

THE IMPACT OF AUTONOMOUS VEHICLES ON THE CITY STRUCTURE: A CASE STUDY IN ROMANIAN UNIVERSITIES

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Abstract

The development of autonomous vehicle (AV) technology has the potential to disrupt transportation in the coming years. This study explores the perspectives on AVs in Romanian universities, focusing on students' attitudes and perceptions, as well as the views of academics on the AVs impact on the structure of cities. The study employed a cross-sectional survey, collecting data from both online and face-to-face surveys. The research reveals that students generally have a positive opinion of AVs, emphasizing safety and comfort. However, concerns were raised regarding cost, reliability, employment impact, and privacy. Students' opinions changed over time, especially when talking about AVs disadvantages. Academic experts predicted significant changes in cities due to AVs, including reduced congestion, optimized space utilization, and increased emphasis on active transport. However, concerns about urban sprawl and the need for appropriate urban planning were also expressed. The study highlights potential health benefits of AVs, such as reduced air pollution and commuter stress, but also potential negative impacts like sedentary behaviour and reduced social interaction. These findings are emphasizing the need for further investigation into the long-term effects of AVs on city structure and health.

Keywords: automated vehicles (AVs), universities, perceptions and attitudes, urban structure, public health

1. INTRODUCTION

One of the most significant changes in the transportation sector in the past few years has been the emergence of automated vehicles (AVs) that can operate without human drivers. Many research studies have explored how people perceive and embrace AVs worldwide. Employing empirical methods such as surveys and focus groups, these studies have extensively explored various aspects related to users, determining factors, and vehicle features (Rezaei and Caulfield 2020; Rahimi et al. 2020; M. Kyriakidis, Happee, and de Winter 2015). For instance, a study by (Asmussen, Mondal, and Bhat 2020) utilized a ranked choice stated preference design survey in the Austin area, revealing insights that "the first customers in the market would be men and high-income individuals", signalling hesitancy among older individuals to adopt AVs. In Germany (Hohenberger, Spörrle, and Welpé 2016) found that the indirect

effect of gender on willingness to use automated cars remains consistent across different age groups. Additionally, results from (Kolarova and Cherchi 2021) indicated that confidence in automated vehicle technology is positively influenced by experiences with advanced driver assistance systems (ADAS), male gender, and age under 30. These findings collectively contribute to a comprehensive understanding of the factors influencing public attitudes towards AVs across diverse demographics and geographic contexts. These studies reveal common concerns, such as worries about privacy, software vulnerabilities, legal issues, and safety (Meyer-Waarden and Cloarec 2021).

Favourable opinions regarding AVs tend to be more prevalent among younger and middle-aged individuals, as well as among people with impairments and those who rely on public transportation (Butler, Yigitcanlar, and Paz 2021). However, a survey conducted in USA by (Bagli, Shay, and Combs 2022) reveals a nuanced perspective, suggesting that young adults may not be as ready for AVs as previously hypothesized. In a more balanced exploration by (Mourtzouchou et al. 2022), which utilized a combination of on-line and face-to-face focus groups, a demonstration of an automated vehicle prototype, supporting engagement activities, and a post-pre survey, the teenagers acknowledged the potential advantages of AVs, but also expressed concerns. These concerns encompassed aspects such as interactions with other road users, the reliability of automated driving systems, safety considerations, and concerns related to data privacy.

(Islam et al. 2022) outlined that around 59% of the survey participants in the main campus of the University of Florida thought that they would have to pay constant attention to the AVs while the vehicle would be in the autonomous driving mode. The study also found that around 51% of the respondents in Central were concerned about negative aspects of AVs such as facing system/equipment failures, harming the privacy and security, or coming into contact with human operated vehicles or any unexpected situations.

