance.

5 Discussion

This chapter sets out to classify the study's results, answer the research questions and validate or reject the hypotheses.

First, a strong positive tendency towards ATN among the participants is evident. More than 90% of the participants opted for an ATN, selecting "likely" (4) or "very likely" (5), suggesting a high level of existing trust towards an ATN. Also, the respondents recognised an ATN's higher convenience factor. However, the results examining people's thoughts towards an ATN indicate that people associate overwhelmingly positive aspects with autonomous driving, neglecting all negative properties. This finding is reinforced by Ilias Panagiotopoulos and Dimitrakopoulous (2018), who evaluated their study participants' behaviour using the technology acceptance model. The researchers chose similar demographic variables to those used in the current study to arrive at a meaningful result, facilitating comparison with the first part of this study (Panagiotopoulos & Dimitrakopoulos, 2018)

For the high media attention given to digitisation and new technologies in smart mobility and the intensive ethical discourse, the state of technology and the prognosis for realistic implementation in a social context is known (→ see p. 17; 2.2.2). When the test subjects were asked whether they would like to use such a vehicle themselves, a clear positive trend (92%) emerged. In contrast, when asked if they were concerned about giving full responsibility and control to the vehicle, almost 80% agreed. This result corresponds perfectly with the statements made in the autonomous industry (Bartl, 2015). This apparent conflict reveals a type of "trust less euphoria" (→ note pp. 14-15; 2.1.2). The number of absolute opponents of the concept of autonomous driving can also be explained by currently existing software gaps that have led to accidents in the past (see Chapter 2.1.2). The negative aspects damaging the environment could also explain a negative tendency towards autonomous vehicles, which were discussed in more detail in the literature review.

To answer the research question of whether SVO influences environmental and health dilemmas in autonomous driving, the approach developed by Ackerman was used, to quantify the behaviour of respondents (Murphy et al., 2011). In the second part of the study, the SVO of respondents can be investigated with the help of the concept of utilitarianism in seeking to apply this concept. According to Bentham and Mill, utilitarianism positions itself close to altruistic behaviour and follows the well-known principle of "the greatest possible happiness for the greatest possible number" (Shackleton, 1993). However, this work's results differ significantly from those of John Steward Mill. In the present work, no altruistic orientation can be determined, especially not in the areas of environment and finances. The results, which are more in line with the work of Liebrand, showed a strong trend towards an individualistic value orientation. Other studies share these observations that participants have a "self-interested" attitude in a monetary aspect (Liebrand & van Run, 1985).

Individual utility maximises "their behavior and with genuine interaction, individuals tend to weigh their outcomes stronger than of other ones" (Hilbig et al., 2014). That said, Hilbig et al.'s study examined the effects of the five personality factors (conscientiousness, agreeableness, neuroticism, openness to experience and extroversion), and the SVO correlated positively and negatively with them. Accordingly, this study implies that human behaviour and the examined SVO can be traced back to the so-called five big personality traits (Hilbig et al., 2014).

Significant differences between gender are observable, revealing women as greater individual benefit maximisers than men. This result does not agree with the existing research articles, whose analyses show the female gender having a more altruistic value orientation than men. According to Liebrand and van Run, males chose a significant amount of money for themselves compared to female participants (Liebrand & van Run, 1985, p.96). Caldwell, who wanted to test genders' different behaviours using the prisoner's dilemma, came to no conclusions. However, he found women more willing to cooperate, suggesting that women are more conscious of their behaviour (Caldwell, 1976). Also, Luca Caricati, while researching different attitudes about behaviour between male and female participants, found significant results indicating that men have the urge to higher achievement (Caricati, 2007). Perhaps the more individualistic results of the female participants in this study can be explained by the higher emancipation of women, who have had to gradually fight their way to equal rights. Notably, some articles cited in this study are over 15 years old but are the most recent ones in this research area. Much progress has been made to create equality between men and women, and efforts in recent years have turned to establishing female role models in higher positions, though much remains to be accomplished. The struggle for a fairer distribution of roles reflects women's adoption of more individualistic behaviour to be competitive and achieve equality.

