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To Share or to Own? Understanding the Willingness to Adopt Shared and Owned Electric Automated Vehicles on Three Continents

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Abstract: Electric automated vehicles (AVs) are expected to become part of the transportation system within the coming years. The implications of their implementation are still uncertain. What is known is that human behaviour will be central to determining AV adoption. This research aims to gain insight into how potential users of privately owned (PAVs) and shared (SAV) electric automated vehicles are characterised across three different continents assessing the influence of cultural and geographic features, personal attitudes and characteristics and the perceived advantages and disadvantages of AVs. Using survey data collected among residents (*N* = 1440) in Greater Sydney, Australia; Greater Montréal, Canada; and the Randstad, the Netherlands, this paper explores individuals' willingness to adopt PAVs and SAVs using statistical descriptive analysis and logistic regression models. The study supports the impact of personal characteristics (e.g., age and travel characteristics) and attitudes towards personal and societal gains on the willingness to adopt AVs. Furthermore, this paper provides cross-continental evidence for the regional socio-urban context, affecting the desire to adopt AVs in different forms. Policy-makers should consider these factors and tailor different strategies according to cultural norms in order to motivate a coherent and sustainable implementation of AVs into existing and future mobility landscapes.

Keywords: Shared Automated Vehicles; private automated vehicles; cross-regional analysis; Canada; Australia; Netherlands; transport innovation; social acceptance

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1. Introduction

In 2016, the chief executive of Ford Motor Company, stated that his company would sell self-driving cars by 2025, and would provide them via ride-hailing service by 2021 [1]. In 2022, the first self-driving taxis by General Motors were available for hire in San Francisco as a test ride, with limited evidence to show how these vehicles would or could become part of the greater mobility system [2]. Yet, both scholars and motor vehicle companies have predicted that automated vehicles (AVs) are expected to become part of the transportation system within the coming years, and the integration of AVs into the transportation system will have far-reaching, and unknown implications [3]. These implications are uncertain because AV use is in an experimental stage and not yet well-incorporated into wider mobility systems [4]. What is known, is that human behaviour will be central to determining AV adoption. For example, Calthorpe and Walters (2017) [5] state that every new transportation technology affects the geography of communities and the structure of human lives. The widespread availability of AVs would likely affect the build environment, land use as well as the use of other modes. An experiment by Harb et al. (2018) [4] revealed that the most significant importance in potential AV adoption was not having to be behind the wheel personally driving the car or even to be in the car at all as empty trips are possible. This feature would arguably cause a significant change in travel behaviour. At the same time, the future adoption of AVs is strongly influenced by users' preferences, values and attitudes. Previous studies have suggested that the current embedded socio-cultural dependence on car-centric systems supporting the private car is not easily aligned with the use of shared mobility systems and therefore neither with the adoption of shared automated vehicle systems (SAVs) [6]. The focus of most AV research is on this full automation, or level five of the driving automation levels as provided by The Society of Automotive Engineers [SAE] (2014).

The present research concerns fully electric automated vehicles and sets out to gain insight into how potential users of privately owned electric automated vehicles (PAVs) and shared electric automated vehicles (SAVs) are characterised across three different continents. We assess what explains individuals' likeliness to buy a privately owned automated vehicle or use a shared one, and to what extent individuals' personal characteristics and cultural and geographic features at their home location play a role in their adoption decision-making process. In order to answer the main research question, we assess (1). whether there are certain cultural and geographic features (e.g., home region) which determine the likeliness to buy or share an electric AV; (2). which personal characteristics (e.g., age and gender) explain the likeliness to buy a privately owned AV or use a shared one, and whether there are differences between the two AV modes; and (3). the role that the perceived advantages and disadvantages of AVs play in an individual's likeliness to buy or share an electric AV.

The remainder of this paper is organized as follows. In the next section, the automated vehicle research literature is presented and the study's theoretical framework for empirical analysis and results is constructed. Next, the study context, data collection process and methodology are introduced. The subsequent sections highlight the analysis and results based on descriptive and logistic regression analysis and then the final section presents a discussion, conclusions and topics for future research and potential policy implications.

2. Literature Review

2.1. Automated Vehicles

An automated vehicle (AV) can be defined as a vehicle in which at least some aspects of a safety-critical functions occur without direct driver input (National Highway Traffic Safety Administration, 2013). Vehicles that provide safety warnings to the driver but do not perform a control function are, in this context, not considered as fully automated. Two main taxonomies of vehicle automation are distinguished internationally, namely the once by SAE and NHTSA [7]. Central to these classifications are the respective roles of the human user and the automated driving system (ADS) in relation to each other. A change in the functionality of the ADS changes the role of the human user [8]. Whereas the SAE segments vehicle automation into six levels, the NHTSA uses five levels. The levels range from vehicles that do not have any of their control systems automated (level 0 for both of the taxonomies) through high or fully automated vehicles (levels 4 or 5). The difference between the two taxonomies occur within the highest level of automation. If a ADS can perform the entire driving task without control of the user, the car is at the full automation level [7]. Any users present in the vehicle while the ADS is engaged are seen as passengers, and not as drivers [8]. The SAE makes a distinction within the highest levels between AVs which are designed to function under specific conditions and AVs which function under any given condition. Fuel type is not mentioned in most classifications but is usually assumed to be electric.