A literature review showed that limited literature has been published on the connected and autonomous vehicles acceptance in South-eastern European countries, including Romania. Based on similar characteristics as former communist countries, it is interesting to find the similarities and differences towards the adoption of CAVs. In Poland (Dudziak et al. 2021; Stoma et al. 2021), a survey carried out on 576 persons, showed that participants believe that the AVs will improve road safety and will reduce energy consumption, and the obstacles for the AVs deployment are legal liability, high cost, cybersecurity legal framework. In a survey carried out in Serbia (Cveticanin and Ninkov 2021), similarly as in Poland, it was found that AVs could reduce pollution and raise cybersecurity problems, but they have potential for social inclusion and liberate parking spaces. Hungary has been involved in more studies (Etzioni et al. 2020; Polydoropoulou et al. 2021; Miltos Kyriakidis et al. 2020) together with other SEE countries: Slovenia, Montenegro, Cyprus and Greece. The results of these studies suggested that the acceptance

of AVs depends on technological factors (reliability), costs, household size, but this preference was found to be different among the genders. It was not found any study carried out in Romania in this regard. It is observed that the perception and attitudes towards AVs in SEE countries do not differ compared to other international studies.

A notable gap exists in the available literature regarding the acceptance of AVs within the education sector, particularly among students and professors in South-Eastern European countries, including Romania. This scarcity of published research necessitates an exploration of the perspectives within the educational landscape concerning the upcoming integration of AVs. As a response to this gap, the primary objective of this paper is to present an integrated perspective from the education sector in Romania. This involves shedding light on the perceptions and attitudes not only of students but also of professors regarding the anticipated introduction of AVs. The paper aims to contribute valuable insights into the specific dynamics and considerations within the educational community concerning this transformative technological shift.

2. MATERIALS AND METHODS

2.1. Online survey

The first series of responses is obtained in the framework of the WISE ACT (“WISE-ACT – Wider Impacts and Scenario Evaluation of Autonomous and Connected Transport,” n.d.) project focusing on the wider impacts of AVs and funded by EU COST program, after the application of an online survey in Romania (Andrei, Negulescu, and Luca 2022). The survey has previously been deployed in most European countries and investigated daily transport habits specific to the most important journeys and the modes of transport used, as well as awareness, perception, and attitudes towards autonomous vehicles. Although the data were collected during the pandemic, respondents were requested to consider their usual travel behaviour prior to the restrictions, so the data collected and analysed in this study reflect pre-COVID-19 conditions. From the 309 responses received, 60 responses were retained, of those who declared themselves students. A definition of AVs has been included to avoid any misunderstanding: “...a vehicle that takes full and permanent control of speed and direction, on all roads and in all situations.” Respondents were asked to consider a fully automated vehicle, according to the SAE (“J3016_202104: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles - SAE International,” n.d.) level 5. The survey received ethical approval, and the data were collected anonymously between January–March 2021. The survey was performed in the second wave of the COST Action.

2.2. Face to face survey

The second set of the responses was obtained through face-to-face survey, conducted in Technical University of Civil Engineering Bucharest during the second semester of the academic year (from March to May 2023). A total of 50 students participated voluntarily in the survey and all the responses were valid (all questions answered). Sample characteristics are presented in Table 1.

TABLE 1 – SAMPLE CHARACTERISTICS IN 2021 AND 2023

Characteristics		2021 (%)	2023 (%)
Gender	Male	36,6	38
	Female	63,4	62
Driving license	Yes	75	74
	No	25	26

Source: Own processing

2.2. Interviews with professors

Finally, 10 professors from Romanian universities, experts in the fields of transport planning, traffic engineering, urban planning and public health were interviewed face-to-face or online in March 2023, regarding the impact of AVs on urban structure and their potential health benefits.

TABLE 2 – BACKGROUND OF PROFESSORS

Feature	Participant	%
Professional profile	Traffic engineer	20
	Public health	10
	Economist	10
	Urban Planner	20
	Urban Engineer	30
	Sociologist	10

Source: Own processing

To analyse the survey results and to perform the correlations, we used the IBM SPSS Statistics Grand Pack 28.0 PREMIUM, a widely used research tool in engineering, marketing and education, social sciences, healthcare, and data mining.

3. RESULTS AND DISCUSSION

3.1. Online survey results

The results in 2021 suggest that students have a positive opinion about the potential of automated vehicles, especially in terms of safety and comfort. However, they expressed concerns about the cost and reliability of the technology, as much as the potential impact on employment and privacy. The study further found that students are willing to pay more for a reduced travel time, but this willingness varies depending on factors such as income, travel distance, time of the day and mode of transport.

