Impact assessment of governance models on the integration of connected and autonomous vehicles

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TRA TRANSPORT RESEARCH ARENA DUBLIN 2024 10th CONFERENCE • 15-18 April

National Technical University of Athens

Abstract

The development of Connected and Autonomous Vehicles (CAVs), with vehicle-to-everything (V2X) communication technologies, has catalyzed the digital transformation of the vehicle and infrastructure automation industry. These advancements aim, among others, to benefit users by reducing traffic congestion and emissions, enhancing safety, providing comfortable travel, and saving fuel costs. Society's approval of such implementations, as well as the expected impact of **Connected, Cooperative, and Automated Mobility (CCAM)** on traffic performance, are still, however, areas with limited exploration. Although many studies have investigated the influence of CAVs on traffic congestion, there exists a lack of governance policies and regulations related to the uptake of CCAM. To fill this gap, we review the **regulatory frameworks** already implemented in Europe and we investigate through a **stated preference survey** important aspects related to the **barriers of using CAVs**. Finally, we analyze the results of the surveys, leading to a well-educated selection of targeted actions that can increase the uptake of CAVs throughout Europe.

Introduction and Background

Vehicular automation in Europe is driven by the demand for frequent and driverless travel and technological evolution. The European Union (EU) foresees a transition from Conventional Vehicles (CVs) to Autonomous Vehicles (AVs) in the coming decades, although with unresolved issues regarding the legal framework and road infrastructure [1]. The Society of Automotive Engineers (SAE) categorizes AVs into six progressive levels of automation from Level 0: No automation to Level 5: Steering wheel optional - Full automation [2]. Autonomous driving offers multiple benefits, including enhanced safety, reduced driver stress, and increased parking availability [3],[4]. Additionally, according to a SWOT analysis conducted by the University of Kentucky, automation promotes the adoption of electric vehicle technology, resulting in reduced carbon emissions [5].

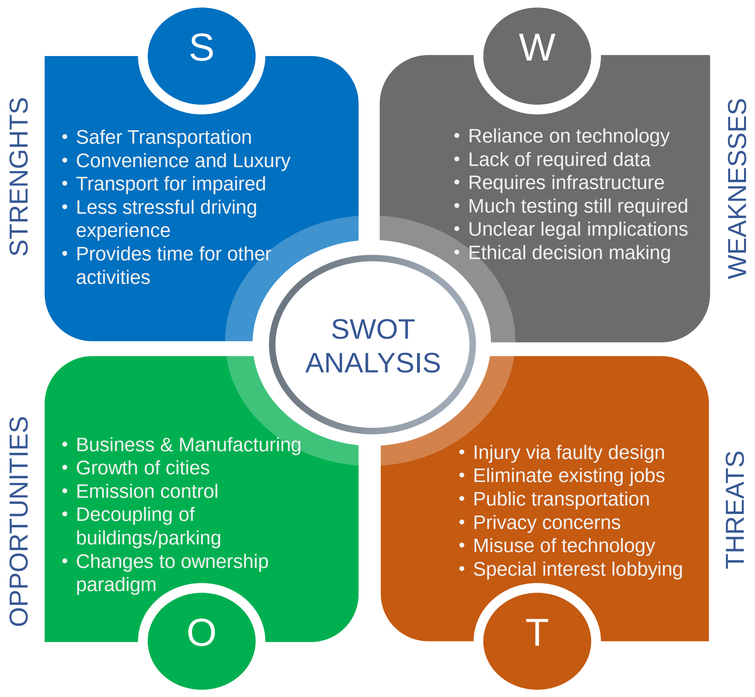

Figure 1: SWOT analysis for Autonomous Vehicles [7]

AV integration presents challenges such as legal ambiguity, ethical concerns, and economic implications [6]. In Europe, ongoing debates revolve around creating or revising tech-specific laws to ensure consumer protection and promote innovation [7], [8]. Despite rapid technological advancements, establishing common rules poses legislative challenges. The European Commission plans an EU-wide platform for testing AVs, emphasizing data protection and accident responsibility [9].

To enhance road safety, Europe needs harmonized traffic rules and innovative infrastructure, especially with unmanned vehicles sharing roads [1]. In Germany, plans are underway for daily automated trips using electric AVs, despite legislative challenges due to the absence of proper European frameworks [10]. In the Netherlands, the Future Bus debuted on public roads in 2016, with plans to automate commercial and delivery vehicles for economic gains [11],[12]. Lastly, the UK has funded pilot projects and introduced its first autonomous bus, underlining the ongoing need for government intervention to address regulatory gaps [13]. Legislation from 2018 makes insurance compulsory for AVs, covering third-party compensation and usually the driver, while uninsured AVs fall under vehicle owners' responsibility [7].

