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The Evolution of Shared Autonomous Vehicles (SAV)

Part 1: Market potential, user acceptance and early adopter groups

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University of St.Gallen

Institute for Mobility

The Evolution of Shared Autonomous Vehicles (SAV)

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"The challenges of transforming mobility are enormous. To develop new solutions, we must also ask new questions. Through the close exchange with the IMO-HSG, we expect to gain important impulses."

Felix Kuhnert
Partner and Automotive Leader, PwC Germany

"In the new lab, we want to put current mobility systems to the test. Our goal is to research mobility behavior in order to make mobility more efficient, accessible and environmentally friendly in the future."

Prof. Dr. Andreas Herrmann
Director Institute for Mobility, University of St. Gallen

PwC Lab for Smart Mobility

The mobility sector faces numerous future challenges: mobility needs to be highly connected, environmentally sustainable, universally accessible at all times and in all places. At the same time, it should continue to be affordable – essentially, it should be "smart". Creating concepts and solutions that meet all these requirements demands a comprehensive understanding of the complexities involved.

To address this, the Institute for Mobility (IMO-HSG), one of 40 independently managed research institutes and centres at the University of St. Gallen, joined forces with PwC Germany to establish the PwC Lab for Smart Mobility. This newly formed think tank examines models of connected and sustainable mobility for the future as well as their impact on people's mobility behaviour. In addition, the Lab for Smart Mobility explores how the mobility industry evolves, and which products and solutions it will be likely to offer.

The present study is part of a series of publications by the PwC Lab for Smart Mobility. It is based on the research conducted by Marvin Greifenstein, in close collaboration with the Smart Mobility team at PwC Germany. Marvin is a doctoral student and research assistant at the Institute for Mobility at the University of St. Gallen (IMO-HSG).

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1 Four global megatrends influencing the evolution of smart mobility

The mobility sector is presently undergoing tremendous changes, with some of the most radical ones yet to come. Four global megatrends in particular influence current developments in this field: (1) Breakthrough technologies, (2) climate change, (3) rapid urbanization and (4) demographic & societal changes.

These megatrends also push developments in the field of autonomous driving which is seen as a gamechanger for mobility advancements. The intense competition among key players in this field (such as Waymo, Cruise or Mobileye) is sparked by the race for efficient and reliable automation technologies – on the one hand, to enable more cost and resource efficient mobility services; on the other hand, to find solutions for an intensifying shortage of public transport staff and skilled labour in various regions.[1] Furthermore, the growing emphasis on climate-friendly mobility solutions fosters a more efficient use of resources and supports the development of technologies that enable such advancements. Also, the global acceleration of urbanisation leads to a rapid growth in transport volumes, increasing the need for solutions that optimise the use of scarce urban space, reduce emissions and satisfy the growing demand for mobility. Finally, current demographic and societal changes emphasize the need for alternative ways to "consume" mobility (e.g., sharing instead of owning vehicles) as well as for mobility solutions that provide assistance when needed (e.g., for the increasing amount of elderly people that do not wish to or cannot drive themselves anymore).[2,3]

Fig. 1 Four global megatrends shape the direction of the smart mobility evolution

Breakthrough Technologies

Autonomous driving as game changer in transportation
- First use case scaling up in 2025
- Labour shortage in public transport (e.g., Germany will have a shortage of 87,000 drivers by 2030)
- Possible cost benefits after successful scaling

Climate Change

Transport accounts for 24% of global CO_2 emissions – road (passenger) transport for 10.8%
- Change to "green", sustainable and efficient transportation

Rapid Urbanization

60% of global population will live in urban areas by 2030 – 68% by 2050
- Rapid growth of urban transport volumes
- Cities desperate for more efficient traffic solutions

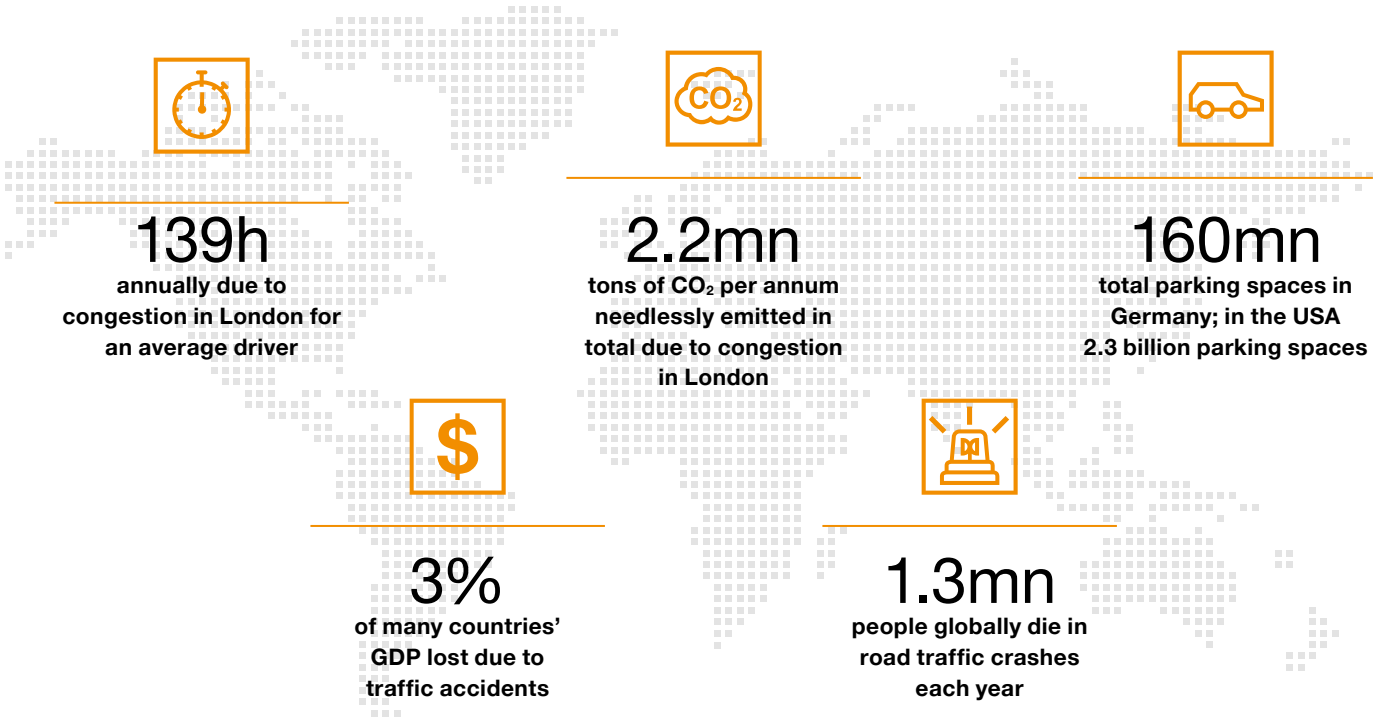
Demographic & Societal Changes

Growing digital divide with people >80 years tripling from 150m to 430m by 2050
- Sharing economy gaining importance
- Growing demand for alternative car ownership models
- Growing demand for assisted mobility services

Source: IMO-HSG and PwC Analysis.

