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The transformation of mobility in Europe: Technological change and social conditionings

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ABSTRACT

The mobility of persons is changing due to technological innovation linked to autonomous and electric vehicles or to connectivity and data communication technologies. Furthermore, it is being conditioned by social behaviours. Qualitative research based on in-depth interviews with experts in mobility from three European countries is used to analyse the main trends that characterize the current transformation of mobility. Results show that the transformation towards the new autonomous, connected, shared and electric mobility is not only driven by technological development, but mainly by social conditionings such as environmental values, behavioural change or adaptability to users' habits, and socio-demographic features of citizens to adopt servitization. These changes involve different impacts depending on the segment or niche of population, especially in terms of different age groups. The main conclusion of the research is that the new mobility can be considered a social challenge rather than a technological one.

1. Introduction

Mobility is a relevant topic for researchers and policy makers and its transformation is analysed from different perspectives. Over recent years, mobility has been undergoing a profound change in such aspects as the use of new powertrains (Wanniarachchi et al., 2023), the implementation of Autonomous Vehicles (AVs) (Hakak et al., 2023) and MaaS Services (Smith et al., 2022). However, not only technological changes are involved in this transformation. Some researchers have recently included social and behavioural change in their studies on the matter (Whittle et al., 2019; Kriswardhana and Esztergár-Kiss, 2023; Turienzo et al., 2022a).

Different research papers point out the relevance of social issues in mobility transformation. These include changes in the mobility preferences of the population, such as the reduction of individual car owners (Focas and Christidis, 2017; Jain et al., 2022), or increasing concerns about environmental values, which means sustainability should be included when choosing the type of transport (Alyavina et al., 2020, Arroyo et al., 2020). It is also recognized that mobility is influenced by the availability of information and data communication between transport means and the population. This communication process encourages people to use different mobility solutions in the most efficient way, especially in the use of distinct forms of shared mobility (Guyader and Piscicelli, 2019; Smith et al., 2019). Finally, the adoption of AVs (Wadud et al., 2016) involves a series of ethical and legal concerns with a philosophical background, which include safety or decision-making of automation (Turienzo et al., 2022a). In this context, Mobility-as-a-Service (MaaS) firms have emerged to offer new services to satisfy a changing demand in transportation (Zhao et al., 2020; Corwin et al., 2019).

Although these studies have made it possible to identify the main social aspects that are conditioning the evolution of mobility, the existence of different limitations make it necessary to study them in-depth. First, certain trends are still under analysis. For example, there is no consensus among researchers regarding the preference for individual car ownership and its generalization to all countries (Kuhnimhof et al., 2013); furthermore, scholars are not aligned on the motivations behind this trend. Researchers associate this preference with different factors, which include the socio-economic situation of individuals (Stapleton et al, 2017) or environmental values (Geels, 2018). In addition, the implementation of AVs is at a nascent stage and therefore different uncertainties arise regarding their use (Epting, 2018; Paddeu et al.,

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2020). Second, certain aspects such as information and data sharing or car ownership show different behaviours among segments of the population, such as age groups. For example, young people ask for a cost-effective and flexible transport service in contrast to the oldest population that is more interested in reliability (Whittle et al., 2019; Athanasopoulou et al, 2019; Kriswardhana and Esztergár-Kiss, 2023). In summary, the emergence of technologies in the mobility sector requires an exhaustive analysis that considers the characteristics of each social group.

This study aims to analyse the trends that are redefining and modifying mobility paying special attention to the social perspective through long-term forecasting of trends. In particular, the paper looks in depth at social issues to understand the new tendencies in mobility that are closely connected with technological change to answer the following research question:

***RQ** - What are the main social aspects and how are they conditioning the transformation of mobility?*

In order to answer this question, the organization of the paper is the next: Section 2 includes the literature review focused on mobility and its associated social issues, Section 3 presents the methodology applied in the empirical work, Section 4 displays the results obtained and Section 5 presents the analysis of results and conclusions.

2. Literature review

2.1. Population's mobility preferences

The diversity of many individuals' daily activities, characterized by great dispersion and variable schedules, has fostered the use of individual vehicles (e.g., usually cars) because they offer great flexibility when moving people at a relatively low marginal cost (Lucas, 2009; Wikstrøm and Røe, 2022). The advantages associated with those vehicles also increased as they became social symbols above and beyond mobility (Kanger and Schot, 2016). Nowadays, the freedom and social status associated with their ownership and use is declining as certain segments of population show a growing rejection to owing cars (Lyons, 2015; Iacobucci, 2022).