3.2. Comparative assessment of the surveys’ results in 2021 and 2023

A significant shift appears in awareness about Autonomous Vehicles from 2021 to 2023. The percentage of those who are aware has decreased, and there is a notable increase in the percentage of respondents who are uncertain about their awareness. This change could be influenced by various factors such as COVID-19 pandemic, the ethical dilemmas or the safety concerns associated with AVs. Further analysis or survey data may be needed to understand the reasons behind these shifts in awareness.

Another notable shift in the data is that in 2023, none of the surveyed respondents claimed to have travelled in an Autonomous Vehicle, which is a significant change from 2021 when a small proportion had reported such experiences. This could be caused by a lack of awareness, education, or information about AVs and their benefits and challenges. It could also indicate a difficulty in distinguishing between different levels of automation or different types of AVs.

The survey found that students became more comfortable and trusting of AVs over time. However, the ratings varied depending on the existence of a human supervision. In both years, the highest rating was given to the condition WITH the supervision of a human operator IN THE VEHICLE, followed by the condition WITH the REMOTE supervision of a human operator at a distant location. The lowest rating was given to the condition WITHOUT the supervision of a human operator, suggesting that people still prefer some form of human oversight when traveling in an AV.

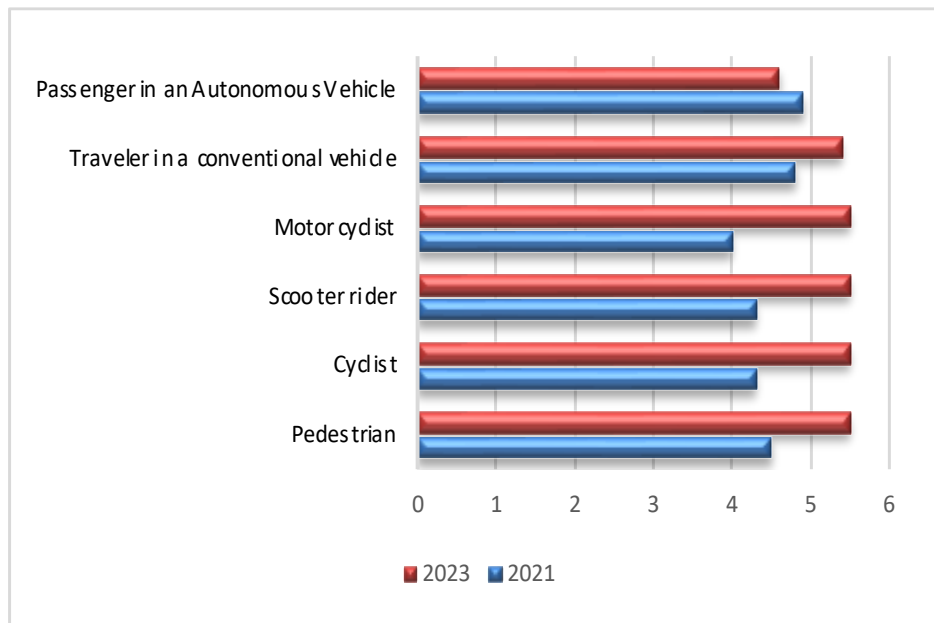


FIGURE 2 - I WOULD FEEL COMFORTABLE IN THE PRESENCE OF AVS NEAR ME IF I WAS A ...

The level of comfort that different road users would perceive in the presence of AVs has increased from 2021 to 2023 (Figure 1). The results show that pedestrians, cyclists, scooter riders, motorcyclists and travellers in conventional vehicles reported higher comfort levels in 2023 than in 2021. The only group that reported a lower comfort level was passengers in AVs, who rated their comfort higher in 2021 in comparison with 2023. This may reflect changing perceptions and attitudes towards AVs over time and suggests that there is still room for improvement in the design and operation of AVs to enhance the trust and satisfaction of their users.

