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Mode switch in the era of driverless cars: Melbourne CBD car commuters

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Abstract

The driverless car has the potential to revolutionize commuting. This is particularly true for commuting to central business districts (CBDs) since driverless cars can drive itself to park in a nearby free parking suburb after dropping its riders in the CBD, rather than paying expensive CBD parking fees. This paper focuses on Melbourne CBD-based car commuters, aiming to understand their willingness to use driverless cars. We specifically investigated the willingness to use driverless cars based on the CBD commuters parking characteristics e.g. whether the parking fee is paid by the commuters (self-paid) or by their employers (employer-paid) using an online survey. Results indicate that, on aggregate, 54% of car commuters would opt in using driverless cars for their daily commute. However, this proportion increases to 61% for self-paid parking commuters but drops to 47.6% for employer-paid parking individuals. This suggests a significant association between current parking fee payment arrangements and the future intention to use driverless cars for CBD commute trips. Furthermore, based on the future preferred parking location and payment arrangement, while a majority of self-paid parking respondents express an intention to use driverless cars and park them for free in nearby suburbs or send them home, employer-paid parking respondents willing to use driverless cars, prefer to continue parking in the CBD at their employers expense. Residents of inner suburbs show a higher propensity to use driverless cars, likely due to higher income and educational qualifications. Implications for transport and parking policy and practice are discussed.

1 Introduction

It is widely believed that autonomous cars, also known as self-driving cars or driverless cars may substantially change our current patterns of conventional car use. Research findings indicate that fully automated driverless cars have the potential to take over all human-related driving tasks, offering significant advantages including but not limited to (a) improving mobility options for elderly, disabled, or non-driving individuals by enabling them to travel without actively operating a vehicle (Harper et al., 2016), (b) reducing traffic congestion along with fuel consumption and emissions (Wadud et al., 2016), (c) notably decreasing traffic accidents caused by human errors through the implementation of automated driving systems (Bansal et al., 2016), and (d) influencing travel behaviours, e.g., engaging in other activities while travelling (Singleton, 2019, Wadud and Huda, 2019), lower ownership rates of personal vehicles (Kim et al., 2020, Menon et al., 2019) and changes in trip durations and frequencies (Zhang et al., 2018). If fully automated driverless cars can perform all the driving tasks itself it can also park itself somewhere where the parking fee is substantially cheaper or free after dropping off its riders at their destination point and then come back again to pick them up. This feature could also change travel behaviour, especially parking choices at the destination end like central business districts (CBD) where land price and parking costs are high and parking dominates land use.

According to the Australian Bureau of Statistics (ABS) Census 2016[1] data, 436,752 people commute to work in Melbourne CBD of which 27% (116,796) commute by car as a driver (ABS, 2024a). These commuters park their car in on-street or off-street car parks where parking fees are very high. The City of Melbourne Census of Land Use and Employment (CLUE) data shows that in 2022, in Melbourne CBD, both private and commercial parking comprises a total floor space of 1.62M square meters which is consecutively the fourth and fifth largest floor space use among all types of usage (Melbourne, 2024a). This indicates a very large availability of parking spaces in CBD which attracts car commuters to park their car and then walk to their nearby workplaces. However, fully automated driverless cars can directly drop off its rider at their workplace doorstep avoiding the extra amount of walking from the parking lot to their workplace and then park in the nearby suburb for free or go back to home rather than paying high parking fees at CBD. This may significantly change the travel and parking behaviour of Melbourne CBD car commuters. Consequently, any change in parking behaviour may substantially change land-use, land-use policy, parking policy and long-term planning for parking facilities in CBDs. Thus, it is crucial to gain a comprehensive understanding of how CBD-based car commuters will adjust their travel and parking choices in the era of driverless cars.

This paper aims to understand how driverless cars will impact the travel mode choice and whether parking arrangement influences the mode switch behaviour of Melbourne CBD car commuters. To facilitate our understanding, this paper reports the findings of a large-scale survey of Melbourne CBD car commuters to explore their current travel and parking behaviours and future travel behaviour under driverless cars. Several interlinked research questions are investigated for this purpose:

a) Will Melbourne CBD car commuters switch to driverless cars?

b) How do the Melbourne CBD car commuters park their car and pay for their parking fees in the present scenario?

c) How would CBD-based driverless car commuters park their car in future and how will this impact mode switch behaviour?

d) What trip, socio-demographic and socio-economic characteristics are associated with this travel mode switch behaviour?

The paper is organized as follows, section 2 discusses the research context, section 3 presents the research methodology, section 4 presents and discusses the research findings and section 5 concludes the paper.

2 Research context

2.1 Relevant literature

A range of research explores the intention to use driverless cars. Payre et al. (2014) explored the attitudinal intention to use fully automated driverless cars among 421 French drivers through an online questionnaire and reported that two-thirds of the participants wanted to use them. In their study, the researchers mentioned that the intention depends on the road type and driving environment. Participants preferred using driverless cars on highways, congested road conditions, and for automated parking. Through a public opinion survey in three different countries, the USA, the UK and Australia, Schoettle and Sivak (2014) examined the intention of having self-driving vehicle technology in individuals' next car. They reported that the respondents who had heard about the technology before had a positive opinion of having this technology in their car although they expressed high levels of concern for the security of such

[1] We used census 2016 data instead of the latest census 2021 because the 2021 census data is impacted by COVID-19 and thus can’t reveal the actual travel pattern by car commuters.

technology. Female respondents in particular expressed higher levels of concern and were more cautious regarding the benefits of using self-driving cars than their male counterparts.