The burden of today's mobility
Many countries and major cities are facing the challenges of rapid urbanisation, the growth in traffic volumes and climate change on a daily basis: in London, drivers are losing roughly 139 hours per annum due to traffic jams – and this is just for a 10 km commute. During these 139 hours, they needlessly emit an additional 253-282 kg of CO_2, if the vehicle is fuelled by petrol or diesel. Drivers in Paris are wasting 109 hours in traffic each year, and in Los Angeles time lost in congestion amounts to 81 hours.[4] The consequences are obvious: frustrated people waste valuable working or leisure time, and city developers react by planning more and wider roads, parking spaces and car parks. In Germany, there is an average of 2.4 available parking spaces for each registered vehicle, while the United States even boast 8 parking spaces per vehicle.[5,6] Precious space that could be dedicated to parks, playgrounds, greenery or other amenities. Furthermore, road traffic accidents cost many countries up to 3% of their annual GDP – and on a global scale approximately 1.3 million people die in road traffic crashes each year.[7]

Fig. 2 Challenges of our cities today



Source: IMO-HSG and PwC Analysis.

"With the potential to enhance convenience, efficiency, accessibility and safety, self-driving vehicles add significant value and will shape the future of urban mobility."

Johann Jungwirth
Executive Vice President of AV, Mobileye

Is autonomous mobility going to solve all current traffic problems?
The introduction of autonomous vehicles (AVs) is likely to not only provide new thrilling ways of travelling, but should also ensure safer, more convenient and efficient navigation through sprawling urban networks and on highways. Passengers might get the chance to relax during their journeys or even productively transform travel into work time. A crucial risk is that all these advantages of AVs might increase the demand for individual motorised transport. The convenience of AV travel might entice individuals to use their private autonomous vehicles (PAVs) more often and even change their long-distance travel behaviour (e.g., substituting train or air travel by PAVs). Thus, more and longer trips as well as more people being able to travel driverless (e.g., people with disabilities, seniors or those without a driver's license), empty vehicle driving (if permitted, e.g., for parking spot search) and modal shifts (e.g., substituting bike, rail or plane travel by PAVs) can lead to an enormous increase in annual per-capita vehicle-kilometres and, ultimately, to more traffic and congested roads.[8,9]

Consequently, shared autonomous vehicles (SAVs) will play a crucial role in the evolution of this new technology. Firstly, they have the potential to make this technology accessible to a wider public, thereby enabling a critical mass in demand to introduce and develop this technology. Secondly, SAVs have the potential to be intelligently integrated into public transport systems, thereby reducing possible environmental and social downsides of the new technology. Finally, and perhaps most importantly, introducing shared AVs to a broader market may foster the general perception of AVs as a shared mobility service (versus privately owned vehicles).

Shared autonomous mobility as a gamechanger?
While many established OEMs, such as Mercedes-Benz, BMW, Nio or Tesla, are currently developing autonomous driving technology for their own vehicles, the development of autonomous taxis or shuttles is left to relatively new players, including Navya, EasyMile, Zoox (Amazon), Waymo (Google), Cruise (GM), MOIA (VW) or Apollo (Baidu).[10,11] As outlined above, the introduction of shared AVs is likely to bring several advantages: fleets of SAVs in urban and suburban areas might substantially reduce conventional and autonomous private car ownership, preventing the above-mentioned disadvantages of PAVs. With higher utilisation and occupancy rates per vehicle as compared to privately owned cars, SAVs have the potential to use road networks more efficiently by reducing congestion and emissions as well as the need for parking lots, thus freeing up space. Major studies have validated those findings in various scenario analyses, as for example the studies on Lisbon[12] or Oslo, where 30,000 SAVs are expected to replace around 600,000 privately owned vehicles.[13] Furthermore, many cities are already facing a shortage of trained drivers for public transport. SAVs can tackle this issue by reducing the need for personnel in this field and – in the long run – enable affordable trips.

The main research objectives
On the basis of what has been said so far, it seems safe to predict that AVs will radically change current mobility systems and corresponding behaviours. As outlined, the most promising utilisation of AVs will be their shared usage. This joint research project of PwC Germany and IMO-HSG builds on this rationale. We are investigating potential market entrance strategies as well as drivers of and barriers to a commercial rollout of SAVs. Constructive interaction between key players (legislation, authorities, transport operators, mobility providers, manufacturers and suppliers) will be a key factor of success here. While we will address crucial managerial prerequisites, ecosystem developments and main barriers in a joint subsequent paper (Part 2), we will take a closer look at market potentials as well as relevant early adopter groups and their attitudes in this first publication (Part 1).

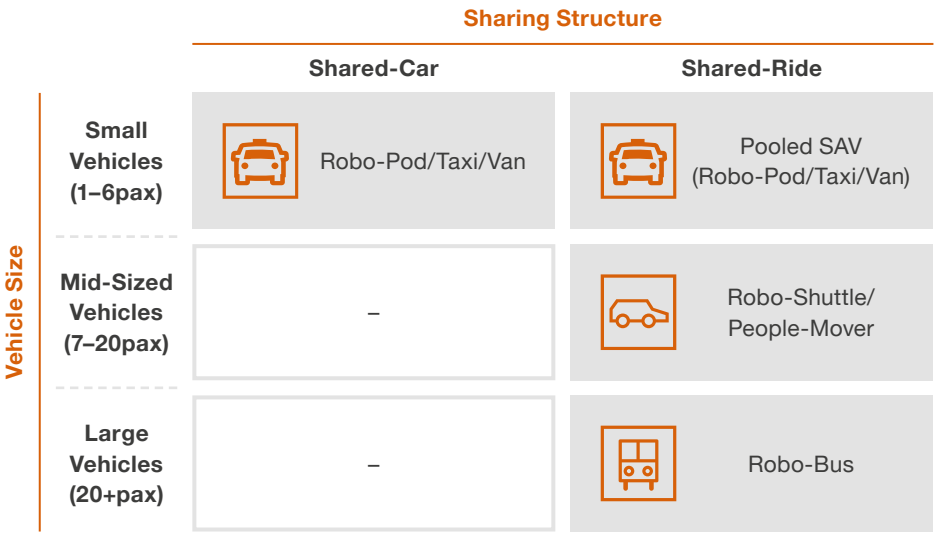
"We see shared autonomous vehicles as a game changer for public transportation. This will enable real systemic change within the transportation sector, reducing congestion, optimizing existing resources, and creating more attractive, tailored, beneficial on-demand services for citizens."

Endre Angelvik
Executive Vice President Radical Innovation, Ruter

2 Defining SAV types and anticipating a market scenario for a shared autonomous era

To get a clearer idea of the SAV landscape, let's first have a closer look at the different types of SAVs. In general, the term SAV denotes a combination of autonomous vehicle and shared mobility. Most commonly, SAVs are differentiated by vehicle size and sharing structure. There are three vehicle sizes: small vehicles for 1–6 PAX (= passengers), mid-sized vehicles for 7–20 PAX and large vehicles for 20+ PAX. As far as sharing structures are concerned, we talk of a shared car mode if a single user or a group of users requests a private ride (e.g., traditional taxi, Uber or Lyft ride) or a shared ride mode if multiple users or user groups share the same ride (e.g., MOIA or UberPool ride).[14] Please see figure 3 for an illustration of the different SAV types.

Fig. 3 SAV types include robo-taxis, robo-shuttles and robo-buses



Source: IMO-HSG and PwC Analysis.

