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The illusion of the shared electric automated mobility transition

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A R T I C L E I N F O

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A B S T R A C T

Shared electric automated vehicles (AVs) are advertised as the silver bullet for the sustainable transition of private internal combustion engine-based automobility by private and public entities. We explore the extent to which private automobility will be reconfigured into a private electric automated mobility regime or substituted by a shared electric automated mobility regime that could effectively address societal sustainability challenges. We draw from the multi-level perspective of technological transition, develop a conceptual model outlining possible transition advancements towards private and shared electric automated mobility and review pertinent literature supporting such developments. Our analysis reveals that shared, particularly pooled, mobility emerges slowly (niche level). Key actors resist a shift from private to shared electric automated mobility for economic (vehicle manufacturers), instrumental, affective, symbolic (users and societal groups), tax-revenue, governance and administrative (public authorities) reasons (regime level). The private automobility regime receives only moderate pressure from the socio-technical landscape pertaining to safety, congestion and environmental issues and effectively reacts by electrifying and automating vehicles (landscape level). We conclude that the most likely transition will primarily entail privately-owned electric AVs as opposed to shared (especially pooled) AVs, unless a landscape "shock" such as a climate breakdown, energy crisis or a significant political shift towards collective mobility exerts substantial pressure on the regime. Hence, the socioeconomic benefits of the so-called "three revolutions of automobility" could be diminished.

1. Introduction

Shared electric automated vehicles (AVs) are presented as the key solution for the sustainable transition of automobility by the research community, automotive manufacturers, tech industry, consulting firms and public authorities. As Dan Ammann, former CEO of Cruise, an automated vehicle company, subsidiary of General Motors, blog-posted during the COVID-19 pandemic: "*City dwellers, in a sad twist on social distancing, are now buying more cars than ever. Traffic won't just come back, it will suck worse than ever. But self-driving cars, which can be shared safely and efficiently, will reduce congestion dramatically and permanently. The impact on our cities, our world, and our climate will be real and sooner than you might think.*" (Ammann, 2020). Although presented with different acronyms by different actors (e.g., SEAM: Shared, electric, automated, mobility; CASE: Connected, autonomous, shared and electric vehicles; ACES: Autonomous, connected, electric shared vehicles; SAEV: Shared autonomous electric vehicles), the common underlying rhetoric among them is that the environmental and social benefits of AVs do not stem from the deployment of this vehicle technology per se but from the potential of bringing changes to the vehicle operation, vehicle design, transportation system design and choice of fuels (Taiebat and Xu, 2019; Wadud et al., 2016). The term "shared" is often used to describe both on-demand vehicles shared simultaneously by multiple riders following flexible schedules and routes (i.e., ride-pooling) and vehicles shared sequentially by one rider, driven to her destination by a personal driver (i.e., ride-hailing). In this paper, we differentiate between the two vehicle sharing options using the terms ride-pooling, ride-pooled, or shared (pooled) AVs and ride-hailing, ride-hailed, or shared (solo) AVs when needed.

Evidence suggests that, if AVs are shared (i.e., ride-pooled) and electric (i.e., green-sourced), they are expected to reduce vehicle ownership and congestion, enhance energy efficiency through right-sizing, virtually eliminate greenhouse gas emissions, allow urban space reclaiming through reduced parking needs and enhance social equity for disadvantaged groups (Fulton, 2018; Greenblatt and Saxena, 2015; Kontar et al., 2021; Li et al., 2022; Milakis et al., 2017; Milakis and Van Wee, 2020; Nikitas et al., 2021; Pan et al., 2021; Rodier et al., 2022; Silva et al., 2022; Zwick et al., 2022). In comparison, a deployment

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scenario of primarily private or non-pooled shared electric AVs (i.e., ride-hailed), although still beneficial from greenhouse gas emissions perspective, it is expected to cause further societal harm because of increased total travel demand (Circella et al., 2022; Emberger and Pfaffenbichler, 2020; Harb et al., 2021; Narayanan et al., 2020; Saleh and Hatzopoulou, 2020; Schaller, 2021; Soteropoulos et al., 2019), modal shift from public transport and active modes (Hörl et al., 2021), further congestion delays (Beojone and Geroliminis, 2021; Childress et al., 2015; Diao et al., 2021; Tarduno, 2021) further suburbanisation, increased space consumption for parking, reduced social equity (Milakis et al., 2018), increased energy consumption (Nunes et al., 2021) and reduced physical activity (Rojas-Rueda et al., 2020).

Thus, the question is to what extent the current private automobility regime will be reconfigured into a private electric automated mobility regime or substituted by a shared (particularly pooled) electric automated mobility regime that could effectively respond to key societal sustainability challenges. Despite the rhetoric of various actors supporting the second transition path, there are strong indications in the literature that the first transition path will likely prevail. This position paper draws theoretically from the multi-level perspective of technological transition and develops a conceptual model that describes a transition pathway for the private automobility regime as well as the potential influence dynamics from electrification, automation, and sharing. The model suggests that a transition pathway where electric AVs are mostly privately owned rather than shared will likely emerge, unless a landscape "shock" such as a climate breakdown, energy crisis or a significant political shift towards collective mobility exerts substantial pressure on the regime. The paper then reviews the literature pertaining to the various elements of this conceptual model. This includes the niche and structural developments incubating a reconfiguration transition pathway of the private automobility regime through electrification and automation as well as the critical resistance of key actors (i.e., vehicle manufacturers, users and societal groups, public authorities) to a substitution pathway towards a shared electric automated mobility regime. We eventually argue, based on the literature review outcomes, that a transition pathway where electric AVs are mostly privately owned rather than shared will likely emerge, significantly limiting the potential synergistic societal benefits of the so-called three revolutions of automobility (electric-shared-automated).

The paper is structured as follows. Section 2 describes our methods, while Section 3 outlines the theoretical background of our study and the conceptual model depicting the assumed transition pathway for the private automobility regime. Section 4 presents the outcomes of the literature review pertaining to the three levels of the conceptual model: niche, regime and landscape. Section 5 provides the discussion and conclusions of our study.

2. Methods

Our methodology involves two steps (see Fig. 1, created with Whimsical Starter). In the first step, we develop a conceptual model based on the multi-level theoretical perspective (Geels, 2002). We argue that the private automobility regime will likely follow a reconfiguration transition pathway (incorporating the symbiotic innovations of electrification and automation), unless a landscape "shock" such as a climate breakdown, energy crisis or a significant political shift towards collective mobility exerts substantial pressure on the regime. In this case, a substitution pathway would be possible, leading towards a new shared (particularly pooled) automated mobility regime. To develop the conceptual model, we consider the timing (e.g., state of niche-developments, landscape pressures on the regime) and nature (e.g., reinforcing or disrupting impact) of the emerging transition of private automobility regime involving vehicle automation, electrification and sharing. We then identify the key pathways (i.e., reconfiguration, substitution) that could represent the timing and nature of the transition towards private and shared electric automated mobility based on Geels' (2007) pathways of technological transition. We complete our conceptual model with a description of the dynamic interactions between the three analytical levels of the transition: the regime, the landscape, and the niche.

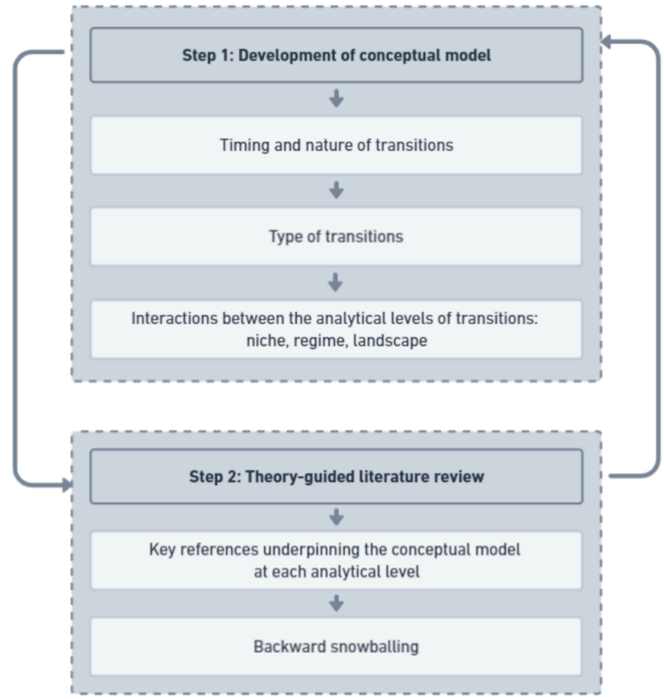


Fig. 1. The two-step method for developing the conceptual model and review the relevant literature that underpins it.

In the second step, we review the relevant literature that underpins this conceptual model at each analytical level. Our review starts with key references per topic based on our knowledge of the literature and then we apply backward snowballing (Wohlin, 2014) to further expand the depth and coverage of our analysis. Our review covers predominantly peer-reviewed articles published in Scopus-listed scientific journals, but expands also in grey literature when there is limited published work or evidence in a topic (see e.g., section 4.1). Our analysis does not intend to cover all references per topic, and therefore, a systematic literature review or *meta*-analysis method, such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), is not applied. Rather our analysis focuses on the references underpinning the key elements of the conceptual model. According to Van Wee and Banister (2016), a review paper can first propose a conceptual model and then examine the literature underpinning the suggested innovative framework without necessarily covering all references in the field of the paper. Along the same line, Kanger et al. (2020), argue that a systematic literature review of empirical evidence runs the risk of reproducing existing bias, not providing opportunities for theory-driven identification of alternative framings or possibilities implied by existing theoretical frameworks, but not empirically examined yet. These researchers recommend that a two-step approach involving concept formulation and analytical reasoning, followed by theory-guided literature review can alleviate this problem.

At the niche level, we analyse the developments, business landscape and prospects of the shared (pooled) mobility market indicating that it still remains at an emergent stage in the transport market. At the regime level, we analyse key actors' (i.e., vehicle manufacturers, users and societal groups and public authorities) preferences and motivations towards shared (solo and pooled) electric AVs to identify possible resistances against a substitution transition path of the personal to a shared mobility regime. To this end, we identify analytically the key areas of resistance for each actor and explore the literature evidence within each area. At the landscape level, we analyse the type and intensity of pressures to the private automobility regime from different actors. Our analysis comprises public opinion surveys (citizens), policy documents (public authorities), reports and statements of original equipment manufacturers (OEMs), indicating that the pressures to the private automobility regime are rather moderate and focused on the safety, congestion and environmental problems of the transport sector, for which the regime already responds with its reconfiguration through vehicle electrification and automation.

3. Conceptual model of the possible transitions towards private and shared electric automated mobility

The AVs represent a socio-technical transition of the automobility system associated with changes in transport infrastructure, industry, science, user practices, and policy among others (Hopkins and Schwanen, 2018; Milakis and Müller, 2021). The multi-level perspective (MLP) provides a theoretical framework describing such technology transitions as dynamic interactions between three analytical levels: the landscape, the regime, and the niche (Geels, 2002, Fig. 2). The landscape level refers to a set of slow-changing deep structural trends that are external to the technology itself such as economic growth, cultural and normative values, and environmental problems. The landscape level is represented by the two long-waved arrows at the top of Fig. 2. The regime level refers to the socio-technical rules that orientate and coordinate the activities of the relevant actor groups (e.g., engineers, users, policy makers, societal groups, suppliers, scientists, capital banks) towards maintaining the dynamic stability of a socio-technical configuration (e.g., the automobility system). The dynamic stability of the socio-technical regime is maintained through incremental innovations and improvements. In Fig. 2, the regime level is represented by the polygons (rules and relationships) and the straight long arrows starting/ending from/to the polygon vertices (actor groups). The regime level can only be disturbed by internal regime tensions (represented by shorter diverging arrows at the regime level), as well as pressures and changes from the landscape (represented by the dashed downward curved arrow from the landscape to the regime level in Fig. 2) and the niche levels that create windows of opportunity for novelties to grow. The niche level refers to the market-protected space where radical innovations are generated allowing for learning processes (e.g., learning by using) and supporting networks (e.g., supply chains) to evolve. In Fig. 2, the niche level is represented by the small arrows, going in different directions and growing longer and fatter towards the regime level. The niche, regime and landscape levels are sequentially nested. Thus, new technologies at the niche level and structural changes at the landscape level exert pressure to the regime to adapt through a technology transition process. Moreover, the niche level (i.e., niche actors and support networks) is influenced by the landscape and regime levels (represented by the long downward dashed arrows in Fig. 2), while the new regime exerts influence to the landscape level itself (represented by the curved dashed upward arrow from regime to landscape level in Fig. 2).

