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

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Abstract

Automated vehicles (AVs) are expected to become integrated into mobility systems around the world within the coming years. The implementation and integration of AVs will have far-reaching societal, environmental and economic implications. However, the specifics of these implications are still unknown. Using survey data collected among residents in Greater Sydney, Australia; Greater Montréal, Canada and the Randstad, the Netherlands, this paper presents an investigation into individuals` willingness to adopt privately owned automated vehicles (PAVs) and shared automated vehicles (SAVs). The effects of personal characteristics and geographic features, as for example home region, are also identified.

The results reveal that perceptions about safety, personal gains, societal gains, sharing and optimism about technology play a significant role in the likeliness to buy a PAV or use a SAV. For both PAV and SAV adoption, understanding potential personal gains and safety improvement increase the likeliness to buy a PAV or use a SAV. The results of the analysis also suggest that age has a significant effect on the likeliness to buy a PAV or use a SAV. Having a carsharing membership has a significant effect on the likeliness of using a SAV and the number of cars in the household has a significant effect on the likeliness of buying a PAV. Home region has a significant effect on the likeliness to use a SAV, but not on the likeliness to buy a PAV. Respondents living in the Randstad significantly differed from the respondents living in Sydney. A lower odds of using a SAV suggests people in the Randstad are less likely to use a SAV. The findings suggest there may be differences between regions so policy-makers should look at region-specific factors.

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 (Ross, 2016). In February 2022 the first self-driving taxis by General Motors were available for hire in San Francisco as a test ride (Autoredactie, 2022). Automated vehicles (AVs) are expected to be 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 (Milakis et al., 2015). These implications are yet unknown for the simple reason that AVs for ordinary usage do not yet currently exist (Harb et al., 2018). What is known, is that there is a certainty that human behaviour will be central to determining Av adoption. For example, Calthorpe and Walters (2017) state that every new transportation technology affects the geography of communities and the structure of human`s lives. The widespread availability of AVs will likely remake and reshape the metropolis once again. An experiment by Harb et al. (2018) revealed that most significant importance in potential AV adoption is not having to be behind the wheel personally driving the car or even to be in the car at all as it travels from one place to another. This feature will arguably cause the most change in travel behaviour. The focus in most research is on this full automation, or level five of the driving automation levels as provided by The Society of Automotive Engineers [SAE] (2014). This research is looking into full automation well.

The aim of this research is to gain insight into how potential users of privately owned automated vehicles (PAVs) and shared automated vehicles (SAVs) are characterised. The research is scientifically relevant because the results add to the literature since little research is done on the subject. The research is socially relevant because policy can be adjusted when it is more clear who is willing to buy a PAV or use a SAV. Policy makers and transportation planners can use the results to better plan and prepare for the integration of both PAVs and SAVs.

The main research question reads as follows:

What explains the individuals` likeliness to buy a privately owned automated vehicle or use a shared one, and to what extent do individuals` personal characteristics and cultural and geographic features at their home location play a role?

In order to answer the main research question, the following sub questions are composed:

1. Are certain cultural and geographic features (e.g. home region) determinant of the likeliness to buy or share an AV?
2. Which personal characteristics (e.g. age and gender) explain the likeliness to buy a privately owned AV or use a shared one? Are there differences between the two AV modes?
3. Which perceived advantages and disadvantages of AVs play a role in the likeliness to buy or share an 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 after which the final section presents a discussion, conclusions, 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 function 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 (Milakis et al., 2015). 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 (Society of Automotive Engineers, 2014). Whereas the SAE segmented vehicle automation into six levels, the NHTSA segmented into 5 levels. The levels are ranging 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(National Highway Traffic Safety Administration, 2013). Any users present in the vehicle while the ADS is engaged are seen as passengers (Society of Automotive Engineers, 2014). The SAE makes a distinction within this level between AVs which are designed to function under specific conditions and AVs which function under any given condition. Fuel type is not mentioned in the 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 (Milakis et al., 2015).
Childress, Nichols, Charlton & Coe (2015) state 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 more suburban context. This increased accessibility is a huge societal benefit of AVs (Hörl et al., 2016). This does depend on the affordability of the AVs (Brown et al., 2013).