2.2. Effect of AVs on Society and the Build Environment

The implementation of AVs has potential impact on the society as a whole. The impact largely depends on the penetration rate and ways in which the technology is adopted [3]. For example, Childress, Nichols, Charlton and Coe (2015) [9] suggest that AVs provide new mobility opportunities to those unable or unwilling to drive a vehicle themselves. These groups could be able to make more trips and access more destinations, especially in suburban contexts. Increased accessibility is often presented as a major societal benefit of AVs within the mobility system [10]. However, others have warned that the accessibility benefit will only have positive results if the services are also financially accessible across population segments [11]. Another possible benefit related to the introduction of AVs is improvements in traffic flow efficiency due to a decrease in time gaps between vehicles. Relatedly, when cars travel closer together, increases in traffic capacity may lead to reductions in the need for road expansions [3]. The implementation of AVs could also significantly reduce the amount of space needed for parking in urban areas. Parking norms will likely change because after dropping off passengers, a vehicle could drive itself empty to a car park outside the urban area where space is not as scarce [12]. There, AVs could be parked closely together since there would be no need to open doors. If people make use of an SAV instead of a privately owned AV, this would reduce the need for parking spaces in residential areas even further. Even at peak usage time today, only 12% of vehicles are on the road in urban areas; therefore, in a shared-use model there could be many fewer total vehicles on the road at a given time, reducing pressure on parking and road capacity [11]. However, the results of (S)AVs driving empty to peripheral parking areas would likely also lead to major increases in vehicle-miles-travel (VMTs), therefore significantly contributing to urban congestion [13].

The implementation of AVs could also potentially result in traffic safety gains, as vehicle automation technology could prevent common vehicle accidents caused by human error in judgement [11]. For example, AVs are less affected by common human distractions such tiredness, consumption of alcohol or distracting passengers. However, research shows that humans will likely only trust an AV if it behaves like a human, but Fagnant and Kockelman (2015) [14] state that in the US, driver error is believed to be the main reason behind over 90% of all crashes [13]. Designing a system that can perform safely in nearly every situation is challenging but some analysts predict AVs will overcome the obstacles that keep them from accurately responding. ADS could as well prevent injury to vulnerable road users such as pedestrians and cyclists, or animals crossing the road [12]. If mass AV adoption would result in reduces in necessary road-capacity, more urban space could be converted into pedestrian areas or bicycle infrastructure, which would likely further improve the safety of these more vulnerable road users [3].

The introduction of AVs and especially SAVs are expected to negatively influence the use of conventional public transport [3]. If SAVs are inexpensive enough they could compete with conventional fixed-route public transport such as bus and rail [15]. However, SAVs could also serve as an important on-demand extension to traditional public transport and potentially also become highly attractive to people who are currently unable to drive [11]. If the integration of SAVs is not planned carefully into existing public transit systems, then they could make traditional public transport obsolete, particularly in areas with lower densities.

The implementation of electric AVs may also effect transportation energy consumption, due to reductions in CO_2 emissions and fuel consumption, which would lead to improvements in air quality [11]. However, the gains are only likely if AVs are fully electric and the electricity is sustainably sourced and based on renewable energy sources.

2.3. Change in Vehicle-Miles Travelled

The introduction of AVs into urban systems would likely increase individual vehicle-miles travelled (VMT) and change travel and activity patterns [4]. These changes are expected to occur because of several possible reasons. First, AVs can run empty [14], for example to pick up groceries or park in a more remote location. Second, changes in perceived and actual travel times could result in more time spent in vehicles [9]. Specifically, actual travel times may be reduced due to less congestion because of increased road capacity, passenger comfort and productivity [4]. These changes could lead to an increase in the total amount of trips and the decreased perceived travel time leads to people being willing to travel farther [9]. In addition, according to Harb et al. (2018) [4], increases in convenience at the individual level, related to multitasking, alcohol consumption and driving under other distracted or non-ideal conditions could also lead to increases in overall VMTs [16,17].

There is also concern that the introduction of AVs may have detrimental effects on the mode share of active modes. Harb et al. (2018) [4] suggest that walking could decrease because on-demand AVs could replace walking trips. Similarly, Lavieri et al. (2017) [18] state that especially for people who identify as being "green," the availability of AVs might take away modal share from walking, cycling and public transportation. A decrease in active transport would have negative health effects both at the individual and societal levels [11].

2.4. Differences Because of Personal Characteristics

The literature reveals that differences in the likeliness of AV adoption may occur because of personal characteristics. For example, Harb et al. (2018) [4] show a difference between different household types and age groups. Numerous survey-based studies provided evidence that young people are more open and positive towards AV adoption [3,19], while other studies found the opposite direction or even no effects when mediated by other factors such as personal attitudes [20–22]. On the one hand, the literature on shared mobility also mentions that these services are mainly adopted by young, well educated, male and high-income persons [23,24], which is in line with social-psychological theories that explain the adoption of new technologies, such as the technology diffusion model (TAM) [25]. On the other hand, AVs could improve the accessibility and usage of disadvantaged groups such as older adults [15]. In this sense, AVs may facilitate increased accessibility to other social activities and places (e.g., social events, healthcare centres, groceries work) enhancing their well-being and the self-sense of independence [26]. A difference in gender is found as well, as men tend to state a higher acceptance of AVs compared to women [20,27]. With regard to income, Childress et al. (2015) [9] found no difference in impact between income groups on perceived accessibility. Lavieri et al. (2017) [18], however, did show a difference between income groups when looking at the level of willingness to adopt AV technology. Individuals with a lower income appeared to be largely averse to the adoption of AV technology in any form. Seebauer et al. (2015) [28] stated that persons with a higher educational level tended to adopt or use technology quicker, yet Lavieri et al. (2017) [18] found that education did not have a statistically significant impact on whether individuals where interested in sharing or owning and AV.