Geels and Schot (2007) identify four variations of transition pathways based on the timing (e.g., landscape pressures to a regime in relation to the state of niche-developments) and nature (e.g., reinforcing or disrupting relationships) of the multi-level interactions: transformation, reconfiguration, de-alignment and re-alignment, and technological substitution (Fig. 3). A sequential combination of transition pathways is also possible. The transformation pathway refers to the

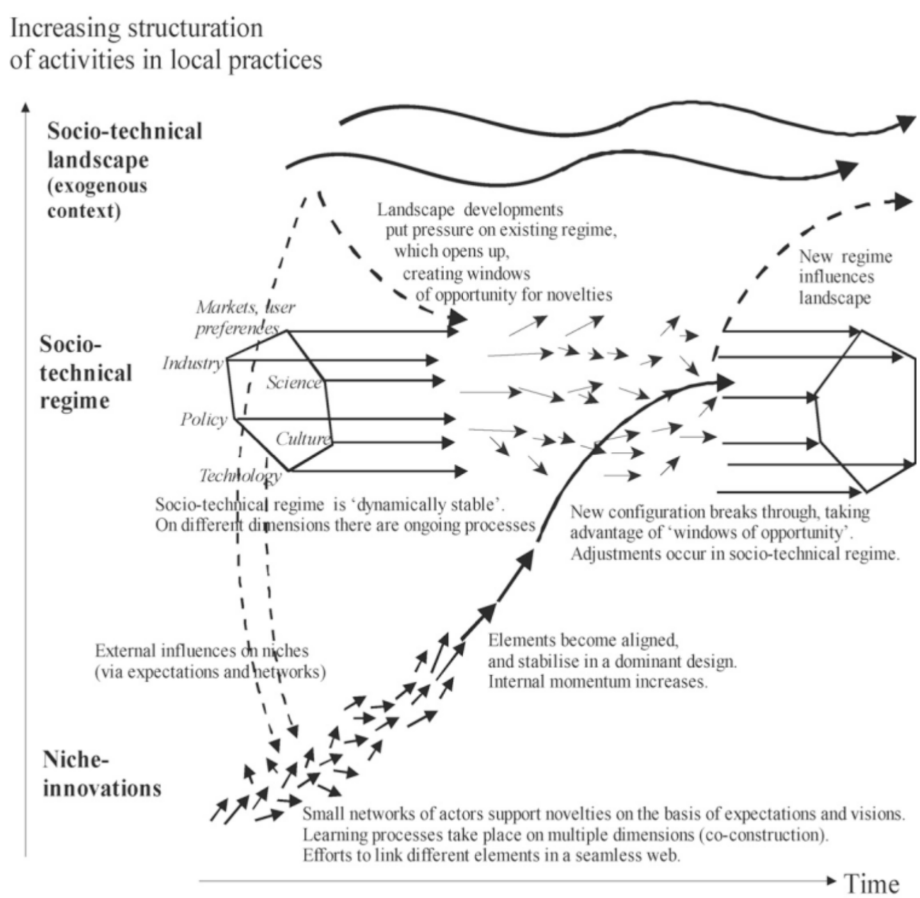
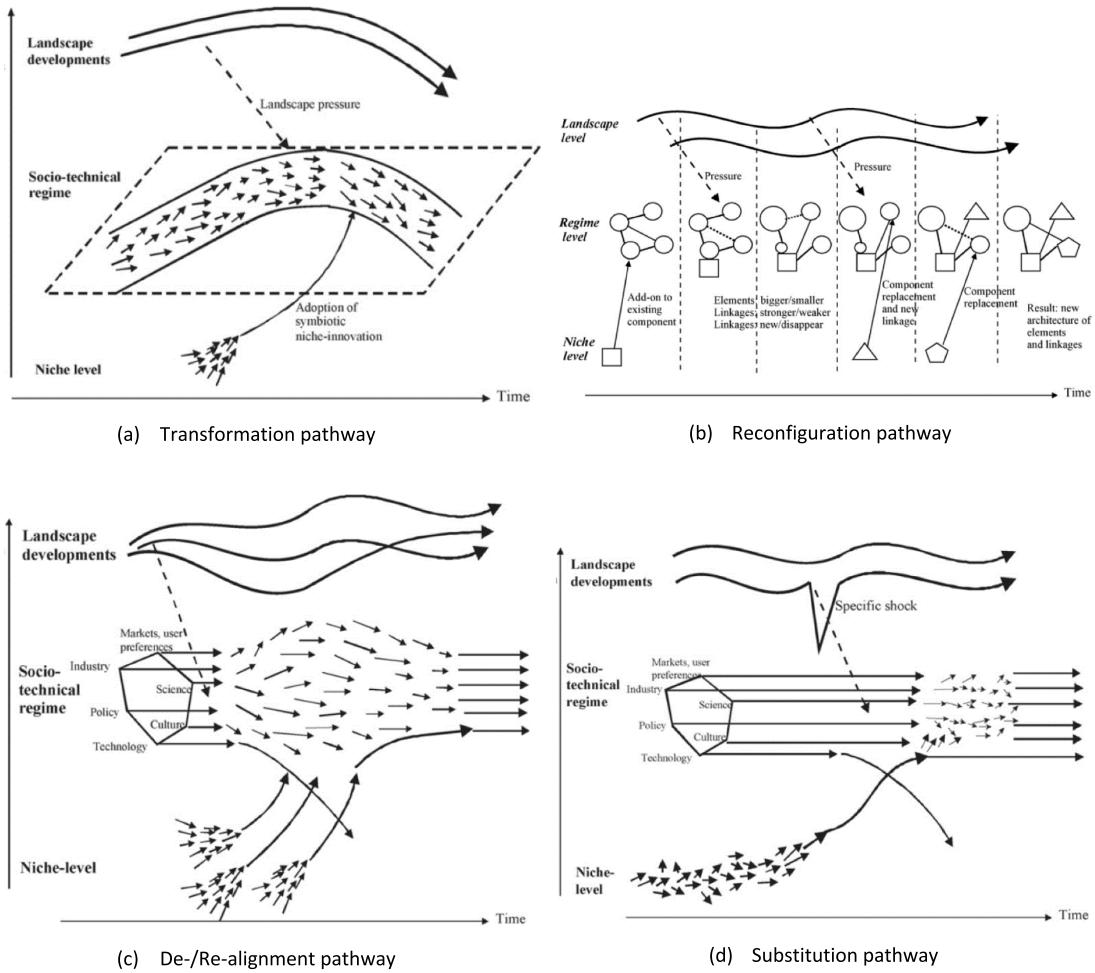


Fig. 2. The multi-level perspective on technological transitions (Geels, 2007). The dashed arrows depict inter-level pressures. The small arrows from the niche level, growing in length and width towards the regime, depict niche innovations. The short arrows diverging at the regime level indicate regime tensions and opportunities for niche innovation breakthroughs.



Transition pathway	**Niche readiness**	**Regime impact**	**Landscape pressure**
a. Transformation	Not sufficiently developed	Reinforced	Moderate
b. Reconfiguration	Sufficiently developed	Reinforced	Moderate
c. De-/Re-alignment	Not sufficiently developed	Disrupted	Divergent, large, sudden
d. Substitution	Sufficiently developed	Disrupted	Divergent, large, sudden

Fig. 3. The four transition pathways, characterized by the timing (i.e., landscape pressures to the regime in relation to niche developments) and the nature (reinforcing or disrupting the regime) of the interactions among the MLP levels (adapted from Geels, 2007).

modifications and reorientations of a regime's developments and innovations in response to rather moderate landscape pressures voiced by societal pressure groups, social movements, scientists (Fig. 3, Graph a). Niche innovations by outsiders such as firms, entrepreneurs, and activists remain underdeveloped and thus, unable to induce major regime changes, although their ideas, alternative technologies and practices could be adopted or trigger the regime's reorientation of innovation activities (i.e., symbiotic innovations). The reconfiguration pathway appears when the adopted symbiotic niche innovations subsequently trigger significant changes in the core architecture of the regime (e.g., technical, user practices, perceptions; Fig. 3, Graph b). Regime actors remain largely the same, yet competition occurs among innovation and new component suppliers. The de-alignment and re-alignment pathway occurs when the landscape changes are divergent, large, and sudden putting a regime under intense and rapid pressure (Fig. 3, Graph c). The regime destabilises within evolving uncertainty leading to a decline in research and development investments and eventually to erosion and de-alignment. Multiple emergent niche-innovations compete and co-evolve until one of them prevails re-aligning and establishing a new sociotechnical regime. If niche-innovations are mature enough at the moment of a regime erosion under substantial landscape pressures, then it breaks through, dominates and establishes and new regime following a technological substitution pathway (Fig. 3, Graph d).

In this paper, we develop a conceptual model (Fig. 4, created with Microsoft Word 2019, licence number: 00414-50000-00000-AA622) suggesting that the private automobility regime follows a reconfiguration transition pathway gradually incorporating symbiotic niche-innovations (see the 'electrification' and 'automation' arrows in Fig. 4) as add-ons or component replacements (e.g., electric instead of internal combustion engine (ICE) powertrain) responding to moderate, at the moment, landscape pressures (see the 'climate change', 'road safety', 'congestion' dashed arrows in Fig. 4). The model indicates that the incorporation of electrification within the regime precedes that of automation (see the dashed vertical lines separating the two transition phases in Fig. 4), without implying that the transition to electromobility must be fully realised before the automation transition starts. Such transition has been described also in earlier scenario studies including the "evolution scenario" by Fraedrich et al. (2015) and the "Letting go on highways" and "Fully automated private luxury" scenarios by Tillema et al. (2015).

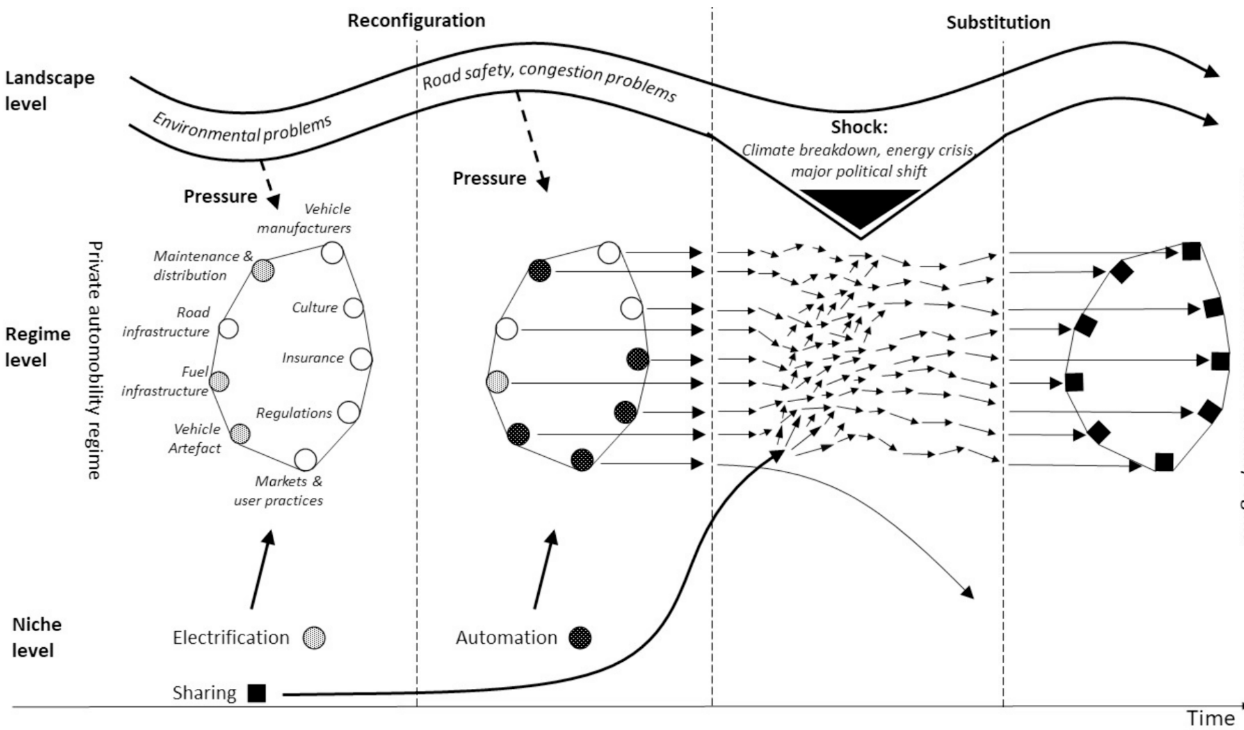


Fig. 4. Our conceptual model of the possible transition pathways for the private automobility regime. A shift from the reconfiguration to the substitution pathway towards a shared electric automated mobility regime is only possible following a "shock" at the landscape level.

Technical as well as user practice changes are being initiated within the private automobility regime in the process of reconfiguration (see the grey and black circles in the 'Reconfiguration' side of the conceptual model, Fig. 4). Technical changes involve fuel/charging infrastructure, maintenance, service and repair infrastructure, raw materials suppliers, automated vehicle hardware and software technology suppliers including road environment sensing and interpretation, prediction, decision making, and navigation. User practices involve in-vehicle time-use, travel behaviour, driving regulations and human–machine interaction. The primary actors in the "reconfigured" reinforced private automobility regime remain largely the same vehicle manufacturers and suppliers, developing the symbiotic innovations either in-house (e.g., electric powertrains) or by acquiring or developing partnerships with automated technology companies. For example, General Motors acquired Cruise, while Volkswagen and Ford partnered with Argo AI, which was eventually shut down. Toyota acquired Lyft's self-driving unit, invested in pony.ai and partnered with Aurora, who also acquired the Uber AVs unit, while Volvo, Renault and Nissan partnered with Waymo. Some new players have also been introduced to the reconfigured regime coming from the electric vehicles niche market (e.g., Tesla, NIO), having designed and engineered in-house its own AVs technology.