Secondly, the introduction of AVs is estimated to reduce the need for conventional infrastructure investments due to traffic flow efficiency significantly improving because of a decrease in time gap between vehicles. This might also increase traffic capacity and therefore reduce the need for further road expansions (Milakis et al., 2015).

The implementation of AVs could significantly reduce the amount of space needed for parking in urban areas. Parking will change because after dropping of its passengers, a vehicle could drive itself to a car park outside the urban area where space is not scarce (Begg, 2014). AVs could be parked close together since there would be no need to open doors. If people make use of a SAV instead of privately owning one, this would reduce the amount of parking space even more. Even at peak usage time, only 12% of vehicles are on the road in urban areas, so in a shared-use model there could be many fewer total vehicles at a given time, reducing pressure on parking (Brown et al., 2013). The movement of the AVs towards a car park outside the urban area would mean the AVs travel empty, which needs to be implemented into the transportation system and leads to an increase in vehicle-miles travelled (VMT) (Kolekar et al., 2020).

The implementation of AVs could as well make traffic safer. Vehicle automation technology could prevent common vehicle accidents caused by human error in judgement (Brown et al., 2013). The AVs are potentially more reliable and would be less affected by distractions like tiredness, consumption of alcohol or distracting passengers. Research shows that humans will only trust an AV if it behaves like a human, but Fagnant and Kockelman (2015) state that in the US, driver error is believed to be the main reason behind over 90% of all crashes (Kolekar et al., 2020). 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 like pedestrians and cyclists, or animals crossing the road (Begg, 2014). If AVs can provide the same traffic in less space, there is more space left that can be converted to pedestrian or bicycle uses, which could further improve their safety (Milakis et al., 2015). This conversion into for instance pedestrian area does cost money.

The introduction of AVs and especially SAVs are expected to reduce the need for conventional public transport (Milakis et al., 2015). If the SAVs are inexpensive enough it could compete with the public transport, especially attracting people who are currently unable to drive (Brown et al., 2013). It even could make public transport obsolete, particularly in areas with lower densities. This does, again, depend on the affordability of the AVs (Brown et al., 2013).

The implementation of AVs may also effect transportation energy consumption. The electric AVs have a high energy efficiency, reduce CO_2 emissions and fuel consumption, leading to a better air quality (Brown et al., 2013). On the other hand, automated vehicles could also lead to increased fuel consumption, as a result of the longer distances driven and higher speeds. The gains are only likely if the AVs are electric and the electricity is sustainable.

As will be discussed in the next part of this section, Harb et al. (2018)and Lavieri et al. (2017) state that the implementation of AVs may affect the modal share. If this means a decrease in active transport, this influences health as well. The better air quality because of reduced pollution benefits health (Brown et al., 2013).

2.3 Change in vehicle-miles travelled

The implementation of automated vehicles has potential impact on persons as well. Again, this impact largely depends on the penetration rate of automated vehicles(Milakis et al., 2015). Researchers seem to agree that AVs will increase individual vehicle-miles travelled (VMT) and change travel and activity patterns (Harb et al., 2018). These changes occur because of several possible reasons. The increase of individual VMT may first of all be caused by the fact the vehicle can be used empty (Fagnant & Kockelman, 2015). The car can be send away to pick up groceries or park itself. The VMT may also increase because of the change in perceived and actual travel time (Childress et al., 2015). The actual travel time may reduce due to less congestion because of increased road capacity and the perceived travel time reduces because of increased comfort and productivity (Harb et al., 2018). These changes lead to an increase in the total amount of trips and the decreased perceived travel time leads to people traveling further (Childress et al., 2015). According to Harb et al. (2018) the VMT may also increase because of the convenience of AVs. The vehicle can be used for a longer time period, during the night when people are more afraid to drive themselves or when under influence of alcohol. The activity and travel patterns change due to the new mobility possibilities.