A secondary aspect, recognisable in all regressions of personal value orientations, is the sub-selection between rural and urban participants. All participants living in rural areas show a positive correlation to SVO. This finding is confirmed by Timilsina et al.'s study examining generativity in connection with SVO. Here, it becomes apparent that an urban way of life leads to a more individualistic social tendency. The reason given is the high density of people and colleagues, which results in less interpersonal intimacy and less concern for others. A higher level of distrust and competitive behaviour with colleagues could also be shaped by urban areas. On the other hand, more social rural behaviour is justified by nature-based community living. Traditions are passed on through generations of parents, relatives or neighbours, requiring close interaction and a basis of trust (Timilsina et al., 2019).

When examining the different age groups, an increase in SVO corresponds to increasing age. A continuous increase can be noted both in the orientation towards the environment and in health. This phenomenon is also consistent with the literature review. In Hellevik's study on "Age Differences in Value Orientation", a direct connection between different value orientations with increasing age was evident. This relationship is explained by a modern, materialistic behaviour structure, especially in age groups that grew up in the 80s and 90s. The economic upswing after the war initially resulted in a materialistic disinterest. However, in 1980, economic security became more dominant and led to more individualistic behaviour (Hellevik, 2002).

In terms of income variables and education, no patterns could be identified among the three value orientations. Moreover, no studies were identified that deal with income or the level of education in the literature. Nevertheless, as described above, these variables demonstrate different significant values in the SVOs.

In the third part of the survey, against the second and third hypothesis, people chose environmental pollution reduction instead of their health. In social dilemmas, a substantial proportion of individuals are typically willing to forgo some health profits to benefit the environment and display altruistic behaviour. Hardisty and Weber reported similar results, which they attributed to an already existing high level of safety, making the trade-off unequal (Hardisty & Weber, 2009). On the other hand, the fear of higher air pollution is a more present risk, also reflected in this study's results regarding square metres of land. In contrast, no significant differences in monetary and environmental differences were detected (Hardisty & Weber, 2009).

6 Conclusion

The extent to which the technological progress of an autonomous transport system will affect people's lives and the environment in the future is difficult to estimate and depends on a number of variables. This thesis aimed to identify how SVO decisions could influence environmental and health aspects in combination to an ATN. Based on a quantitative analysis of 1,097 austrian participants with different sociodemographic backgrounds, it can be concluded that SVO could have a rather individualisic impact on environment and health, compared to equally contucted studies.
First, the current status of the development of the autonomous driving concept was mapped, focusing on respondents' unconventional behaviour regarding ethical aspects of their social behaviour in specific distribution situations. The results represent that autonomous transport networks are met with quite euphoria, which supports hypothesis 1. The sustainability aspect, relating to the environment or health, play a subordinate role to the participants. Due to the rather individualistic results of the SVO from the survey on money and the environment, the second and third hypothesis also apply to a large extent. On the one hand, due to the dilemma situation in the third part of the survey, a higher level of environmental awareness can be observed, nevertheless, part two of the survey shows that the participants are more willing to sacrifice environmental units than their money.
However, regression analysis of the attitudes of the individual groups of participants makes it possible to closely examine the tendencies subgroups have and analyse behaviour in terms of different sociodemographics. One example would be an analysis of higher-income groups with increased concerns about autonomous cars displaying a higher SVO result when purchasing an AV because of their better financial situation. The conflict in rural participants' objectives is also worth mentioning. Analysis revealed a more altruistic attitude for their part towards both the safety and environmental aspects. While autonomous transport networks will primarily affect younger generations, the following aspect is a significant factor in the discussion. The results of the regression revealed that older generations had a more altruistic attitude than younger ones. The respondents reflected this outlook in terms of financial and environmental aspects, which also suggests the need for guidance on the part of regulatory bodies and structure over the course of technological progress concerning autonomous transport networks.