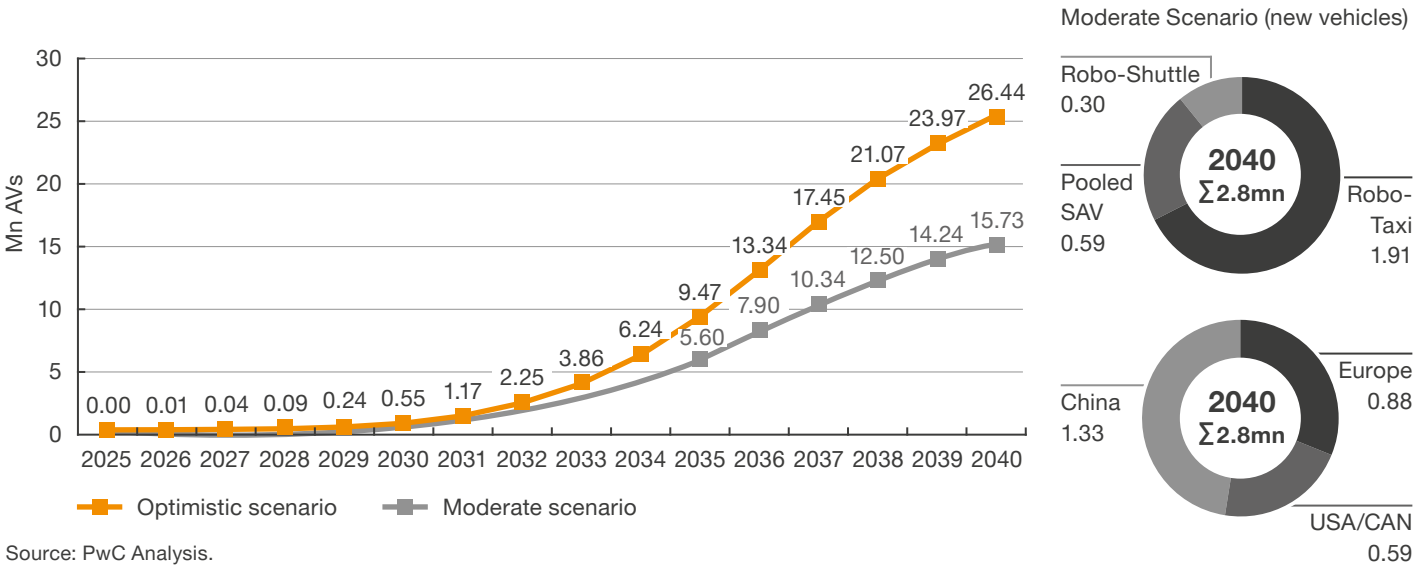
The road ahead: expected SAV population of up to 26.4 million by 2040

The best path towards a shared autonomous era has not been fully explored yet. We already saw the advent of driverless robo-shuttles with low speeds of up to 30 km/h, which are used in specific environments such as airports, campuses and corporate complexes. These first commercially viable robo-shuttles offer efficient transportation for short distances within pre-defined areas and use cases. So far, there are still very few of them. However, the introduction of commercially viable SAVs with speeds of up to 50 or even 60 km/h, with on-demand or fixed routes for use in urban, suburban and rural areas, is likely to substantially boost the number of robo-shuttles.

We anticipate that commercially viable SAVs at Level 4 (high driving automation) and beyond, with speeds up to 60 km/h, will start to become available for urban use cases from 2024/25 and expand to rural areas a bit later. For example, Cruise and Waymo are already offering 24/7 robo-taxi services in the Bay Area of San Francisco and recently secured approval to charge fares for these driverless rides in certain areas, which rendered the service commercially viable.[15] However, Cruise's permits are currently suspended – underscoring the uncertainty and volatility connected to the role out of these new technologies and related services.

How will the SAV population evolve over time? To get a sense of the market potential, we have applied MaaS (Mobility as a Service) demand models to the entire world population of over 8 billion people. Based on 17 relevant use cases – including rides to work, going out in the evening and doctor's visits – we made estimates for the ramp-up of three types of SAVs: robo-taxis, pooled SAVs and robo-shuttles. Subsequently, we adjusted the models for various parameters, including population restrictions, allocation of area, use cases, roles and mobility types. As a result, we expect a SAV population of up to 5.6 million units (robo-taxis, pooled SAVs and robo-shuttles) by 2035 in our moderate and 9.5 million in our optimistic scenario. By 2040, we expect these figures to have grown to 15.7 million and 26.4 million, respectively (Figure 4). As far as robo-buses with a capacity of 20+ PAX are concerned, we expect them to be less commercially viable initially and thus slower to come to market than the other three categories of SAVs.

Fig. 4 **Expected SAV population comprising of robo-taxi, pooled SAVs and robo-shuttle (top; in million) and new vehicles in 2040 by vehicle type and region**



Source: PwC Analysis.

From our perspective, SAVs have the potential to play a fundamental role in the urban transportation systems of the future. Not only do they have the power to gradually replace private car ownership in numerous cities within the next decades, but they could also progressively supplant traditional taxi, ride-hailing and bus services. Two fundamental success factors for the effective introduction of SAVs and the realisation of the presented market potential will be their targeted market launch and subsequent marketing. This includes the handling of regulatory, technical and managerial prerequisites (dealt with in Part 2 of this paper) and, as a first step, the identification of relevant target and early adopter groups. The success of the new technology and business models will depend on these factors, among others.

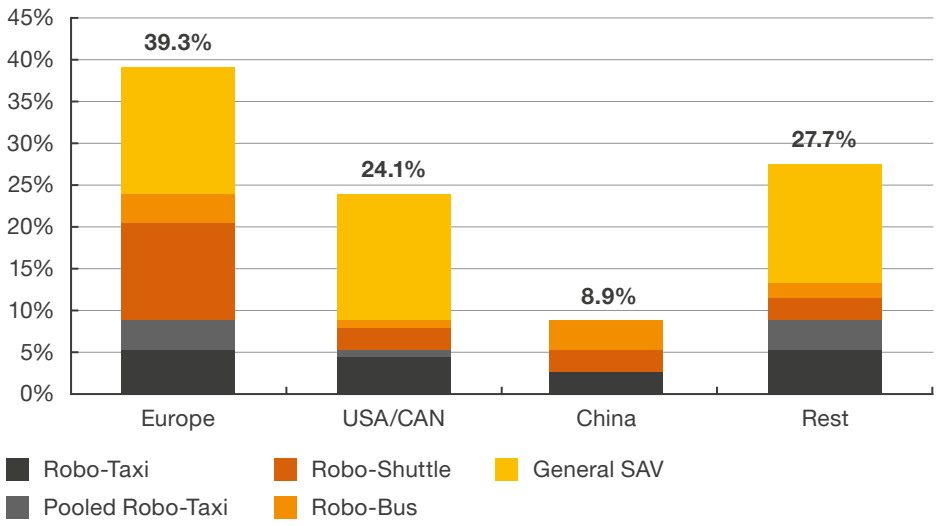
"In the future, shared autonomous shuttles will play a pivotal role in transforming urban mobility. By combining cutting-edge autonomous technology with a pooled riding model, we can revolutionize the way people move within cities."

Sascha Meyer
CEO, MOIA

3 Increase in SAV consumer studies around the globe and across various vehicle types

In line with their increasing relevance in recent years, there has been a plethora of consumer studies on the willingness to use SAVs. This substantial body of existing academic work provides comprehensive and valuable insights in the drivers of and barriers to SAV acceptance by end users. Therefore, PwC Germany and the IMO-HSG have conducted a systematic review of the pertinent studies published since 2016. We identified 112 relevant academic studies conducted in 30+ countries on 5 continents and consolidated the data from these studies conducted in various heterogeneous contexts into one extensive database. This approach allows us to structure and synthesise existing knowledge and provide a holistic picture on the intention to use SAVs. For details on the methodology used please refer to Greifenstein (2024).[16]

Fig. 5 Top 3 research regions with the highest number of published studies



Note: N = 112
Source: IMO-HSG and PwC Analysis.

"We are working to bring this technology on the roads across Europe in a safe and integrated way. Our goal is to unlock the massive potential of this technology for the benefit of everyone."