Literature is not aligned on the effect of implementing AVs on the modal share. Harb et al. (2018) state that walking can decrease because the AV replaces these walks, but walking can increase as well due to a more active lifestyle represented by the greater amount of trips. Lavieri et al. (2017) state that for especially people who are "green" the AV might take away modal share from walking, cycling and public transportation. A decrease in active transport would have a negative effect on the societies health whereas an increase in walking due to a more active lifestyle would have a negative effect on the societies health (Brown et al., 2013).

2.4 Differences because of personal characteristics

The literature reveals that differences in the likeliness of AV adoption may occur because of personal characteristics. Harb et al. (2018) shows a difference between different household types and different age groups. A difference between gender is found as well (Becker & Axhausen, 2017; Schrauth et al., 2021). Males tend to state a higher acceptance of AVs than females and results indicate a higher acceptance among younger respondents. Childress et al. (2015)found no difference in impact for different income groups on perceived accessibility. Lavieri et al. (2017) however do show a difference between different 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) state that persons with a higher educational level tend to adopt or use technology quicker. Lavieri et al. (2017) found that education did not have a statistically significant impact on the interest in AV sharing or ownership in their research.

2.5 Differences because of environmental characteristics

Becker and Axhausen (2017) state a difference between people who live in different urban densities. Lavieri et al. (2017) underline this influence of density in the effect of implementing AVs. Their research shows that residence in neighbourhoods with a higher density were more likely to favour AV sharing. The region or metropolitan area people live in may influence their view on AVs as well; areas may have different cultures. Many studies distinguish between individualistic and collectivist cultures; individualists see themselves as autonomous individuals and collectivists see themselves as part of a group (Dykstra & Fokkema, 2012). Northern European countries are generally characterized as individualistic, so this is the common culture in The Randstad as well. Literature shows Australia and Canada don`t differ in their culture, so people in Sydney and Montréal are individualistic as well (Gerlach et al., 2018; Noordin & Jusoff, 2010). The Canadians are self-focused and prioritise individuals goals. By looking at individualism-collectivism scores, Hofstede et al. (2010), reveal Canada and the Netherlands both have a score of 80, while Australia has a score of 90. This means Australia is seen as more individualistic than Canada and the Netherlands.

3. Data and methods

3.1 Data

The data for this study was collected using an online survey in June 2021. Because there might be differences between countries and regions, this research is done in three different metropolitan areas in three different countries. These are 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 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 transportation mode between the three countries. Walking and cycling are far more common in the Netherlands than Australia and Canada (Bassett et al., 2008). 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. Since the definition of an automated vehicle is not specified in the used survey, an automated vehicle is in this research seen as a vehicle which can drive to a destination defined by its passenger, without the assistance of a driver or user.

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. A weigh 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 population 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 done separately for every region. The categories for the variable household composition were recoded to ensure valid cell frequencies as well. Respondents could give multiple answers but were assigned to the category which was assumed to influence their lives the most. Respondents who for example lived with their children (18 or younger) and another composition were assigned to with children (18 or younger). 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 urbanisation was generated by calculating the ratio between the number of addresses (household) and the surface area in square kilometre for every three or four digits postal code area, by using OpenStreetMap, and associate this to the respondents, according to their postal code. The ratio was classified and calculated to approach the definition of degree of urbanisation by Centraal Bureau voor de Statistiek (2022b).

Table 1: Summary characteristics.

		Sydney (*N*= 277)		Montréal (*N*=808)		Randstad (*N*=355)		Total (N=1440)
Variables	**Definitions**	***N* (%)**	**Exp. *N* (%)**	***N* (%)**	**Exp. *N* (%)**	***N* (%)**	**Exp. *N* (%)**	***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 & 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)
	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)

Table 1. *Cont.*

Variables	Definitions	Sydney (*N*= 277) *N* (%)	Exp. *N* (%)	Montréal (*N*=808) *N* (%)	Exp. *N* (%)	Randstad (*N*=355) *N* (%)	Exp. *N* (%)	Total (N=1440) *N* (%)
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 minutes	73 (26.4)		321 (39.7)		132 (37.2)		526 (36.5)
	More than 30 minutes	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

Note. Data Exp. *N (%) retrieved from:* Australian Bureau of Statistics (2017), Statistics Canada (2017) & (Centraal Bureau voor de Statistiek, 2022a).