Concurrently, statistical data reveal that younger generations are neither interested in driving license holding nor owning private motor vehicles (Focas and Christidis, 2017). They have changed their mentality and habits towards a phenomenon known as 'peak car', which indicates how important social trends are in determining how people move (Tilley and Houston, 2016). Therefore, walking, using bicycles or taking public transport are increasingly becoming alternatives to driving private vehicles, particularly for generations born since 1981 (Focas and Christidis, 2017; Whittle et al., 2019; Athanasopoulou et al, 2019; Iacobucci, 2022).

At the same time, the lower income available for young people is a determining factor for selecting their means of mobility. Governments can take advantage of this circumstance by supporting sustainable mobility through subsidies to public services or capital contributions to sustainable businesses, favouring a highly competitive service in economic terms (Jittrapirom et al., 2018). The interrelation of cost reduction and environmental protection can be intensified in mobility through the application of concepts of the circular economy and efficient use of resources (Alaerts et al, 2019). Consequently, the involvement of policymakers in the development of sustainable mobility makes it possible to modify people's habits (Brown and Mitchell, 2010; Jain et al., 2022). The application of measures aimed at promoting new behaviours and representative examples of social leaders (celebrities, athletes, or politicians, among others) can create a favourable environment for the implementation of new mobility preferences (Cropanzano et al, 2017).

2.2. Environmental values

In parallel, environmental awareness is promoting the use of more sustainable vehicles. The electrification of vehicles or the implementation of sustainable fuels (e.g., hydrogen) has important environmental benefits (Whittle et al., 2019; Wanniarachchi et al., 2023). However, the current situation of technological evolution still limits their use due to economic and geographical reasons, as they are unavailable to a large part of the population and their implementation is more favourable for public service vehicles (Globisch et al., 2019) and local goods deliver vehicles. Thus, automotive industry is investing important resources on the development of EV technologies to increase the charging capacity, density and decrease the weight and prices of batteries (Zhao et al. 2019; Burd et al., 2021). This situation reveals the need to balance social awareness and sustainability in the face of the extra cost of those technologies when deciding to purchase or consume mobility services (Krutilla and Graham, 2012; Liu et al., 2021).

In addition, these technologies must not only be technically feasible, but must be socially extensible through standardization and adaptation of the infrastructure (Turienzo et al., 2022a). Thus, policymakers, aware of the environmental impact of mobility, should encourage the use of sustainable means of transport in detriment to private motor vehicles by providing economic support, enabling infrastructure, creating regulations and spreading knowledge about the benefits of the cleanest mobility technologies (Brown and Mitchell, 2010; Eckhardt et al. 2018).

Recently, thanks to the policy implemented, the vehicle fleet is adopting more environmentally friendly motor systems (Turienzo et al., 2022b). However, even though electric vehicles and hydrogen engines have great environmental benefits (Chapman, 2007; Whittle et al., 2019; Globisch et al., 2019) and social reputational (Buhmann and Criado, 2023), their use is not widespread due to economic or mistrust factors (Almaraz et al, 2022). The degree of novelty of the technology results in a high cost of the vehicles (Turienzo et al., 2022b), which can be an economic barrier for large sectors of the population (Globisch et al., 2019).

2.3. Social acceptance of AVs

Original Equipment Manufacturers (OEMs) and services providers (insurance companies, repair workshops, service stations, infrastructure operators) will need to adapt their business and face the new scenario (Surakka et al., 2018; Daviy and Shakina, 2021). The client of mobility related companies (e.g., services peer-to-peer such as *Blablacar*) will become another competitor instead of only customers (Pütz et al., 2019), and those enterprises with a more digital mindset will better adapt their activities to the new business models (Guyader and Piscicelli, 2019). Thus, the increasing importance of MaaS, the greater is the interest of companies in AVs. OEMs, technology companies, research centers and Governments are studying how integrate the new advances in autonomous driving. Since 2016, the usage of AVs in closed and open traffic is being tested (Monios and Bergqvist, 2019). AVs will enable economic savings due to the no-need of a driver and will also lead to more efficient driving, but they require the infrastructure that supports it (Epting, 2018). Aiming at obtaining the maximum possible performance, OEMs and service providers are promoting the creation of ecosystems (Pütz et al., 2019). Mobility ecosystems are a network of interconnected mobility vehicles that contribute to improve the securance and availability or speed limit (Turienzo et al., 2024). Therefore, the data obtained from the vehicles connected through networks could be used to calculate routes, optimizing current resources and allowing a better study of future infrastructures, opening new avenues to increase efficiency, security and market opportunities (Van Alstyne et al., 2016; Cabanelas et al., 2023). In addition, the usage of AVs could improve the quality of the service of multiple type of business (e.g., restaurants, retail shops, supermarket, gas stations, insurance…) due to the information provided by the vehicles (Turienzo et al., 2023).