Christian Bering Pedersen
former CEO, Holo

Almost half of all considered studies investigated SAVs in general (48%), 52% focus on individual vehicle types. Of the latter, robo-shuttles and robo-taxis are being more frequently researched (32.8.0%/34.6%) while fewer studies deal with pooled robo-taxis (15.4%) and robo-buses (17.2%). Given the rising interest in SAVs and their upcoming commercialisation, research will certainly accelerate and focus more intensely on the specific vehicle types in the future. We predict that research momentum on robo-taxis and robo-shuttles will continue to increase in the coming years, closely followed by research on robo-buses. Meanwhile, investigations of pooled robo-taxi services are unlikely to increase and studies on SAVs in general will decline in favour of rising robo-taxi and robo-shuttle research. This expected ramp-up in academic research seems to be in sync with market development predictions.

In terms of regions, almost 40% of all studies have been executed in Europe, followed by the United States with roughly one quarter and China with 8.9% of all studies. In a country comparison, Germany ranked third overall and is thus leading academic research endeavours in Europe. When comparing studies on individual vehicle types and setting aside research on SAVs in general, it stands out that most studies in Europe have explored robo-shuttles, while North America focused on robo-taxis and China on robo-taxis and robo-buses (see Figure 5).

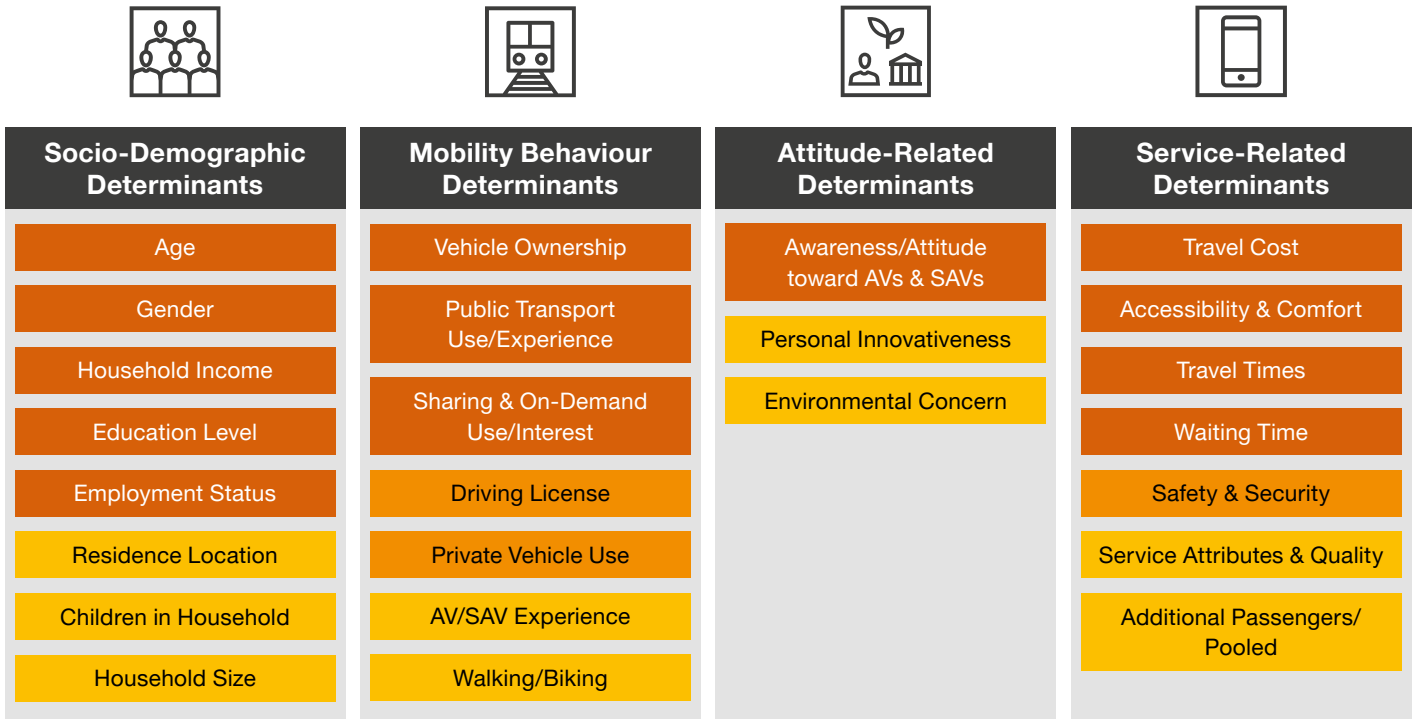
Once SAVs enter the mass market and gain momentum, it will be crucial to unravel the complexities surrounding their implementation and understand the path towards an era of shared autonomous mobility. This whitepaper explores market potential by highlighting consumer needs and identifying promising early adopter groups.

4 Determinants shaping consumer acceptance of SAVs

To investigate the willingness of consumers to use SAVs in the future, we built a database comprising the 25 most relevant determinants influencing and predicting user acceptance, derived from all reviewed studies (see Figure 6 and Appendix for detailed results on each determinant).

Those 25 determinants were categorised into four groups: socio-demographic determinants, mobility behaviour determinants, attitude-related determinants, and service-related determinants. Reviewing all studies, we delved into each determinant investigated in them and identified if they were having a positive, negative or neutral effect. This yielded tendencies regarding consumer intention to use SAVs. It is important to note that the outlined findings are not universally agreed upon in literature, but rather reflect prevailing trends.[16]

Fig. 6 Overview of 25 determinants influencing SAV user acceptance, categorised in four groups



Source: IMO-HSG and PwC Analysis.

We found the tendencies fostered by each determinant in the four groups to be as follows:

- **Socio-demographic determinants**
  The reviewed studies indicate that SAVs are more likely to be utilised by individuals who are young, male, well-educated, employed, from households with moderate to high incomes or from young families living in larger households with children. While in the US and Europe, well-educated individuals are more likely to use SAVs, this effect is not visible in China. Conversely, employment status (being employed part or full time) seems to have a positive effect on the intention to use SAVs in the USA, while this effect is not seen in Europe or China. Moreover, it seems that consumers residing in urban areas show a higher probability of using SAVs. This is especially true for Europe, but not supported by US findings.
- **Mobility behaviour determinants**
  Overall, the determinants related to mobility behaviour show divergent tendencies. For instance, owning a private vehicle seems to have a negative effect on the willingness to use SAVs, while regular use of a private vehicle (self-owned or borrowed from friends/family members) may increase the inclination to use SAVs. Regional differences may explain this. For instance, using a private vehicle and possessing a driver's license has a negative impact on the willingness to use SAVs in the US, while the opposite is true for Europe. However, there is a visible general tendency that factors such as having experience with or interest in sharing/on-demand services, regularly using public transport to commute or take leisure trips and possessing a driver's license increase willingness to utilise SAVs. A promising result with regard to environmental concerns: individuals that regularly walk or cycle to certain destinations show little intention to switch to SAVs to reach them.
- **Attitude-related determinants**
  Unsurprisingly, individuals who are aware of and have a positive attitude towards AVs and SAVs also show a higher willingness to use SAVs. While this is especially true for the US and China, the determinant does not show a clear tendency on the acceptance of SAVs in Europe. Furthermore, individuals exhibiting a positive attitude towards innovation and a keen interest in and familiarity with new technologies (aggregated as personal innovativeness determinant) are also more likely to opt for SAVs as a transportation choice in the future. Lastly, individuals prioritising environmental concerns when choosing means of transportation demonstrate a higher interest in using SAVs.
- **Service-related determinants**
  In general, it seems reasonable to assume that as travel costs and waiting times decrease, there is a growing inclination among individuals to use SAVs. With increasing accessibility and comfort as well as improving service attributes and quality, consumers are more willing to use SAVs, preferably for shorter travel durations. However, the presence of additional passengers and the concept of pooling may lower consumers' willingness to utilise SAVs. Surprisingly, there are not sufficient conclusive results on the determinant safety and security to draw clear conclusions regarding its impact on the willingness to use SAVs. However, it seems that safety and security concerns no longer prevent individuals from accepting SAVs, even though they had previously been regarded as a strong barrier to adoption.