The niche innovation of shared mobility services (i.e., on-demand pooled rides involving commercial transaction) developed by public mobility and transportation network companies (e.g., Via, UberPool, Lyft Share rides, GrabShare) does not play a key role to the automobility reconfiguration and therefore, it remains at the niche level (see the "Sharing" arrow developing only at the niche level during the reconfiguration of the private automobility regime, Fig. 4). Contrary to the niche innovations of electrification and automation, shared mobility services do not improve the regime's (e.g., automotive manufacturers and suppliers) economic performance (in fact, they might yield economic losses), while user practices and established culture and symbolic meanings seem to resist such a transition. Moreover, landscape pressures to the automobility regime such as enhancing social equity, reclaiming urban space, reducing urban sprawl, and enhancing active lifestyles that could be resolved through shared mobility service innovations are considered far milder than congestion, climate change and road safety. Thus, the reconfigured automobility regime tend to pay little attention to niche innovations in shared mobility services developed by outsiders and fringe actors or simply add (or develop in-house) some of these innovations into their portfolio. These services seem to have a complementary role, competing more the traditional public transport services (Docherty et al., 2022; Yantao et al., 2021) rather than challenging individual automobility, which lies at the core of the private automobility regime (see e.g., MOIA, a ride-pooling service company, subsidiary of Volkswagen; Chariot, a commuter pooled-ride service company, subsidiary of Ford; and MONET, an on-demand mobility services company, joint venture of Toyota and Softbank). A substitution transition pathway for the automobility regime involving a primary role for sharing mobility services might still be possible in the case of a "specific shock", "avalanche change", or "disruptive change" that would exert substantial landscape pressure on the regime (e.g., climate breakdown, severe energy crisis, significant political and ideological shifts in favour of collective over individual mobility; Christiansen, 2020; Klein et al., 2022; Næss and Vogel, 2012; Si et al., 2022). In the 'Substitution' side of our conceptual model, this transition is depicted by the sharing mobility services disrupting the current regime (represented by small diverging arrows) and leading eventually to a new set of regime elements and actor groups supporting these services (represented by the black squares). For example, changes to support sharing mobility services would involve maintenance (e.g., service hubs for shared vehicles), fuel infrastructure (e.g., fast-charging electric vehicle stations in high-demand areas), road infrastructure (e.g., priority lanes for shared mobility), vehicle artifact (e.g., rightsizing), regulations (e.g., restrictions on private vehicle use), and the overall mobility culture (e.g., educational and marketing campaigns). Indeed, such a landscape "shock" would provide the window of opportunity and enable sharing mobility services to directly challenge and eventually breakthrough the existing private automobility regime, by influencing both the supply and demand for such services and making them as the most sensible and accessible option for both the mobility providers and people.

4. Analysis of the developments at the niche, regime, and landscape levels of the conceptual model

Our conceptual model suggests that private automobility will likely transition towards a private rather than a shared electric automated mobility regime, unless a landscape "shock" such as a climate breakdown, energy crisis, or a significant political shift towards collective mobility exerts substantial pressure on the regime. In this case, a substitution transition pathway would be possible leading towards a new shared electric automated mobility regime (Fig. 4).

In this section, we examine the relevant literature and evidence at each analytical level (niche, regime, landscape) that underpins this conceptual model. We start our analysis at the niche level describing the weak developments in shared (pooled) mobility (Section 4.1). Then, we focus on the regime level and analyse the areas of resistance of key actors (i.e., vehicle manufacturers, users and societal groups, and public authorities) towards shared automated electric vehicles (Section 4.2). We close this section with an analysis at the landscape level presenting evidence on the moderate pressure that private automobility regime receives to transition towards a shared electric automated mobility regime (Section 4.3).

4.1. Niche level: Weak developments in shared (pooled) mobility

The on-demand ride-pooling market has undergone a significant transition during the last two decades. Despite initiatives by major OEMs and pilots in cities, on-demand ride-pooling remains a niche in the transport market due largely to high operating costs and slow adoption rates. The industry's shift away from early investments in ride-pooling schemes (e.g., Daimler and Ford), underscores the economic challenges and market resistance to shared mobility platforms (Table 1).

For example, Haarstad et al. (2022) explored the introduction of shared mobility innovations in four cities (i.e., Birmingham, Stavanger, Milton Keynes, and Melbourne) concluding that in none of these cities asset-sharing (e.g., car-sharing) and ride-sharing (demand responsive bus) services are being adopted at a rate that promises significant change to the current individual high-carbon mobility regime. Zwick and Axhausen (2022) note that real world, large-scale ride-pooling services are rare due to high operating costs among other reasons, while Kostorz et al. (2021) suggest that ride-pooling still remains a novelty in the German context, used occasionally and particularly during the evening or the night.

Indeed, major OEMs were the first to enter the market by developing products and educating the market (e.g., Daimler with Via and moovel; Ford with Chariot and Transloc) in an attempt to diversify their business model by acting also as mobility providers rather than solely as car makers (Foljanty, 2022; Fournier and Donada, 2016; Hecking, 2014). However, after heavy investments in multiple ride-pooling schemes (i.e., own and joint ventures, shareholdings) the automotive industry started gradually, by the end of 2010, to withdraw from the ride-pooling market space not realising the anticipated economic benefits.

In recent years, the ride-pooling market is still in an emerging phase. Foljanty (2023) provides an overview of the ride-pooling services around the globe. Although, this list might not be complete, it still provides some useful insights. The ride-pooling market is dominated by Business-to-Government (B2G) projects (occurring mainly in USA, Germany, and Japan) where public authorities provide funding for certain pilot period (typically 12 months) to ride-pooling companies to operate small fleets of less than 10 vehicles given that most likely these services are not profitable. Business-to-Consumer (B2C) projects that were initially introduced by the major OEMs tend to disappear, while Business-to-Business (B2B) projects (e.g., university campus shuttles, demand-responsive employee transport services) appear to further grow during 2022 and 2023. Major players in the market, such as Via, further consolidate their position by acquiring smaller companies in the field and diversifying their portfolio of services, thus enhancing their potential to accelerate development beyond pilots and enter new markets such as the fixed-route bus services. Zwick et al. (2022) argue that the deployment of ride-pooling services in small scale fleets would likely not offer the theoretically expected societal benefits (e.g., reduce vehicle kilometres travelled (VKT), emissions) from such services. These benefits are expected when ride-pooling services are deployed in large vehicle fleets where demand density is high.

Table 1
Publications on the weak developments in shared (pooled) mobility market.

Publication	Country	Key Findings	Weak developments in shared (pooled) mobility
Haarstad et al. (2022)	UK, Norway, Australia	In four cities (Birmingham, Stavanger, Milton Keynes, Melbourne), car-sharing and ride-sharing services are not being adopted at a rate promising significant change to the high-carbon mobility regime.	Slow adoption rates of asset-sharing and ride-sharing services in urban contexts.
Zwick and Axhausen (2022)	Switzerland	Real-world, large-scale ride-pooling services are rare due to high operating costs among other reasons.	High operating costs limit the scalability of ride-pooling services.
Kostorz et al. (2021)	Germany	Ride-pooling remains a novelty in the German context, used occasionally and particularly during evening and night hours.	Ride-pooling services still have a novelty status and used occasionally in Germany.
Foljanty (2023)	Global	The ride-pooling market is dominated by Business-to-Government (B2G) projects with small fleets, mainly in the USA, Germany, and Japan.	Ride-pooling market dominated by small scale Business-to-Government (B2G) projects.
Foljanty (2022); Fournier and Donada (2016); Hecking, 2014	Global	Business-to-Consumer (B2C) ride-pooling projects initially introduced by major OEMs to diversify their business model tend to disappear, leading to a narrowing ride-pooling market.	OEM withdrawal from B2C ride-pooling indicates a lack of anticipated economic benefits.
Zwick et al. (2022)	Switzerland	Small-scale fleets in the ride-pooling market are unlikely to offer significant societal benefits. Large fleets with high demand density are required.	Expected benefits from ride-pooling services will not be realised by small scale fleet deployments.

4.2. Regime level: Resistances of key actors towards shared automated electric mobility

4.2.1. Vehicle manufacturers

Despite the industry-wide shift towards electric and automated mobility technologies, manufacturers show significant reluctance to adopt shared mobility models. Three main factors influencing this hesitancy: the potential decline in private vehicle sales, the economic uncertainties of the shared mobility market, and the strategic repositioning required to compete in an evolving automotive landscape (Table 2).

Table 2
Publications on factors contributing to vehicle manufacturers' resistance to the transition from private automobility to shared electric automated mobility.

Publication	Country	Key findings	Resistance factors for vehicle manufacturers
Schmidt (2020)	Germany	One free-floating car sharing vehicle reduces new car sales in Germany by three vehicles per year, particularly affecting small, compact, and medium-sized car models.	Decline in car sales due to free-floating car sharing.
Jochem et al. (2020)	Europe (11 cities)	Each free-floating car sharing vehicle accounted for 2.1 to 5.3 sold cars and 7.8 to 18.6 avoided purchases in the 11 European cities studied.	Decline in car sales in urban areas with high car sharing adoption.
Wang et al. (2021)	United States	Regular and active ride-hailing users tend to own fewer vehicles.	Decrease in vehicle ownership among active ride-hailing service users.
Ward et al. (2019, 2021)	United States	A 3 % decline in per capita vehicle registrations linked to Uber and Lyft from 2005 to 2015, and an average increase of 0.7 % in vehicle registration with significant heterogeneity observed.	Inconsistent vehicle demand due to the influence of ride-hailing services.
Czerlinsky et al. (2022)	Germany	Vehicle sales could be partly compensated by the sales increase in the shared vehicles segment and the positive brand image effects.	Changing sales dynamics driven by shared mobility services.
Beiker and Burgelman (2020)	n/a	Commercial clients of shared mobility services might shift from "friendly competitors" to "threatening competitors" for vehicle manufacturers.	Shift in market dynamics as shared mobility providers could potentially become direct competitors.

These challenges show the complex trade-offs that manufacturers must navigate in aligning their business strategies with the emerging demands of the mobility sector. Indeed, with a transition from the private vehicle to the shared vehicle business model manufacturers would likely be confronted with market conditions that differ from today's conditions in a number of aspects.

With an increase in shared mobility, vehicle manufacturers are likely to face a decline of vehicle sales in the private segment as (some) households will forgo the purchase of a new car or sell an existing one when start using shared mobility services. There have been several studies supporting this statement both for car-sharing and ride-hailing services. For example, Schmidt (2020) estimated that one free-floating car sharing vehicle reduces new car sales in Germany by three vehicles per year, particularly small, compact and medium-sized car models. Moreover, Jochem et al. (2020) reported 2.1 to 5.3 sold cars and 7.8 to 18.6 avoided purchases per free-floating car sharing vehicle in the 11 European cities of their survey with more than 10,000 free-floating car sharing users. In the US context, Wang et al. (2021) suggested that regular and active ride-hailing users tend to own fewer vehicles, while Ward et al. (2019) reported a decline of 3 %, on average, in state per capita vehicle registrations associated with the entrance of the ride-hailing companies Uber and Lyft for the period between 2005 and 2015. In their subsequent study, for the period between 2011 and 2017, they reported an average increase of 0.7 % in vehicle registration with significant heterogeneity though across urban areas (Ward et al., 2021). Indeed, the possible decline in vehicle sales could be partly compensated by a sales increase (a) in the shared vehicles segment due to the fact that shared vehicles are used much more intensively and, therefore, are replaced more often than private vehicles and (b) in the private vehicles segment through positive marketing effects to the brand image (e.g., modern, cool, environmentally aware) of vehicle manufacturers being also active in shared mobility services (Czerlinsky et al., 2022).

Furthermore, long-standing market powers could shift. In the event of substantial expansion for shared automated mobility services, commercial clients, such as ride-hailing companies, could change from "friendly competitors" considered as extra distributional channels for vehicle manufacturers, to "threatening competitors" (Beiker and Burgelman, 2020). In this scenario, vehicle manufacturers will not only see a sharp decline in the private segment sales, but they will also lose negotiating leverage with fleet operators because, in contrast to private customers, they buy large numbers of vehicles and place a strong emphasis on cost-related factors, both of which put pressure on vehicle prices.

4.2.2. Users and societal groups

The literature suggests that people's preference towards shared (solo and pooled) AVs is significantly lower than owned AVs for (a) instrumental (e.g., limited vehicle availability, higher waiting or access time, increased journey time, lower time and cost reliability, higher total cost of ownership and use), (b) affective (e.g., aversion of sharing, privacy and security concerns, self-efficacy concerns, inherent attractiveness of ownership) and (c) symbolic reasons (e.g., socio-economic status, subjective identity, freedom, superiority, proprietorship, individuality, masculinity). In the following paragraphs, we analyse the resistance factors towards shared AVs in each of the three areas, as identified in the relevant literature.

4.2.2.1. Instrumental factors. Travel cost (price), comfort, and travel time are key mode choice determinants (Buehler, 2011) including ride-pooling in particular (Asgari and Jin, 2020; Greifenstein, 2024; Krueger et al., 2016; Stoiber et al., 2019; Taiebat et al., 2022; Webb et al., 2019). Studies across various contexts and comparative analyses reveal that the direct and indirect costs of shared electric AVs often outweigh those of private AVs ownership, and concerns over increased travel times and decreased comfort further discourage users from transitioning to shared mobility options (Table 3). Thus, the instrumental factors (i.e., travel cost/price, comfort, travel time) represent important barriers to adopting shared mobility services.

Several studies have explored how the instrumental factors will compare between private and shared electric AVs assessing potential modal shifts between them. A first group of studies has focused on the travel cost (price) of future electric automated modes estimating the total cost of ownership comprising fixed (e.g., vehicle purchase, interest, insurance, tax) and variable (e.g., depreciation, maintenance, cleaning, tires, fuel) costs. Bösch et al. (2018) estimated, for the case of Switzerland, the out-of-pocket cost for private AVs at 0.17 CHF/km (0.15 €/km) that is significantly lower than the respective user cost for a mid-size shared taxi (at 0.34 CHF/km or 0.29 €/km). These researchers suggested that private cars would likely represent the most attractive option cost-wise in the AVs era, while shared (solo and pooled) AVs would possibly compete with (automated) line-based mass public transport (0.42 CHF/km or 0.36 €/km), but the level of competition remains unclear given the uncertainty of hidden costs for shared mobility (e.g., cleaning) and the occupancy levels. Expanding the same methodology of cost structure estimation for future modes across 17 global cities, Becker et al. (2020) provided further evidence that the cost of electric automated taxi services will approach this of buses in high income countries attracting a significant share of bus trips. For low-income countries, no major changes are expected since the cost

Table 3
Publications on the instrumental factors contributing to the resistance of users and societal groups to a transition from private automobility to shared electric automated mobility.