In the interest of offering a safe and environmentally friendly solution for society in the future, educational work must be carried out, alongside establishing sustainable regulations and guidelines for implementing an ATN in the existing transport system. Also, a well-regulated balance of company leadership and institutional work is necessary to achieve technological development as well as maintenance of the common good. While the used tool of SVO limits the generalizability of the results and the conclusions drawn to an ATN, this approach provides new insight into the value bahavior of human values and behaviors. To better understand and evaluate the implications of these results, a better understanding of "Human Machine Interaction" in particular about building trust between human and machine is much needed.

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8 Appendix

Questionnaire:

Section 1

Ten years from now, do you think we will have a network of vehicles which will move autonomously? *

	1	2	3	4	5	
Very unlikely	○	○	○	○	○	Very likely

Would you use an autonomous vehicle in 10 years for your daily trips? *

- [ ] Yes
- [ ] No

Would you be concerned about giving an autonomous vehicle full control and let it drive and select a route for you automatically to your destination? *

- [ ] Yes
- [ ] No

Would you be willing to pay more to buy an autonomous vehicle than to buy a regular one? *

- [ ] Yes
- [ ] No

Are you aware of the distortions autonomous network could have to the environment? *

- [ ] Yes
- [ ] No

How concerned are you about the damage of technological advances (like self-driving vehicles, 5G- Network, interconnected infrastructure) in the transport sector, regarding possible environmental damage? *

	1	2	3	4	5	
Not concerned	○	○	○	○	○	Very concerned

Section 2

As whatever we do impacts our surrounding, in this section of the questionnaire, we will explore on how much you would be willing to adjust your decision so that others can have a better condition for themselves.

We will explore this trade-off in three different units of currencies:
money (€), environmental units (e.g. m2 of land) and safety units (fewer accidents / 10.000 inhabitants) between you and a hypothetical person/society. This hypothetical person/society is not related to you and you will never meet her/ him. Each division decision is divided into 3 subcategories:

Money: The first line of the bar below relates to the distribution of money. The more money you claim for yourself, the better for you and the worse for the other person.

Environmental unit: imagine how you would you set a quota of square meters of land or cubic meters of water between you and others. Like in the first example above, the more you claim for yourself, the better it is for you and less for others.

Safety: The higher the number you choose, the safer the condition for you yourself and the more likely for others to have an accident.

For each of the 6 questions, you can choose between 9 answer options in 3 categories.

For example, if you select option 1 in the money category for question 1, you will receive an amount of 85, as well as the other person 85.

Please enter your answers in the following fields.

Distribution option 1 *

Option	1	2	3	4	5	6	7	8	9
You receive	85	85	85	85	85	85	85	85	85
Other receives	85	76	68	59	50	41	33	24	15

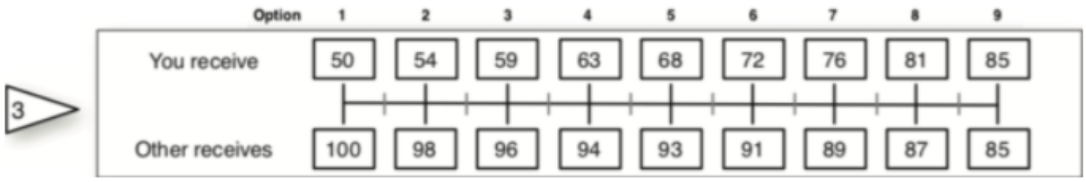
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money	○	○	○	○	○	○	○	○	○
Environ...	○	○	○	○	○	○	○	○	○
Safety	○	○	○	○	○	○	○	○	○

Distribution option 2 *

Option	1	2	3	4	5	6	7	8	9
You receive	85	87	89	91	93	94	96	98	100
Other receives	15	19	24	28	33	37	41	46	50

