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Who is buying electric vehicles in Australia? A study of early adopters in Queensland

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2021-07

Series editors Dr Nicholas Rohde and Dr Athula Naranpanawa **ISSN** 1837-7750

Department of Accounting, Finance and Economics

Explaining Who is buying electric vehicles in Australia? A study of early adopters in Queensland

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Abstract

Electric vehicle (EV) adoption is one of the most effective strategies to reduce CO2 emissions. To devise appropriate policy measures to accelerate the adoption of EVs, it is necessary to understand the motives and experiences of early adopters. However, there are not many studies around the world and none in Australia that have examined the characteristics of early adopters. This paper contributes to this knowledge gap by using a novel survey dataset from Queensland, Australia. The data has been analysed for two purposes: to understand the socio-demographic profiles of early adopters and to explore variations between Tesla and non-Tesla owners. The analysis suggests that the early adopters are predominantly male, university educated and have substantially higher incomes. This indicates that EVs in Queensland (Australia) are still a luxury item appealing to a specific customer segment. The motivating factor for most respondents to adopt an EV is low or zero carbon dioxide emissions followed by the ability to charge vehicles at home. Wealthier households and younger people are more likely to own a Tesla. Social networks and media play a significant role in influencing EV ownership. There is substantial difference between Tesla and non-Tesla groups in terms of use patterns, charging behaviour and source of electricity. In general, Tesla owners have a higher level of satisfaction compared to non-Tesla owners, even though both groups suffer from a lack of public charging infrastructures. Government subsidies and charging infrastructure support are required for the wider adoption of EVs in Australia.

Keywords: Australia, Early adopters, Electric vehicle, Tesla

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1. Introduction

The transport sector, which is expected to grow at a faster rate than any other sector, contributes to more than 25% of global carbon emissions. Of these global transport emissions, 70% is attributed to road transport which is dominated by conventional internal combustion engine vehicles (ICEVs) fuelled with petrol or diesel (Wang and Ge, 2019). To decarbonize road transport and mitigate greenhouse gas emissions, many countries are transitioning to electric vehicles (EVs) because they are one of the most effective alternatives to ICEVs to reduce carbon dioxide (CO2) emissions (Muneer et al., 2015).

In Australia, transport is the fastest growing and the third-largest source of emissions behind electricity and stationary energy sectors (Lynskey et al., 2020). The transport sector accounted for 18% of the total emissions in 2019, of which 80% came from road transport emissions (Tracker, n.d.). Australia's road fleet is one of the most energy-intensive fleets in the world. The national average for CO2 emission intensity from new light vehicles, consisting of passenger motor vehicles, sports utility vehicles and light commercial vehicles, in 2019 was 180.5 gram/kilometre which was only a 0.2% decrease from 2018. This was the smallest improvement in average emission intensity since reporting began in 2002 (National Transport Commission, 2020). Reducing road transport emissions requires the country's fleet to transition from ICEVs to EVs. However, Australia is known as a laggard in transitioning to EVs, given that EVs represent less than 1% of new vehicle sales, in comparison with 3% to 5% in some other developed countries (Broadbent et al., 2019).

Transitioning from ICEVs to EVs would require governments to adopt a combination of supply and demand-side policy measures. Supply-side measures comprise regulatory CO2 emission standards which set targets for car manufacturers and distributors to reduce CO2 emissions at the source. Demand-side measures aim to reduce CO2 emissions by influencing the demand for certain vehicle types through taxation measures, financial incentives, exemptions and subsidies.

Australia, however, currently does not have any national supply-side and demand-side policy measures to encourage the uptake of EVs. Each State and Territory government may independently offer incentives, but they have not been very effective in influencing the national transition to EVs. Stamp duty (known as vehicle purchase taxes) levied on ICEVs is relatively low. EVs cost at least twice as much as their equivalent ICEVs and with no financial incentives or support from governments, they are an unlikely choice of vehicle for consumers. Despite this clear lack of support, there is a group of early adopters of EVs in Australia who have paid a premium to acquire an EV; it is important to understand their profile and adoption behaviour to devise appropriate policy interventions to promote EVs (Vassileva and Campillo, 2017).