Publication	Country	Key findings	Resistance factors for users and societal groups (Instrumental)
Bösch et al. (2018)	Switzerland	Out-of-pocket costs for private AVs (0.17 CHF/km or 0.15 €/km) are estimated to be about half of the respective cost for shared AVs (0.34 CHF/km or 0.29 €/km).	Higher monetary costs associated with shared AVs compared to private AVs.
Becker et al. (2020)	Global (17 cities)	The cost of electric automated taxi services could match the cost of buses in high-income countries, but it would be higher in low-income countries.	Higher monetary costs associated with shared AVs compared to private AVs in low-income countries.
Asgari and Jin (2020)	United States	People would expect simultaneous travel cost and time savings (116 $/month (102€/month) and 20 min/trip respectively) before choosing shared modes.	Expectation for high monetary and travel time savings before switching to shared modes.
Haboucha et al. (2017)	Israel and United States	Even when shared AVs cost is zero, only 75 % of the respondents would choose it.	Expectation for high monetary savings before switching to shared modes.
Kuhnimhof and Eisenmann (2021)	Germany	Private cars remain the lowest cost mode for the majority of travel, even compared to prices for automated ride-hailing services as low as 0.3€/km.	Higher monetary costs associated with shared AVs compared to private AVs.
Wadud and Mattioli (2021)	United Kingdom	Private AVs likely to remain the least-cost option due to travel time valuation and ownership benefits.	Perceived and actual benefits of private AV ownership higher compared to potential cost savings of shared AVs.
Moody et al. (2021)	United States	Access to a personal car highly valued, far above shared mobility options, due to control, certainty, and flexibility.	High value of personal car access compared to benefits of shared mobility options.
Gkartzonikas et al. (2022)	United States	The value of travel time is lower for pooled than riding alone AVs, possibly due to lower level of comfort and higher travel time for pooled AVs.	Higher value of travel time for riding alone than pooled AVs.
Fulton (2021)	United States	Private AVs will likely offer lower overall trip costs (e.g., time and money) compared to shared (solo and pooled) AVs.	Higher monetary and travel time costs associated with shared AVs compared to private AVs.
Compostella et al. (2021)	United States	Pooled AVs will likely be the least attractive option cost-wise for short trips. For longer trips it becomes more attractive than private AVs for middle- and lower-income groups.	Higher monetary and travel time costs associated with shared AVs (with the exception of longer trips for low- and mid- income groups) compared to private AVs.
Kolarova et al. (2019)	Germany	Pooled AVs are less attractive than private AVs.	Shared AVs not as attractive as private AVs.

changes for automated taxis and buses are not expected to be so dramatic given the relatively lower contribution of the labour costs to the total costs of taxi and bus operations. In the US context, Asgari and Jin (2020) found in their survey in 11 metropolitan areas that people would expect simultaneous savings on travel cost and time before switching from a personal car to shared options at the level of 116 $/month (102 €/month) and 20 min/trip respectively. Similarly, Haboucha et al. (2017) reported, based on a vehicle choice model for individuals living in Israel and the US, that even when shared AVs cost is zero (either trip or subscription cost), only 75 % of the respondents would choose it. In the German context, Kuhnimhof and Eisenmann (2021) showed that the personal car would still be the lowest cost mode option for 94 % and 76 % of the car user kilometres if mobility on demand services (e.g., automated ride-hailing) would be valued at 0.5 €/km (i.e., current price of free-floating car sharing in Germany) and 0.3 €/km respectively (i.e., a typically expected price for shared automated mobility services in urban areas). Only for prices significantly below 0.3 €/km the automated mobility on demand services are expected to be competitive for the majority of private car user travel kilometres.

A second group of studies expands beyond the travel cost component to include travel time in the total cost of ownership and use of future modes. Travel time (i.e., wait time, access/egress walking time, and in-vehicle time) appears to be a critical factor for shared (solo and pooled) mobility options with its value varying across different geographies and incomes (Greifenstein, 2024; Lazarus et al., 2021). Wadud and Mattioli (2021) incorporated usefulness of travel time to estimate the total cost of ownership and use for every vehicle based on data for the UK context. These researchers concluded that private AVs will likely continue to be the least-cost option in most cases compared to shared (solo and pooled) electric automated vehicle options. Time use and the ownership seem to balance out any potential competitive travel cost benefits of shared automated mobility options against private AVs. Indeed, Moody et al. (2021) found in a study in four US metropolitan areas that the value of access to a personal car for one year is at the level of 16,890$ (14,287€) with all shared travel modes such as car sharing, ride-hailing, and ride-pooling being valued below 5$ (4.2€) per option. The perceived value of personal car is higher than its cost and it is derived mainly by the ownership and secondarily by the use, with control, certainty, reliability, and flexibility being the most important reasons for not giving up the personal car. Moreover, Gkartzonikas et al. (2022) found that the value of travel time is lower for pooled than riding alone AVs, possibly due to lower level of comfort and higher travel time for pooled AVs. According to Fulton (2021), private AVs will likely continue in the future to have lower generalised travel costs (i.e., travel time cost and monetary cost) than shared (solo and pooled) AVs. The reason is that ride-pooling's disadvantages such as waiting time, loading/unloading time and sharing rides with other people will remain, despite lower driver costs. Compostella et al. (2021) reached similar conclusions in their study of travel cost (time and monetary) in the US for a hypothetical future automated scenario in 2030–2035. For short trips (3-mile), pooled AVs is the least attractive option cost-wise, while for longer trips (15-mile) it becomes competitive to private AVs for middle- and lower-income groups mainly due to lower valuation of travel time. Pooled AVs were also found to be less attractive than private AVs in a study conducted in Germany (Kolarova et al., 2019). Wadud and Mattioli (2021) suggest that the consideration of psycho-social factors beyond out-of-pocket and time costs would possibly increase the attractiveness of ownership in the AVs era. Below we analyse such resistance factors towards shared AVs.

4.2.2.2. Affective factors. Affective factors such as privacy, the comfort of personal space, and the habitual attachment to owning a vehicle prevent users from adopting shared mobility options. Also, concerns over sharing a vehicle with strangers, coupled with the loss of personal control and security, significantly influence the low adoption rates of shared vehicles. Thus, the attractiveness of ownership and the aversion of sharing strongly drive the resistance towards shared electric AVs (Table 4).

Regarding the attractiveness of ownership, Zmud et al. (2016) found in their online and face-to-face interview survey in Austin, Texas that most respondents would prefer owning than sharing an AV mainly due to the convenience of vehicle ownership. The respondents indicated that

Table 4
Publications on the affective factors contributing to the resistance of users and societal groups to a transition from private automobility to shared electric automated mobility.

Publication	Country	Key findings	Resistance factors for users and societal groups (Affective)
Zmud et al. (2016)	United States	Most respondents preferred owning rather than sharing automated vehicles, citing convenience of vehicle ownership.	Perceived convenience of vehicle ownership.
Saeed et al. (2020)	United States	Participants showed a strong preference for private automated vehicles, linking it to independence, convenience, vehicle availability and freedom.	Perceived independence, convenience, vehicle availability and freedom.
Menon et al. (2019)	United States	Only 25.9 % of the respondents were likely to relinquish a household vehicle in the presence of shared automated vehicles.	Uncertainty about SAV effectiveness during emergencies, risk aversion to new technologies, entrenched private-vehicle ownership culture.
Wali et al. (2023)	United States	Only 9.1 % of the households analysed based on data from the 2019 California Vehicle Survey were willing to use shared AVs and give up their current vehicles.	Preference for owning a car instead of using shared AVs linked to the enjoyment of driving and having control over the vehicle.
Tian et al. (2021)	China	People preferred owning a car (conventional or automated) over sharing, with vehicle availability being key factor for their preference.	Perceived convenience of vehicle availability.
Wang et al. (2021)	Canada	Strong inertia of respondents towards conventional private vehicles instead of shared AVs was identified.	Habit and comfort with traditional car ownership over shared mobility options.
Clayton et al. (2020)	United Kingdom	Private AVs were the most preferred mode, with ride-hailed AVs, ride-pooled AVs, and automated buses ranked lower.	Perceived convenience of vehicle ownership.
Acheampong et al. (2021)	Ireland	Private AVs were the most preferred mode, with respondents indicating a strong car ownership preference.	Deep-rooted attachment to car ownership.
Jabbari et al. (2022)	United States	Psychological attachment to car ownership significantly influenced the choice between private and shared automated mobility.	Psychological attachment to car ownership.
Doody et al. (2021)	Norway, the Netherlands, Sweden, and the UK	Shared mobility habits are more fragile and less ingrained compared to car ownership practices.	Fragility of shared mobility habits.
Lee et al. (2019)	South Korea	Psychological ownership could improve acceptance of shared mobility options.	Limited sense of ownership for shared mobility options.
Dowling et al. (2018)	Australia	Shared mobility practices can be easily disrupted due to many reasons (e.g., booking failure, forgetting personal objects in the shared car).	Shared mobility practices easily disrupted.
Wadud and Chintakayala (2021)	United Kingdom	Inherent attractiveness of private AVs and inconvenience in sharing rides were associated with the preference of private over shared AVs.	Inherent attractiveness of private AVs and inconvenience of shared AVS
Lavieri and Bhat (2019)	United States	Privacy concerns, particularly in leisure trips, contribute to the aversion to ride-pooling and ride-pooled AVs.	Privacy concerns for shared mobility options, especially for leisure trips.
Kolarova et al. (2019)	Germany	Security concerns due to the absence of a driver who can intervene, are associated to a preference for private AVs.	Security concerns for shared AVs due to the absence of a professional guardian (driver).
Wang et al. (2020)	United States	About 79 % of the survey participants were not willing to share a pooled AV taxi with strangers.	Reluctance to share rides with strangers.
Jabbari and MacKenzie (2020)	United States	Reluctance to share rides with strangers, increased by the COVID-19 pandemic.	Reluctance to share rides due to health concerns.
Olaru et al. (2021)	Australia	About 70 % of participants were willing to use AV technology, but they had reservations about sharing their own vehicle.	Concerns about sharing one's own vehicle in a peer-to-peer car-sharing program.
Israel and Plaut (2024)	Israel	A more nuanced approach to pairing riders based on their personal social preferences could increase adoption of shared AVs.	Reluctance to share rides with strangers.
Stoiber et al. (2019)	Switzerland	Higher acceptance rate for pooled AVs (61 %) compared to privately owned AVs (39 %) was found, possibly due to a well-developed public transport system and car-sharing network in Switzerland.	More favourable attitudes towards shared mobility in areas with robust public transport and car-sharing systems.
Chng et al. (2021)	North America, Europe and Asia	Citizens acknowledged societal benefits from a shared deployment path for AVs, but also recognised that it is the least likely path compared to private AVs.	Expectation for limited deployment of shared AVs
Pettigrew (2021)	Australia	Shared AVs is the least likely deployment path compared to private AVs.	Expectation for limited deployment of shared AVs

they would use the AVs just as their current private conventional vehicle. Similarly, Saeed et al. (2020), suggested, based on an online questionnaire survey in small- and medium-sized metropolitan areas of the US, that people were more interested in having their own private AV rather than using ride-pooling or ride-hailing AV services, during the early stages of AV introduction in the transport system. AV familiarity, longer commute and larger household were identified as key factors for preferring private AVs, while factors associated with ownership such as independence, convenience of access, vehicle availability, freedom were reported also as possible factors explaining this outcome. Furthermore, Menon et al. (2019) reported that only 25.9 % of the respondents in their web-based survey in the University of South Florida and the American Automobile Association South indicated that it is likely to relinquish a household vehicle in the presence of shared automated vehicles. Wali et al. (2023) reported, along the same line, that only 9.1 % of the households in their study in California based on data from the 2019 California Vehicle Survey were willing to use shared AVs and renounce their current vehicles. This low percentage is connected to the fact that people who think they would miss the joy of driving and controlling the vehicle were, on average, less likely to use shared AVs and give up their current vehicles.

In the Chinese context, Tian et al. (2021) concluded, based on a stated-choice experiment in the city of Dalian, that people would prefer to own a car, either conventional or automated, than to share one with vehicle availability being among the key motivating factors to own an AV, beyond the operational costs of the different mode options. Similarly, Wang et al. (2021) identified a strong inertia, of the participants in their stated-choice survey in Toronto, to stay with the current conventional private vehicle involving driver assistance systems instead of using shared AVs. Moreover, Clayton et al. (2020) found, based on a stated preference survey in the UK, that a private AV were the most preferred future mode, followed by a ride-hailed AV, a ride-pooled AV and an automated bus with the last two options being the least preferred options by a significant margin. Convenience was identified as the most common reason for selecting a private AV. Shared AVs were also reported as the least preferred option, in a questionnaire survey in Dublin (Acheampong et al., 2021). The preference for private AVs either as single option or in combination with shared and public transport mobility options was found to be high. Participants in this survey who favoured car ownership and use were more likely to prefer a private AV.