3.2 Methods

Using a series of binary logistic regression models, this research assesses individuals` likeliness to buy a PAV and the likeliness to use a SAV. The dependent variables (Likeliness to buy a PAV and likeliness to use a SAV) were collected using a 7 point scale and transformed into binary outcomes (see Figure 3.1 and Figure 3.2). Respondents are either likely, or not likely to buy a PAV or use a SAV. Recoding scale questions as dichotomous variables is common practice (Gagliardi et al., 2004; Gomez et al., 2019), and examples include Pontes & Griffiths (2015) recategorization of individuals having a gaming disorder or not, as well as Nusbaum et al. (2000) 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 adequate cell size for analysis with an even distribution, respondents who answered neutral are recoded to not no as well(Xiao & Barber, 2008). They may as well be in doubt whether to accept the technology, which makes them suit better to the not no answer.

Figure 3.1: Percentage of respondents` likeliness to buy a PAV.

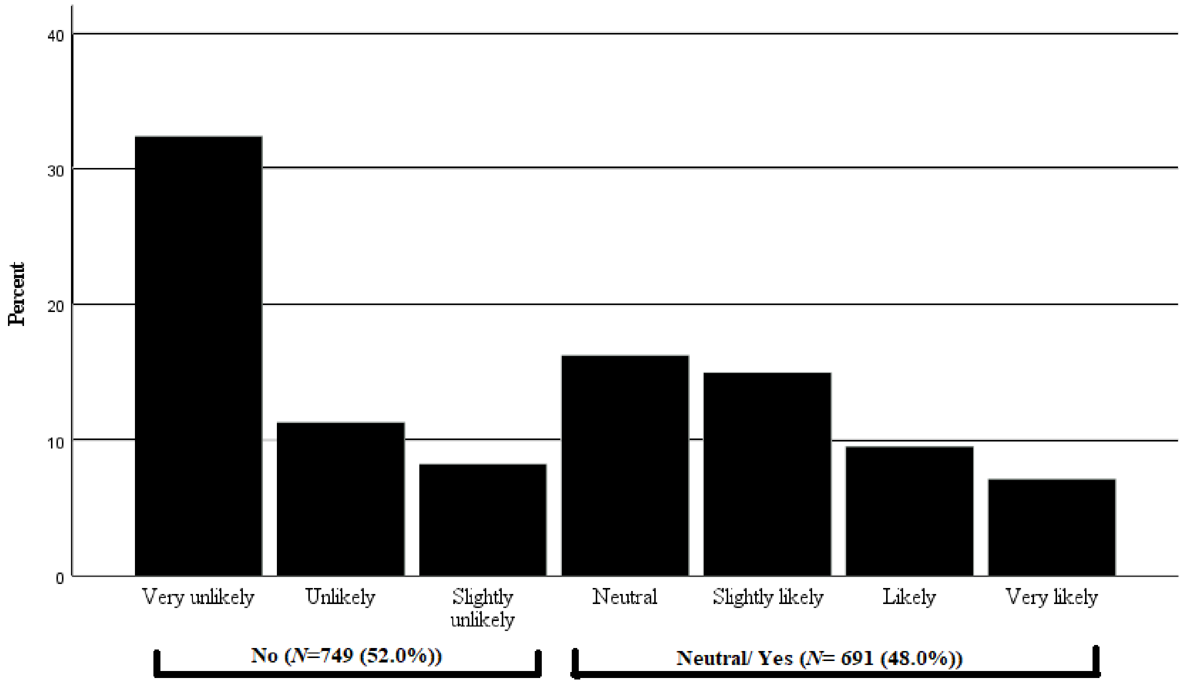

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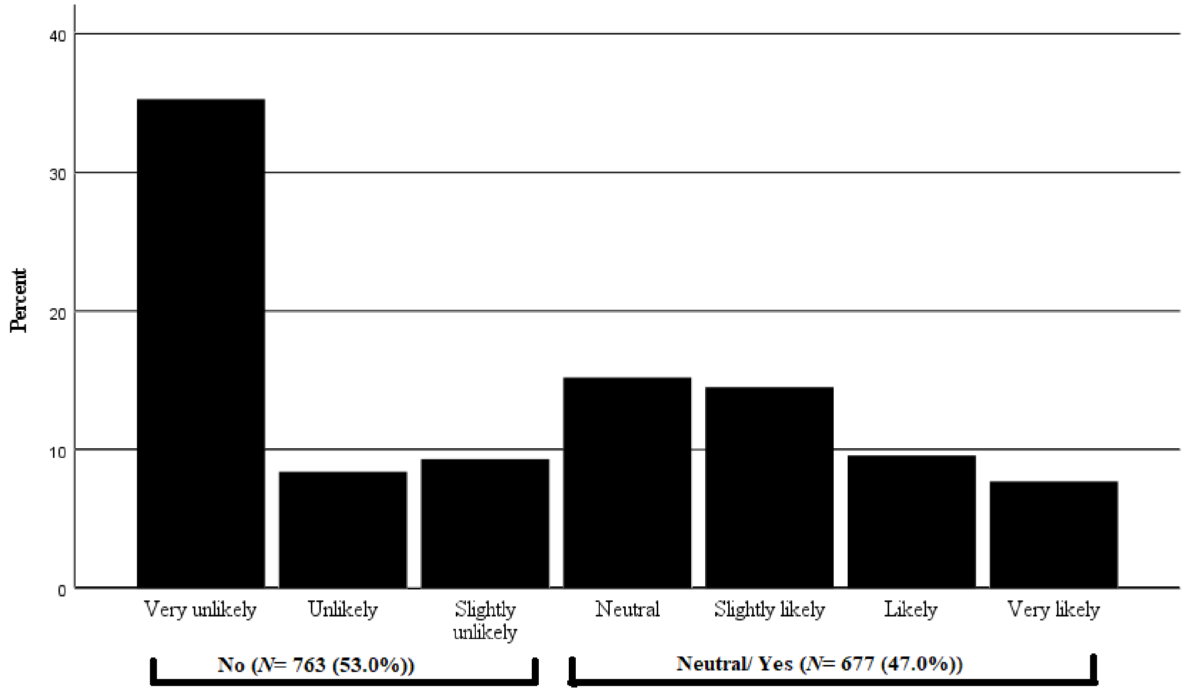
Figure 3.2: Percentage of respondents` likeliness to use a SAV



The relationship between individuals willingness to use a SAV or PAV, their personal characteristics, land use density at their home address, their home region, as well as their opinions about AVs is tested. The analysis is done in SPSS. Table 2 presents the results of the exploratory factor analysis which is applied to the original survey questions of the respondents` stated preferences to reduce the number of observed variables into fewer dimensions. In this way, multiple questions from the survey can be taken into account to