2.5. Differences in Environmental Characteristics

Becker and Axhausen (2017) [20] suggested that AV acceptance changes across urban densities. Similarly, Lavieri et al. (2017) [18] underlined the influence of density in the effect of implementing AVs and suggested that individuals living in neighbourhoods with relatively higher urban densities were more likely to favour AV sharing (SAVs). The region or metropolitan area in which people live may also influence their view on PAVs and SAVs as well; this would like be due to differences in cultural norms and existing mobility systems. For example, many studies distinguish between individualistic and collectivist cultures, where individualists see themselves as autonomous individuals and collectivists see themselves as part of a group [29].

In the present study we assess potential electric AV use across three regions. Northern European countries are generally characterized as individualistic, so this is the common culture in the Netherlands as well. The literature also only suggests slight differences in individualism and collectivism between Australia and Canada, with both cultures tending to lean more towards being individualistic [30,31]. Hofstede et al. (2010) [32], rank Canada and the Netherlands as slightly less individualist than Australia. Differences in individualism and collectivism across cultures are expected to influence how populations expect to adopt SAV vs. PAVs (This paper is based on a research outcome from a collaboration between four academic institutes (Utrecht University, McGill University, Polytechnique Montréal and Georgia Institute of Technology). In this sense, the cooperation provides an interesting opportunity to compare/contrast how autonomous vehicles (AVs) and automated car-sharing might impact active transport in car-dominated yet relative newcomers to the AV space (Australia and Canada) versus a bicycle-dominated yet acknowledged leader in the AV domain (The Netherlands)).

3. Data and Methods

3.1. Data

The data for this study were collected using an online survey in June 2021 in the Randstad (The Netherlands), Greater Montréal (Canada) and Greater Sydney (Australia). Participants who were at least 18 years or older and lived in either the Randstad, Greater Montréal or Greater Sydney were invited to participate via a web-panel. The survey was available in Dutch, English and French and asked questions regarding individuals' sociodemographic characteristics, travel behaviour, opinions about the perceived (dis)advantages of AVs for them personally and for society as a whole and the different situations in which they might consider using AVs in the future. Important to note is the difference in existing transportation modes between the three regions. Walking and cycling are far more common in the Netherlands than Australia and Canada [33]. The use of public transport, which normally requires walking or cycling towards the transit stop, is also more common in the Netherlands. Control questions were used to screen out erroneous responses and a total of 1440 valid responses were collected (original number of raw data was 3684 respondents, including no completed surveys). An AV was defined in the survey as a vehicle which could drive to a destination selected by users without the assistance of a driver. Two different modalities were explained: Shared Automated Vehicles (SAVs) and Privately owned Automated Vehicles (PAVs). Both modes were described as being fully electric.

Table 1 presents a summary description of the respondents' characteristics. The sample is representative for the populations when looking at gender, but overrepresents persons 50 years and older in all of the three regions. In the regression models, a weight factor for the variable age was added to the data in order to transform the sample to represent the total population of the research area. The representativity could not be checked for more than these two variables because of a lack of matching categories between the available population census data and the survey data.

The categories for the variable household income were made by splitting the categories in the survey into three, based on the distribution. This was carried out separately for every region. The categories for the variable household composition were recoded to ensure valid cell frequencies as well. The categories for the variable education level were recoded into categories matching all of the three regions. Respondents could give multiple answers for their employment status as well. However, respondents who had a full-time job and another status were assigned to the category "full time job" and respondents were assigned to the category "student" even if they had a part time job as well. Respondents who were retired and working part time were assigned to part time as well. The data for the degree of urbanization were generated by calculating the ratio between the number of addresses (household) and the surface area in square kilometres for every three or four digits of postal code area, by using OpenStreetMap. The ratio was classified and calculated to approach the definition of degree of urbanization used by the Netherlands' Centraal Bureau voor de Statistiek (2022) [34].

Table 1. Summary characteristics.

Variables	Definitions	Sydney (*N* = 277) *N* (%)	Sydney Exp. *N* (%)	Montréal (*N* = 808) *N* (%)	Montréal Exp. *N* (%)	Randstad (*N* = 355) *N* (%)	Randstad Exp. *N* (%)	Total (*N* = 1440) *N* (%)
Gender	Male	144 (52.0)	137 (49.3)	405 (50.1)	394 (48.8)	186 (52.4)	175 (49.4)	735 (51.0)
	Female	133 (48.0)	140 (50.7)	398 (49.3)	414 (51.2)	168 (47.3)	180 (50.6)	699 (48.5)
	Other	0 (0.0)		5 (0.6)		1 (0.3)		6 (0.5)
Age	19–35 years	50 (18.1)	94 (33.9)	202 (25.0)	233 (28.8)	78 (22.0)	103 (29.0)	330 (22.9)
	36–50 years	59 (21.3)	75 (27.1)	216 (26.7)	212 (26.3)	79 (22.3)	87 (24.5)	354 (24.6)
	51–65 years	76 (27.4)	61 (22.0)	223 (27.6)	206 (25.5)	107 (30.1)	89 (25.1)	406 (28.2)
	66 years and older	92 (33.2)	47 (17.0)	167 (20.7)	157 (19.4)	91 (25.6)	76 (21.4)	350 (24.3)
Household Income	Low income	93 (38.7)		281 (38.9)		107 (37.0)		481 (38.4)
	Middle income	83 (34.6)		216 (29.9)		115 (39.8)		414 (33.1)
	High income	64 (26.7)		226 (31.2)		67 (23.2)		357 (28.5)
	Missing values	37		85		66		188
Household Composition	Living alone	63 (22.7)		193 (23.9)		131 (36.9)		387 (26.9)
	Together with partner/spouse and Together with partner/spouse and non-dependent person(s)	104 (37.6)		322 (39.8)		123 (34.6)		549 (38.1)
	With children (18 or younger)	53 (19.1)		142 (17.6)		55 (15.5)		250 (17.4)
	With non-dependent person(s)	57 (20.6)		151 (18.7)		46 (13.0)		254 (17.6)
Education level	Secondary	57 (20.7)		121 (15.1)		101 (28.5)		279 (19.5)
	Vocational	78 (28.2)		333 (41.4)		77 (21.7)		488 (34.0)
	Bachelor's Degree	96 (34.8)		239 (29.8)		97 (27.3)		432 (30.1)
	Graduate Degree	45 (16.3)		110 (13.7)		80 (22.5)		235 (16.4)