Jabbari et al. (2022) found, in their stated-choice experiment in the US, that car ownership has a significant effect on the choice between private and shared automated mobility in the future, suggesting that the higher the psychological attachment to the car the more likely a private AV to be chosen. Indeed, Doody et al. (2021) drawing from qualitative interviews with households in Norway, the Netherlands, Sweden and the UK, confirmed that shared mobility habits are rather fragile and less ingrained compared to habits connected to car ownership. Lee et al. (2019) recommended that psychological ownership (i.e., feel of owning a vehicle) could be an important path to increase acceptance of shared mobility options (e.g., music or movies, driving routes, air conditioning and indoor lighting based on user's preferences). Yet, Dowling et al. (2018) suggested that such form of ownership can be fragile and disrupted, for example, the moment the technology fails and a contact to a help centre is necessary, having delays in booking a car or the children leaving toys behind in a shared vehicle. Wadud and Chintakayala (2021) interestingly identified the value of AV ownership (named as convenience or inherent attractiveness) in addition to the typical wait and trip time or reliability benefits. According to these researchers, the inherent attractiveness of a private AV may be originated to factors such as the opportunity to keep a child's scooter in the boot, having the child-seat always fitted, the phone and the music system always connected or simply feel secure having a private vehicle available in the case of an emergency situation. These researchers found, in their stated choice experiment in London and Manchester, that private AVs are preferred over shared (solo and pooled) AVs.

Apart from the inherent attractiveness of a private AV, Wadud and Chintakayala (2021) identified also an important inconvenience cost associated with ride-pooled AVs that was attributed to people's aversion of sharing rides. Likewise, aversion of using current ride-pooling services and future ride-pooled AVs, particularly for leisure trips, was reported by Lavieri and Bhat (2019). The main reason was privacy concerns, which could be enhanced by security concerns in the AVs era given the absence of a driver that could take the role of a "professional guardian". Security concerns such as the inability to take control or intervene in a shared automated vehicle was also among the factors motivating people to report a preference towards private automated vehicles, according to the results of an online questionnaire survey in Germany (Kolarova et al., 2019). Moreover, about 79 % of the US-based participants in the online questionnaire survey by Wang et al. (2020) responded that they were not willing to share a pooled AV taxi with strangers. Willingness to share AV rides was found to be positively correlated with familiarity of the AV and ride-sharing technology possibly attenuating the risk-perception for this future transport mode. The aversion of sharing rides was reported to remain at a rather high level during the COVID-19 pandemic in the US according to Jabbari and MacKenzie (2020). Respondents in this questionnaire survey reported feeling uncomfortable with sharing a ride with strangers both before and during the pandemic, while in the latter case people appeared more reluctant to share rides to save money or even trying more to use transportation modes that avoid contact with other people compared to their responses before the pandemic. Olaru et al. (2021) explored the willingness to use AVs and peer-to-peer car sharing (i.e., sharing own vehicle in a peer-to-peer car sharing program) in the Australian context finding that about 70 % of the participants were willing to embrace the AV technology, but they were concerned or not seeing the benefit in sharing their own vehicle. Personality traits such as low open mindedness and high conscientiousness together with values focusing on security, tradition, conformity, and benevolence were typical in the group of people resisting the idea of car sharing. Israel and Plaut (2024) suggested that a more nuanced matching of riders based on personal social preferences (e.g., preference to share the trip with women, passengers of a similar age, or non-smokers) could enhance adoption shared AVs.

A higher acceptance rate (61 %) for pooled AVs (i.e., auto-shuttle/train combination or pooled-use shared AVs) compared to privately owned AVs (39 %) has been reported by Stoiber et al. (2019). According to these researchers this outcome could be attributed to the facts that (a) they did offer the status quo option of the current conventional private vehicle in their stated choice experiment, and (b) Switzerland has already a well-developed public transport system and a nationwide car-sharing system in a rather dense urban context. Citizens do, indeed, acknowledge the possible societal benefits of a public transport deployment path of AVs, especially in survey contexts allowing elicitation of their preferences through participatory survey techniques (e.g., citizen dialogues, in-depth interviews; Chng et al., 2021). Yet, they also acknowledge that this deployment path is the least likely compared to private AVs (Pettigrew, 2021).

4.2.2.3. Symbolic factors. Symbolic factors are critical in shaping user preferences towards private over shared electric AVs. These factors include socio-economic status, subjective identity, freedom, superiority, proprietorship, individuality, and masculinity (Fitt, 2021; Gartman, 2016; Gatersleben, 2011; Hiscock et al., 2002; Sheller and Urry, 2000; Steg, 2005), suggesting that car ownership and use is embedded in today's society as hegemonic ideology informing people of who they are, who they would like to become in the future and how they would like to be seen by others (Mohammadzadeh, 2021). Thus, the perceived reduction in social status and the dilution of personal identity through the use of shared vehicles pose significant barriers to their adoption (Table 5).

Using a mixed method questionnaire and focus groups approach in Auckland, New Zealand, Mohammadzadeh (2021) concluded that most respondents (63 %) would use private instead of shared AVs for three main reasons. First, car is considered as part of the identity of middle-class New Zealand families. Second, private car ownership is associated with a sense of autonomy and freedom. Third, shared mobility services are considered as complimentary rather than as alternative to private car ownership. Sovacool and Axsen (2018) proposed a set of eight frames for automobility comprising combinations of private and societal with functional and symbolic dimensions. These researchers applied the frames in the case of electrification, automation, and shared mobility. They suggested that the private-symbolic dimensions of automobility associated with car ownership (i.e., expression of gender, identify, class, and wealth) will likely be maintained or strengthened by vehicle electrification and automation and weakened by shared mobility, making the latter mode less likely to be adopted since significant changes to today's car ownership and use practices would be required. Along similar lines, Gauer et al. (2022) found in their study in Canada that privately owned and shared (solo) AVs are more appealing options to the respondents being more car-dependent and considering car as means of their self-identity and status expression. Fraedrich (2021) explored current and future car ownership and use practices through a practice theory approach, focusing not only on individual motives, but also on the socio-technical structures influencing daily practices. Group discussions with people from Germany, revealed that at a first surface-level perspectives for car ownership, use and AVs were rather sceptical. Nevertheless, their underlying orientations remain car-friendly and most importantly ingrained into people's life, thus making any possible change highly unlikely. The analysis revealed that the discussants' private car-orientation is motivated not only by functional (e.g., carrying capacity) and affective factors (e.g., freedom, autonomy), but also from symbolic (e.g., status) factors and the firm bundling for car

Table 5
Publications on the symbolic factors contributing to the resistance of users and societal groups to a transition from private automobility to shared electric automated mobility.

Publication	Country	Key findings	Resistance factors for users and societal groups (Symbolic)
Mohammadzadeh (2021)	New Zealand	Private car ownership is considered part of the identity of middle-class families, linked to autonomy and freedom, while shared mobility services are regarded as complimentary to private car.	Perceived identity, freedom and autonomy associated with private car.
Sovacool and Axsen (2018)	n/a	Private-symbolic dimensions of automobility (e.g., expression of gender, class, and wealth) likely maintained or strengthened by vehicle automation and electrification and weakened by shared mobility.	Weakened symbolic dimensions of automobility (e.g., expression of gender, class, and wealth) by shared mobility options.
Gauer et al. (2022)	Canada	Private and shared (solo) AVs are more attractive to those who depend on cars and view them as a way to express their self-identity and social status.	Car dependence, self-identify and social status expression through car ownership.
Fraedrich (2021)	Germany	Group discussions revealed an underlying car-friendly orientation in peoples' life, influenced by functional, affective, and symbolic factors, such as status and identity formation.	Deep-rooted car-friendly orientations associated with status and identity formation.
Dangschat and Stickler (2023)	n/a	Economic, political, and cultural transformations leading to changes in societal values would be needed to support shared or public transport services, instead of private automobility though AVs.	Automobile oriented societal values strengthened by private AVs

use to other practices such as identity formation (becoming adult, expressing your character) and family development (e.g., having children). Dangschat and Stickler (2023) calls for governance strategies that would initiative economic, political, and cultural transformations leading to changes in societal values in favour of collectively shared or public transport services. Otherwise, AVs would further strengthen the societal formation of private automobility.

4.2.3. Public authorities

Public authorities show caution in the governance and regulation of shared electric AVs. The likely significant losses in transport-related tax revenues, the complex new public and private governance landscape involving new actors at different scales, the challenging and complex changes in the administration required to ensure public value in this transition, the shrinking role of the state globally, and the de facto segregation of the AV deployment from public transport and Mobility as a Service (MaaS) transport are some of the factors slowing down or preventing a transition towards shared AVs (Table 6). And certainly, these challenges and public authorities associated reservations do not reflect a significant shift or a policy "shock" in favour of the collective modes.

Vehicle automation, electrification, and shared (particularly pooled) mobility services are expected to have a negative impact on public finances through possible losses in transport-related tax revenues (Adler et al., 2019). In particular, shared mobility services could lead to lower car ownership and reduced need for parking translating to less public revenues from sales and property taxes, license plate and registration fees, parking tickets and traffic fines. If a transport-related tax structure is mainly based on property, sales and use taxes then a reduction of the vehicle fleet due to shared mobility could have a significant impact on public revenues. In their study for Buenos Aires, Blas et al. (2020) found that a scenario of a mainly privately-owned electric automated vehicle fleet (70 % owned, 30 % shared vehicles) would result in losses of transport-related tax revenues between 6 % and 17.9 % compared to losses between 25.8 % and 57.4 % for a scenario of a shared mobility services dominance (30 % owned, 70 % shared vehicles). These losses could have an impact on the public investments in transport infrastructure and services, particularly in public transport. They would also require reconsideration of taxes, charges and subsidies distribution among the users of the transport infrastructures (e.g., private cars, public transport, shared mobility services), which is a complex and politically charged problem (Docherty et al., 2018).

Indeed, Docherty et al. (2018) suggest that there is a brief window of opportunity for public authorities to ensure and enhance public value in the smart mobility transition that includes shared mobility services. However, a governance transition in four challenge areas (i.e., short vs long term regulation, taxation, information provision and sharing, equity and inclusion) involving negotiations with a complex network of new actors in different scales, that might pertain asymmetries in power and resources would be necessary. Such governance transitions could also require structural changes in the administration that would involve significant technical, political, legal, and organisation and working culture challenges (Millard, 2013). However, Docherty et al. (2018) conclude that such governance transition is rather unlikely given the goal of state shrinking and administrative costs reduction, shared by most governments globally. Along similar lines, Legacy et al. (2019) suggested that public sector planners in Australia retain a reactionary "wait and watch" stance due to the difficulties they experience in steering and coordinating AV deployment path within a complex public and private governance landscape. In the US context, planners appear concerned that AVs might result in increased vehicle miles travelled, urban sprawl, reduced public transport use, and lower local revenues (Freemark et al., 2019). Moreover, only few local governments in the US have started planning for AVs. Besides, no connection between AV deployment and public transport or MaaS was identified by Grindsted et al. (2022) who analysed urban plans of 10 European capitals. These researchers conclude that AVs are possible to further promote individualised mobility and intensify the existing automobility regime.

4.3. Landscape level: Moderate pressure towards shared electric automated mobility

The actual pressure on the private automobility regime to transition towards shared electric automated mobility remains moderate and focused, according to policy documents and national strategies, mainly on safety, congestion, and environmental concerns (Table 7). Moreover, citizens view these challenges as more critical than other issues such as social equity, enhancing public health and well-being, reclaiming urban spaces, reducing urban sprawl, and encouraging active lifestyles, which could primarily be addressed through shared mobility. The private automobility regime responds to the key pressures with its reconfiguration through vehicle electrification (targeting the environmental pressure) and automation (targeting mainly the road safety, but also the congestion pressure).

This triad of key benefits expected from vehicle automation and electrification are clearly reported in policy documents (see e.g., National Science and Technology Council and United States Department of Transportation, 2020), vehicle manufacturers', and OEMs' reports and websites (see e.g., BMW Group, 2021; General Motors, 2022; THALES Group, 2021; Toyota, 2020; Volvo Group, 2022). Additional, more recent, landscape pressures to the automobility regime such as the enhancement of social equity, improvement of public health and well-being, reclamation of urban space, reduction of urban sprawl, and promotion of active lifestyles that could be resolved mainly through shared mobility service innovations are considered milder than the primary pressures of congestion, climate change and road safety.

Table 6
Publications on the factors contributing to the resistance of public authorities to a transition from private automobility to shared electric automated mobility.

Publication	Country	Key findings	Resistance factors for public authorities
Adler et al. (2019)	OECD countries	Shared mobility services could lead to reduced car ownership, resulting in significant transport-related tax revenue, fees, ticket, and fine losses.	Losses in transport-related revenues.
Blas et al. (2020)	Argentina	Losses in transport-related tax revenues between 6 % and 17.9 % in a privately-owned electric automated vehicle fleet scenario, compared to 25.8 %-57.4 % for shared mobility services dominance.	Losses in transport-related tax revenues and negative impact on public investments in transport infrastructure and services.
Docherty et al. (2018)	n/a	Smart mobility transition would involve negotiations with complex networks of new actors in different scales, that might pertain asymmetries in power and resources.	Navigating governance complexities with a diverse network of new actors at different scales.
Millard (2013)	n/a	Significant technical, political, legal, and organisational challenges arise in administration during significant governance transitions.	Managing political, legal, and organisational challenges in governance transitions.
Legacy et al. (2019)	Australia	Public sector planners maintain a reactionary approach, facing difficulties in steering and coordinating AV deployment within a complex public and private governance landscape.	Complex public and private governance landscape for AVs.
Freemark et al. (2019)	United States	Only few local governments in the US have started planning for AVs, while planners are concerned that AVs might lead to increased vehicle miles travelled, urban sprawl, reduced public transport use, and lower local revenues.	Possibly adverse effects of AVs for sustainability and revenues at the local level.
Grindsted et al. (2022)	Europe	No clear connection between AV deployment and public transport or MaaS in urban plans across 10 European capitals.	Techno-oriented, path dependent, auto centric, planning practices.