In a systematic review of behavioural intention to use autonomous vehicles, Keszey (2020) reported that the intention significantly differs with the level of personal information technology innovativeness of respondents. Keszey reported that when it comes to the adoption of using autonomous vehicles, the behavioural intent of innovative users is impacted by specific technological apprehensions such as data privacy concerns, whereas laggards' adoption decisions are more influenced by general technological anxieties rather than specific issues. In another review paper, Golbabaei et al. (2020) studied individual predictors of public acceptance of and intention to use driverless vehicles. The authors reported that public perceptions and adoption intentions vary significantly among different socio-demographic cohorts. The authors emphasized that commuters prioritize various aspects related to autonomous vehicles which in turn influence their attitudes towards acceptance and adoption of such vehicles. In addition, prior experience of driverless cars coupled with education and direct communication, can effectively shift people's attitudes towards driverless car in a favourable direction.

Anania et al. (2018) studied the effects of different types of information provided for driverless cars on consumers' willingness to ride them. The authors reported that positive information about driverless cars encourages individuals to ride them while hearing negative information decreases willingness. Clayton et al. (2020) studied the willingness to use autonomous vehicles in the UK and reported that significant uncertainty lies in the adoption of such vehicles. The authors reported that half of their respondents were unwilling to use driverless cars either as a personal transport mode or for shared usage.

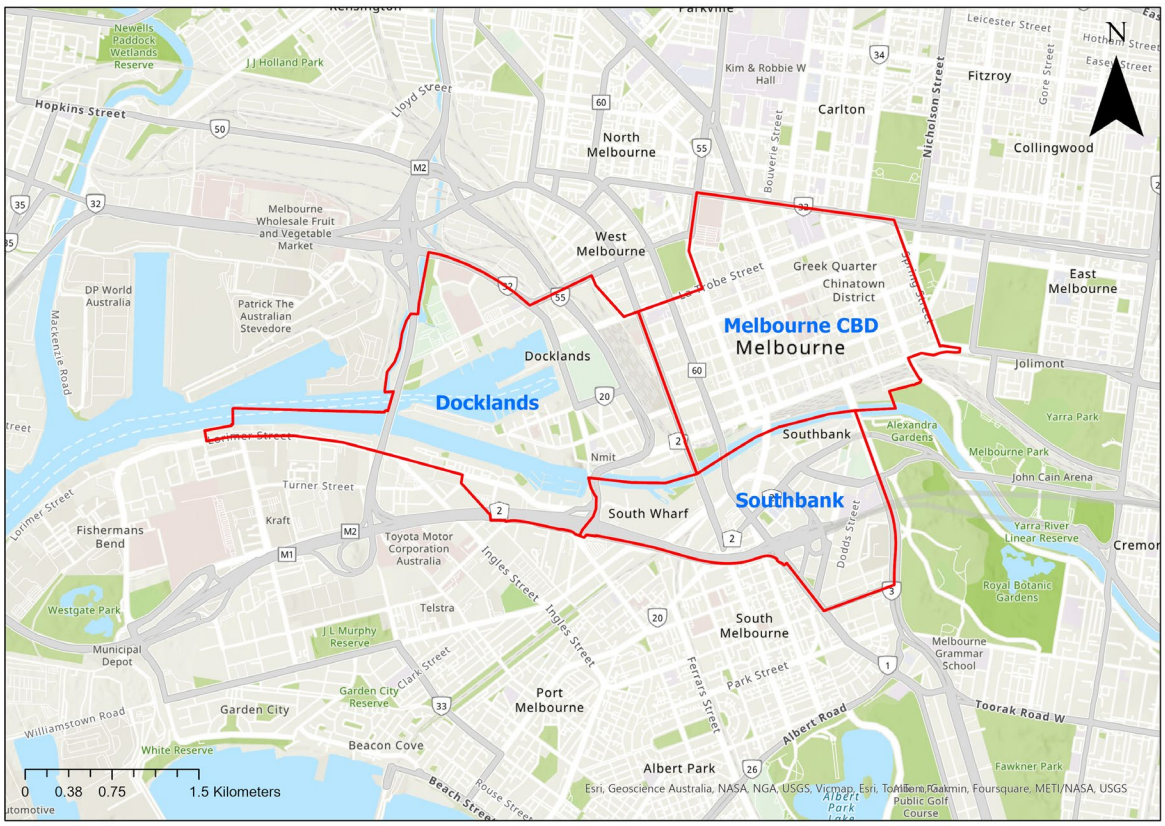
A literature scan on the preffered parking of driverless cars resulted in very few articles as parking have been more focused on conventional vehicles rather than driverless cars. Millard-Ball (2019) studied the parking behaviour of driverless cars through a traffic microsimulation model and reported that driverless cars can implicitly coordinate to reduce the cost of cruising for parking through self-generated congestion in city centres as cruising is less costly at lower speeds. Thus, rather than paying for parking in urban cores, driverless cars might choose to cruise around the city centres for short-term parking or go back home for long-term parking which in both cases results in increasing empty vehicle miles travelled (VMT). Zakharenko (2016) also reported that with driverless cars, per kilometre travel costs are reduced substantially and as such, daytime parking might move to peripheral locations leaving CBD land area to be used for other purposes. Ye et al. (2022) studied the parking choice behaviour of shared driverless cars by measuring users' intention to use them. Researchers reported that the main factors that determine the travellers' choice of parking are travel time, travel cost, parking cost, cruising cost, and parking time. From an economic perspective, Fagnant and Kockelman (2015) stated that if 10% of total adopted driverless cars are publicly shared that could save $250 per new driverless car. Su and Wang (2020) explored distant parking options for morning commuters suggesting driverless car users might opt for shared usage of parking in CBDs rather than permanent whole-day parking or cruising for peripheral parking or home parking regardless of higher total travel cost. Correia and van Arem (2016) examined the overall effects of replacing conventional private vehicles with driverless cars and how this transition impacts parking demand in urban areas. They addressed a user-centric assignment problem concerning privately owned driverless cars, dynamically allocating family trips in driverless cars based on user equilibrium principles. In a more recent research, Bahrami et al. (2021) assessed parking strategies using agent-based simulations for driverless cars, assuming individuals minimize their total parking expenses following Wardrop equilibrium principles. They explored how changes in parking fees influence overall vehicle kilometres travelled.