Despite those benefits, the certainty and confidence in emerging technologies and the confidentiality of the data generated by connectivity is essential in order to favour the adoption of new technologies by potential consumers as a whole instead of niches or segments of the population (Geels and Schot, 2007; Turienzo et al., 2022a; Cabanelas et al., 2023). At the same time, automation leads to moral and ethical dilemmas in its programming and safety. What is known as the "trolley dilemma" raises the ethical issue of killing the driver or killing other people in the event of an unavoidable accident (Lin, 2015). In situations of imminent and unavoidable accidents, there are two alternatives: protecting vehicle occupants supported by OEMs or minimizing the number of victims, favouring the weak party (Gogoll and Müller, 2016). Therefore, it is essential to know the psychosocial and cultural perspectives of the population to understand the possible transformation of mobility and clarify the ethical and moral dilemmas (Geels, 2011; Weigl et al., 2022).

2.4. The use of MaaS

The characteristics of shared mobility in terms of costs and versatility favours the adoption of the mobility system because purchasing power is less exposed and a lower risk is associated to the selection of the service as it does not involve a major investment in rapidly obsolete products or the selection of failed technologies (Mayer et al., 2018). Thus, linked to a higher level of education, people have started to assess the costs and benefits associated with the use and ownership of various means of transport (Turienzo et al., 2022a). This servitization of mobility will increase the efficiency of shared vehicles and their benefits through the implementation of data-sharing techniques related to routes, destinations, origins and schedules (Guyader and Piscicelli, 2019). The ability to improve benefits and lower the cost of services will lead to a shift from private vehicles to the use of public mobility means (Marletto, 2018; Kriswardhana and Esztergár-Kiss, 2023). As consequence, MaaS can be considered a turning point to generalize transport due to its versatility and low cost (Mayer et al., 2018).

In parallel, associated to the new vehicles' technology, despite the initiatives to market multiple alternatives to the individual purchase of vehicles (e.g., rental, leasing, shared ownership…) consumers are not properly aware of them (Pütz et al., 2019). At the same time, private and on-demand transportation services are increasingly widespread and accessible, being considered an alternative in large cities (Guyader & Piscicelli, 2019). However, the usage of shared vehicles entails the adaptation of customs and habits of citizens to adapt to the services offered (Hazée et al., 2017; Kim and Rasouli, 2022).

3. Methodology

Research into the implications and the degree of social acceptance of novel technologies has linked the existence of multiple uncertainties to the technology itself. Consequently, the analysis of trends and perceived acceptance through qualitative exploratory techniques is appropriate (Stake, 2010). The qualitative approach based on inductive techniques allows for studying the evolution and diversity of social perceptions relative to incoming trends and technologies (Creswell, 2014). The degree of novelty of the technology implies that only a few people have enough knowledge on the matter and its potential social impact. Specifically, qualitative techniques are the most widely used methodologies in the study of behavioural patterns and social acceptance (Jones et al., 2005). In particular, the methodology used for data collection was in-depth interviews. The use of this technique allows the researchers to dialogue with professional and experts who will serve the aim of the in-depth study (Cooper and Schindler, 2008).

A group of experts was selected based on their academic expertise and industrial experience and drawn across central roles in the present novel mobility sector, providing a wide sectorial perspective that involves different perspectives and viewpoints. The sample was selected from three European countries. The countries were Spain – the second in Europe in number of units of cars manufactured by the automotive industry, the UK – a leader country in research and development activities in Europe, and Portugal – a country with emerging business and start-ups with novel automotive technologies.

A script was designed, based on open questions, for the interviews to maximize the information gathered from the experts. The interviews were recorded and subsequent transcribed, including notes regarding the behaviour of the expert, for later detailed analysis. Addressing the research through open maximized the chance of obtaining response that were not conditioned by the established perspective of the researchers. According to Creswell (2014), the usage of closed questions could result in the unintentional guide of the results due to the biased responses. A pilot test with two interviews was carried out to validate the data collection procedures and to help in the development of the questions. A total of 18 interviews were conducted from November 2019 to April 2020 by the researchers (Table 1 details the characteristics of the sample). The interviews took place in two different ways: most were conducted in person and others by telephone with an approximate duration of 30–80 min. The transcribed recordings ran to more than 130 pages and 55,000 words. Content analysis was used as the analysis method to process the collected data. The interpretation of the data can be carried out through the application of three strategies (conventional content analysis; directed or summative content analysis) to analyse the content of the interviews coding schemes (Hsieh and Shannon, 2005). Through a

Table 1
Characteristics of the sample.