Indeed, the pressure from the citizens to the automobility regime seems to primarily refer to congestion, safety, environment, and travel cost. According to the Eurobarometer survey in 2013 involving 27,680 respondents, the majority of European citizens considered air pollution (81 %), congestion (76 %), travel cost (74 %), and accidents (73 %) as serious problems that the authorities should take action to mitigate (European Commission, 2013). In a subsequent Eurobarometer survey in 2019, citizens (27565 participants) responded again, in an open question this time, that congestion (39 %), travel cost (39 %), environmental issues (29 %), and accidents (24 %) are among the most critical issues for daily mobility, while health impacts (15 %) and accessibility (12 %; e.g., for persons with reduced mobility) were ranked much lower (European Commission, 2020b). At the same time, European citizens expect that connected and automated vehicles will primarily reduce accidents (27 %), traffic congestion (25 %) and reduce greenhouse gas emissions and energy consumption (24 %), while making driving more comfortable (25 %) (European Commission, 2020a). Similarly, the results of citizen dialogues with 945 participants in 15 cities across North America, Europe and Asia showed that road safety improvement was the most frequently reported expectation from AVs (Chng et al., 2021).

Furthermore, national transport policy strategies around the world refer predominantly to the safety, congestion, and environmental protection goals triad. For example, the overarching goals of the US Department of Transportation for the period 2018–2022 (US DoT, 2018) focus on safety (i.e., reduce transportation-related fatalities and serious injuries), infrastructure (i.e., stimulate economic growth, improve condition and enable efficient and safe mobility), and innovation (i.e., support technology transfer and ensure the safety and security of new transport technologies). The Department of Transport in Canada identifies, safety and security, greening and innovation, and efficiency as the three core responsibilities of their plan for 2021–2022 (Transport Canada, 2020). The European transport strategy is centred around the goals of zero-emission, smart (i.e., seamless, safe and efficient connectivity), and resilient (single market, fair and just, safe and secure) mobility (European Commission, 2020c). Finally, New Zealand sets out four strategic priorities in the 10-year land transport plan. These are ensuring safety, providing better travel options that enhance accessibility, developing a low-carbon transport system, and improving freight (New Zealand Government, 2020). However, even these goals are not always translated into policy action denoting a rather mild pressure to existing automobility regime for deep change. Biermann et al. (2022) reviewed 3000 scientific studies on the 17 United Nations Sustainable Development Goals (including those directly referring to automobility such as good health and well-being, reduced inequalities, sustainable cities, and communities) and concluded that their normative and institutional integration in terms of legislative action to changing resource allocation is rather limited. These researchers suggest that the political impact of the UN-SDGs is more discursive (i.e., helping to understand and communicate sustainability goals) than transformative.

5. Discussion and conclusions

Shared electric AVs are anticipated to bring about a number of positive societal changes (e.g., reducing vehicle ownership and congestion, enhancing energy efficiency, eliminate greenhouse gas emissions, reclaiming urban space, enhance social equity). As a result, the scientific community, automakers, tech sector, consultancy firms, and public authorities frequently present those vehicles as the silver bullet for the sustainable transition of private automobility. Contrarily, evidence indicates that many of the costs of the current automobility regime will likely be maintained or perhaps exacerbated by a shift to electric private AVs.

In this paper, we explored the extent to which the current private automobility regime will be reconfigured into a private electric automated mobility regime or substituted by a shared electric automated

Table 7
Publications reflecting moderate landscape pressures to the private automobility regime (focused on safety, congestion and the environment) to transition towards shared electric automated mobility.

Publication	Country	Key findings	Landscape pressures
European Commission (2013)	Europe	Majority of European citizens consider air pollution (81 %), congestion (76 %), travel cost (74 %), and accidents (73 %) as serious problems.	Serious problems: Air pollution, congestion, travel cost, and accidents.
European Commission (2020b)	Europe	Citizens ranked congestion (39 %), travel cost (39 %), environmental issues (29 %), and accidents (24 %) as top concerns for daily mobility, with health impacts (15 %) and accessibility (13 %) ranking lower.	Top ranked: congestion, travel cost, environmental issues, and accidents. Lower ranked: health impacts and accessibility.
European Commission (2020a)	Europe	European citizens expect that connected and automated vehicles will primarily reduce accidents (27 %), traffic congestion (25 %), greenhouse gas emissions and energy consumption (24 %), making driving more comfortable (25 %).	Expectation from AVs: reduce accidents, traffic congestion, greenhouse gas emissions and energy consumption and driving more comfortable.
Chng et al. (2021)	Global	Road safety improvement is the most frequently reported expectation from AVs among citizens in 15 cities across North America, Europe, and Asia.	Expectation from AVs: road safety improvement.
US DoT (2018)	United States	US Department of Transportation's goals for 2018–2022 focused on safety, infrastructure, and innovation.	US DoT goals: safety, infrastructure, and innovation.
Transport Canada (2020)	Canada	Canada Department of Transport identifies safety and security, greening and innovation, as well as efficiency, as the three core responsibilities in the 2021–2022 plan.	Canada Department of Transportation goals: safety and security, greening and innovation, efficiency.
New Zealand Government (2020)	New Zealand	New Zealand sets out four strategic priorities: safety, better travel options, developing a low-carbon transport system, and improving freight.	New Zealand 10-year land transport plan: safety, better travel options, low-carbon transport system, improving freight.
Biermann et al. (2022)	n/a	Normative and institutional integration of UN-SDGs (including those directly referring to automobility such as good health and well-being, reduced inequalities, sustainable cities, and communities) to changing resource allocation is limited and the impact discursive.	Limited integration of UN-SDGs into normative and legislative action regarding resources allocation.

mobility regime that could successfully address important societal sustainability challenges. According to our analysis, the most likely transition pathway will involve a majority of privately-owned electric AVs as opposed to shared (especially pooled) vehicles, unless a landscape "shock" such as a climate breakdown, energy crisis or a significant political shift towards collective mobility exerts substantial pressure on the regime. As a result, the societal advantages of the so-called "three revolutions of automobility" (electric-shared-automated) could be greatly diminished. Methodologically, we first developed a conceptual model based on the multi-level perspective of technological transition outlining potential advancements for a pathway towards private and shared electric automated mobility. Then, we reviewed relevant literature supporting such developments at the niche, regime, and landscape level. Below, we present our conclusions per analytical level.

At the niche level, evidence suggests that shared, particularly pooled, mobility is still at an early emerging phase. Two key developments describe the business developments in the field. First, major OEMs, who were the first to enter the on-demand ride-pooling market more than a decade ago to diversify their business model, have gradually withdrawn from this market. The reasons were the small fleet size of ride-pooling services compared to their mass-market expectations, the delays in integrating vehicle automation that could expand this market, the potential to maintain high private car sales through electric vehicles without compromising their traditional core model and the relative mismatching with public transport authorities, which would be a key ally in this market. Second, current market is dominated by small Business-to-Government (B2G) projects, where ride-pooling companies operate small fleets of less than 10 vehicles on behalf of public authorities for a pilot period (usually 12 months).

At the regime level, evidence reveals that key actors (i.e., vehicle manufacturers, users and society groups, public authorities) resist a shift from private to shared electric automated mobility for a variety of reasons. For vehicle manufacturers, an increase in shared mobility would mean (a) a reduction in sales of private vehicles as (some) households will forego buying new cars or sell their current ones. These losses may be partially offset by rising sales of shared vehicles, (b) fierce competition, and weak negotiating position with large fleet clients (such as ride-hailing services) who prioritise financial rather than sentimental aspects of cars. For users and societal groups, evidence suggest a preference towards private rather shared AVs due to instrumental factors (e.g., lower total cost of ownership and use, higher usefulness of travel time, lower waiting or access time, higher reliability and flexibility), (b) affective factors (i.e., inherent attractiveness of ownership: convenience, vehicle availability, independence, car ownership habit and inertia, private space; aversion of sharing: inconvenience, privacy and security concerns, discomfort), and (c) symbolic factors (i.e., socio-economic status, subjective identity, freedom, superiority, proprietorship, individuality, masculinity). For public authorities, evidence indicates a resistance or lagging in governing a transition towards shared AVs due to (a) likely significant losses in transport-related tax revenues, (b) the complex new public and private governance landscape involving new actors at different scales, (c) the challenging and complex changes in the administration required to ensure public value in this transition, and (d) the shrinking role of the state globally, and the de facto segregation of the AV deployment from public transport and MaaS services.

At the landscape level, evidence suggests a moderate pressure of the socio-technical landscape to the private automobility regime originating predominantly in the safety, congestion, and environmental problems of the transport sector. The private automobility regime adapts to these constraints by electrifying (which targets the environmental pressure) and automating vehicles (which targets the road safety and the congestion pressures). Landscape pressures that could be addressed by a shift towards shared mobility services, such as those that call for the improvement of social equity, public health, reclamation of urban space, reduction of urban sprawl, and the promotion of active lifestyles, are seen as milder and less influential to the regime. A critical landscape-level "shock" that places significant pressure on the private automobility regime (such as a complete collapse of the climate system, a severe energy crisis, or a significant political and ideological shift in favour of collective over individual mobility) could very well open up a pathway to a shared electric automated mobility regime.

Future research could provide insights into the landscape-level "shock" conditions that may trigger a transition towards a shared electric automated mobility regime and inform anticipatory policies that could prepare for such a transition. Thus far, behavioural and practice-oriented research has attributed such a change to individual life and mobility events (e.g., having new home, joining the workforce, retirement, introduction of car sharing services) or shocks and disruptions (e.g., international relocation, broken-down car, job loss; see Doody et al., 2021). An empirical investigation of the suggested conceptual model across diverse geographical, economic, cultural, and political contexts and potentially through natural experiments could provide further insights on the validity of the model. Further exploration of the true motivations (e.g., greenwashing of vehicle automation, Dixon, 2020; justifying market overcapitalisation of automotive companies, Levy and Kolodny, 2021) behind the mainstream discourses of key actors in favour of the shared electric automated mobility transition could offer better insights into the forthcoming automobility transition.

CRediT authorship contribution statement

Dimitris Milakis: Conceptualization, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Dennis Seibert:** Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

References

Acheampong, R.A., Cugurullo, F., Gueriau, M., Dusparic, I., 2021. Can autonomous vehicles enable sustainable mobility in future cities? Insights and policy challenges from user preferences over different urban transport options. Cities 112, 103134. https://doi.org/10.1016/j.cities.2021.103134.

Adler, M.W., Peer, S., Sinozic, T., 2019. Autonomous, connected, electric shared vehicles (ACES) and public finance: an explorative analysis. Transp. Res. Interdiscip. Perspect. 2 https://doi.org/10.1016/j.trip.2019.100038.

Ammann, D., 2020, 15.10.2020. It's Time To Drive Change. https://medium.com/cruise/its-time-to-drive-change-f447f27cb353.

Asgari, H., Jin, X., 2020. Propensity toward ride-sourcing: desired savings in travel time and mobility cost to switch from private mobility. Transp. Res. Part C Emerg. Technol. 121, 102883 https://doi.org/10.1016/j.trc.2020.102883.

Becker, H., Becker, F., Abe, R., Bekhor, S., Belgiawan, P.F., Compostella, J., Frazzoli, E., Fulton, L.M., Guggisberg Bicudo, D., Murthy Gurumurthy, K., Hensher, D.A., Joubert, J.W., Kockelman, K.M., Kröger, L., Le Vine, S., Malik, J., Marczuk, K., Ashari Nasution, R., Rich, J., Axhausen, K.W., 2020. Impact of vehicle automation and electric propulsion on production costs for mobility services worldwide. Transp. Res. A Policy Pract. 138, 105–126. https://doi.org/10.1016/j.tra.2020.04.021.

Beiker, S., Burgelman, R.A., 2020. The Future of the Automated Mobility Industry: A Strategic Management Perspective.

Beojone, C.V., Geroliminis, N., 2021. On the inefficiency of ride-sourcing services towards urban congestion. Transp. Res. Part C Emerg. Technol. 124, 102890 https://doi.org/10.1016/j.trc.2020.102890.

Biermann, F., Hickmann, T., Sénit, C.-A., Beisheim, M., Bernstein, S., Chasek, P., Grob, L., Kim, R.E., Kotzé, L.J., Nilsson, M., Ordóñez Llanos, A., Okereke, C., Pradhan, P., Raven, R., Sun, Y., Vijge, M.J., van Vuuren, D., Wicke, B., 2022. Scientific evidence on the political impact of the Sustainable Development Goals. Nat. Sustainability. https://doi.org/10.1038/s41893-022-00909-5.

Blas, F., Giacobone, G., Massin, T., Rodríguez Tourón, F., 2020. Impacts of vehicle automation in public revenues and transport equity. Economic challenges and policy paths for Buenos Aires. Res. Transp. Bus. Manag. 100566 https://doi.org/10.1016/j.rtbm.2020.100566.

BMW Group., 2021. "Automated driving can only serve one purpose: to make driving safer and more comfortable." Eight questions for Dr. Nicolai Martin, Senior Vice President Automated Driving DevelopmentBMW Group. Retrieved 22.7.2022 from https://www.press.bmwgroup.com/global/article/detail/T0326833EN/%E2%80%9Cautomated-driving-can-only-serve-one-purpose:-to-make-driving-safer-and-more-comfortable-%E2%80%9D?language=en.

Bösch, P.M., Becker, F., Becker, H., Axhausen, K.W., 2018. Cost-based analysis of autonomous mobility services. Transp. Policy 64, 76–91. https://doi.org/10.1016/J.TRANPOL.2017.09.005.