5 Users embracing SAVs: exploring early adopter groups

In order to fully utilise the market potential of SAVs, it is crucial to identify early adopter groups and carefully target them with appropriate marketing strategies. To define such relevant user groups, we utilised the previously identified 25 determinants and created user categories, each based on two socio-demographic, two mobility behaviour and one attitude-related determinant. The determinants included were chosen according to the highest number of mentions and their predictive strength. By determining these user categories, we uncovered the most promising early adopter groups to enable the exploitation of most of the anticipated market potential.

In the following, we present the Top 3 most promising early adopter groups for SAVs and their defining characteristics:

1. **Young Free Adventurers**
   This user group predominantly consists of young individuals, typically in their twenties or thirties, who are open to adopting new technologies and innovative transportation solutions. They are medium to highly educated, which makes them receptive to and capable of understanding the benefits and potential of SAVs. The Young Free Adventurers primarily rely on public transportation services for their daily travel needs, appreciating their convenience and affordability, but they also seek the additional flexibility and autonomy that SAVs might offer. Furthermore, they do not possess their own vehicle due to various reasons, such as total cost of ownership, environmental consciousness or the desire to avoid the responsibilities associated with car ownership. Instead, with a constantly open spirit for innovation, they prefer to use alternative modes of transportation, actively seeking novel, disruptive solutions that support their lifestyle and enhance their travel experience.
2. **Urban Professionals**
   The second promising user group are Urban Professionals. This group consists of individuals who are employed part or full time in blue as well as white-collar professions. They are primarily male and live in urban areas, though not exclusively. This user group partly relies on their own private vehicles to meet daily commuting needs and is accustomed to the convenience and flexibility coming with personal vehicle ownership. Most members of this user group possess a driving license, which indicates familiarity with and experience in driving. The portion of Urban Professionals who are aware of and showing a positive attitude towards emerging technologies around AVs/ SAVs and awareness of their potential benefits, such as improved convenience, reduced congestion and increased safety, is particularly open to using SAVs.
3. **Modern Sustainable Families**
   Lastly, Modern Sustainable Families, who are privileged with a medium to high household income, allowing them to afford more expensive transportation services and strive for sustainable lifestyle choices, are promising early adopters as well. This user group mostly consists of larger households in which parents and children live together. Their transportation needs often involve accommodating multiple family members pursuing various activities. Previously, they may have used ride-hailing/ on-demand services, car-sharing or even advanced driver assistance systems, showing a certain openness to innovative transportation solutions. Thus, they are more comfortable with the idea of sharing resources, including transportation, to reduce costs, environmental impact and the overall burden of ownership.

While those potential early adopter groups are defined by different socio-demographic, mobility behaviour and attitude-related determinants, the same service-related determinants overarchingly apply to all of them. They are eager to use SAVs when they are inexpensive and provide easy access, comfort as well as short waiting and travel times. However, safety and security considerations do not influence the intention to use SAVs.

By targeting these early adopter groups, SAV services can realise their full value potential, establish trust and refine their offerings to cater to a growing user base in the future. Ultimately, it is these user groups that will help to exploit most of the market potential indicated above.

Fig. 7 The three most promising early adopter groups for SAVs

User Category/ Determinants	Young Free Adventurers	Urban Professionals	Modern Sustainable Families
Socio-demographic	Young	Employed	Medium to high household income
	Medium to highly educated	Mostly male	Medium to large household size with children in household
Mobility behaviour	Public transport user	High private vehicle use	High sharing & on-demand use/interest
	No vehicle ownership	Possessing a driving license	Optional: AV/SAV experience
Attitude-related	High personal innovativeness	AV/SAV aware	Environmentally conscious
Service-related	Low travel cost, easy access and comfort, short travel and waiting time, safety and security does not increase/considerations do not influence intention to use SAVs		

Source: IMO-HSG and PwC Analysis.

6 SAVs at our doorstep: key practical implications

In the coming years, the evolution of AVs will significantly change the mobility landscape. Scalable pilot projects will be crucial for the successful rollout of this new technology and related mobility services. While scaling AVs for private use will initially not be realistic due to the high unit costs – and is also not systemically desirable – the targeted introduction of SAVs offers the opportunity to directly accustom people to the shared use of AVs and autonomous mobility services (versus PAVs).

Our market analysis shows a potential SAV population of between 15.7 and 26.4 million vehicles by 2040. In order to optimally utilise this market potential, a targeted marketing strategy addressing promising early adopter groups is essential. In the following section, we will look at the prerequisites and important areas of cooperation between three key stakeholder groups: Legislation & authorities, transport operators & mobility providers, and manufacturers & suppliers. Furthermore, this paper provides indications as to which market conditions need to be taken into account when designing SAV offers – and who will be responsible for considering them (see Figure 8).

1. **Tailored Service/Product & Features**
   The identified 25 determinants provide insights into the needs and expectations of potential early adopter groups. This information can be utilised to design and develop services, products and features in line with these requirements. For instance, catering to the preferences of Modern Sustainable Families might include ensuring that SAVs offer family-friendly seating accommodation, amenities or services. By incorporating user-centric design principles, transport operators, mobility service providers, manufacturers and suppliers can enhance user experience and the likelihood of adoption. Even more important are high comfort and easy accessibility/frequent availability of the services. These appeared as crucial determinants for use in many of the research studies examined.

2. **Customised Communication**
   Illuminating the characteristics and preferences of the mentioned early adopter groups enables transport operators, mobility service providers, manufacturers and suppliers to precisely customise marketing strategies and communication. For instance, Young Free Adventurers might be targeted by highlighting the flexibility and autonomy of SAVs, while emphasising convenience and time-savings can be an effective way to target Urban Professionals.