Table 1. *Cont.*

Variables	Definitions	Sydney (*N* = 277)		Montréal (*N* = 808)		Randstad (*N* = 355)		Total (*N* = 1440)
		N (%)	Exp. *N* (%)	*N* (%)	Exp. *N* (%)	*N* (%)	Exp. *N* (%)	*N* (%)
	Missing Values	1		5		0		6
Employment status	Full time job	92 (33.2)		375 (46.4)		111 (31.3)		578 (40.1)
	Part time job	49 (17.7)		80 (9.9)		82 (23.1)		211 (14.7)
	Student	13 (4.7)		98 (12.1)		27 (7.6)		138 (9.6)
	Other: Retired, Stay-at-home parent, Caregiver, Volunteer, Unemployed or Other	123 (44.4)		255 (31.6)		135 (38.0)		513 (35.6)
Member car sharing	Yes	12 (4.3)		45 (5.6)		26 (7.3)		83 (5.8)
	No	265 (95.7)		763 (94.4)		329 (92.7)		1357 (94.2)
Valid driver's licence	Yes	249 (89.9)		726 (89.9)		286 (80.6)		1261 (87.6)
	No	28 (10.1)		82 (10.1)		69 (19.4)		179 (12.4)
Owned cars per household	0	25 (9.5)		105 (13.3)		86 (24.4)		216 (15.4)
	1	134 (51.2)		397 (50.2)		218 (62.0)		749 (53.3)
	2+	103 (39.3)		288 (36.5)		48 (13.6)		439 (31.3)
	Missing values	15		18		3		36
Duration trip to work	Until 30 min	73 (26.4)		321 (39.7)		132 (37.2)		526 (36.5)
	More than 30 min	66 (23.8)		231 (28.6)		79 (22.2)		376 (26.1)
	Other: Variable, Not working or Working from home	138 (49.8)		256 (31.7)		144 (40.6)		538 (37.4)
Urbanisation degree	Extremely urbanised	19 (6.9)		255 (32.2)		234 (66.9)		508 (35.8)
	Strongly urbanised	45 (16.2)		133 (16.8)		70 (20.0)		248 (17.5)
	Moderately urbanised	55 (19.9)		91 (11.5)		17 (4.9)		163 (11.5)
	Hardly urbanised	91 (32.9)		129 (16.3)		18 (5.1)		238 (16.8)
	Not urbanised	67 (24.2)		184 (23.2)		11 (3.1)		262 (18.4)
	Missing values	0		16		5		21

3.2. Methods

Using a series of binary logistic regression models, this research assesses individuals' likeliness to buy a PAV and their likeliness to use an SAV. The dependent variables (likeliness to buy a PAV and likeliness to use an SAV) were collected using a 7-point scale and transformed into binary outcomes (see Figure 1). Respondents are either likely, or not likely to buy a PAV or use an SAV. Recoding scale questions as dichotomous variables is common practice [35,36], and examples include Pontes and Griffiths (2015) [37] recategorization of individuals having a gaming disorder or not, as well as Nusbaum et al.'s (2000) [38] research on individuals having sexual concerns or not. Respondents tend to report high levels of unlikeliness to use or share a PAV or SAV. Therefore, to ensure an adequate distribution, respondents who answered neutral are included in the "yes" category. This decision was made because, although this group may be in doubt about whether to accept the technology, they do not state any opposition and may be open to the situation within a certain context.

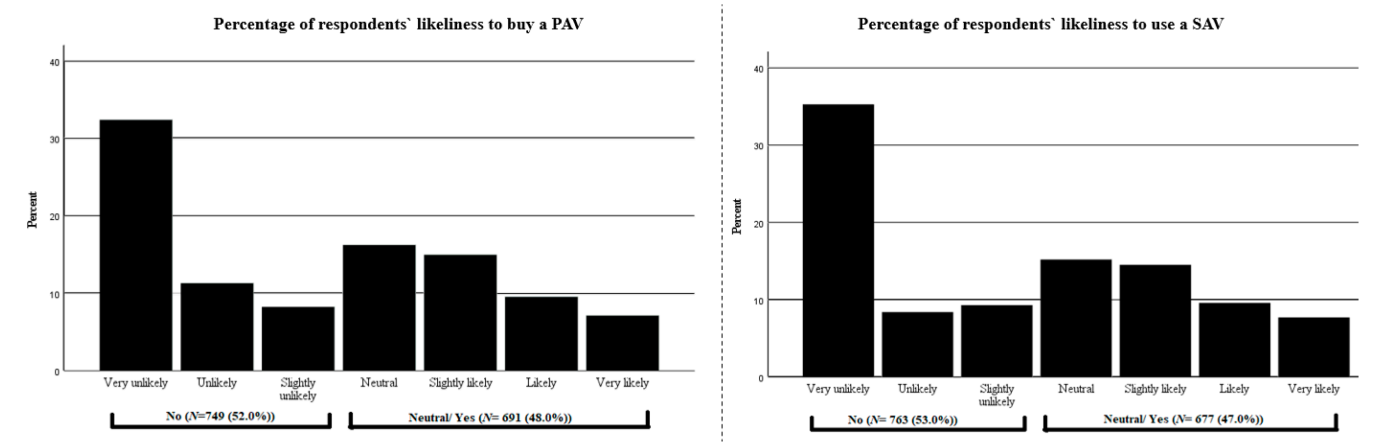

Figure 1. Percentage of respondents' likeliness to buy a PAV (**left**) and an SAV (**right**).