Buehler, R., 2011. Determinants of transport mode choice: a comparison of Germany and the USA. J. Transp. Geogr. 19 (4), 644–657. https://doi.org/10.1016/j.jtrangeo.2010.07.005.

Childress, S., Nichols, B., Coe, S., 2015. Using an activity-based model to explore possilbe impacts of automated vehicles. Transp. Res. Rec. 2493, 99–106.

Chng, S., Kong, P., Lim, P.Y., Cornet, H., Cheah, L., 2021. Engaging citizens in driverless mobility: insights from a global dialogue for research, design and policy. Transp. Res. Interdiscip. Perspect. 11 https://doi.org/10.1016/j.trip.2021.100443.

Christiansen, P., 2020. The effects of transportation priority congruence for political legitimacy. Transp. Res. A Policy Pract. 132, 61–76. https://doi.org/10.1016/j.tra.2019.11.005.

Circella, G., Jaller, M., Sun, R., Qian, X., Alemi, F., 2022. Future Connected and Automated Vehicle Adoption Will Likely Increase Car Dependence and Reduce Transit Use without Policy Intervention. N. C. f. S. Transportation.

Clayton, W., Paddeu, D., Parkhurst, G., Parkin, J., 2020. Autonomous vehicles: who will use them, and will they share? Transp. Plan. Technol. 43 (4), 343–364. https://doi.org/10.1080/03081060.2020.1747200.

Compostella, J., Fulton, L.M., De Kleine, R., Kim, H.C., Wallington, T.J., Brown, A.L., 2021. Travel time costs in the near- (circa 2020) and long-term (2030–2035) for automated, electrified, and shared mobility in the United States. Transp. Policy 105, 153–165. https://doi.org/10.1016/j.tranpol.2020.12.014.

Czerlinsky, N., Murawski, M., Bick, M., 2022. Why do German car manufacturers get engaged in mobility concepts? In: Comprehensible Science (pp. 74–85). doi: 10.1007/978-3-030-85799-8_7.

Dangschat, J.S., Stickler, A., 2023. Does automation strengthen the 'system of automobility'? Critical considerations and alternatives to connected and automated vehicles. Appl. Mobil. 1–20 https://doi.org/10.1080/23800127.2023.2243579.

Diao, M., Kong, H., Zhao, J., 2021. Impacts of transportation network companies on urban mobility. Nat. Sustainability. https://doi.org/10.1038/s41893-020-00678-z.

Dixon, L., 2020. Autonowashing: the Greenwashing of Vehicle Automation. Transp. Res. Interdiscip. Perspect. 5, 100113 https://doi.org/10.1016/j.trip.2020.100113.

Docherty, I., Marsden, G., Anable, J., 2018. The governance of smart mobility. Transp. Res. A Policy Pract. 115, 114–125. https://doi.org/10.1016/J.TRA.2017.09.012.

Docherty, I., Stone, J., Curtis, C., Sørensen, C.H., Paulsson, A., Legacy, C., Marsden, G., 2022. The case for 'public' transport in the age of automated mobility. Cities 128. https://doi.org/10.1016/j.cities.2022.103784.

Doody, B.J., Schwanen, T., Loorbach, D.A., Oxenaar, S., Arnfalk, P., Svennevik, E.M.C., Julsrud, T.E., Farstad, E., 2021. Entering, enduring and exiting: the durability of shared mobility arrangements and habits. Mobilities 1–17. https://doi.org/10.1080/17450101.2021.1958365.

DoT, U.S., 2018. US Department of Transportation Strategic Plan for FY 2018–2022. USDOT, Washington, DC.

Dowling, R., Maalsen, S., Kent, J.L., 2018. Sharing as sociomaterial practice: car sharing and the material reconstitution of automobility. Geoforum 88, 10–16. https://doi.org/10.1016/j.geoforum.2017.11.004.

Emberger, G., Pfaffenbichler, P., 2020. A quantitative analysis of potential impacts of automated vehicles in Austria using a dynamic integrated land use and transport interaction model. Transp. Policy 98, 57–67. https://doi.org/10.1016/j.tranpol.2020.06.014.

European Commission, 2013. Attitudes of Europeans towards urban mobility. Special Eurobarometer 406, 1–98.

European Commission, 2020a. Expectations and concerns from a connected and automated mobility. Special Eurobarometer 496.

European Commission, 2020b. Mobility and transport. Special Eurobarometer 495, 1.

European Commission, 2020c. Sustainable and smart mobility strategy—putting european transport on track for the future. In: European Commission Brussels, Belgium.

Fitt, H., 2021. The status of being or the achievement of becoming? Towards better understandings of cars as status symbols. Soc. Cult. Geogr. 1–19 https://doi.org/10.1080/14649365.2021.2000014.

Foljanty, L., 2022. The On-Demand Ridepooling Market in 2022 – further growth or signs of saturation?>. Retrieved 4.8.2022, from https://www.linkedin.com/pulse/on-demand-ridepooling-market-2022-further-growth-signs-lukas-foljanty/?trackingId=eBlCzqljSM6nADFpAy%2FzzQ%3D%3D&utm_source=pocket_mylist.

Foljanty, L., 2023. On-Demand Transit Market Report – 2023 Recap. Retrieved 25.04.2024, from https://www.linkedin.com/pulse/on-demand-transit-market-report-2023-recap-lukas-foljanty-ngyzc/?trackingId=dZ8FY5SMTISo7mnntM5wEA%3D%3D.

Fournier, G., Donada, C., 2016. Future business models and shapers for the automotive mobility? In: Nationale und internationale Trends in der Mobilität (pp. 27–41). doi: 10.1007/978-3-658-14563-7_3.

Fraedrich, E., 2021. How collective frames of orientation toward automobile practices provide hints for a future with autonomous vehicles. Appl. Mobil. 6 (3), 253–272. https://doi.org/10.1080/23800127.2018.1501198.

Fraedrich, E., Beiker, S., Lenz, B., 2015. Transition pathways to fully automated driving and its implications for the sociotechnical system of automobility. Eur. J. Fut. Res. 3, 11. https://doi.org/10.1007/s40309-015-0067-8.
Freemark, Y., Hudson, A., Zhao, J., 2019. Are cities prepared for autonomous vehicles? J. Am. Plann. Assoc. 1–19 https://doi.org/10.1080/01944363.2019.1603760.
Fulton, L.M., 2018. Three revolutions in urban passenger travel. Joule 2 (4), 575–578. https://doi.org/10.1016/j.joule.2018.03.005.
Fulton, L.M., 2021. The Monetary and Non-Monetary Factors Influencing Travel Choices in an Automated, Shared, and Electric Vehicle Future. N. C. f. S. Transportation.
Gartman, D., 2016. Three ages of the automobile. Theory Cult. Soc. 21 (4–5), 169–195. https://doi.org/10.1177/0263276404046066.
Gatersleben, B., 2011. The car as a material possession: exploring the link between materialism and car ownership and use. In: Lucas, K., Blumenberg, E., Weinberger, R. (Eds.), Auto Motives. Emerald Group Publishing Limited, pp. 137–148. https://doi.org/10.1108/9780857242341-007.
Gauer, V.H., Axsen, J., Dütschke, E., Long, Z., 2022. Exploring "automobility engagement": a predictor of shared, automated, and electric mobility interest? Transp. Res. Part D: Transp. Environ. 109 https://doi.org/10.1016/j.trd.2022.103353.
Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy 31, 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8.
Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36, 399–417. https://doi.org/10.1016/j.respol.2007.01.003.
Gkartzonikas, C., Ke, Y., Gkritza, K., 2022. A tale of two modes: who will use single user and shared autonomous vehicles. Case Stud. Transp. Policy 10 (3), 1566–1580. https://doi.org/10.1016/j.cstp.2022.05.015.
Greenblatt, J.B., Saxena, S., 2015. Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. Nat. Clim. Chang. 5, 860–863. https://doi.org/10.1038/nclimate2685.
Greifenstein, M., 2024. Factors influencing the user behaviour of shared autonomous vehicles (SAVs): a systematic literature review. Transport. Res. F: Traffic Psychol. Behav. 100, 323–345. https://doi.org/10.1016/j.trf.2023.10.027.
Grindsted, T.S., Christensen, T.H., Freudendal-Pedersen, M., Friis, F., Hartmann-Petersen, K., 2022. The urban governance of autonomous vehicles – In love with AVs or critical sustainability risks to future mobility transitions. Cities 120. https://doi.org/10.1016/j.cities.2021.103504.
Haarstad, H., Sareen, S., Kandt, J., Coenen, L., Cook, M., 2022. Beyond automobility? Lock-in of past failures in low-carbon urban mobility innovations. Energy Policy 166. https://doi.org/10.1016/j.enpol.2022.113002.
Haboucha, C.J., Ishaq, R., Shiftan, Y., 2017. User preferences regarding autonomous vehicles. Transp. Res. Part C Emerg. Technol. 78, 37–49. https://doi.org/10.1016/j.trc.2017.01.010.
Harb, M., Stathopoulos, A., Shiftan, Y., Walker, J.L., 2021. What do we (Not) know about our future with automated vehicles? Transp. Res. Part C Emerg. Technol. 123, 102948 https://doi.org/10.1016/j.trc.2020.102948.
Hecking, M., 2014. Daimler-Tochter Moovel "Wir wollen das Amazon der Mobilität werden". Manager Magazin. https://www.manager-magazin.de/unternehmen/autoindustrie/daimler-tochter-moovel-wir-wollen-das-amazon-der-mobilitaet-werden-a-993755.html.
Hiscock, R., Macintyre, S., Kearns, A., 2002. Means of transport and ontological security: do cars provide psycho-social benefits to their users? Transp. Res. Part D: Transp. Environ. 7, 119–135.
Hopkins, D., Schwanen, T., 2018. Automated mobility transitions: governing processes in the UK. Sustainability (switzerland) 10. https://doi.org/10.3390/su10040956.
Hörl, S., Becker, F., Axhausen, K.W., 2021. Simulation of price, customer behaviour and system impact for a cost-covering automated taxi system in Zurich. Transp. Res. Part C Emerg. Technol. 123, 102974 https://doi.org/10.1016/j.trc.2021.102974.
Israel, F., Plaut, P., 2024. The relevance of social factors in sharing a trip with strangers: creating travel communities in the autonomous vehicles era. Travel Behav. Soc. 35 https://doi.org/10.1016/j.tbs.2024.100740.
Jabbari, P., MacKenzie, D., 2020. Ride sharing attitudes before and during the COVID-19 pandemic in the United States. Findings. https://doi.org/10.32866/001c.17991.
Jabbari, P., Auld, J., MacKenzie, D., 2022. How do perceptions of safety and car ownership importance affect autonomous vehicle adoption? Travel Behav. Soc. 28, 128–140. https://doi.org/10.1016/j.tbs.2022.02.002.
Jochem, P., Frankenhauser, D., Ewald, L., Ensslen, A., Fromm, H., 2020. Does free-floating carsharing reduce private vehicle ownership? The case of SHARE NOW in European cities. Transp. Res. Part A Policy Pract. 141, 373–395. https://doi.org/10.1016/j.tra.2020.09.016.
Kanger, L., Sovacool, B.K., Noorkõiv, M., 2020. Six policy intervention points for sustainability transitions: a conceptual framework and a systematic literature review. Res. Policy 49 (7). https://doi.org/10.1016/j.respol.2020.104072.
Klein, N.J., Ralph, K., Thigpen, C., Brown, A., 2022. Political partisanship and transportation reform. J. Am. Plann. Assoc. 88 (2), 163–178. https://doi.org/10.1080/01944363.2021.1965495.
Kolarova, V., Steck, F., Bahamonde-Birke, F.J., 2019. Assessing the effect of autonomous driving on value of travel time savings: a comparison between current and future preferences. Transp. Res. A Policy Pract. 129, 155–169. https://doi.org/10.1016/j.tra.2019.08.011.
Kontar, W., Ahn, S., Hicks, A., 2021. Autonomous vehicle adoption: use phase environmental implications. Environ. Res. Lett. 16 (6), 064010 https://doi.org/10.1088/1748-9326/abf6f4.
Kostorz, N., Fraedrich, E., Kagerbauer, M., 2021. Usage and user characteristics—insights from MOIA, Europe's largest ridepooling service. Sustainability 13 (2). https://doi.org/10.3390/su13020958.
Krueger, R., Rashidi, T.H., Rose, J.M., 2016. Preferences for shared autonomous vehicles. Transp. Res. C 69, 343–355. https://doi.org/10.1016/j.trc.2016.06.015.
Kuhnimhof, T., Eisenmann, C., 2021. Mobility-on-demand pricing versus private vehicle TCO: how cost structures hinder the dethroning of the car. Transportation. https://doi.org/10.1007/s11116-021-10258-5.
Lavieri, P.S., Bhat, C.R., 2019. Modeling individuals' willingness to share trips with strangers in an autonomous vehicle future. Transp. Res. A Policy Pract. 124, 242–261. https://doi.org/10.1016/J.TRA.2019.03.009.
Lazarus, J.R., Caicedo, J.D., Bayen, A.M., Shaheen, S.A., 2021. To Pool or Not to Pool? Understanding opportunities, challenges, and equity considerations to expanding the market for pooling. Transp. Res. A Policy Pract. 148, 199–222. https://doi.org/10.1016/j.tra.2020.10.007.
Lee, J., Lee, D., Park, Y., Lee, S., Ha, T., 2019. Autonomous vehicles can be shared, but a feeling of ownership is important: examination of the influential factors for intention to use autonomous vehicles. Transp. Res. Part C Emerg. Technol. 107, 411–422. https://doi.org/10.1016/j.trc.2019.08.020.
Legacy, C., Ashmore, D., Scheurer, J., Stone, J., Curtis, C., 2019. Planning the driverless city. Transp. Rev. 39, 84–102. https://doi.org/10.1080/01441647.2018.1466835.
Levy, A., Kolodny, L., 2021. Elon Musk explains how self-driving robotaxis will justify Tesla's massive valuation. https://www.cnbc.com. Retrieved September 12 from https://www.cnbc.com/2021/01/27/elon-musk-explains-how-self-driving-robotaxis-justify-tesla-valuation.html.
Li, Y., Li, X., Jenn, A., 2022. Evaluating the emission benefits of shared autonomous electric vehicle fleets: a case study in California. Appl. Energy 323. https://doi.org/10.1016/j.apenergy.2022.119638.
Menon, N., Barbour, N., Zhang, Y., Pinjari, A.R., Mannering, F., 2019. Shared autonomous vehicles and their potential impacts on household vehicle ownership: an exploratory empirical assessment. Int. J. Sustain. Transp. 13 (2), 111–122. https://doi.org/10.1080/15568318.2018.1443178.
Milakis, D., Müller, S., 2021. The societal dimension of the automated vehicles transition: towards a research agenda. Cities 113, 103144.
Milakis, D., van Arem, B., van Wee, B., 2017. Policy and society related implications of automated driving : a review of literature and directions for future research. J. Intell. Transp. Syst. Technol. Plann. Oper. 21, 324–348. https://doi.org/10.1080/15472450.2017.1291351.
Milakis, D., Kroesen, M., van Wee, B., 2018. Implications of automated vehicles for accessibility and location choices: evidence from an expert-based experiment. J. Transp. Geogr. 68, 142–148. https://doi.org/10.1016/j.jtrangeo.2018.03.010.
Milakis, D., Van Wee, B., 2020. Implications of vehicle automation for accessibility and social inclusion of people on low income, people with physical and sensory disabilities, and older people. In: Antoniou, C., Efthymiou, D., Chaniotakis, E. (Eds.), Demand for Emerging Transportation Systems. Elsevier, pp. 61–73. https://doi.org/10.1016/b978-0-12-815018-4.00004-8.
Millard, J., 2013. ICT-enabled public sector innovation: trends and prospects. Proceedings of the 7th International Conference on Theory and Practice of Electronic Governance.
Mohammadzadeh, M., 2021. Sharing or owning autonomous vehicles? Comprehending the role of ideology in the adoption of autonomous vehicles in the society of automobility. Transp. Res. Interdiscip. Perspect. 9, 100294 https://doi.org/10.1016/j.trip.2020.100294.
Moody, J., Farr, E., Papagelis, M., Keith, D.R., 2021. The value of car ownership and use in the United States. Nat. Sustainability 4 (9), 769–774. https://doi.org/10.1038/s41893-021-00731-5.
General Motors, 2022. Path to Autonomous. Our vision is that autonomous vehicles can help lead to a safe, less congested future for all. Retrieved 20.7.2022 from https://www.gm.com/commitments/path-to-autonomous.
Næss, P., Vogel, N., 2012. Sustainable urban development and the multi-level transition perspective. Environ. Innov. Soc. Trans. 4, 36–50. https://doi.org/10.1016/j.eist.2012.07.001.
Narayanan, S., Chaniotakis, E., Antoniou, C., 2020. Shared autonomous vehicle services: a comprehensive review. Transp. Res. Part C Emerg. Technol. 111, 255–293. https://doi.org/10.1016/j.trc.2019.12.008.
National Science and Technology Council and United States Department of Transportation, 2020. Ensuring American leadership in automated vehicle technologies: automated vehicles 4.0. U. DOT. https://www.transportation.gov/sites/dot.gov/files/2020-02/EnsuringAmericanLeadershipAVTech4.pdf.
New Zealand Government, 2020. Government policy statement on land transport: 2021/2022-2030/2031. In: Ministry of Transport Wellington, New Zealand.
Nikitas, A., Thomopoulos, N., Milakis, D., 2021. The environmental and resource dimensions of automated transport: a nexus for enabling vehicle automation to support sustainable urban mobility. Annu. Rev. Env. Resour. 46 (1), 167–192. https://doi.org/10.1146/annurev-environ-012220-024657.
Nunes, A., Huh, L., Kagan, N., Freeman, R.B., 2021. Estimating the energy impact of electric, autonomous taxis: evidence from a select market [Article]. Environ. Res. Lett. 16 (9), 094036 https://doi.org/10.1088/1748-9326/ac1bd9.
Olaru, D., Greaves, S., Leighton, C., Smith, B., Arnold, T., 2021. Peer-to-Peer (P2P) carsharing and driverless vehicles: attitudes and values of vehicle owners. Transp. Res. A Policy Pract. 151, 180–194. https://doi.org/10.1016/j.tra.2021.07.008.
Pan, S., Fulton, L.M., Roy, A., Jung, J., Choi, Y., Gao, H.O., 2021. Shared use of electric autonomous vehicles: air quality and health impacts of future mobility in the United States. Renew. Sustain. Energy Rev. 149 https://doi.org/10.1016/j.rser.2021.111380.
Pettigrew, S., 2021. The potential effects of autonomous vehicles on walking. Glob. Health Promot., 17579759211019219 https://doi.org/10.1177/17579759211019219.