Objectives

The objectives of this study refer to:

- reviewing existing advantages and barriers of CAV adoption and to determine how the EU intends to resolve them.
- employing a questionnaire and stated choice survey to analyze factors influencing European citizens' opinions and devise strategies to enhance automation adoption while mitigating barriers.

Data collection method

To measure European citizens' acceptance of highly automated vehicles, an **online questionnaire** including a **Stated Preference (SP) survey** was conducted with **223 participants** by the time of this research study. Available in English, Greek, Spanish, and German, was developed collaboratively with project partners across Europe. It included **sociodemographic** inquiries and questions on **mobility behavior** and **perceptions of autonomous vehicles**. The assessed SP key parameters were financial affordability, passenger safety, data privacy protection, road infrastructure sufficiency, and legislative framework adequacy for CAVs. Participants responded to the SP questions about their **preference for AVs** under varying conditions, where one parameter was negative and the other four were positive. Each respondent answered "Yes" or "No" to the four questions with no constraints between them, as illustrated in **Table 1**.

Would you prefer an Autonomous Vehicle when:		
16. The vehicle is not financially affordable, but …	**Yes**	**No**
the protection of data privacy is ensured.		
the car industry guarantees for the safety of its passengers.		
there is sufficient road infrastructure.		
there is an adequate legislative framework.		

Table 1: Example question of the SP experiment

Results

The socio-demographic profile and key mobility findings of respondents, crucial for understanding factors influencing AV acceptance and sample-specific trends, are presented as follows. The online survey reflects diverse respondent categories: 56% employees, 31% university students, and 8% self-employed. Gender distribution: 50% female, 48% male, and 2% diverse. 87% of participants consisted of university students and employees, with few individuals over the age of 56. Respondents represented **eleven countries: Belgium, Germany, Greece, Hungary, Italy, Luxembourg, Netherlands, Portugal, Slovenia, Spain, and the UK**.

In terms of respondent mobility, satisfaction with available transport modes generally leans positive, although Public Transport (PT) adequacy in neighborhoods is a concern. Additionally, main trip purposes and transport modes were examined (**Table 2**). Regarding autonomous driving knowledge and perception, responses vary widely, while **opinions for autonomous vehicle safety generally favor AVs over CVs**. Moreover, there is notable **willingness to use driverless public transport**, with some expressing potential interest.

Mobility behavior (N=223 Responses)						
		1= totally dissatisfied	2	3	4	5= totally satisfied
Satisfaction with transport modes		4%	17%	41%	29%	9%
Adequacy of PT service		14%	32%	28%	20%	6%
Main transport mode	Vehicle as driver	Vehicle as passenger	Public urban transport	Motorcycle	Bicycle	On foot
	31%	6%	34%	5%	5%	19%
Main trip purpose	Work	Education	Entertainment	Leisure trip	Shopping	Family duties
	45%	14%	19%	4%	7%	11%

Table 2: Mobility behavior information of the respondents

Furthermore, respondents' trust in AV operation in city centers and on highways was assessed (**Figure 2**). In addition, economic affordability emerged as a key factor. Two more factors influencing AV preference were data privacy and user familiarity. Moreover, **73% were aware of autonomous public transport operations in European countries**.

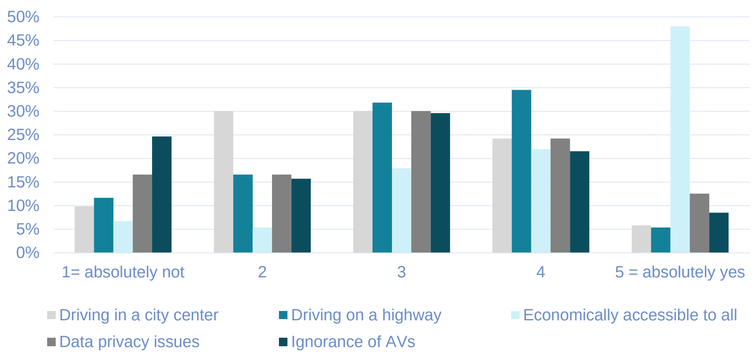

Figure 2: Preference for Autonomous Vehicles

Lastly, the SP experiment evaluated five factors impacting autonomous vehicle adoption. The results are summarized in **Table 3**. Safety emerges as the primary influencer, with over 80% prioritizing safety assurance, and road infrastructure follows closely. Adequate legislation is also crucial, with data privacy showing mixed effects. Economic accessibility matters least, with 60% prioritizing safety over affordability.