Interview	Country	Position	Entity	Entity's core business
#1	Portugal	Manager	Research Centre	Development of technologies and formation
#2	UK	Researcher	University	Societal and environmental impacts of transport
#3	UK	Business Developer	Public Administration	Planning and economic development
#4	Spain	CEO	Transport Company	Road transport service
#5	UK	CEO	IT Company	Connectivity and sensors for AVs
#6	UK	CEO	OEM	Autonomous driving vehicles
#7	Portugal	CEO	Start-up	Clean mobility platform
#8	Spain	CEO	Technological Company	Assistance driving systems
#9	UK	CEO	Technological Company	Sensor and control systems for AVs
#10	Spain	CEO	OEM	Electric vehicles
#11	Portugal	CEO	Motorcycle sharing Company	Personal electro-mobility sharing
#12	Spain	Region Manager	Transport Company	Taxi service
#13	Portugal	Researcher	Research Laboratory	Collaborative projects in digital transformation
#14	UK	CMO	R&D Company	Designing, modelling and simulation of routes
#15	Spain	CEO	Technological Company	Development of connectivity devices
#16	UK	Product Manager	Technological Company	Smart cameras for AVs decision making
#17	Spain	CEO	Engineering Company	Real-time objects inventory of infrastructures
#18	Spain	Technical Director	Consulting Company	Mobility inter-modal planning

Table 2
Data collected from interviews classified by social issues and trends.

Social issues	Trends identified	Interview	Main quotes selected
Population's mobility preferences	No individual car-ownership as preference	#2, #3, #5, #8, #10, #11, #14, #16, #17	*Q#2-1: "It's true, young people don't have a car. The weak part of the argument is that they still want to own and drive cars, but they do it later. Instead of doing it at 20, they do it at 30, when they have family, children, when they want to live in the surroundings instead of in the centre of the city".* *Q#3-1: "[…] There has been a change that is modifying mobility. Citizens do not seek to own a car; they intend to use vehicles. People only show interest on the service provided by the car, changing the culture associated to mobility"* *Q#11-1: "Not having a car if not using it makes it easier for you to get around in your or other cities or in different countries, pay and move is a very comfortable method".*
	Demand for travel by car will reach a peak	#2, #3, #5, #8, #9¸ #10, #11, #16, #17	*Q#1-1: "It is key to ensure the social acceptance of the workers to the new vehicles to avoid the fall of sales in Europe. It is important to ensure the continuity of the companies and investments of the next years".* *Q#9-1: "We can speak now of the Peak Car, but the future is not clear, because the production of cars creates jobs".* *Q#10-1: "The interpretation of trends in demographics and user preferences such as in most of Western Europe the share of the population holding a driver's license has stabilised across generations, give the impression that we have reached the moment of lowering the dependence on the car".*
Environmental values	Acceptance of clean mobility provided it is affordable	#1, #2, #4, #7, #11, #12, #15, #16, #18	*Q#1-2: "The point is that we find cars on the market worth € 15,000 than in Europe, similar electric models have a price higher than € 70,000. This complicates competitiveness".* *Q#2-2: "Climate change is very relevant, but keep in mind social justice is paramount. […] Electric cars will be very expensive and even carpooling can be very expensive".* *Q#4-1: "If the electric car does not offer a solution for all budgets, it will be very difficult. The problem today is that there are no low-cost solutions for the ordinary citizen who can give them the mobility solution that is now provided by a combustion vehicle".* *Q#7-1: "In theory, the electric vehicle must be valued not only economically. It is important to save emissions from mobility, not because of the price per ton of emissions, but it must be valued for its real impact, also on health. But what if the salary does not reach you?".* *Q#11-2: "There is a growing awareness that it is necessary to decarbonise the environment, but it seems that cost savings still weigh more at this time".*
	Environmental values subordinated to service and technology uncertainties	#1, #4, #6, #8, #9, #10, #13, #17	*Q#1-3: "Who is going to buy is not aware of many of the technologies linked to electric, hybrid, hydrogen cars […] This lack of knowledge influences the non-investment in these vehicles".* *Q#4-2: "Electric car in this case, the idea is good, but it gives worse service than the combustion that you already own".* *Q#6-1: "People have realized that electrical technology is not as good as they believed it to be. It does not operate in all climates, it is reliable, but they are not traditional cars and people do not trust them".* *Q#10-2: "One of the biggest risks of the commitment to electric mobility is the lack of a sufficient charging network to provide a good service".*
Social acceptance of AVs	AVs conditioned to the ethical dilemma and development of a robust legal framework	#1, #2, #3, #4, #6, #7, #8, #12, #13, #14, #16, #18	*Q#1-4: "Suppose that car without driver is involved in an accident. who will be responsible?? I am just the owner, not the driver… Do OEMs have to insure their autonomous vehicles? Do they have to do it forever or just during the warranty? There must be a responsible.".* *Q#4-3: "The implementation of AVs requires a sense of ethics, and this is a notoriously difficult capability to reduce into algorithms for a computer to follow".* *Q#8-1: "[…] in industrial environments with accidents that have implications in materials that imply restrictions and regulations but in the city. It is much more complex to regulate due to the variables".* *Q#12-1: "The regulation of traffic in all cities is in the hands of the city council. In the same country or even region, it can be 15 cities with their own rules. This circumstance can create a total confusion".* *Q#13-1: "The implementation delay is not due to technological problems. Autonomous vehicles are facing social and political inconveniences. Once solved and regulated, step by step; first, it will be used in highways and, finally, in cities".* *Q#14-1: "AVs level 5 will never appear in highly regulated countries or some believe not for at least the next 10 years. Regulation and the ethics that determine it is the first thing we must solve. The key is to define those responsible in the event of an accident".*
The use of MaaS	The massive use of MaaS depends on its affordability	#1, #2, #3, #9, #10, #11, #12, #13, #15	*Q#2-3: "In rural areas or in cities there is poor people for whom the service could be expensive. This society segment will suffer the transformation due to the prediction of the elimination and reduction of public transport services because to private mobility services like Uber".* *Q#3-2: "The difficult thing is to find an economic viability. For this reason, governments should be strongly involved in the approach to the pricing system in*