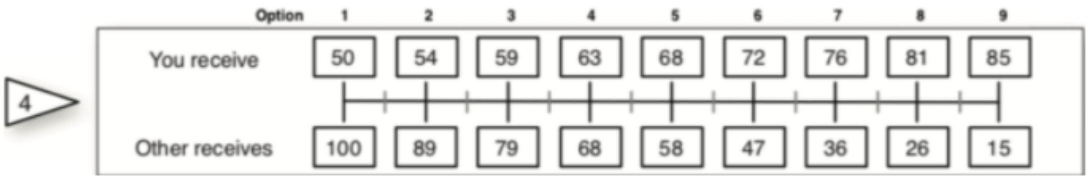
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money	○	○	○	○	○	○	○	○	○
Environ...	○	○	○	○	○	○	○	○	○
Safety	○	○	○	○	○	○	○	○	○

Distribution option 3 *



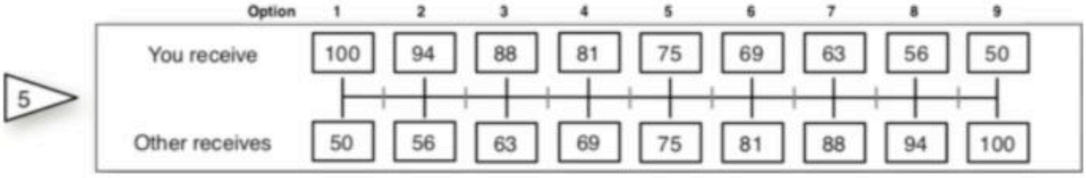
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money									
Environ...									
Safety									

Distribution option 4 *



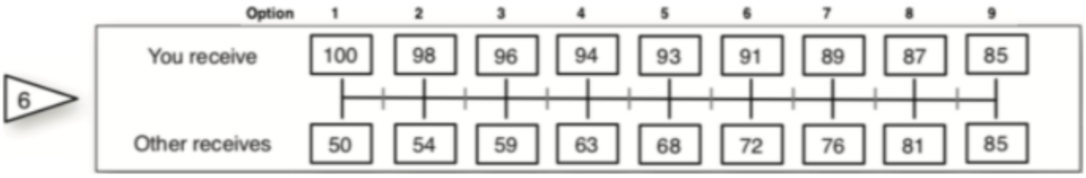
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money									
Environ...									
Safety									

Distribution option 5 *



	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money	○	○	○	○	○	○	○	○	○
Environ...	○	○	○	○	○	○	○	○	○
Safety	○	○	○	○	○	○	○	○	○

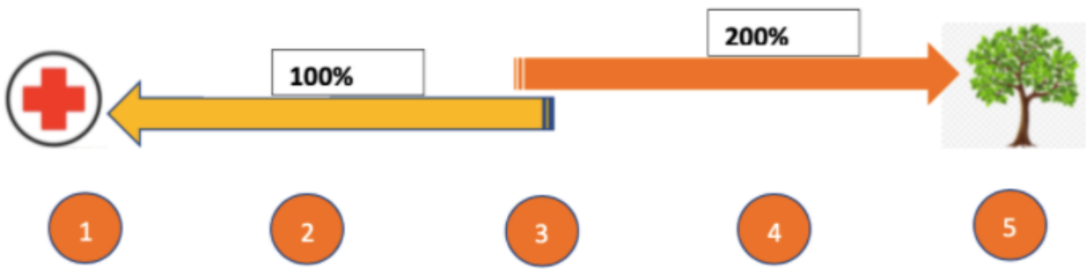
Distribution option 6 *



	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Money	○	○	○	○	○	○	○	○	○
Environ...	○	○	○	○	○	○	○	○	○
Safety	○	○	○	○	○	○	○	○	○

Section 3

The next question shows a dilemma situation in which you will have to choose between two outcomes: One is to reduce the probability of you being hit by an other car into over a half, or more than double your CO2 savings from the given trip; please indicate your preference between 1-5. *



	1	2	3	4	5	
Safety	○	○	○	○	○	Environment