There has been an increase in the perceived acceptability of traveling with other unknown people in an AV from 2021 to 2023 (Figure 2). This suggests that students are more comfortable or open to the idea of sharing an AV with unknown companion(s) in 2023, compared to the attitudes expressed in 2021. This change may reflect evolving perceptions and increasing trust in autonomous vehicle technology over time.

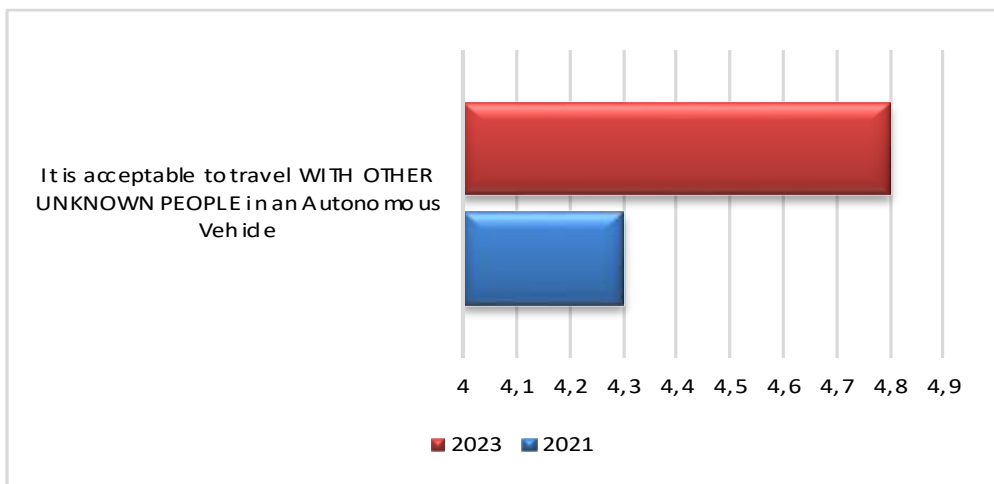


FIGURE 2 - IT IS ACCEPTABLE TO TRAVEL WITH OTHER UNKNOWN PEOPLE IN AN AV

A slightly increase in the willingness to use AVs for goods transportation across all scenarios presented from 2021 to 2023 (Figure 3). Respondents in 2023 are generally more willing to trust autonomous vehicles for transporting their goods, whether with human supervision inside the vehicle, remote human supervision, or without human supervision. This increase in willingness may reflect a growing trust in autonomous vehicle technology and its potential for safe and efficient transportation of goods.

The data indicates that respondents in 2023 are generally willing to use Autonomous Vehicles for both low-value and high-value goods, although there has been a slight decrease in willingness for low-value goods and a notable increase in willingness for high-value goods compared to 2021. This shift in attitudes may reflect increasing confidence in the safety and reliability of AV for transporting valuable items. The growth of e-commerce, the preference for contactless delivery, or the innovation of new products and services could be some of the factors that influence these attitudes.

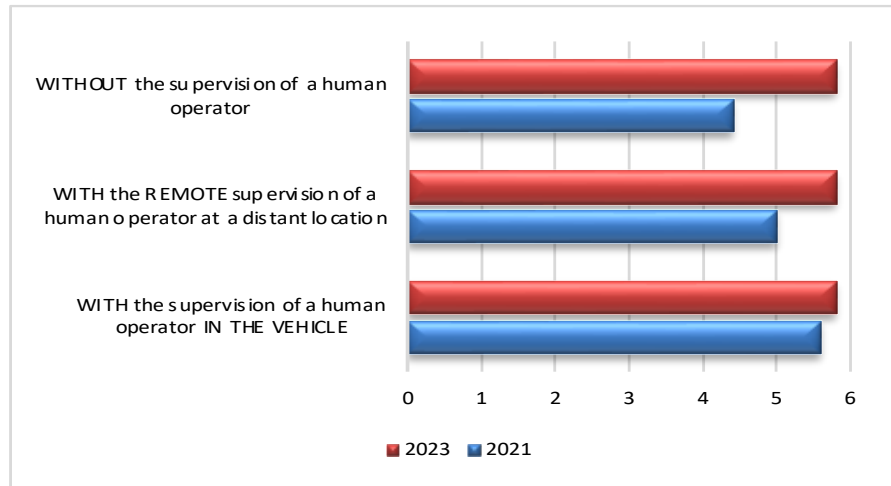


FIGURE 3 - I WOULD ALLOW MY GOODS TO BE TRANSPORTED IN AN AV UNDER THE FOLLOWING CONDITIONS...