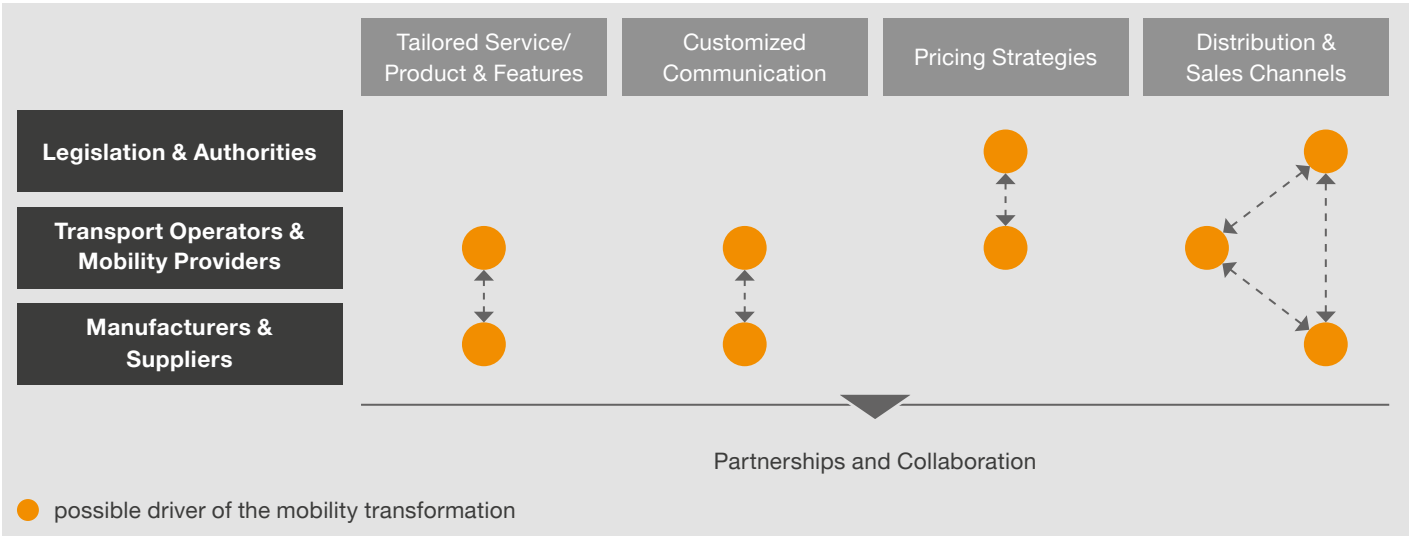
3. **Pricing Strategies**
   In the category of service-related determinants, the cost factor plays a major role, with many studies confirming the intuitive assumption that lower prices significantly increase the willingness to use SAVs. Thus, pricing models must be carefully considered to attract and retain early adopters. For instance, offering flexible payment options, or even subscription-based plans or passes, can make SAVs more appealing to potential users. Overall, providing affordable services will probably have the biggest impact on SAV adoption. This implies that transport operators, mobility service providers, manufacturers or suppliers might initially need to subsidise their offerings or be subsidised by governments, until the cost of hardware and technology declines and renders SAV services cheaper for providers. Hence, the collaboration of legislation authorities, transport operators and mobility providers will be crucial in determining pricing strategies.

4. Distribution and Sales Channels
The investigated studies show that some individuals already use alternative modes of transportation, such as ride-hailing, car-sharing or micro-mobility services. We believe that SAVs will complement as well as extend existing public transport services. Consequently, partnerships and integration with existing public and private mobility platforms might increase the adoption rate. In Europe, a collaborative approach involving partnerships between manufacturers, transport operators, mobility providers and local governments is likely to dominate. Thus, SAV services will probably be distributed via existing public or private transport operators and mobility providers. In Asia, particularly in China, the distribution of SAV may surge through tech-driven platforms and partnerships with ride-hailing services. North America, with its sprawling urban areas, may witness a model where tech players such as Waymo or Cruise provide SAV services alone or together with ride-hailing partners such as Uber. In any case, it is apparent that collaboration among all three stakeholder groups (Legislation & Authorities, Transport Operators & Mobility Providers, Manufacturers & Suppliers is likely play an important role in the autonomous mobility transformation.

To sum it up, all practical implications highlight that collaboration and early preparation will help SAV equipment and service providers in their efforts to attract and cater to the mentioned early adopter groups (Young Free Adventurers, Urban Professionals & Modern Sustainable Families). Those user groups might have the power to increase the chances of a successful adoption and establish a strong foundation for future SAV growth. However, besides exploiting most of the expected market potential with early adopter groups, it is of key importance to understand what a future SAV-related ecosystem might look like – and to be aware of the biggest current barriers to implementation.

The upcoming Part 2 of this series will address these issues by delving into the crucial prerequisites, the dynamics of constructive interaction between key stakeholders and the evolving structures of a SAV-related ecosystem.

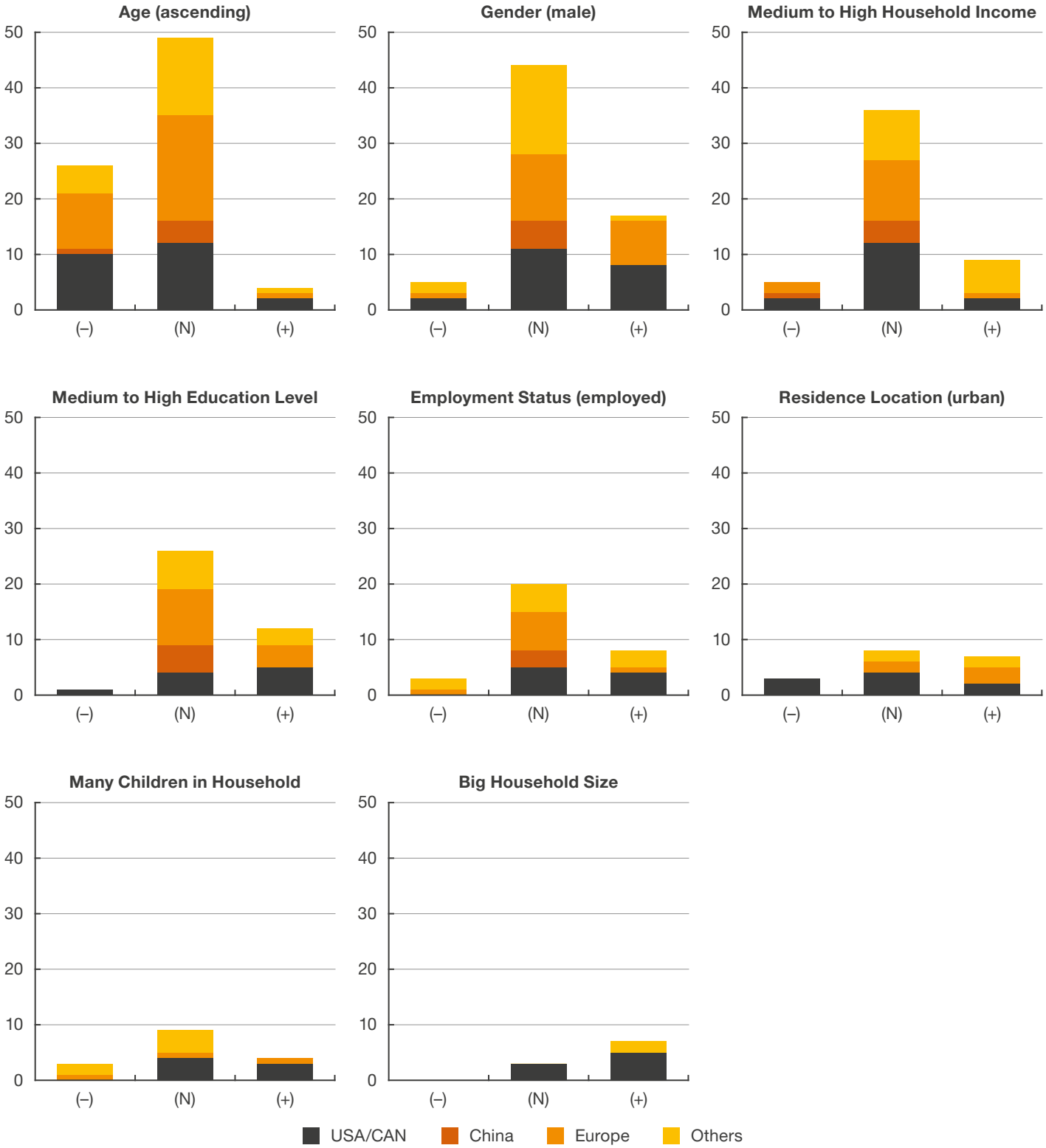
Fig. 8 Drivers of the mobility transformation to ensure SAV adoption



Source: IMO-HSG and PwC Analysis.