Previous studies focusing on driverless car parking have commonly neglected to analyze the parking decision-making process from a behavioural viewpoint. While numerous studies highlight the advantages of driverless cars in various parking scenarios, they frequently fail to quantify the preference of individuals to ride them. In addition, to the best of our knowledge, no studies have studied the preference or intention to use or ride a DC based on parking location. Thus, comprehending the travel mode switch based on parking behaviour is crucial for crafting efficient travel and parking policies as well as tackling the challenges associated with land use. Therefore, this paper represents the first study to examine the travel mode switch behaviour of driverless car users together with parking through a large-scale online survey conducted on Melbourne CBD-based car commuters.

2.2 Melbourne CBD car commuting and parking context

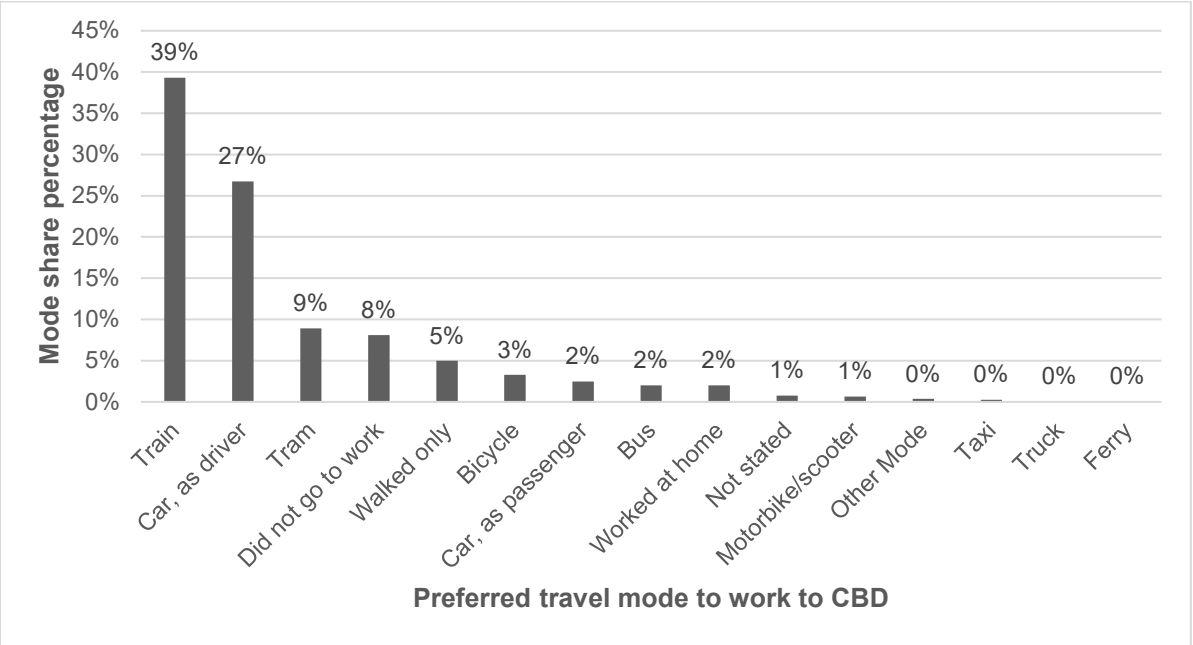
The Melbourne Central Business District (CBD), as illustrated in Figure 1, stands as Metropolitan Melbourne's largest employment centre, hosting 228,795 jobs as of 2022 (Melbourne, 2024a). This substantial job count draws a significant number of commuters utilizing various modes of transportation to reach the CBD daily. According to the 2016 census journey-to-work (JTW) data, as illustrated in Figure 2, driving a car ranks as the second most popular mode of transport for Melbournians commuting to the CBD, accounting for 27% of trips, following train travel at 39% and only 9% reported to use a tram (ABS, 2024a).

Figure 1: Area coverage of the Melbourne CBD, Southbank and Docklands.



The latest census data from 2021 was affected by the COVID-19 pandemic. While the 2016 census data indicates that a mere 2% of CBD workers opted for *work from home*, this figure surged to 57% in the 2021 census. This reflects the social distancing and enforced home-working measures in place at the time. Despite this, the second most popular mode of transportation for commuting to the CBD in 2021 remained driving a car (14%), with *train* travel (9%) ranking third (ABS, 2024b). On the census day of 2021, over 70,000 individuals drove their cars to work in the CBD, compared to the 117,000 reported in the 2016 census. This highlights that car driving remains a popular means of commuting for CBD workers.

Figure 2: Percentage of CBD commuters travelling by different transport modes (source: author's analysis of ABS census 2016 JTW data).