(continued on next page)

Table 2 (*continued*)

Social issues	Trends identified	Interview	Main quotes selected
			order to be extensible by poor people".
			Q#11-3: "It is very practical; you have less cost, less hassle with parking cars or having garages… If prices drop, the massive use of MaaS is inevitable".
	Limitations in sharing information and data communication on MaaS	#2, #3, #8, #14, #16, #17, #18	*Q#2-4: "Companies have to make money in some way. So, there is a problem as people seem to be happy sharing their information with Google".*
			Q#14-2: "It is necessary be cautious in the storage and in data gathering. It is necessary be aware to fulfil the Data Protection Law requirements, but also to generate confidence in the population".
			Q#17-1: "Some users, especially young people are looking for mobility designed in real time and to adjust the response of the service to reality and not to a prediction, data must be shared".
			Q#18-1: "Measurement with embedded systems in cars… they generate a large volume of information. However, if the car is mine, why am I going to give it free?".
	Adaptability to users' habits and socio-demographic features as main driver for servitization	#2, #3, #4, #8, #9, #10, #11, #12, #15	*Q#2-5: "You have to adapt the technology to the user; the technology is for the user. It is wrong to focus on the product instead of the service it is offering to the user features and demands: People who live in neighbourhoods, families"*
			Q#3-3: "In terms of MaaS the group favoured is people with technological knowledge, educated in that. People who don't have these technological skills will have problems to access of shared mobility".
			Q#9-2: "The study of the flows of movements of citizens will make it possible to improve public services. Therefore, people will begin to leave the car at home because it is not necessary for their daily activity".
			Q#10-3: "Elderly people, who have money, have time, but who can no longer drive. These are clearly candidates to benefit from MaaS".
			Q#11-4: "City dwellers will benefit from the fact that services will be created in cities. However, rural areas will not have access to services due to remoteness, being excluded. You may have a huge competence in some cities like Madrid, Barcelona or Lisbon and in the neighbouring city you may have nothing, no shared mobility services".
			Q#15-1: "Find the most optimize route to public service is more relevant than to save resources. Nowadays, time is like gold".

directed approach, analysis of the transcribed records begun with a theory review, posed on the literature review, as guidance for initial codes of the analysis process (Hsieh and Shannon, 2005).This method of analysis consisted of the systematic description of the contents of the interviews in order to interpret them and better understand the matter under research (Schreier, 2012), in this case the social changes associated with the transformation of mobility.