say something about for instance safety. By doing a principal components factor analysis with varimax rotation, 6 significant latent factors from 21 variables, with respondents` ratings on a 7-point scale ranging from "totally disagree" to "totally agree", were extracted. The Cronbach`s α (Cronbach`s $\alpha = 0.854 > 0.7$) indicated an internal consistency among the indicators. The outcome is six factors; safety, personal gains, societal gains, sharing, tech optimism and AV tech scepticism.

Table 2: Derived factors.

Factors	Indicators	Loadings
Safety	*Self-driving cars will make motorized traffic safer*	0.785
	Self-driving cars will make traffic safer for pedestrians	0.890
	Self-driving cars will make traffic safer for cyclists	0.892
	Self-driving cars will make it safer for animals to cross roads and highways	0.815
Personal gains	*If I used a self-driving car, I would be less stressed than driving myself*	0.640
	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 miss the feeling of being in control while driving	-0.630
	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 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
Societal gains	*Self-driving cars will lead to less pollution*	0.591
	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
Sharing	*If I used a shared self-driving car, similarly to a taxi, I would be open to sharing the vehicle with strangers*	0.882
	If I used a shared self-driving car, similarly to a taxi, I would feel safe sharing with strangers	0.889
Tech optimism	*In my day-to-day experience, people are good drivers*	0.609
	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
AV tech scepticism	*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
	Self-driving cars will reduce personal data privacy	0.705

Note. N = 1440.