Would you prefer an Autonomous Vehicle when:	the vehicle is financially affordable?	there is an adequate legislative framework?	there is sufficient road infrastructure?	the car industry guarantees for the safety of its passengers?	the protection of data privacy is ensured?
The vehicle is not financially affordable, but…	-	**50%***	**54%***	**61%***	54%
The legislative framework is insufficient, but…	63%	-	57%	53%	60%
There is no road infrastructure, but...	74%	68%	-	61%	70%
The car industry does not guarantee for the safety of its passengers, but…	83%	79%	81%	-	82%
The protection of data privacy is not ensured, but…	52%	55%	56%	**53%***	-

Table 3: Preference on choosing an AV considering different factors (*with green are the higher "Yes" proportions).

Conclusion

This study investigates the benefits and challenges of implementing connected and autonomous vehicles (CAVs) and explores EU mitigation strategies. We analyze legislative frameworks, particularly European cases, identifying five key factors influencing CAV acceptance: **passenger safety, road infrastructure, data privacy, legislation, and affordability**. To assess the governance models' impact on CAV integration and understand adoption factors, we conducted **online stated preference surveys** focusing on the five CAV utilization obstacles. Survey analysis highlights **passenger safety as the most crucial aspect** when evaluating autonomous vehicles. Government attention to road infrastructure adequacy and the establishment of strong legislative frameworks addressing accidents and data privacy issues are also emphasized. Economic accessibility is deemed essential by most citizens, underscoring the belief that CAVs should be accessible to all. The findings of the current research can serve as a foundation **for developing a mathematical model** to predict the adoption of CAVs among European citizens.

Future research

In light of examining CAV regulatory frameworks and influential factors through a literature review and analysis of an SP survey, we propose several directions for future research:

- Create a **binary logit model** to precisely quantify the impact of each influencing factor on CAV acceptance.
- Expand sample socio-demographics to include data on **vehicle ownership and trip mode** for a more comprehensive analysis.
- Explore **cross-country or regional** comparisons to better understand variations in outcomes.
- Enlarge the **survey sample** and **diversify EU respondents** for data **representativeness** and **model accuracy**. The QR code for the online survey is provided.

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References

[1] E. Commission, "An EU strategy on cooperative, connected and automated mobility," 2016.
[2] D. Hopkins and T. Schwanen, "Talking about automated vehicles: What do levels of automation do?," Technol. Soc., 2021.
[3] A. Davola, "A Model for Tort Liability in a World of Driverless Cars: Establishing a Framework for the Upcoming Technology," SSRN Electron. J., 2018.
[4] D. J. Fagnant and K. Kockelman, "Preparing a nation for autonomous vehicles: Opportunities, Barriers and Policy Recommendations for capitalizing on self-driven vehicles," Transp. Res. Part A, 2015.
[5] University of Kentucky, "SWOT | Self Driving Car".
[6] L. Collingwood, "Privacy implications and liability issues of Autonomous Vehicles," Inf. Commun. Technol. Law, 2017.
[7] J. Turner, "Robot rules: Regulating artificial intelligence," Robot Rules Regul. Artif. Intell., 2018.
[8] R. Kelley, E. Schaerer, M. Gomez, and M. Nicolescu, "Liability in robotics: An international perspective on robots as animals," Adv. Robot., 2010.
[9] E. Commission, "Final report of the single platform for open road testing and pre-deployment of Cooperative, Connected and Automated and Autonomous Mobility platform (CCAM Platform)," 2021.
[10] Newsroom, "Στη Γερμανία τα πρώτα δρομολόγια μεταφοράς επιβατών με αυτόνομα οχήματα," 2023.
[11] Κ. Βλαχάκης, "Mercedes-Benz Future Bus με CityPilot: Ξεκίνησε τις διαδρομές στο Άμστερνταμ," Autonomous.gr, 2016.
[12] Η Καθημερινή, "Στην Ολλανδία θα πρωτοκυκλοφορήσουν φορτηγά με «αυτόματο πιλότο»," Η Καθημερινή, 2014.
[13] Newsauto, "Μόλις το 12% στη Βρετανία εμπιστεύεται τα αυτόνομα οχήματα," 2021.

Acknowledgements

This research received funding from the CONDUCTOR project within the Horizon Europe Research and Innovation programme of the European Union, under Grant Agreement No. 101077049.

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This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056931