Parking capacity information can be found on the City of Melbourne website (Melbourne, 2024a). According to the website, the City of Melbourne has approximately 217,000 parking spaces around the municipality comprising both on-street and off-street spaces and also accounting for the short-term and long-term stays (Melbourne, 2024c). According to the Census of Land Use and Employment (CLUE) open data platform, there are approximately 40,000 off-street parking spaces in various private and commercial garages in the CBD in 2022 (Melbourne, 2024a). Table 1 shows the distribution of off-street parking spaces in Melbourne CBD and its nearby places e.g., Docklands and Southbank where CBD car commuters park their car. Compared to 2012, the number of off-street parking spaces reduced at CBD area by 7% (N = 2,880) and at Southbank by 10% (N = 2,093) while the number increased at Docklands by 16% (N = 2,616) with a combined reduction of 3% (N = 2,357) for these three area in 2022. In terms of on-street parking, the City of Melbourne has approximately 23,000 spaces across the municipality and around 3,400 of them are in the CBD (Melbourne, 2024c).

Table 1: Distribution of off-street parking spaces (source: (Melbourne, 2024b)).

Location	Census year	Private	Commercial	Total
CBD	2012	12,714	30,080	42,794
	2022	15,222	24,692	39,914
Docklands	2012	5,463	10,438	15,901
	2022	11,632	6,885	18,517
Southbank	2012	5,983	14,282	20,265
	2022	5,873	12,299	18,172
Total	2012	24,160	54,800	78,960
	2022	32,727	43,873	76,603

Through our investigation, we found that among a large number of CBD car commuters, some pay for their parking fees by themselves (self-paid) and for others, the parking fees are paid by their employers (employer-paid). Hamer et al. (2012) reported that 54% of CBD car commuters are from the self-paid group while the rest 46% are paid by their employers. Based

on the Victorian Integrated Survey of Travel and Activity (VISTA) 2007-08 data, we found that the distribution among the self-paid and employer-paid parking fees is very similar (55% self-paid vs 45% employer-paid). This parking fee distribution arrangement may have a significant impact on the intention to ride driverless cars in future. CBD car commuters who pay their parking fees by themselves might be more inclined to ride driverless cars instead of paying the high parking cost at CBD. Thus, understanding the travel behaviour of CBD car commuters in relation to driverless cars is of significant importance.

3 Methodology

3.1 Survey approach

The aim of this research project is to understand the intention of Melbourne CBD car commuters to ride driverless cars. An online survey using a Monash University-hosted online platform (Qualtrics) was adopted. The survey targeted respondents who live in Metropolitan Melbourne, work full-time or part-time in Melbourne CBD, drive to work and are aged 18 years and above. A sampling frame was developed to provided a good sample of CBD car commuters who paid their own parking and also a sample who had their parking paid for by their employers. The sample was also structured to cover the residential location of commuters including inner, middle and outer area residents. Table 2 shows the share of samples in the resulting quota cohorts. The share of region-based quota (inner, middle and outer) was based on the known residential share of CBD car commuters from the census. We split the self-paid and employer-paid parking quota based on the parking fee payment distribution ratio mentioned by Hamer et al. (2012). A final total sample target of 500 was defined based on sample size caculators. Sampling was undertaken by a number of methods. Two separate market research panels were used to find qualifying respondents. In addition, the sample was increased using a CBD invitation card distributed at CBD parking lots and via a Facebook online ad and social media post. The latter two methods included an incentive prize draw to encourage participation. The methodology was reviewed and cleared by the Monash University Human Research Ethics Committee.

A questionnaire was developed to explore existing commuting patterns and responses to travel and parking choices when driverless cars would be available. The questionnaire started with screening questions to identify sample cohort groups followed by questions on current commute patterns. Next, choice experiment questions were asked to respondents to choose between a conventional car (hereafter named as CAR) and a driverless car for their next commute. Each respondent addressed five-choice questions covering five choice attributes i.e. travel time, travel cost, parking cost, empty cruising cost and walk time from the parking spot to the final destination. These were pivoted to the revealed preference data that respondents provided as part of their current commute pattern. Before the choice task, the respondents were provided with an introduction to driverless cars as follows:

> "*We would like you to think about a driverless car that can safely perform all the driving-related tasks by itself, i.e., acceleration, brake, lane changing, signalling, parking, etc. much like a chauffeur-driven car.*
>
> *Once commanded, the driverless car will start automatically, pick you up from your home doorstep and drop you off at your office building. Once you reach the workplace, you can command your driverless car to park at any nearby free parking spot or send it back home for other family members to use.*
>
> *In a driverless car, you will not have to pay attention to driving. You'll be able to enjoy your in-vehicle journey time in the driverless car*."

The final section of the questionnaire survey ended with socio-demographic and socio-economic questions.

3.2 Survey data outcome

The online survey link was distributed between 19 October 2023 to 27 January 2024. 8,246 people initiated the survey within this timeline of whom 7,819 completed the screening section. Based on the screening criteria, 1,035 had finished the complete survey (the response rate is 13% based on the number of respondents who had opened and initiated the survey). Finally, based on the validation criteria set by the researchers, the final valid number of samples is **528**. The distribution of this final sample size according to the adopted sampling frame is shown in Table 2. Except for commuters who self-pay their parking fees and live in the middle local government areas (LGAs) of Melbourne, we achieved all cells criteria and exceeded most.

Table 2: Distribution of the data samples by place of residence and parking fee arrangement.