Rodier, C., Chai, H., Kaddoura, I., 2022. Simulating the Effects of Shared Automated Vehicles and Benefits to Low-Income Communities in Los Angeles.
Rojas-Rueda, D., Nieuwenhuijsen, M.J., Khreis, H., Frumkin, H., 2020. Autonomous vehicles and public health. Annu. Rev. Public Health 41 (1), 329–345. https://doi.org/10.1146/annurev-publhealth-040119-094035.
Saeed, T.U., Burris, M.W., Labi, S., Sinha, K.C., 2020. An empirical discourse on forecasting the use of autonomous vehicles using consumers' preferences. Technol. Forecast. Soc. Chang. 158 https://doi.org/10.1016/j.techfore.2020.120130.
Saleh, M., Hatzopoulou, M., 2020. Greenhouse gas emissions attributed to empty kilometers in automated vehicles. Transp. Res. Part D: Transp. Environ. 88, 102567 https://doi.org/10.1016/j.trd.2020.102567.
Schaller, B., 2021. Can sharing a ride make for less traffic? Evidence from Uber and Lyft and implications for cities. Transp. Policy 102, 1–10. https://doi.org/10.1016/j.tranpol.2020.12.015.
Schmidt, P., 2020. The effect of car sharing on car sales. Int. J. Ind. Organiz. 71, 102622 https://doi.org/10.1016/j.ijindorg.2020.102622.
Sheller, M., Urry, J., 2000. The city and the car. Int. J. Urban Reg. Res. 24 (4), 737–757.
Si, H., Su, Y., Wu, G., Li, W., Cheng, L., 2022. Can government regulation, carbon-emission reduction certification and information publicity promote carpooling behavior? Transp. Res. Part D: Transp. Environ. 109 https://doi.org/10.1016/j.trd.2022.103384.
Silva, Ó., Cordera, R., González-González, E., Nogués, S., 2022. Environmental impacts of autonomous vehicles: a review of the scientific literature. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2022.154615.
Soteropoulos, A., Berger, M., Ciari, F., 2019. Impacts of automated vehicles on travel behaviour and land use: an international review of modelling studies. Transp. Rev. 39, 29–49. https://doi.org/10.1080/01441647.2018.1523253.
Sovacool, B.K., Axsen, J., 2018. Functional, symbolic and societal frames for automobility: implications for sustainability transitions. Transp. Res. A Policy Pract. 118, 730–746. https://doi.org/10.1016/j.tra.2018.10.008.
Steg, L., 2005. Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transp. Res. A Policy Pract. 39 (2–3), 147–162. https://doi.org/10.1016/j.tra.2004.07.001.
Stoiber, T., Schubert, I., Hoerler, R., Burger, P., 2019. Will consumers prefer shared and pooled-use autonomous vehicles? A stated choice experiment with Swiss households. Transp. Res. Part D: Transp. Environ. https://doi.org/10.1016/J.TRD.2018.12.019.
Taiebat, M., Amini, E., Xu, M., 2022. Sharing behavior in ride-hailing trips: a machine learning inference approach. Transp. Res. Part D: Transp. Environ. 103 https://doi.org/10.1016/j.trd.2021.103166.
Taiebat, M., Xu, M., 2019. Synergies of four emerging technologies for accelerated adoption of electric vehicles: shared mobility, wireless charging, vehicle-to-grid, and vehicle automation. J. Clean. Prod. 230, 794–797. https://doi.org/10.1016/j.jclepro.2019.05.142.
Tarduno, M., 2021. The congestion costs of Uber and Lyft. J. Urban Econ. 103318 https://doi.org/10.1016/j.jue.2020.103318.
THALES Group, 2021. 7 benefits of autonomous cars. Retrieved 22.7.2022 from https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/magazine/7-benefits-autonomous-cars.
Tian, Z., Feng, T., Timmermans, H.J.P., Yao, B., 2021. Using autonomous vehicles or shared cars? Results of a stated choice experiment. Transp. Res. Part C Emerg. Technol. 128 https://doi.org/10.1016/j.trc.2021.103117.
Tillema, T., Berveling, J., Gelauff, G., Waard, J. v. d., Harms, L., Derriks, H., 2015. Driver at the wheel? Self-driving vehicles and transport system of the future.
Toyota, 2020. Toyota Automated Driving. Whitepaper. https://amrd.toyota.com/app/uploads/2022/02/ATwhitepaper.pdf.
Transport Canada, 2020. Transport Canada - Departmental Plan 2021–22. Transport Canada.
Van Wee, B., Banister, D., 2016. How to write a literature review paper? Transp. Rev. 36, 278–288. https://doi.org/10.1080/01441647.2015.1065456.
Volvo Group, 2022. Shaping the Future of Transportation. Volvo Group. Retrieved 22.7.2022 from https://www.volvogroup.com/en/future-of-transportation.html.
Wadud, Z., Chintakayala, P.K., 2021. To own or not to own – That is the question: the value of owning a (fully automated) vehicle. Transp. Res. Part C Emerg. Technol. 123, 102978 https://doi.org/10.1016/j.trc.2021.102978.
Wadud, Z., Mackenzie, D., Leiby, P., 2016. Help or hindrance ? The travel, energy and carbon impacts of highly automated vehicles. Transp. Res. A 86, 1–18. https://doi.org/10.1016/j.tra.2015.12.001.
Wadud, Z., Mattioli, G., 2021. Fully automated vehicles: a cost-based analysis of the share of ownership and mobility services, and its socio-economic determinants. Transp. Res. A Policy Pract. 151, 228–244. https://doi.org/10.1016/j.tra.2021.06.024.
Wali, B., Santi, P., Ratti, C., 2023. Are californians willing to use shared automated vehicles (SAV) & renounce existing vehicles? An empirical analysis of factors determining SAV use & household vehicle ownership. Technol. Forecast. Soc. Chang. 195 https://doi.org/10.1016/j.techfore.2023.122757.
Wang, S., Jiang, Z., Noland, R.B., Mondschein, A.S., 2020. Attitudes towards privately-owned and shared autonomous vehicles. Transport. Res. F: Traffic Psychol. Behav. 72, 297–306. https://doi.org/10.1016/j.trf.2020.05.014.
Wang, Salehin, M.F., Nurul Habib, K., 2021. A discrete choice experiment on consumer's willingness-to-pay for vehicle automation in the Greater Toronto Area. Transp. Res. A Policy Pract. 149, 12–30. https://doi.org/10.1016/j.tra.2021.04.020.
Wang, Y., Shi, W., Chen, Z., 2021. Impact of ride-hailing usage on vehicle ownership in the United States. Transp. Res. Part D: Transp. Environ. 101 https://doi.org/10.1016/j.trd.2021.103085.
Ward, J.W., Michalek, J.J., Azevedo, I.L., Samaras, C., Ferreira, P., 2019. Effects of on-demand ridesourcing on vehicle ownership, fuel consumption, vehicle miles traveled, and emissions per capita in U.S. States. Transp. Res. Part C Emerg. Technol. 108, 289–301. https://doi.org/10.1016/j.trc.2019.07.026.
Ward, J.W., Michalek, J.J., Samaras, C., Azevedo, I.L., Henao, A., Rames, C., Wenzel, T., 2021. The impact of Uber and Lyft on vehicle ownership, fuel economy, and transit across U.S. cities. iScience 24 (1), 101933. https://doi.org/10.1016/j.isci.2020.101933.
Webb, J., Wilson, C., Kularatne, T., 2019. Will people accept shared autonomous electric vehicles? A survey before and after receipt of the costs and benefits. Econ. Anal. Policy 61, 118–135. https://doi.org/10.1016/j.eap.2018.12.004.
Wohlin, C., 2014. Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE '14.
Yantao, H., Kockelman, K.M., Truong, L.T., Zhao, J., 2021. SAV operations on a bus line corridor: travel demand, service frequency, and vehicle size. J. Adv. Transp. 2021, 1–15. https://doi.org/10.1155/2021/5577500.
Zmud, J., Sener, I.N., Wagner, J., 2016. Self-driving vehicles determinants of adoption and conditions of usage. Transp. Res. Rec. 2665, 57–64. https://doi.org/10.3141/2565-07.
Zwick, F., Axhausen, K.W., 2022. Ride-pooling demand prediction: a spatiotemporal assessment in Germany. J. Transp. Geogr. 100 https://doi.org/10.1016/j.jtrangeo.2022.103307.
Zwick, F., Kuehnel, N., Axhausen, K.W., 2022, May 18-20, 2022. Review on theoretical assessments and practical implementations of ridepooling 22nd Swiss Transport Research Conference, Monte Verità / Ascona.