Appendix

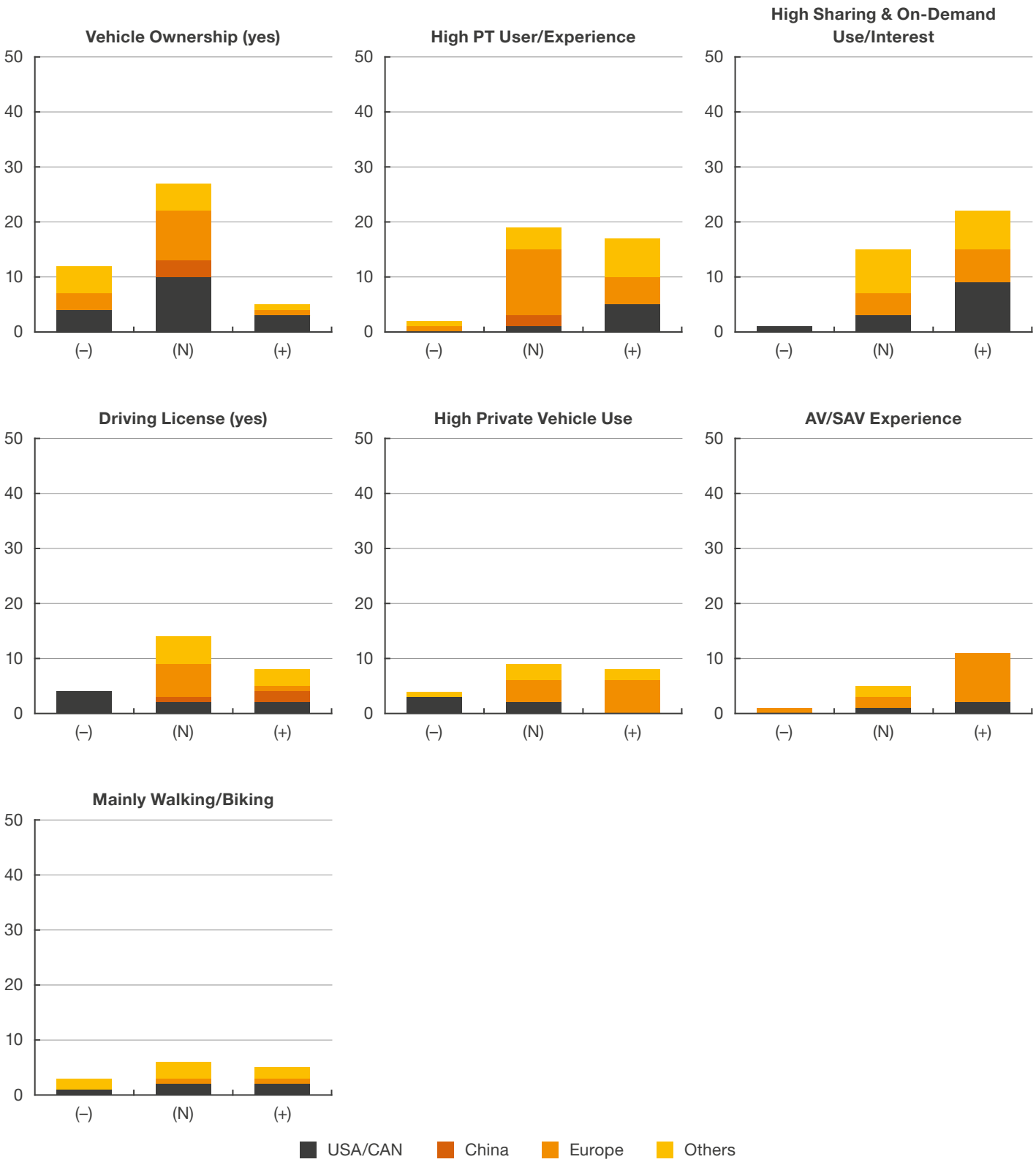
Fig. 9 Effect of socio-demographic determinants on the intention to use SAVs



Note: This figure summarizes the reported results on the respective determinant regarding the intention to use SAVs. The effect direction indicates the number of studies reporting either positive/negative significant effects (“+”/“–”) or non-significant effects (“N”) on the intention to use SAVs.

Source: IMO-HSG and PwC Analysis.

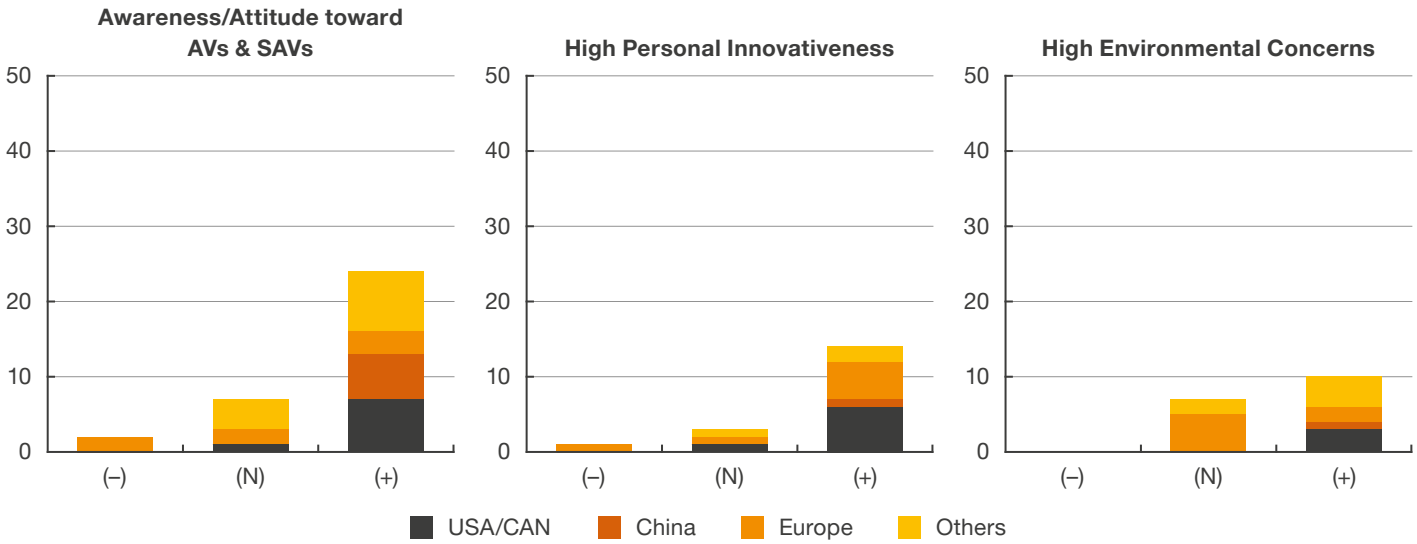
Fig. 10 Effect of mobility behaviour determinants on the intention to use SAVs



Note: This figure summarizes the reported results on the respective determinant regarding the intention to use SAVs. The effect direction indicates the number of studies reporting either positive/negative significant effects (“+”/“–”) or non-significant effects (“N”) on the intention to use SAVs.

Source: IMO-HSG and PwC Analysis.