The paper adds to the limited number of studies of early adopters in Australia by understanding their experiences and preferences based on a survey of EV owners in Queensland. However, early adopters may not be a homogenous group and they could have been influenced by different factors (Hardman et al., 2016). Therefore, to understand the potential variation in motives and experience of early adopters this paper compares two groups of early adopters: high-end owners characterized by Tesla ownership and low-end owners who possess non-Tesla EVs. Globally, there are not many studies that have compared different groups of early adopters; however, previous studies have shown that Tesla owners display socio-economic characteristics that are different from non-Tesla owners of EVs (Lee et al., 2019).

Queensland was selected for the case study as the state has a reasonable number of EV owners. As at 1 April 2020, there were 2,220 registered EVs which is about 0.5% of the total car fleet (Transport and Public Works Committee, 2020). However, there is no information about the profiles of the early adopters which makes this research policy- and industry-relevant as this is the first comprehensive survey of early adopters of EVs in Queensland. The specific aims of this study are to (i) understand the early adopters' socio-demographic profile and motivations to buy EVs, and (ii) determine the factors affecting Tesla ownership as opposed to non-Tesla EV ownership.

This paper is organized as follows. The next section provides a brief review of the existing literature followed by a presentation of the data and methodology. The following section presents the findings of the survey and discusses the results. Section 5 concludes the paper.

2. Literature

The literature review section is divided into three parts: (a) general attitudes towards EVs, (b) characteristics of early adopters, and (c) differences in the socio-economic conditions of low- and high-end adopters.

2.1. General attitudes towards EVs

Existing studies in Australia have mainly focussed on surveying the general population to understand their reasons to purchase an EV as their next vehicle and the role of different factors influencing their decisions to purchase an EV. The surveys focus on key factors that are considered to be relevant at the time of purchasing an EV (e.g., purchase cost, driving range, and range anxiety), operational considerations (e.g., lower running and maintenance costs, and reduced environmental footprint), and the place of charging and importance of public charging infrastructure.

Broadbent et al. (2019) survey identified the barriers and incentives to the uptake of EVs in Australia for private motor vehicle customers. Their online survey of 330 respondents in 2015, of which only 2.1% were EV owners, found that fuel efficiency and vehicle price were the most decisive issues when buying any car. High purchase price (44% respondents) and recharging issues (29% respondents) were perceived as the major barriers to purchasing an EV, compounded by the limited availability of EV models in the market. When respondents were asked to rank what would encourage EV purchase, they prioritized four factors: affordability (56%), an increase in vehicle range (26%), an adequate recharge network (28%), and greater consideration of environmental impacts (13%). Gong et al. (2020) surveyed 1,076 New South Wales residents in 2018 to examine their preferences and attitudes towards EV acquisition. The study found respondents were very sensitive to the purchase price of EVs and preferred rebates on the upfront price of EVs.

According to the Electric Vehicle Council's annual survey of 2,902 Australians in 2020, 56% were ready to consider purchasing an EV as their next vehicle which was an increase of eight percentage points from 2018. However, the price of EVs was still considered a major barrier with 68% of the respondents calling for government subsidies to reduce the cost of EVs. The driving range discouraged many consumers of which almost 80% had underestimated the range of EVs currently available in Australia. Further, respondents placed importance on the availability of charging infrastructure. In terms of the source of electricity for the EVs, 31% of the respondents would use solar panels or battery storage, 21% would purchase from the grid through standard contracts, and 14% would use a green-power contract or carbon offsets. The remainder either did not know or were not bothered with the electricity source (Electric Vehicle Council, 2020).

The Royal Automobile Club of Victoria (RACV) conducted its fifth annual survey of Victorian consumers' attitudes to EVs in partnership with the Electric Vehicle Council of Australia. More than 1,000 Victorians were surveyed in May 2020, with 60% of respondents saying that they would consider buying an EV, which was an increase of 13 percentage points from 2019. Thirty-one percent of the respondents were willing to buy an EV if the vehicle's price was the same as equivalent petrol or diesel vehicles, while 19% had no interest in buying an EV, irrespective of the price. Range anxiety and the limited choice of models were identified as key deterrents. In terms of the source of electricity for the EVs, the responses were mixed, about 30% said they were keen to use solar and battery, another 30% did not care where the energy came from, 25% were happy to buy it from the grid and the remainder (15%) preferred to buy from the grid via a green-power contract (Nicholson, 2020).