	Spatial distribution of place of residence in Metropolitan Melbourne											
	Inner			Middle			Outer			Total		
Parking fee payment type	Target	Achieved	%	Target	Achieved	%	Target	Achieved	%	Target	Achieved	%
Self-paid	51	52	102	130	106	82	89	90	101	270	248	92
Employer-paid	44	78	177	110	110	100	76	92	121	230	280	122
Total	95	130	137	240	216	90	165	182	110	500	528	106

Table 3 shows the descriptive statistics of our final survey sample. Compared to the 2016 CBD car commuters population data, our sample has some online bias having a high proportion of female respondents compared to males. In terms of education status, our sample has a high proportion of highly educated individuals compared to the census data for Metropolitan Melbourne. Respondents earning annually between $100,000 and $155,999 before any tax deduction are also in higher proportion in the sample category.

Table 3: Descriptive statistics of the survey sample (N = 528).

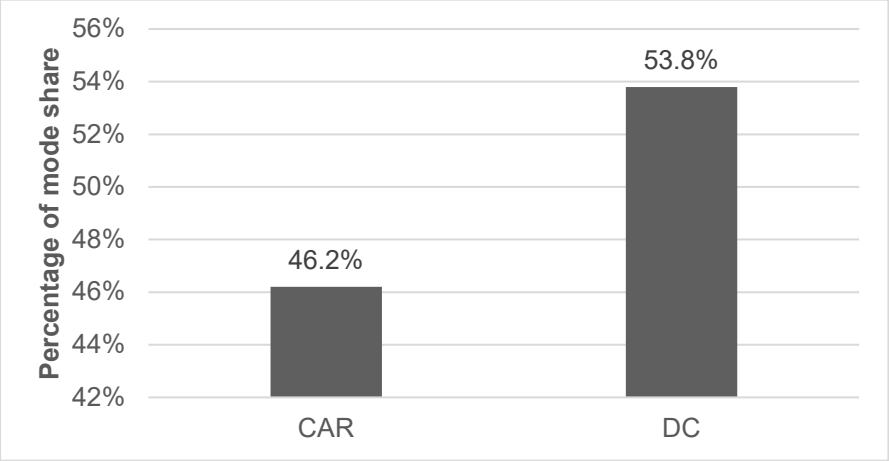
Variable	Category	Survey sample	Census Population 2016
Age	18 – 29 years	17%	18%
	30 – 39 years	36%	28%
	40 – 49 years	26%	27%
	50 – 59 years	13%	19%
	>= 60 years	7%	8%
Gender	Male	46%	60%
	Female	54%	40%
Education	Grade 12 or school certificate or lower	12%	22%
	Technical certificate or qualification	18%	26%
	Undergraduate university degree	37%	33%
	Postgraduate university degree	33%	18%
Annual Personal Income	$1 - $34,999	4%	9%
	$35,000 - $64,999	16%	28%
	$65,000 - $99,999	35%	30%
	$100,000 - $155,999	31%	16%
	$156,000 & more	15%	17%

4 Results and discussion

4.1 CBD-based car commuters switching to driverless cars

Based on the aggregate sample size (N = 528), we found that 54% of the respondents would like to ride in driverless cars in future for their daily commute to Melbourne CBD (Figure 3). This is higher than suggested in an Australian study by Schoettle and Sivak (2014) (41%). In another cross-national study conducted by Etzioni et al. (2020), the authors reported that 30% of the respondents chose to ride in driverless cars. In a more recent study performed by Hamadneh and Esztergár-Kiss (2022), the authors reported that 38% of respondents would like to ride in private driverless cars and another 30.7% would like to ride in shared driverless cars. The reason that our sample size resulted in a higher inclination to ride driverless cars could be because of the sample characteristics. While our sample size is completely focused on CBD car commuters who drive daily in the current scenario, other studies included respondents both workers and non-workers, CBD-based and non CBD-based, commuters and non-commuters, and drivers vs non-drivers. We also presume that respondents are now more inclined to use driverless cars because of their increasing level of awareness of such new technology in recent cars. Thus, we conclude that commuters who daily drive to their work in the CBD perceive better benefits of riding in driverless cars than others.

Figure 3: Mode choice distribution of the aggregate sample (N = 528).



We have disaggregated our sample based on parking fee payment arrangement i.e. self-paid and employer-paid, analysed the result and presented in Table 4. We wanted to understand whether parking fee payment has any impact on the intention to ride in driverless cars. Our analysis shows that self-paid parking individuals have a higher inclination (60.8%) to ride driverless cars while the employer-paid sample group has a higher inclination to ride their conventional CAR (52.4%) and the distribution is statistically significant with a chi-squared test ($chi^2 = 46.340$, $p < 0.001$). This indicates that self-paid respondents value the benefits of riding driverless cars more than employer-paid individuals. The implication is that those who self-pay for parking might avoid paying the higher parking cost to park a CAR in the CBD. They could send their driverless cars to either home or a nearby suburb for free parking. However, employer-paid parking fee individuals are less concerned about avoiding parking fee payments as their employer already pays these costs.

As noted earlier, one of the benefits of driverless cars is the potential to send them for free parking. We therefore explored if future parking location would have any impact on the intention of the respondent to choose their preferred travel mode. For this purpose, we categorised the preferred parking location for future driverless car riders into the following three categories:

1. Paid parking at CBD
2. Free parking at a nearby suburb, and

3. Free parking at home.

We found that the parking location is significantly associated with the intention to ride in driverless cars through a chi-squared test ($chi^2 = 152.532$, $p < 0.001$). Table 4 shows that if the parking location is under category 1 (paid CBD parking) then 57% would choose to ride a driverless car. However, if the parking location is under category 2 (free suburb parking) then the proportion to ride driverless cars increases to a significant level e.g. 81%. Alternatively, for free home parking locations, majority (55.5%) of the respondents would choose to ride their conventional CAR.

Table 4: Distribution of mode choice based on the parking fee payment arrangement.