Binominal regression models were used stepwise to assess individuals likeliness to buy a PAV or use a SAV. Model 1 only consists the home region as independent variable for the chance of buying or using an PAV or SAV as dependent variable. Model 2 builds upon this by adding the relevant personal characteristics. Model 3 also includes the retrieved factors. Variables which were not significant (Sig. > 0.05) for both the PAV and the SAV model, were left out of the models.

4. Results

4.1 Descriptive results

The data set 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 a SAV (53.0%). But 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 ($X^2(2)= 19.945$; $p= <0.001$) and the likeliness to use a SAV ($X^2(2)= 21.144$; $p= <0.001$).

Table 3: Frequencies dependent variables.

Variables	Definitions	Sydney (N= 277) n (%)	Montréal (N= 808) n (%)	Randstad (N= 355) n (%)	Total (N= 1440) 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 a 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)

Respondents living in the Sydney region are more unlikely to use a SAV (56.3%) than to buy a PAV (51.6%). This difference is not there for the respondents in the Randstad region and is only very little for the Montréal respondents. This suggests that people in Sydney tend to be more sharing averse compared to buying one, compared to people in the other regions. This finding is in line with theory by Hofstede et al. (2010) stating the Australians as more individualistic than the other two regions. Respondents living in the Montréal region are slightly more likely to buy a PAV (52.2%) or to use a SAV (52.1%) than they are unlikely to buy a PAV (47.8%) or use a SAV (47.9%). Respondents living in the Randstad region have a more clear likeliness than respondents for the other regions. Sixty-two percent of the respondents for the Randstad are stating they are unlikely to buy a PAV or use a SAV. The same results for both the PAV and the SAV suggests that if respondents in the Randstad are unlikely to adopt AVs, the difference between a private vehicle or a shared one is not relevant.

4.2 Model results

Tables 4 and 5 display the regression results of Model 1, Model 2 and Model 3 for both the PAV and the SAV, as well as goodness-of-fit statistics. Model 3 is used for the results section since the Nagelkerke R^2 is the highest for this model, as shown in table 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 and the “Count” columns refer to the coefficients and significance levels of the binominal modelling results. 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.

4.2.1 PAV

The results revealed no significant effect of home region on the likeliness to buy a PAV. 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 findings by Harb et al. (2018) and Schrauth et al. (2021).Carsharing membership has no significant effect on the likeliness to buy a PAV. This seems logical since this variable is more relevant for the likeliness of using a SAV; SAVs and carsharing are both part of the sharing economy. Owned cars per household 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 ($P < 0.001$). The same applies to households with two or more cars (OR = 3.870, $P < 0.001$).

The factors safety, personal gains, societal gains, sharing and tech optimism have a significant impact on the likeliness to buy a PAV. If people believe in the safety improvement by the implementation of PAVs, they are more likely to buy one. If they believe in the personal gains the PAV gives them, they are more likely to buy one. If they believe in the societal gains the PAV implementation would have, they are more likely to buy one. If people state they would be open to sharing an AV with strangers and would feel safe in doing so, they are more likely to buy a PAV. If they are optimistic about technology, they are more likely to buy a PAV. Improvement in the believes in safety and personal gains would have the largest effect; these factors have the largest odds ratios. The odds ratio for personal gains for instance means that for every extra "personal gains", the likeliness of buying a PAV compared to not buying one increases by a factor of 3.030. These odds ratios suggests that convincing people from the safety improvement the implementation of AVs has, and convincing them from the personal gains they could have when buying a PAV, would have the largest effect in the likeliness they would buy a PAV. Scepticism about AV technology has not significant effect on the likeliness to buy a PAV. People may be sceptical about their data privacy or tracked location, but this does not significantly influence their likeliness to buy a PAV.

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

	Model 1		Model 2		Model 3		
	Count	Std.err.	Count	Std.err	Count	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)***		

Note. "*" $p < 0.05$; "**" $p < 0.01$; "***" $p < 0.001$.