4. Results

The data collected in the interviews and selected for analysis for the current paper are presented in Table 2. This table summarizes the responses found in the interviews for each of the social issues being analysed, grouping them into what constitutes a trend. Only those trends resulting from the answers indicated by the experts and in which there has also been a degree of consensus among the experts are presented. To provide detailed information, the interviews in which this trend has been identified are detailed (coded as #1, #2, …, #18). In addition, literal responses (quotes) have been selected as they serve to illustrate the trends presented and to highlight some nuances about these tendencies. These quotes have been coded as Q#i-j, where #i is the interview number and –j is the consecutive number of the quote for each interview.

Therefore, the trends reflected in the table can be considered as the main points of convergence among experts. Furthermore, there are nuances regarding some of the trends that have been exposed in the selected quotes that are discussed in the results analysis section which follows.

5. Discussion

5.1. Population's mobility preferences

The results show two predominant trends in mobility preferences. On the one hand, experts point out that the population is changing its habits towards the consumption of services rather than the purchase of their own motor vehicles. This is because buying a car has already partially lost its high social and cultural value, and the appearance of alternatives for 'on-demand' mobility is a trend that is pushing this evolution (Q#3-1, Q#11-1). However, despite the consensus of experts and previous research on the growing trend of using services instead of purchasing by certain population groups (Lyons, 2015; Focas and Christidis, 2017; Iacobucci, 2022), there are some nuances that need to be observed. While young citizens living in the city are less likely to own vehicles, those more complex family units (with dependent children or elderly members) living in the suburbs of cities still maintain their interest in owing a vehicle (Q#2-1).

On the other hand, the results support the view that the 'peak car' has been reached. It suggests a lower dependence on the car (Q#9-1; Q#10-1), supporting the trend advanced by previous literature about a future with fewer private motor vehicles in circulation (Tilley and Houston, 2016). However, it is important to note that some interviewed experts point out the future employment factor as a potential barrier to consolidating this trend. The strong fear of losing jobs in mobility industries (e.g., drivers, vehicle construction companies) can lead to a rejection of servitization, encouraging people and society to possess their own vehicles (Q#1-1; Q#9-1). Of course, every trend can have its counter trend. It becomes a concern to deal with during the development of new mobility modes.

5.2. Environmental values

The results also revealed the growing concern about climate change and the impact of mobility on the environment. There is a growing awareness of the need to adopt cleaner vehicles due to their environmental impact in terms of air quality and consequently on health (Q#2-2; Q#7-1; Q#11-2). In this way, our research suggests the relevance of the population's interest in environmental values related to mobility

(Whittle et al., 2019). However, the research also reflects the experts' concerns about the higher prices and features of new, clean mobility technologies, especially electric (Burd et al., 2021), compared to combustion vehicles and similar benefits that are more costly (Q#1-2; Q#2-2; Q#11-2). The research even detects a certain fear of the possible loss of social justice derived from the inability to access clean vehicles due to their price, which could be a barrier to mainstreaming sustainable mobility (Q#4-1; Q#7-1).

At the same time, the results suggested that the state of maturity of electrification technologies and the lack of standardization are important inhibitors to using electric vehicles. This is a result partially explained by the problems caused by the limited range of batteries and the difficulty of the recharging process highlighted by previous works (Globisch et al., 2019; Turienzo et al., 2022b). Our research goes further and hints that the environmental values are currently being subordinated to service and technology uncertainties (Q#4-2; Q#6-1). The coexistence of technologies with diverse characteristics and the absence of complementary services lead to uncertainty when it comes to acquiring cleaner motor vehicles (Almaraz et al, 2022); it delays the purchasing decision or encourages consumers to buy cheaper, better understood, traditional combustion technologies (Q#1-3; Q#10-2).

5.3. Social acceptance of AVs

The results obtained in the interviews confirm the existence of a growing concern among both citizens and regulators regarding the ethical problems and dilemmas associated with autonomous vehicles (Weigl et al., 2022). Although previous studies (Lin, 2015; Gogoll and Müller, 2016) focus their efforts on studying the behaviour of the vehicle in the event of an accident, experts point out the importance of determining ethical issues in the programming and design of vehicles. This can lead to a postponement in the development of new capabilities and autonomous functions of the vehicles (Q#4-3; Q#13-1). In addition, experts point out a potential delay in regulation in more complex environments, such as cities. Furthermore, the existence of multiple regulators with competencies in traffic matters may limit the development of a robust regulatory framework for the use and acceptance of AVs (Q#8-1; Q#12-1; Q#13-1). In fact, experts highlight the uncertainty associated with autonomous vehicles in the case of accidents, making it necessary to clarify the responsibilities of manufacturers and passengers. All these circumstances generate not only mistrust in the implementation but also in related businesses, especially by insurance companies (Q#1-4; Q#14-1), which needs to be addressed for an effective evolution of these vehicles. At the same time, results show some misgivings about using means of transport that share information due to the loss of privacy (Q#18-1) despite the possible advantages in services (Turienzo et al., 2024). However, the ability to improve traffic planning and management inherent to AVs (Cabanelas et al., 2023), could streamline the regulatory framework that delays the implementation of AVs (Q#13-1).