The results show that in both 2021 and 2023, the most preferred activities are listening to music or radio and enjoying the scenery, with average ratings of above 5 in both years (Figure 4). These activities are followed by entertaining oneself, making personal phone calls, working, interacting with other passengers, and sleeping, which all have ratings above 4 in both years. The survey also reveals some interesting changes in preferences over time. For example, the preference for making personal phone calls increased significantly from 4.6 in 2021 to 5.7 in 2023, while the preference for paying attention to vehicle behaviour decreased from 4.4 in 2021 to 2.6 in 2023. These changes may reflect the growing trust and comfort of people with autonomous vehicles as well as the increasing availability of communication and entertainment options during the travel inside the vehicles.

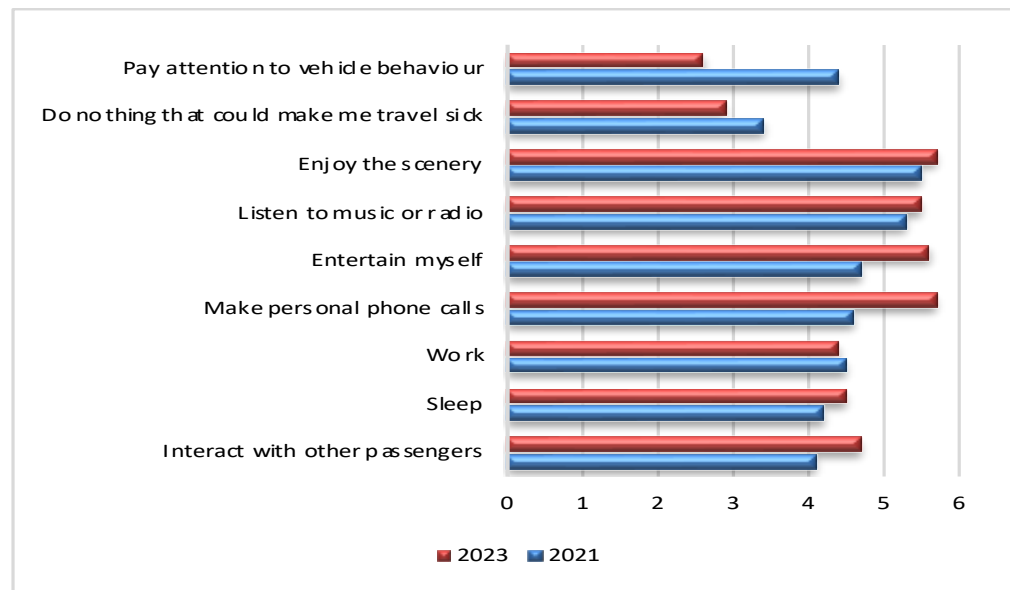


FIGURE 4 - IF I WAS TRAVELLING IN AN AV, INSTEAD OF DRIVING I WOULD PREFER TO ...

Related to the perceived disadvantages of AV, a change in opinions from 2021 to 2023 was observed (Figure 5). This suggests a growing awareness of students related to potential challenges and risks associated with autonomous vehicles, particularly regarding cybersecurity, traffic congestion, and the impact on employment. It also indicates that some concerns, such as reduced pleasure in driving and reduced freedom of travel, are becoming less prominent as AV technology evolves and becomes more accepted.