4.2.2 SAV

The results revealed a significant effect of home region on the likeliness of using a SAV. This was not the case for the PAV model. Living in the Randstad is found to have a negative effect on the likeliness to use a SAV. Living in the Randstad makes the odds of using a SAV 40% smaller compared to Sydney, which is a significant difference. The model reveals living in Montréal means the odds of using a SAV is bigger compared to Sydney.

Age has a significant effect on the likeliness to use a 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 smaller odds of using a SAV compared to people between 19 and 36 years old. Where for PAV people between 36 and 50 years old have no significant difference with the reference group, this is the case for SAV. This suggests that these 36 to 50 years old are more likely to use a PAV than a SAV. This difference has not been described in literature before. Carsharing membership has no significant effect on the likeliness to buy a PAV, but does have a significant effect on the likeliness to use a SAV. The positive effect is significant ($P < 0.001$) with an odds ratio of 3.750 which means the odds of using a SAV for people who have a carsharing membership is almost 4 times the odds of someone who has no carsharing membership. This result seems logical because having a carsharing membership implies you are willing to share a vehicle. Owned cars per household does not have a significant effect on the likeliness to use a SAV. This effect is significant for PAV which means that the amount of owned cars per household is relevant when looking at the likeliness of buying a PAV, but this is not relevant when looking at the likeliness of using a SAV.

The factors safety, personal gains, societal gains, sharing and tech optimism have a significant impact on the likeliness to use a SAV. This is the same for the PAV model and the effect is up here as well positive; if the factors get a higher coefficient, they are more likely to use a SAV. Personal gains is, in this model as well, the factor with the highest odds ratio suggesting that convincing people from the personal gains they could have by using a SAV would have the biggest effect in the likeliness they would use a SAV. Scepticism about AV technology has, similar to the PAV model, no significant effect on the likeliness to use a SAV. People may be sceptical about their data privacy or tracked location, but this does not significantly influence their likeliness to use a SAV neither.

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

	Model 1		Model 2		Model 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
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)***		

Note. “*”p < 0.05; “**” p < 0.01; “***” p < 0.001.

5. Discussion and conclusion

Using survey data collected among residents in Sydney, Greater Montréal and the Randstad, this paper presented an investigation in reasoning why certain individuals would be willing to adopt either SAVs or PAVs. The main goal of the study was to explain individuals` likeliness to buy a privately owned 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.

5.1 Personal gains

For both the PAV and the SAV, understanding the personal gains the usage could lead to, gives the highest improvement in the likeliness to buy a PAV or use a SAV. This is in line with the finding by Harb et al. (2018) that not having to be behind the wheel personally has significant importance in potential Av adoption. The analysis suggests the potential impact on persons found in several other studies (e.g., Childress et al., 2015; Fagnant & Kockelman, 2015; Harb et al., 2018) may be important for the implementation of the AV. The expected personal gains should be possible to realise and potential users should be aware of the possible personal gains.

5.2 Personal characteristics

The analysis suggests that, consistent with what Harb et al. (2018) and Schrauth et al. (2021) revealed, age does have a significant effect on the likeliness to buy a PAV or use a SAV. The PAV model showed older people tend to be less likely to buy a PAV than people under 50 years. The SAV model showed people from 36 years or older are less likely to use a SAV than people between 19 and 35 years. This suggests that these 36 to 50 years old are likelier to use a PAV than a SAV. This means that as people age, the less likely they adopt AVs. Policy-makers should focus on younger people where the likeliness is higher. This is especially the case for SAV adoption.

For both modes there was no significant effect of gender, household type, household income, educational level or employment status on the likeliness to buy a PAV or use a SAV, as proposed by some of the literature (Becker & Axhausen, 2017; Harb et al., 2018; Lavieri et al., 2017; Schrauth et al., 2021; Seebauer et al., 2015). The results add a more robust understanding in different cultural contexts to the mixed findings in the literature.