5.4. The use of MaaS

The results obtained after analysing the experts' insights suggest that the adoption of servitization depends on its affordability (Hazée et al., 2017; Kriswardhana and Esztergár-Kiss, 2023). The respondents point out that, although mobility in private vehicles is an expensive alternative, the use of services for transportation can also be very expensive in some geographical environments (Q#2-3), which is in line with the underlying ideas suggested in previous research (see Mayer et al., 2018). In addition, the incorporation of ad hoc mobility services managed by private companies (e.g., Uber, Cabify) can lead to underuse of traditional public services which are then reduced. However, people with limited economic resources cannot be left behind, suggesting a certain interventionism by policymakers. Consequently, the adoption of the use of MaaS will depend not only on the cost of the services but also on the socio-economic situation of the population (Q#2-3; Q#3-2; #11-3).

Second, the experts' reflections seem to indicate the possible suspicions that part of society may have about servitization due to limitations in sharing information and data communication. On the one hand, there is concern about the loss of privacy resulting from transferring the user's personal data and mobility habits (origin, destination, schedules, etc.). On the other hand, despite these apparent fairs, users are consciously or unconsciously, already giving personal data freely to large communication and internet corporations (e.g., *Google* or *Apple*) (Q#2-4; Q#18-1). Experts agree that companies must respect the law and be transparent in how they conduct data collection and processing in order to avoid public rejection of such things as shared mobility (Q#14-2). Furthermore, while young people demand improvements in the information and communication systems linked to MaaS, the older segments of the population have difficulties adopting certain mobility systems as they require knowledge and experience in the use of software applications and communication technologies (Q#3-3; Q#17-1). This result is partially in line with previous research (Guyader and Piscicelli, 2019), because in our analysis the need to optimize services and new-shared mobility systems through data management is only demanded by part of the population: the young.

Finally, adaptability to users' habits and socio-demographic characteristics becomes a major driver for servitization (Kim and Rasouli, 2022). The results highlight that any technological development linked to MaaS will not be effective unless the services are optimized and designed on the basis of real users' habits and needs (Q#2-5; Q#9-2; Q#15-1). Moreover, previous work on MaaS has focused on the technical aspects as key to its adoption, namely the versatility of the transport mode offer (Mayer et al., 2018) or infrastructures available (Turienzo et al., 2022a), or on a single social aspect related to users such as the geographical environment in which they live (Globisch et al., 2019) or their age (Marletto, 2018). In our case, the results reveal two conclusions. First, social aspects are preponderant in the adoption of MaaS and, second, those social issues are directly related to the socio-demographic characteristics of users. Here, experts have identified different features related to the service, such as time and frequency required, alongside other issues related to the geographical environment where users would live (Q#11-4; Q#15-1) or their family and economic situation, age, or educational background of users (Q#2-5; Q#3-3; Q#10-3).

6. Conclusions and future research

The current research suggests the willingness of some part of the population to evolve in the way people moves. The study reveals that the population begun to modify how they move using more commonly shared services. Despite the advantages offered by MaaS and shared transports in economic and environmental terms, their adoption are highly dependent on cultural changes from behaviours deeply rooted in society. However, a cultural and social change linked to mobility is beginning to emerge, namely Peak Car. Peak Car reveals that the maximum number of cars sold were reached, and now the people is less interested in owning their vehicles nor possess a driver's license.

However, this trend is usual in large cities and for young people, that is, the population with less purchasing power and (maybe) higher environmental awareness. However, the adoption of MaaS depends on the need to adapt the mobility habits of citizens who resort to MaaS services or multimodal transport due to the limited frequency or routes of the private services. This need of adaptation is increasingly important in rural regions due to the lower frequency of services. Therefore, the social acceptance to change the type of private transport for a public or shared one can be reduced in rural areas. At the same time, the economic

advantages may not be enough if the adaptation required is high in certain niches or segments of the population.