Next, we test the relationship between individuals' willingness to use an SAV or PAV, their personal characteristics, land use density at their home address, their home region, as well as their opinions about AVs using descriptive statistics, factor analysis and a set of binomial logistic regression models. The analysis was conducted using SPSS. Table 2 presents the results of the exploratory factor analysis, which is used to reduce the number of observed variables into fewer dimensions. The results of the principal components factor analysis with varimax rotation, revealed the presence of six significant latent factors from 21 variables, with respondents' ratings on a 7-point scale ranging from "totally disagree" to "totally agree", were extracted. Based on the items included in the six factors, we labelled them as: safety, personal gains, societal gains, sharing, tech optimism and AV tech scepticism (Table 2).

Table 2. Derived factors.

Factors	Indicators	Loadings
Safety	Self-driving cars will make traffic safer for cyclists	0.892
	Self-driving cars will make traffic safer for pedestrians	0.890
	Self-driving cars will make it safer for animals to cross roads and highways	0.815
	Self-driving cars will make motorized traffic safer	0.785
Personal gains	If I used a self-driving car, I would enjoy the feeling of being driven more than driving myself	0.755
	If I used a self-driving car, I would gain time by doing activities in the vehicle while it drove itself (such as work or reading)	0.682
	If I used a self-driving car, I would be able to travel more independently, without the assistance of others	0.671
	If I used a self-driving car, I would be less stressed than driving myself	0.640

Table 2. *Cont.*

Factors	Indicators	Loadings
	If I used a self-driving car, I would gain time by sending the vehicle to do errands without me (such as picking up groceries or delivering a package)	0.620
	If I used a self-driving car, I would miss the feeling of being in control while driving	−0.630
Societal gains	Self-driving cars will be available to all population groups without discrimination	0.771
	Self-driving cars will lead to a healthier society, overall	0.686
	Self-driving cars will lead to less pollution	0.591
Sharing	If I used a shared self-driving car, similarly to a taxi, I would feel safe sharing with strangers	0.889
	If I used a shared self-driving car, similarly to a taxi, I would be open to sharing the vehicle with strangers	0.882
Tech optimism	In my day-to-day experience, technology works well	0.865
	In my day-to-day experience, I like to use new technology	0.659
	In my day-to-day experience, people are good drivers	0.609
AV tech scepticism	Self-driving cars will reduce personal data privacy	0.705
	If I used a self-driving car, I would be concerned that the vehicle would track my location	0.693
	Self-driving cars will require users to be tech savvy	0.629

4. Results

4.1. Descriptive Results

The dataset prepared for the data analysis (*N* = 1440) shows that the respondents together tend to be slightly less likely to buy a PAV (52.0%) or to use an SAV (53.0%). However, there are differences between the three regions, as shown in Table 3. The differences are statistically significant for both the likeliness to buy a PAV (X2 (2) = 19.945; p =< 0.001) and the likeliness to use an SAV (X2 (2) = 21.144; $p < 0.001$).

Table 3. Frequencies dependent variables.

		Sydney (*N* = 277)	**Montréal (*N* = 808)**	**Randstad (*N* = 355)**	**Total (*N* = 1440)**
Variables	**Definitions**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Likeliness to buy a PAV	No	143 (51.6)	386 (47.8)	220 (62.0)	749 (52.0)
	Neutral/Yes	134 (48.4)	422 (52.2)	135 (38.0)	691 (48.0)
Likeliness to use an SAV	No	156 (56.3)	387 (47.9)	220 (62.0)	763 (53.0)
	Neutral/Yes	121 (43.7)	421 (52.1)	135 (38.0)	677 (47.0)

Table 3 shows that approximately half of the respondents from Sydney and Montreal are open to the idea of adopting an AV in the future. Respondents from Randstad reported lower levels of willingness to adopt AV for both modalities (shared and private), which can provide support for the differences in travel behaviour. People in The Netherlands in general rely more on public transport and bicycles compared to those in Canada and Australia. Regarding the differences in the desired use of AVs as private or shared, the results show differences only for Sydney with a preference for PAV (48.4 PAV vs. 43.7 for SAV). This finding is in line with theory by Hofstede et al. (2010) [32] stating the Australians as more individualistic than the other two regions.

Figure 2 shows a different preference pattern to adopt a specific AV modality according to the region across urban and suburban areas. Respondents from urban zones in Sydney are less likely to adopt AV than in the suburban area. The opposite is observed for respondents from Randstad, where the higher rates of willingness are located in urban areas. Regarding Montreal, there are no significant preferences across people living in urban or suburban areas.