The analysis revealed having a carsharing membership has a significant effect on the likeliness of using a SAV, but not on buying a PAV. This seems logical since having a carsharing membership suggests people are willing to share a car. The amount of owned cars had a significant effect on the likeliness of buying a PAV, but not on using a SAV. Owning one or more cars made a significant difference in the likeliness of buying a PAV compared to not owning a car. This seems logical since owning a car means that one day you probably replace it.

5.3 Regional differences

The results revealed a significant effect of the home region on the likeliness to use a SAV, but not on the likeliness to buy a PAV. Respondents living in the Randstad significantly differed from the respondents living in Sydney. Their odds of using a SAV was found lower than Sydney which suggests people in the Randstad are less likely to use a SAV. Where scores by Hofstede et al. (2010) revealed Australians can be seen as more individualistic than the Dutch, the results show respondents in the Randstad are less likely to use a SAV than the respondents in Sydney. Difference in transportation mode between the countries as shown by Bassett et al. (2008) might influence this difference since walking, cycling and the usage of public transport are more common in the Netherlands. Influence of for instance this transportation mode differences onto the difference in likeliness of buying a PAV or using a SAV requires further investigation. The descriptive results suggests that people in Sydney tend to be more sharing averse compared to buying one, compared to people in the other regions. This finding is in line with theory by Hofstede et al. (2010) stating the Australians as more individualistic than the other two regions. The lower odds of using a SAV for people in the Randstad compared to Sydney suggests people in the Randstad are less likely to use a SAV than people in Sydney. This is not in line with the theory by Hofstede et al. (2010).

5.4 Factors

The factors safety, personal gains, societal gains, sharing and tech optimism have a significant impact on the likeliness to buy a PAV or use a SAV. This effect is positive; if the factors get a higher coefficient, they are more likely to use a SAV. The odds ratios of the factors are higher compared to the other variables in the models. This means the factors are most important for the likeliness to buy a PAV or use a SAV and they should be investigated further.

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 a SAV. It could be that the effect of the other independent variables in the model differs per region. Therefore, future research could consider remaking the models for every region separately in order to find out whether independent variables have a significant effect for just this region instead of the three regions taken together. In addition, future research could be conducted in additional different cultural and spatial contexts, to determine how the likeliness of buying a PAV or using a SAV differs in this other context. Literature for example stated that all of the three regions can be seen as regions with individualistic cultures (Gerlach et al., 2018; Noordin & Jusoff, 2010). Repeating the research in a context with a collectivist culture might show different outcomes for, for instance the likeliness of using a SAV.

The role of the build environment and the costs of the implementation and integration of AVs could also be considered in future research. This study focusses on the human perspective but the implementation may need changes in the transportation infrastructure with appurtenant costs which should be taken into account by policy makers as well (Milakis et al., 2015). Policy should contribute to for instance the implementation of empty AVs into the transportation network as suggested by the literature(Fagnant & Kockelman, 2015).The literature study shows that AVs, and especially SAVs can improve our transportation system. The SAV may reduce pressure on space within the urban area because of a reduction in parking space and further road expansion (Brown et al., 2013; Milakis et al., 2015). The accessibility and inclusion may improve due to new mobility opportunities (Childress et al., 2015).

The findings of the current study suggest it is important for policy-makers to focus on clear information and promotion if the Avs get introduced. Suggested safety advantages and personal gains are factors which may affect the likeliness to buy a PAV or use a SAV the most. Information and promotion should focus on these factors to ensure society benefits the most from the implementation. SAVs should be promoted over PAVs since the literature underlines there are more advantages to sharing than to owning (Brown et al., 2013; Childress et al., 2015; Hörl et al., 2016; Lavieri et al., 2017; Milakis et al., 2015). Because of the role of the factors in the models, future research should take a closer look into these factors. Qualitative research may for instance shed light upon how people envision an AV doing errands for them. To get people into the SAVs, policy-makers could already initiate schemes to encourage people to use shared cars more in their daily travel instead of their own vehicle. The results suggest people with a carsharing membership are more likely to use a SAV, so getting more people to this memberships seems a good start. This study can also help researchers in repeating this research in other contexts. The findings suggest there may be differences between regions, so policy-makers should look at these region-specific factors and make region-specific policy since there are differences across countries as well.

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