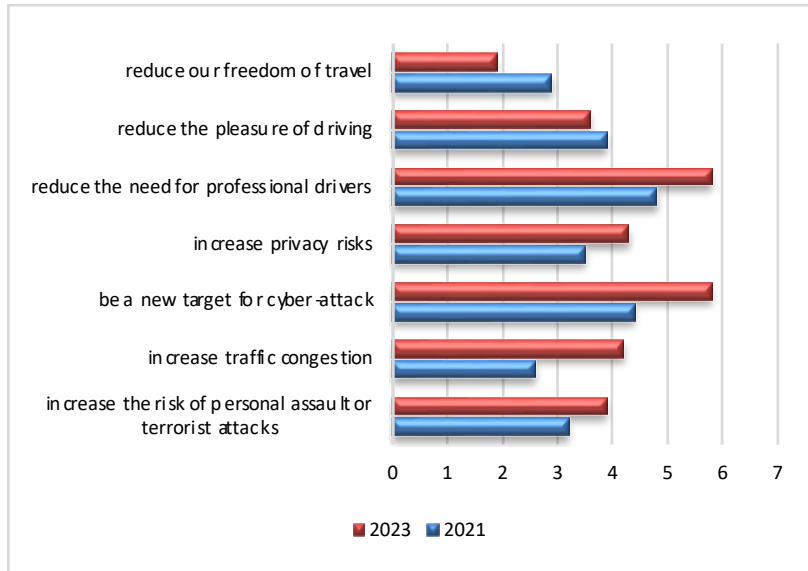


FIGURE 5 - OPINION ON DISADVANTAGES OF AUTONOMOUS VEHICLES

Possible reasons can include the risk of AVs being hacked, hijacked, or remotely manipulated by malicious actors. In addition, the introduction of AVs could potentially increase demand for long-distance journeys and influencing traffic flow and overall transportation efficiency. Integration with existing transportation systems becomes crucial to address these challenges effectively. AVs' heavy reliance on software, sensors, and communication systems also highlights cybersecurity challenges, with the potential for compromise by hackers, viruses, or malware. Such breaches could have severe consequences, including accidents or disruptions in transportation networks. Privacy issues come to the forefront, as AVs collect and share personal passenger information, from location data to preferences and behaviour. Concerns arise over the potential for unwanted surveillance or tracking by third parties. On the economic side, the adoption of AVs in industries like taxi services, deliveries, and trucking may bring about workforce changes, potentially reducing income and employment opportunities for human drivers. Conversely, a large proportion of students see substantial benefits in AVs, appreciating their convenience, comfort, safety features, and improved accessibility. In terms of transportation options, AVs introduce the possibility of enhanced travel choices and greater flexibility for individuals, reshaping the way people move from one place to another.

Some changes in opinions from 2021 to 2023 indicate a mixed perception of the advantages of Autonomous Vehicles (Figure 6). While some benefits like improved mobility options and slightly reduced travel time are being recognized more positively, there is growing scepticism about safety, traffic congestion, car accidents reduction, and environmental benefits associated with AVs.

The survey showed that the average rating of reduce traffic congestion decreased from 4 in 2021 to 2.6 in 2023, suggesting a lower expectation of the impact of AVs on congestion over time. This may be due to the understanding that AVs cannot solve congestion without addressing other factors, such as demand, land use, and public transport.