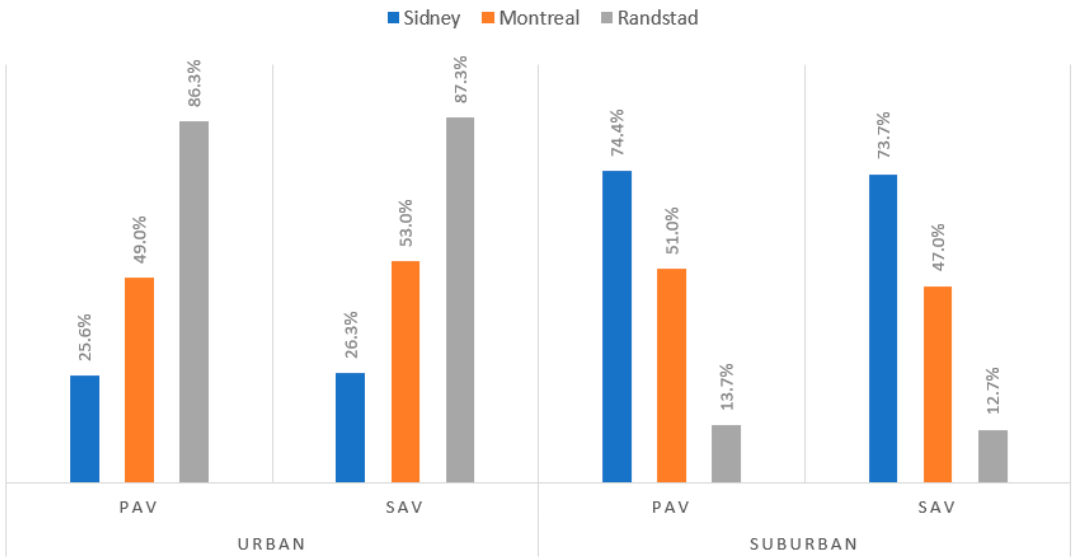

Figure 2. Willingness to adopt AV cross urban and suburban area.

Figure 3 shows the attitudes and affinity to different aspects of AVs across regions. In this sense, it is notorious how personal gains appeal to Sydney and Montreal (especially for safety). However, when looking at societal gains, the picture changes, and Sydney and Randstad have more affinity with these aspects, likely because they represent less individualist cultures [39]. Notably, respondents in the Randstad tend to score higher on statements regarding the benefits of using AV in a shared form. Randstad's societal openness attitudes could be related to their travel characteristics, such as high rates of cycling and use of public transportation. These respondents are less concerned about the personal and car-related issues that are more central for people from Sydney and Canada, which are two regions well known for being private car usage oriented. Moreover, regarding technology, the Dutch population as a whole is often ranked as being culturally more open to technology and likely to accept innovations, compared to other regions, for example, Australia, which displays low technology readiness [40].

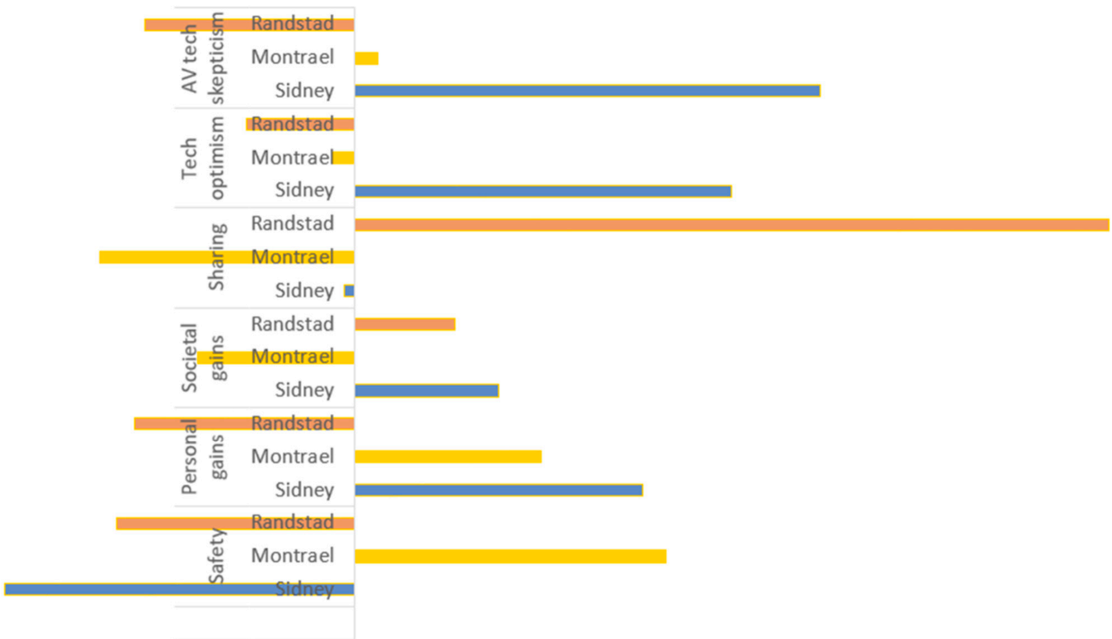

Figure 3. Factor analysis across regions.

4.2. Model Results

Binominal regression models are used stepwise to assess individuals' likeliness to buy a PAV or use an SAV. Tables 4 and 5 display the regression results in three steps for both the PAV and the SAV, as well as goodness-of-fit statistics. In both cases, the first model includes only the home region as an independent variable and the second and third models build upon this by adding the relevant personal characteristics and the latent variables which resulted from the factor analysis. Variables which were not significant (Sig. > 0.05) for both the PAV and the SAV model, were not included in the final models. For both the PAV and SAV analysis, the third model is discussed in the results section since the Nagelkerke R^2 is the highest for these model, as shown in Tables 4 and 5. The model for PAV adoption was statistically significant when compared to the null model, (X^2 (14) = 537.060, $p < 0.001$), had a Nagelkerke R^2 of 0.425 and correctly predicted 75.8% of the cases. The model for SAV usage was statistically significant when compared to the null model, (X^2 (14) = 486.666, $p < 0.001$), had a Nagelkerke R^2 of 0.391 and correctly predicted 74.3% of the cases. The odds ratio is only showed for Model 3 since this is the final model. Gender, household income, household composition, education level, employment status, having a valid driver's licence, duration trip to work and urbanisation degree all had no significant effect on the models ($p > 0.05$) so were left out of the analysis.

Table 4. Results from binominal logistic regression. Dependent variable: Likeliness to buy a PAV.