Variable	Category	Sample size (N)	Mode selected (%)		Chi^2 result (sig.)
			CAR	DC	
Parking fee payment	Self-paid	248	39.2	60.8	46.340 (<0.001)
	Employer-paid	280	52.4	47.6	
Parking location	Paid CBD parking	187	42.9	57.1	152.532 (<0.001)
	Free suburb parking	70	19.4	80.6	
	Free home parking	271	55.5	44.5	
Self-paid	Paid CBD parking	76	47.2	52.8	80.713 (<0.001)
	Free suburb parking	70	19.4	80.6	
	Free home parking	102	46.9	53.1	
Employer-paid	Paid CBD parking	111	39.9	60.1	57.783 (<0.001)
	Free home parking	169	60.7	39.3	

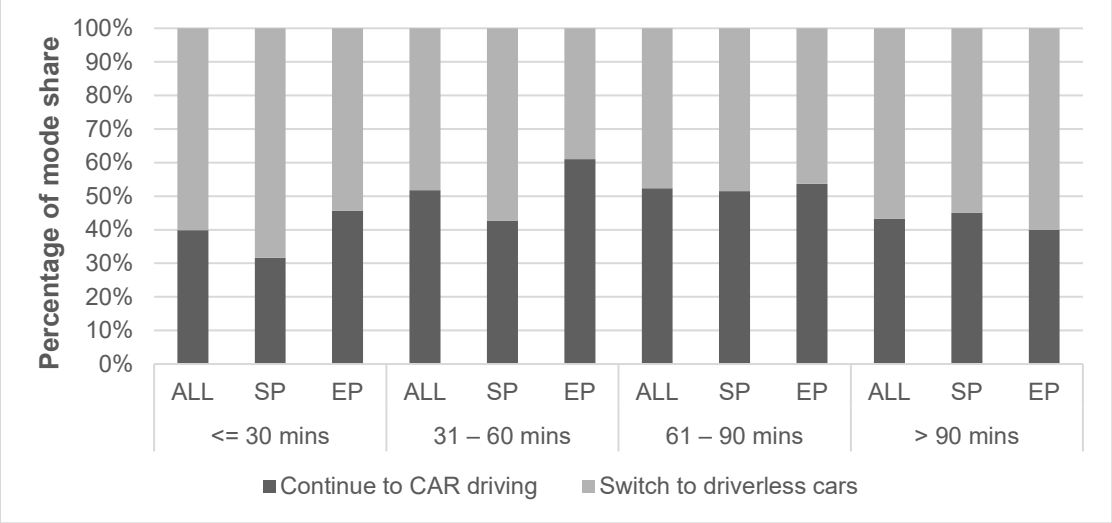
Table 4 also illustrates future parking location and driverless car usage choice intention disaggregated into self-paid and employer-paid groups. This shows that for self-paid parking, the intention to ride driverless cars is significantly higher for all three categories of parking location with the highest proportion for free suburb parking. For employer-paid parking, the proportion to choose to ride a DC for paid CBD parking is 60% while for free home parking location the proportion choosing a conventional CAR is higher (61%). This implies that for the employer-paid sample group as the parking fee payment is not a burden, mode switch distribution might depend on other factors. Employer-paid parking individuals might value their time highly for which they care to have their driverless cars close to their work location. Parking the driverless cars in the CBD would allow them to save the waiting time for the next trip rather than sending it to home for free parking. Conversely, waiting time might not be a significant factor for the self-paid parking fee individuals. Thus, self-paid individuals choose to ride driverless cars in higher proportions if the parking location allows free parking.

4.2 Effect of trip characteristics on mode switch distribution

We investigated whether trip characteristics have any impact on mode switch. In this regard, commute travel time was split into four categories; less than and equal to 30 minutes, 31 to 60 mins, 61 to 90 mins, and more than 90 mins. We performed a chi-square test to check the association of commute time duration to mode choice selection. We found that commute time duration has a statistically significant impact on mode switch both for the aggregate sample ($chi^2 = 37.594$, $p < 0.001$), the self-paid (SP) sub-group ($chi^2 = 31.013$, $p < 0.001$), and the employer-paid (EP) sub-group ($chi^2 = 23.627$, $p < 0.001$). Figure 4 shows that for the aggregate sample, 60% of respondents prefer to ride driverless cars if the commute time duration is less than and equal to 30 minutes. The proportion increases to 68% for the Self-Paid sub-group but reduces to 54% for the Employer-Paid sub-group. As commute time is