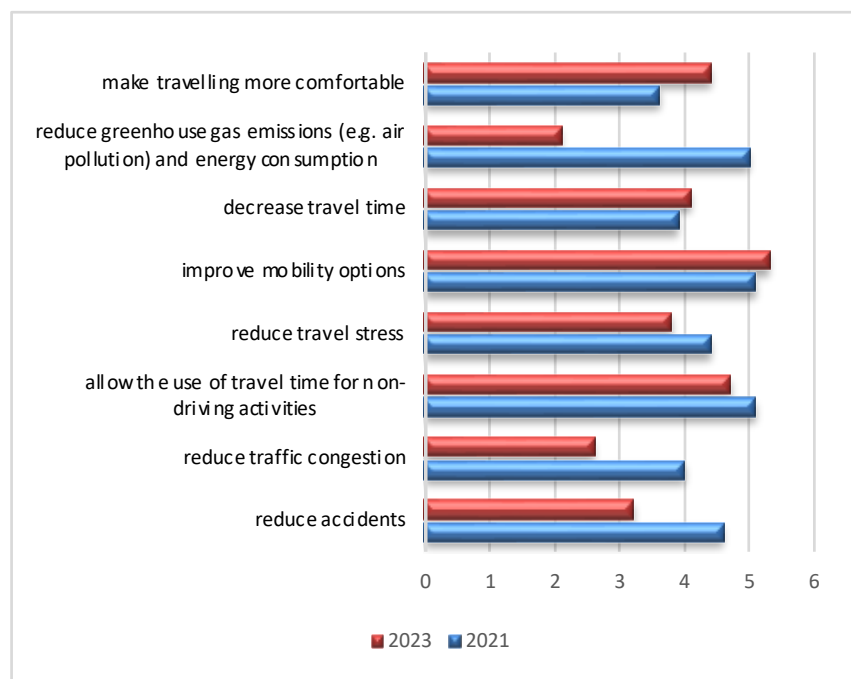


FIGURE 6 - OPINION ON ADVANTAGES OF AUTONOMOUS VEHICLES

The findings indicate a decline in the average rating of reducing greenhouse gas emissions, with a fall from 5 in 2021 to 2.1 in 2023. This suggests a diminishing level of recognition about the environmental advantages associated with autonomous vehicles during the given period. This phenomenon may be attributed to the increased recognition of the compromises and difficulties associated with achieving a sustainable shift towards AVs, including aspects such as development of infrastructure, energy supply, and demand management.

The findings indicate that the participants expressed a higher level of comfort with the responsibility of covering investments in AV infrastructure expenses falling on the national government (Figure 7). This was followed by international organisations, private companies, local government, all road users, and only AV users. The average opinion for the funding sources shown a decline between 2021 and 2023, with the exception of private companies and international organisations, which showed a marginal gain. The

results above indicate a need for more public education and involvement regarding the advantages and challenges of AVs. Additionally, there is a requirement for a well-defined and open framework to determine the allocation and financing of expenses related to the implementation of AVs.

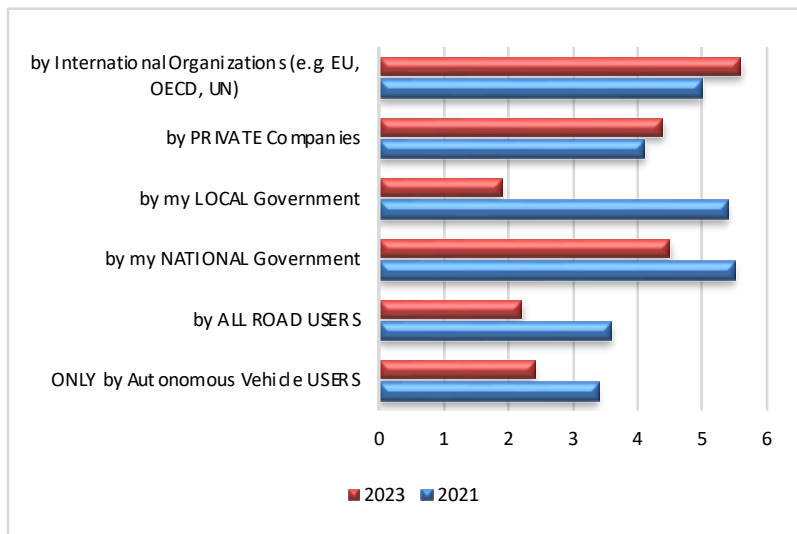


FIGURE 7 - I WOULD BE COMFORTABLE WITH INVESTMENT AND INFRASTRUCTURE NEEDED TO USE AVS PAID

While comfort with AV deployment in the responder’s neighbourhood has decreased slightly, there is an increased interest in participating in AV tests, indicating a growing curiosity and willingness to engage with AV technology and its testing phases (Figure 8). These suggest also that the students are becoming more familiar with and accepting the AVs, but there is still room for improvement in terms of trust and confidence.