	Model 1.1		**Model 1.2**		**Model 1.3**		
	B	**Std.err.**	**B**	**Std.err**	**B**	**Std.err.**	**OR**
Home region (ref = Sydney)							
Montréal	−0.216	0.141	−0.158	0.150	−0.325	0.186	0.723
Randstad	−0.658 ***	0.163	−0.569 ***	0.175	−0.463 *	0.214	0.629
Age (ref = 19–35 years)							
36–50 years			−0.499 ***	0.153	−0.177	0.180	0.838
51–65 years			−0.834 ***	0.154	−0.495 **	0.186	0.610
66 years and older			−1.300 ***	0.170	−0.917 **	0.211	0.400
Carsharing membership (ref = No)			0.054	0.233	−0.309	0.284	0.734
Owned cars per household (ref = 0 cars)							
1 car			0.760 ***	0.170	1.350 ***	0.204	3.859
2 or more cars			0.736 ***	0.183	1.353 ***	0.220	3.870
Safety					0.856 ***	0.076	2.354
Personal gains					1.109 ***	0.080	3.030
Societal gains					0.341 ***	0.071	1.406
Sharing					0.135 *	0.068	1.145
Tech optimism					0.405 ***	0.072	1.499
Av tech scepticism					−0.045	0.071	0.956
Intercept	0.305 *	0.122	0.232	0.222	−0.547 *	0.271	0.579
N	1440		1440		1440		
Nagelkerke R^2	0.017		0.102		0.425		
X^2 (df)	18.698 (2) ***		111.561 (8) ***		537.060 (14) ***		

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 5. Results from binominal logistic regression. Dependent variable: Likeliness to use an SAV.

	Model 2.1		**Model 2.2**		**Model 2.3**		
	Count	**Std.err.**	**Count**	**Std.err**	**Count**	**Std.err.**	**OR**
Country (ref = Sydney)							
Montréal	0.108	0.139	0.101	0.148	0.123	0.180	1.130
Randstad	−0.353 *	0.162	−0.474 **	0.174	−0.504 *	0.211	0.604
Age (ref = 19–35 years)							
36–50 years			−0.629 ***	0.152	−0.442 *	0.176	0.642

Table 5. *Cont.*

	Model 2.1		Model 2.2		Model 2.3		
	Count	**Std.err.**	**Count**	**Std.err**	**Count**	**Std.err.**	**OR**
51–65 years			−0.713 ***	0.153	−0.385 *	0.183	0.681
66 years and older			−1.037 ***	0.167	−0.525 *	0.205	0.591
Carsharing membership (ref = No)			1.402 ***	0.272	1.322 ***	0.315	3.750
Owned cars per household (ref = 0 cars)							
1 car			0.038	0.166	0.417 *	0.194	1.518
2 or more cars			−0.192	0.181	0.253	0.212	1.287
Safety					0.596 ***	0.071	1.815
Personal gains					0.990 ***	0.076	2.692
Societal gains					0.336 ***	0.070	1.400
Sharing					0.654 ***	0.068	1.924
Tech optimism					0.182 **	0.068	1.199
Av tech scepticism					0.075	0.069	1.078
Intercept	−0.024	0.120	0.541 *	0.219	−0.153	0.259	0.858
N	1440		1440		1440		
Nagelkerke R^2	0.012		0.088		0.391		
X^2 (df)	12.992 (2) **		95.168 (8) ***		486.666 (14) ***		

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

4.2.1. PAV

The results revealed a significant effect of the home region on the likeliness to buy a PAV. Individuals residing in the Randstad are less likely to adopt a PAV than those in Sydney, while no statistically significant differences are found between Montreal and Sydney. Age has a significant effect on the likeliness to buy a PAV. The model shows there is no significant difference between people between 19 and 35 years old and 36 and 50 years old ($p > 0.05$), but there is a significant difference between people between 19 and 35 years old and people between 51 and 65 years old and 66 years and older. This suggest that as people age, the less likely they are to buy a PAV, which is in line with the AV literature, which has suggested that young people are more likely to use AV technology as similar to other transport innovation where young individuals are generally considered as innovators [19,27]. Being a member of a carsharing service has no significant effect on the likeliness to buy a PAV. This finding seems logical since this variable is more relevant to the likeliness of using an SAV. Car ownership at the household level does have a significant effect on the likeliness to buy a PAV. The model reveals that households who own one car have 3.859 times the odds of buying a PAV compared to households without a car. This difference is significant ($p < 0.005$). The same applies to households with two or more cars (OR = 3.870, $p < 0.005$). The factors safety, personal gains, societal gains, sharing and tech optimism also have a significant and positive impact on the likeliness to buy a PAV. Improvements in perceived safety, for example, are likely to increase individuals' likeliness to adopt a PAV.

4.2.2. SAV

The results also revealed a significant effect of home region on the likeliness of using an SAV. Living in the Randstad is found to have a negative effect on the likeliness to use an SAV. Living in the Randstad reduces the odds of using an SAV by 40% compared to Sydney, which is a significant difference.

Age has a significant effect on the likeliness to use an SAV. The model shows a significant difference between people in the reference category from 19 to 35 years old and the three other groups. The effect is negative which means the older age groups have lower odds of using an SAV compared to younger groups. While holding a carsharing membership has no significant effect on the likeliness to buy a PAV, it does have a significant effect on the likeliness to use an SAV. The positive effect is significant ($p < 0.005$) and the odds of using an SAV for people who have a carsharing membership is almost four times the odds of someone who does not have a carsharing membership. This result is expected because having a carsharing membership implies openness to using shared vehicles in general. Owning one car increases an individual's likeliness to use an SAV. This effect is also significant for PAV (but significant also for one car and more) suggesting that SAVs could appeal to households with one owned car where an SAV could have a role as a second available car for the household. Finally, and similarly to the PAV model results, the factors safety, personal gains, societal gains, sharing and tech optimism have a significant and positive impact on the likeliness to use an SAV.