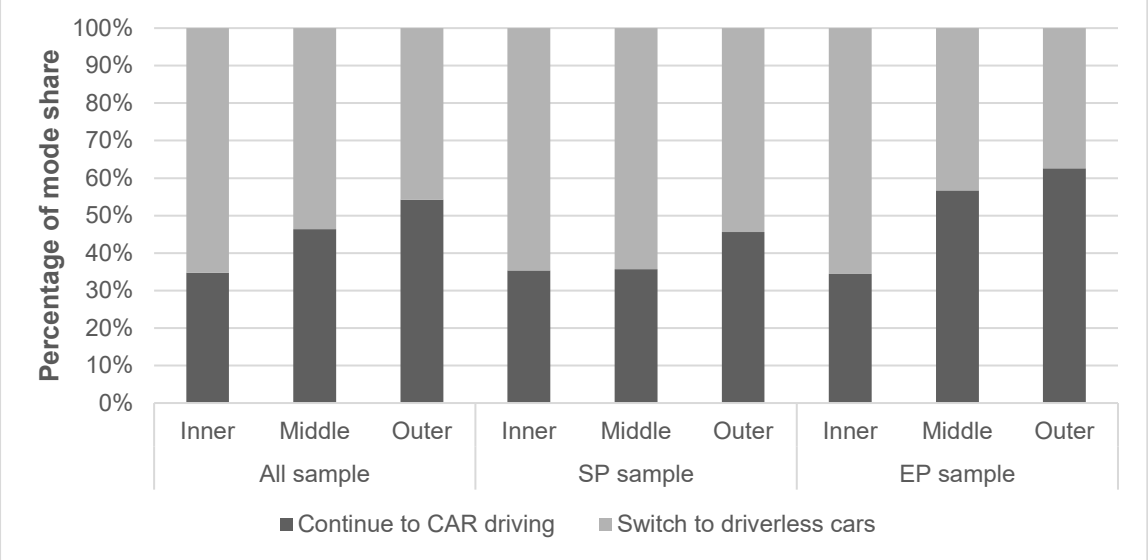
regarded as a disutility in traditional transport economics theory (Mokhtarian and Salomon, 2001), we hypothesized that with the increase in commute time, more respondents would choose to ride in driverless cars than a conventional CAR. Surprisingly, our data shows that for commute time between 31 to 90 minutes, the majority of the respondents prefer to ride their conventional CAR. However, if the commute time increases to more than 90 minutes then majority of the respondents (57% for the aggregate sample, 55% for the SP sub-group and 60% for the EP sub-group) would prefer to ride driverless cars.

Figure 4: Effect of travel time on travel mode choice selection.



We also investigated this phenomenon for the spatial distribution of respondents' place of usual residence and found that individuals living in inner Melbourne suburbs highly prefer (65%) to ride driverless cars compared to those living in other parts of Melbourne. Our analysis shows that the further people live from the CBD the intention to ride in driverless cars decreases substantially ($chi^2 = 57.473$, $p < 0.001$ for all sample, $chi^2 = 12.001$, $p = 0.002$ for SP sample and $chi^2 = 74.245$, $p < 0.001$ for EP sample group). Figure 5 shows that the intention to ride driverless cars for the next commute trip decreases substantially for the respondents who currently live in outer Melbourne suburbs. We presume that the reason could be because individuals living in inner Melbourne and requiring less commute time have higher income, higher educational qualifications and are highly aware of the benefits of driverless cars compared to the rest of the sample group. Thus this group of individuals highly prefer to ride driverless cars for their next commute trip to CBD.

Figure 5: Distribution of mode choice based on spatial distribution of place of residence.



4.3 Determinants of mode switch behaviour between self-paid and employer-paid commuters

To understand the influential factors that would impact the mode switch from conventional CAR to driverless cars, we analysed the data into two separate logistic regression models (Model 1: self-paid sample, and Model 2: employer-paid sample) and present the results in Table 5. The last column in Table 5 indicates the difference in odds ratio across the two sample groups. We interpret the changes in odds ratio, where they are statistically significant, indicating changed behaviour among the sample groups. We found that travel cost is a significant predictor for mode switch behaviour for the self-paid commuters. We also found that regardless of the value of travel cost, the probability of riding driverless cars by self-paid individuals would always be higher than employer-paid individuals. Table 5 confirms this to be statistically significant.

Table 5: Interaction effect of explanatory variables over parking fee payment arrangement [dependent variable: travel mode; continues as CAR driver=0, switch to driverless cars=1].

Explanatory variables	Model 1: self-paid sample		Model 2: employer-paid sample		Changes in odds ratio (Model 1 – Model 2)
	Odds ratio	Std. error	Odds ratio	Std. error	
Travel cost	1.027*	0.012	1.007	0.012	0.020*
Future parking location [ref: paid CBD parking]					
Free home parking	0.995	0.141	0.398*	0.047	0.597
Spatial distribution of place of residence [ref: inner Melbourne]					
Middle Melbourne	1.215	0.215	0.505*	0.078	0.710
Outer Melbourne	0.613*	0.127	0.336*	0.060	0.277*
Level of driverless car awareness [ref: not aware]					
Somewhat aware	1.312	0.209	1.275	0.196	0.037
Moderately aware	1.797*	0.300	1.990*	0.331	-0.193*
Highly aware	2.591*	0.695	2.178*	0.545	0.413*
Driverless car demonstration [ref: picture]					
Animated video	1.118	0.143	1.390*	0.162	-0.272*
Age [ref: 18-29 years]					
30-39 years	1.197	0.225	1.282	0.217	-0.085
40-49 years	0.848	0.162	1.223	0.220	-0.375
50-59 years	1.063	0.263	1.085	0.217	-0.022
60 years & above	0.331*	0.102	0.353*	0.097	-0.022*
Constant	0.665	0.175	1.561	0.370	
Model performance:					
No of observation		*1225*		*1395*	
LR chi^2		*154.03**		*198.44**	
R-squared		*0.094*		*0.103*	
LL (initial)		*-820.21*		*-965.43*	
LL (final)		*-734.19*		*-866.20*	

**statistically significant at 95%*

As noted earlier, one of the benefits of driverless cars is the potential to send them for free parking at home. We, therefore, explore whether the future parking location would have any mode choice impact between the two sample groups. Although not statistically significant, we found that controlling for all other factors, self-paid individuals would consider to switch to driverless cars almost in a similar way regardless of paid CBD parking or free home parking. However, employer paid individuals would be 60% less likely to switch to driverless car commuting if they have to send back to home compared to paid CBD parking. Although the difference between both the models is not statistically significant, we speculate that employer-

paid individuals highly value the disutility of sending the driverless cars back to home as this would incur extra waiting time for its return. Employer-paid individuals seem to prefer having their vehicle close to their work location. Parking the driverless cars in the CBD would allow them to save the waiting time for the next trip rather than sending them back to home for free parking. Conversely, waiting time might not be a significant factor for the self-paid individuals; rather they can save money by allowing the driverless cars for free parking at another place. In addition, employer-paid individuals might consider the disutility of sending the driverless cars back to home as this would incur extra fuel/energy consumption hence require extra money for empty running.