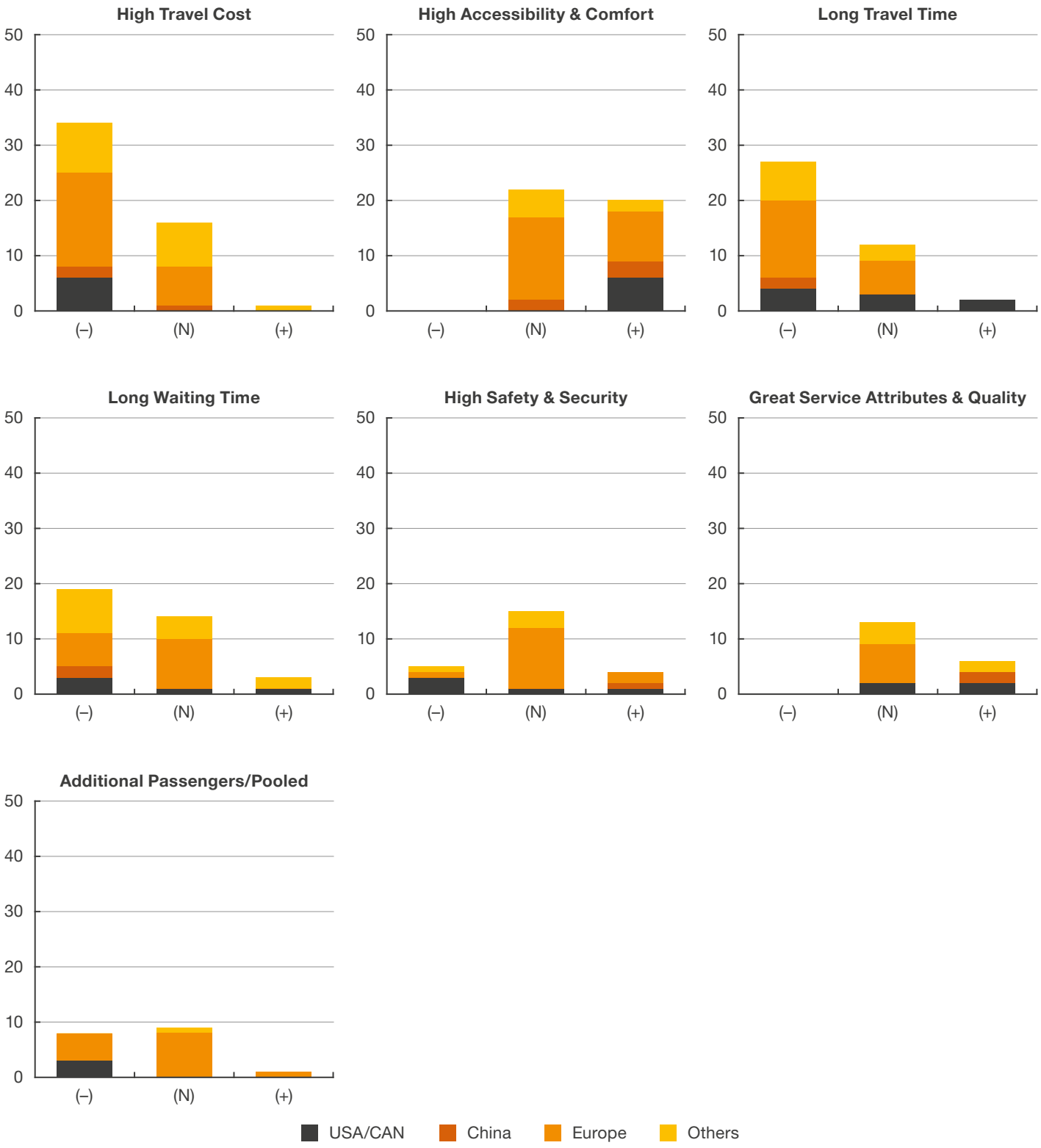
Fig. 11 Effect of attitudinal-related determinants on the intention to use SAVs



Note: This figure summarizes the reported results on the respective determinant regarding the intention to use SAVs. The effect direction indicates the number of studies reporting either positive/negative significant effects ("+"/"–") or non-significant effects ("N") on the intention to use SAVs.

Source: IMO-HSG and PwC Analysis.

Fig. 12 Effect of service-related determinants on the intention to use SAVs



Note: This figure summarizes the reported results on the respective determinant regarding the intention to use SAVs. The effect direction indicates the number of studies reporting either positive/negative significant effects (“+”/“–”) or non-significant effects (“N”) on the intention to use SAVs.

Source: IMO-HSG and PwC Analysis.

References

[1] Javed, A. R., Shahzad, F., Rehman, S. u., Zikria, Y. B., Razzak, I., Jalil, Z., & Xu, G. (2022). Future smart cities: requirements, emerging technologies, applications, challenges, and future aspects. Cities, 129. https://doi.org/10.1016/j.cities.2022.103794

[2] Basselier, R., Langenus, G., & Walravens, L. (2018). The rise of the sharing economy. Economic Review, National Bank of Belgium, 3, 57-78.

[3] Benevolo, C., Dameri, R.P. & D'Auria, B. (2016). Smart Mobility in Smart City. In T. Torre, Braccini, A., Spinelli, R. (eds) (Ed.), Empowering Organizations, Enabling Platforms and Artefacts. Springer International Publishing. https://doi.org/10.1007/978-3-319-23784-8

[4] TomTom (2023). TomTom Traffix Index - Stay ahead of the economic curve, Retrieved from https://www.tomtom.com/traffic-index/ on 27 June 2023

[5] Deutsche Umwelthilfe (2022). PARKEN – öffentlicher Abstellraum, Retrieved from https://www.duh.de/fileadmin/user_upload/download/Projektinformation/Verkehr/Pop-up-Radwege/Infografik_Parkpl%C3%A4tze.pdf on 27 June 2023

[6] Hess, Daniel B. & Rehler, Jeffrey (2021). America has eight parking spaces for every car. Here's how cities are rethinking that land, retrieved from https://www.fastcompany.com/90645900/america-has-eight-parking-spaces-for-every-car-heres-how-cities-are-rethinking-that-land on 27 June 2023

[7] WHO (2022). Road traffic injuries, Retrieved from https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries on 27 June 2023

[8] Bagloee, S.A., Tavana, M., Asadi, M. & Oliver, T. (2016). Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. J. Mod. Transport. 24, 284–303. https://doi.org/10.1007/s40534-016-0117-3

[9] Dean, M.D. & Kockelman, K. (2022), Our self-driving future will be shaped by policies of today. Nat Electron 5, 2–4. https://doi.org/10.1038/s41928-021-00708-4

[10] The Guardian (2023). Mercedes-Benz beats Tesla for approval of automated driving tech in California, Retrieved from https://www.theguardian.com/us-news/2023/jun/09/california-mercedes-benz-self-driving-car-autonomous-vehicles on 27 June 2023

[11] Antonialli, F. (2019). International benchmark on experimentations with Autonomous Shuttles for Collective Transport 27th International Colloquium of Gerpisa, Paris, France. URL: https://inria.hal.science/hal-02489797/

[12] Martinez, L., & Crist, P. (2015). Urban Mobility System Upgrade – How shared self-driving cars could change city traffic. In International transport forum, paris (Vol. 14, p. 24).

[13] Berge, O. (2019). The Oslo Study – How Autonomous Cares May Change Transport in Cities. Ruter: Oslo, Norway.

[14] Golbabaei, F., Yigitcanlar, T., & Bunker, J. (2020). The role of shared autonomous vehicle systems in delivering smart urban mobility: A systematic review of the literature. International Journal of Sustainable Transportation, 15(10), 731-748. https://doi.org/10.1080/15568318.2020.1798571

[15] Templeton, B. (2023). Waymo And Cruise Get Permits For Full-Day Robotaxi For Money In SF, LA, Silicon Valley. Retrieved from https://www.forbes.com/sites/bradtempleton/2023/08/10/waymo-and-cruise-get-permits-for-full-day-robotaxi-for-money-in-sf-la-silicon-valley/ on 11.08.2023

[16] Greifenstein, M. (2024). Factors Influencing the User Behaviour of Shared Autonomous Vehicles (SAVs): A Systematic Literature Review. Transportation Research Part F: Traffic Psychology and Behaviour, 100, 323-345, https://doi.org/10.1016/j.trf.2023.10.027.

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