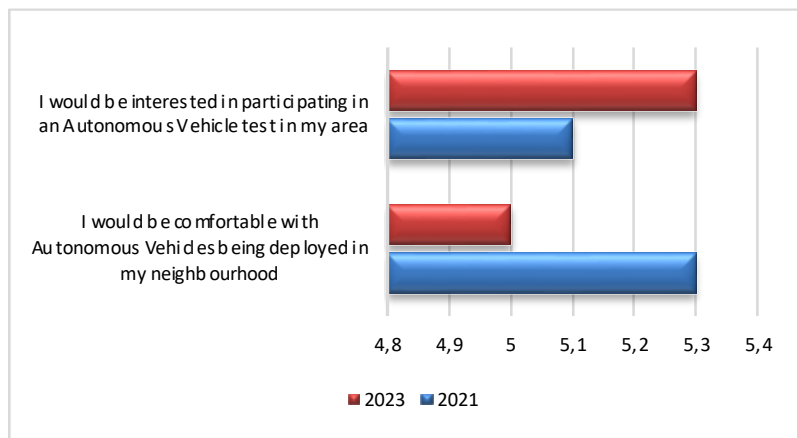


FIGURE 8 - I WOULD BE COMFORTABLE WITH AVS BEING DEPLOYED IN MY NEIGHBOURHOOD

3.3. Interviews' results

The consensus among experts is that there are numerous benefits associated with the adoption of autonomous vehicles. On the positive side, academic experts anticipate reduced traffic congestion as AVs can communicate and coordinate more efficiently, leading to smoother traffic flow as was also outlined in (Foster, 2017). The professors highlighted that, by taking over the driving responsibilities, AVs allow passengers to utilize their travel time more efficiently, and to engage in activities that promote relaxation. This has the potential to reduce stress levels and improve mental health for commuters in Romania. AVs hold the promise of contributing to a cleaner and healthier environment by the potential reduction in air pollution. Improved air quality, in turn, could lead to a decrease in respiratory diseases and other health issues associated with poor air conditions, which is a pressing concern, especially in large cities. Furthermore, several academics outlined that AVs are expected to optimize space utilization in cities. With improved traffic management and the possibility of using shared AVs, less space may be allocated for parking, freeing up valuable urban real estate for other purposes, such as green spaces, as also noted in international research (Schlossberg et al. 2018). Additionally, some experts predicted a renewed emphasis on active transport, such as walking and cycling, aligning with broader urban planning goals to create liveable, pedestrian-friendly cities.

However, alongside these promising changes, concerns about urban sprawl have emerged in some of the interviews, as the increased convenience of AVs might encourage people to live farther from city centres, potentially exacerbating urban sprawl, as was also observed in (Stead and Vaddadi 2019; Anderson et al. 2014). To address this, experts stressed the importance of urban planning that encourages compact, transit-oriented development to maintain the vitality and sustainability of cities, which was also suggested by other researchers (Cohen and Cavoli 2019).

Moreover, the academics underscored there are also potential negative consequences, including the risk of sedentary behaviour as passengers engage in non-driving activities during their journeys. Additionally, it was highlighted that the social fabric of communities could be altered, with less face-to-face interaction among commuters who spend more time in autonomous vehicles. It was generally expressed the opinion that balancing these anticipated changes and challenges requires careful consideration, proactive urban planning, and policies that promote the benefits and mitigate the potential negative effects of AV adoption in cities.

4. CONCLUSION

The findings of the article offer valuable insights into the perceptions of young individuals in universities, regarded as early adopters of AVs, as well as the perspectives of professors who are experts in the field, shedding light on the AV phenomenon in Romania. This research marks the first instance when a paper provides an integrated perspective originating from the higher education sector.

The results suggest an increased level of acceptance of ridesharing in AVs among the students, underscoring the importance of additional research to address concerns and preferences comprehensively. The authors recommend that policymakers and industry stakeholders consider the social and psychological aspects of AVs as well as the technical and economic ones when designing and implementing AV systems and services.

While acknowledging the limitation of a relatively low number of students involved, the employed methodology demonstrates potential for replication. The study emphasizes the urgent need for further investigation, particularly concerning potential structural changes in cities and their long-term impact on health. Future studies could extend their scope by incorporating universities from diverse geographical contexts.

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