In terms of spatial distribution of usual residence, Table 5 indicates that people living in middle suburbs and paying the parking fees by themselves have 1.2 times higher probability to choose driverless cars for their next commute to CBD while the probability reduces 50% if parking fee is paid by the employers. This indicates that if employers continue to pay the parking fees for their employees then employees are more likely to continue their commute trip by their conventional CAR. The difference in odds ratio in Table 5 indicates that the mode switch behaviour is not statistically significant for individuals living in the middle suburbs but it is statistically significant for those living in the outer suburbs.

In terms of level of awareness about driverless cars, we found that individual's preference to ride them increases with higher level of awareness for both self-paid and employer-paid samples. Especially, the likelihood to switch towards driverless cars is significantly higher for individuals who are moderate to highly aware of the benefits of driverless cars trip. The negative value for the change in odds ratio among moderately aware respondents indicates that employer-paid individuals are more likely to switch to driverless car commuting than self-paid individuals while positive value indicates the opposite. Table 5 shows that this change in mode switch behaviour among both sample groups having moderate to highly aware individuals are statistically significant.

Our result indicates that the demonstration process of driverless cars to survey respondent is a significant predictor of mode switch behaviour, at least for employer-paid individuals. Table 5 indicates that demonstration of driverless car trips by showing animated video to the survey respondents would 1.4 times highly attract employer-paid individuals to switch to driverless cars. The negative value of change in odds ratio in Table 5 among self-paid and employer-paid models indicates that employer-paid respondents would be 27% more likely to switch to driverless cars than their counterparts. Earlier research on meta-analysis of factors having a significant impact on the value of time estimates of autonomous vehicles also validate our empirical findings (Huda et al., 2023). In terms of age, we found that senior citizens (aged 60 years and above) are less likely to switch to driverless cars while young adults highly prefer to switch to driverless cars.

5 Conclusion

Melbourne CBD is the largest employment hub in Metropolitan Melbourne and attracts over 400,000 daily commuters to travel to work. Among several transport modes, car driving is the second-largest preferred option by CBD commuters. With the digitalization trend and rapid technological development, the progression towards fully autonomous driverless cars is becoming an increasingly plausible option. In such an era of a driverless cars, how Melbourne CBD car commuters would choose to travel has not yet been studied. This research paper seeks to address this gap by focusing on the Melbourne CBD-based car commuters to understand their willingness to ride driverless cars and whether their parking behaviour has any influence on this mode switch behaviour. Through an online questionnaire survey, our results show that at an aggregate level, 54% of CBD car commuters intend to ride driverless cars for their daily commute. The number however increases to 61% for the respondents who pay the parking fees themselves but drops to 47% for those where the employers pay the

parking costs. This finding has some potential implications for transport and land use policy and research:

- First, CBD car commuters paying their parking fees by themselves would opt for driverless cars usage as they can send it for free parking rather than paying the high amount of daily parking fees. This scenario may lead to a notable presence of zero-occupancy vehicles circulating in the CBD in search of free parking, resulting in increased congestion and pollution levels (Metz, 2018, Saleh and Hatzopoulou, 2020). Furthermore, this trend would also contribute to empty vehicle-miles-travelled (VMT) solely for parking purposes by the driverless cars. Effective policy interventions are therefore necessary to mitigate these challenges.
- Second, as driverless car users would choose to park their driverless cars in a free parking spot outside the CBD once they reach their final destination, a lot of the CBD car parking spaces will become empty. These newly created empty parking spaces might then be used for other purposes that include office space or accommodating housing challenges.
- Third, empty driverless cars looking for free parking in the nearby suburbs will ultimately take over the street parking and make these suburbs into a “car dumping zone”. This may decrease road safety in these areas and reduce street amenity and attractiveness. In addition, residents living in these areas may react negatively due to the excessive amount of parked cars in front of their houses. Policymakers thus need to design effective policies to tackle this challenge.
- Fourth, employers paying employee parking fees might opt out if the employee chooses to ride driverless cars for commute trips to CBD. This will change the current distribution of parking fee payment arrangements by self-paid and employer-paid groups. As a result, the revenue generated from parking fees would reduce substantially which might impact other development projects. Local councils depending on parking revenue would need to find alternative sources to maintain their budget.

We also identified that young adults and middle-aged individuals are highly in favour of riding driverless cars for commute trips to CBD. Our analysis sheds light identifying that people living in inner Melbourne suburbs highly prefer to ride driverless cars for commute trips compared to those living in other suburbs. Although from a general perspective, it would be expected that people living far away from the CBD would understand the burden of daily driving and thus would highly prefer to ride driverless cars, our result rejects this hypothesis. A similar trend has been observed in terms of travel time where respondents having a commute time of equal to or less than 30 minutes prefer to ride driverless cars in higher proportions than those who require more than 30 minutes of commute time. It might also be that the secondary effects of the respondents’ decisions have not been considered by our sample. For example, those living in the inner suburbs and those requiring less commute time in our sample group might also be impacted by slower moving traffic for their daily commute to the CBD due to the large number of empty running driverless cars. Although we couldn’t validate this hypothesis, we suggest future research could shed light onto these issues.

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