At the same time, the technology for the electrification of vehicles or the use of clean fuels shows an increasing level of technological development and benefits. However, its adoption is largely subject to the conviction of end users to the advantages of the new engines. Even though the industry focuses on improving technical characteristics (e.g., recharge time, weight, range…), the biggest drawback is linked to the uncertainty and lack of knowledge of the end user about the different possibilities. Consequently, users postpone the purchase of vehicles with new engines for fear of making a mistake with the technology or mistrust in the useful life.

Finally, the adoption of vehicles with autonomous technology is subject to the insurance and legal guarantee. In addition, the digital nature of the AVs with the ability to share route and passenger information cause misgivings in potential users. Even though that information can generate advantages and it can improve services offered to users, the loss of privacy is shown to be the main cause of social rejection of AVs adoption.

6.1. Practical implications

The transformation of existing mobility depends on the involvement of policy makers in the development of regulations, incentives, or other political initiatives. Governments should endeavour to clarify the characteristics and advantages of the different technologies, even being able to provide technological guidelines based on the circumstances of use. This will accelerate the adoption of safer, more sustainable transport alternatives. However, despite increasing social awareness, the widespread use of sustainable vehicles will not be possible until their prices are like those of combustion vehicles. For this reason, governments should study stimulus measures such as subsidies or tax cuts that equalize the cost of both technologies.

On the other hand, the implementation of MaaS services through private companies could lead to a deterioration of traditional mobility services in rural areas or lower frequencies in the service, so losing their important social 'merit good' benefit unless governments decide to regulate minimum service standards. At the same time, the possible commercialization of the data associated with servitization could cause a strong rejection by some, possibly many, citizens. It is essential to establish a clear framework that regulates data collection and processing to favour the privacy of the information shared. Moreover, this should be founded on the highest level of transparency possible in order to secure deep trust from individuals, giving them the possibility to understand who has access to their personal information and how they gain it. In other words, what is happening with the data in a simple bun not misleading way?

6.2. Limitations and future research

The research has some limitations mainly derived from the methodological approach, which should be addressed in future works. Although the study has focused on mobility in Europe, the selected sample of experts belongs to only three countries. Future research could integrate a larger number of experts from other European countries in order to gain a wider scope in the results obtained. Moreover, this would open up the possibility of identifying the possible specificities connected to the experts' nationalities.

On the other hand, although the work allows us to study the evolution of social perceptions, the qualitative nature of the research does not allow for generalizing the results. In future research, it would be interesting to operationalize the different social aspects through quantitative variables. This, together with an increase in the number of interviews, would allow for the use of econometric models to analyse these variables and obtain statistically significant results for generalization.

Author statement

Javier Turienzo: Conception and design of study, Acquisition of data, Analysis and/or interpretation of data, Drafting the manuscript, Writing – review & editing, Funding acquisition.

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Jesús F. Lampón: Conceptualization, Writing – review & editing, Funding acquisition.

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Appendix:. Script

Entity Contextualization:

1. How would you define your economic or commercial activity? What is your main financial asset?
2. Where do you think the value creation of the associated companies resides? Does the creation of value depend on the geographical area, rural or urban?
3. How do you foresee the future and how do you foresee the evolution of market needs?

New engines:

4. Will the motorization of the vehicles be electric? What reasons can accelerate or delay its implementation?
5. Is the vehicle that uses hydrogen fuel considered as an alternative? What social and professional implications does it have?

Application of technologies and connectivity in vehicles:

6. Will the autonomous and connected vehicle be accepted by society?
7. Can the impact on the employment of professional drivers be a barrier?
8. Do you think that level 4 or 5 of vehicle automation will be reached in Europe?
9. Vehicles with connected and autonomous technologies will generate a large amount of data, who has access to these sources of information? What advantages can they bring to users?
10. Can the confidentiality of the data generated pose problems?

The servitization of mobility as a predominant alternative:

11. Servitization, will that idea be a niche market idea or will it be generalized?
12. What are the social implications of the change towards servitization?

Governmental and social influence on mobility trends:

13. Regarding the geographical area, rural or urban, will it have equal opportunities?
14. Which travel partners do you have for all these changes?
15. Do research centers or universities constitute development support?

Economic implications:

16. Should the investment effort in infrastructure and fleet adaptation be social, business or public? Will it be acceptable to all citizens?
17. Are there investors or entities that lend money for these purposes?

Future prediction:

18. What is your vision of mobility in 5, 10 and 20 years?

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