5. Discussion and Conclusions

Using survey data collected among residents in Sydney, Greater Montréal and the Randstad, this paper investigated why certain individuals would be willing to adopt either SAVs and/or PAVs. The main goal of the study was to explain individuals' likeliness to buy a privately owned electric automated vehicle or use a shared one, and understand to what extent individuals' personal characteristics and cultural and geographic features at their home location play a role in their likeliness to adopt these new modes. Based on the models presented, there is clear evidence that socio-demographic characteristics, cultural differences and travel habits across the regions analysed, as well as personal attitudes, play an important role in how perceived societal impacts of AVs are perceived and on the willingness to adopt the technology in different forms in the future. In this sense, the study provides insights for policymakers, practitioners and researchers on how the transition to automated mobility should be managed in order to maximize the benefits of the technology for the built environment and social inclusion, for example through the promotion of the use of SAVs. However, the impact of shared mobility on urban mobility, amount of travel and travel mode substitution, among other things, is uncertain yet [23,41]. In this sense, a constellation of SAV models that could take advantage of the potential advantages will combine the high occupancy vehicle level principles, integrated into mass transit multimodal systems (including non-motorized modes) and available online for users to access [42–44].

5.1. Personal Characteristics

The results of the analysis suggest that, consistent with what Harb et al. (2018) [4] and Schrauth et al. (2021) [27] revealed, age does have a significant effect on the likeliness to buy a PAV or use an SAV. Specifically, whereas the PAV model suggested that older people tend to be less likely to buy a PAV than people under 50 years of age, the SAV model suggested that people who are 36 years or older are less likely to use an SAV than people between 19 and 35 years old. These results also suggests that the middle-aged (those between 36 and 50 years old) are more likely to use a PAV compared to an SAV. Policy makers should be aware of the difference in preferences across age groups and consider and develop usage configurations that would be attractive across generations.

For both modes there were no significant effects in terms of gender, household type, household income, educational level or employment status on the likeliness to buy a PAV or use an SAV, and these findings are similar to previous AV studies [4,18,28,30,39]. However, the results of the current study add a more robust understanding of the different cultural contexts and AV modal contexts (SAV vs. PAV) to the mixed findings in the literature.

The analysis also revealed that having a carsharing membership has a significant effect on the likeliness of using an SAV, but not on buying a PAV. This result is not surprising since having a carsharing membership suggests willingness to share a car. Car ownership also affects willingness to by an PAV or use an SAV. However, owning more than one car was significant for the PAV while not significant in the SAV model. This suggest that an SAV could be seen as a second and complementary car in households already owning one car.

5.2. Regional Differences

The results revealed a significant effect of the home region on the likeliness to buy a PAV and use an SAV. Respondents living in the Randstad significantly differed from the respondents living in Sydney and Montreal. Their willingness to adopt either a PAV and SAV was lower than Sydney which suggests people in the Randstad are less likely to be interested in adopting AVs in general. In addition, results of the factor analysis suggested that those living in the Randstad tend to have a positive attitude towards sharing, in contrast to the other two regions. Difference in in the current mobility patterns and mode split between the countries, as shown by Bassett et al. (2008) [33], might influence this difference since walking, cycling and the usage of public transport are more common in the Netherlands compared to the more car-centric travel cultures found in Australia and Canada. In this sense, this work suggests that differences in overall rates of AV acceptance should be cautiously considered according to specific travel behaviour and attitudes according to different contexts in future studies.

5.3. Personal Attitudes

The factors safety, personal gains, societal gains, sharing and tech optimism significantly and positively impact the likeliness to buy a PAV or use an SAV. For example, the factor labelled "personal gains" is an important predictor of AV adoption in general, and these findings are similar to previous studies [9,14,19]. Therefore, policy makers aiming to increase potential AV adoption in cities would benefit from promoting potential increases in independence, activity participation and decreased stress with the introduction of this new mode.

6. Future Research Directions and Policy Implications

The present research sheds light on future research directions. First, our models show a significant effect of the home region on the likeliness to use an electric SAV and PAV. Future research could be conducted in additional cultural and spatial contexts, to determine how the likeliness of buying a PAV or using an SAV differs in other regions. The literature, for example, stated that all of the three regions can be seen as regions with individualistic cultures [30,31]. Repeating the research in a context with a collectivist culture might show different outcomes for, for instance, the likeliness of using an SAV. The role of the built environment and the costs of the implementation and integration of AVs could also be considered in future research. For example, how individuals perceive and predict the role of empty roaming vehicles, potential road expansions due to increases in VMTs and AV-related suburban expansion would be interesting and relevant to include in future AV questionnaires and research.

The findings of the current study suggest that it is important for policy makers to focus on developing clear information and promotion for social and personal gains, also called civic education, when AVs are introduced in a region [3]. Suggested safety advantages and personal gains are factors which may affect the likeliness to buy a PAV or use an SAV the most. Informational and promotional campaigns should focus on these factors to ensure society benefits the most from the implementation. The AV literature suggests that electric SAVs should be promoted over PAVs, in order to maximize the societal benefits that AV technology could offer [9–11,18]. Given that the results suggest that people with a carsharing membership are more likely to be willing to adopt SAV usage compared to people who do not have car sharing membership, encouraging the use of carsharing schemes today could be an effective way to indirectly promote future SAV adoption. This results of this study can also help researchers conducting comparative studies in other contexts, as the findings suggest that region-specific implementation strategies are necessary in order to motivate a coherent and sustainable implementation of AVs.

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