In summary, current surveys indicate that mainstream consumers are interested in buying an EV if their price is competitive with ICEVs; but that competition requires financial incentives. Most consumers are unwilling to pay a premium for EVs except those who are early adopters of EVs in Australia. However, the Australian Government's priorities on the uptake of EVs are not in making EVs more cost competitive with ICEVs. In the “Future Fuel Strategy: Discussion Paper” released in February 2021, the Australian Government stated that providing subsidies for EVs would “not represent value-for-money for taxpayers (page 32)” and that closing the gap between EVs and ICEVs was through technological improvements and consumer choice. That is, “ensuring consumer choice and confidence in buying new vehicle technologies and accelerating improvements in enabling technology and infrastructure (page 5)”. Furthermore, the Australian Government is against introducing a policy to phase out or ban ICEVs because this “would limit consumer choice, preventing Australians from driving vehicles they prefer (page 32)” (Commonwealth of Australia, 2021).

2.2. Characteristics of early adopters

It is important to understand the characteristics of early adopters as they may be different to the general population (Bjerkan et al., 2016; Lee et al., 2019). Previous studies conducted in Austria (Wolf and Seebauer, 2014), Canada (Axsen et al., 2016), Germany (Plötz et al., 2014), the United States (Hardman et al., 2016) and Sweden (Vassileva and Campillo, 2017) reveal that early adopters are likely to be from the middle to high-income group, middle-aged, typically males, with graduate or postgraduate degrees and technologically and environmentally inclined.

Early adopters are first buyers of new vehicle technologies who often have a different socio-economic profile and different motivations to purchase an EV compared to non-adopters and late-adopters (Berliner et al., 2019). For example, a report of early adopters of EVs in Norway showed EV drivers usually have a higher income and higher education than the general population and "their decision to purchase an EV was highly motivated by economic savings and or environmental issues" (Amsterdam Roundtables Foundation, 2014). In Germany, Plötz et al. (2014) found that the majority of potential and current EV owners were middle-aged, full-time employed males, living in multi-person households, outside the cities. They mostly commuted daily to work, driving a significant number of kilometres, which made EVs more attractive and profitable for them from an economic and environmental point of view.

2.3. Differences between low- and high-end adopters of EV

There are only a few studies that have systematically examined the differences between various groups of early EV adopters (Axsen et al., 2018; Hardman et al., 2016; Lee et al., 2019). Hardman et al. (2016) hypothesized that a new market segment of high-end EV owners was created with the introduction of Tesla in 2012 (Tesla Model S), which costs between USD70,000-105,000 and has a range of 270 miles (434 kilometres). They surveyed the owners of 340 EVs, explored whether there were differences between the two groups of early adopters, identified as high-end (predominantly Tesla owners) or low-end (predominantly non-Tesla owners) EV adopters, and whether they viewed their vehicles differently. It was observed that both groups had a low number of females; high-end adopters had achieved higher education and were older than low-end adopters; and while both sets of adopters had high incomes, the high-end adopters' income was significantly higher than the low-end adopters. In terms of satisfaction, high-end adopters believed their vehicles were better than ICEVs, whereas low-end adopters believed their vehicles had disadvantages, such as range, time to refuel and purchase price, compared to ICEVs.

Lee et al. (2019) conducted a latent class analysis of 11,037 plug-in electric *vehicle* (PEV) adopters in California and found four distinct classes of early adopters mostly separable in terms of their income and family composition: high-income families (49%), mid/high-income older families (26%), mid/high-income young families (20%) and middle-income renters (5%). Based on their findings they suggested that marketing strategies should target middle-income families to utilize their untapped potential. Finally, Axsen et al. (2018) found a strong relationship between people's lifestyle choices and motivation to own an EV, and suggested that policy makers should consider a variety of motivations for owning an EV. However, as mentioned above we are not aware of any study that has examined such heterogeneity among early adopters of EVs in Australia. Our study contributes to this knowledge gap.

3. Methods

3.1. Questionnaire survey

The survey was designed in collaboration with Energy Queensland and the Department of Transport and Main Roads (TMR) of the Queensland Government. A purposive sampling framework was used to recruit early adopters of EVs to participate in the online questionnaire. The method to contact EV owners included: media releases on the Griffith University and Queensland Government websites, requests on local radio, presentations at local EV associations, and media releases on car websites and Facebook EV-owner forums for Tesla, Nissan Leaf and Hyundai Kona owners. They were sent the link to the online survey. The survey was conducted with the ethics approval of Griffith University (GU Ref No: 2019/1031) between January and April 2020; 348 respondents completed the survey.

3.2. Data Analysis

The first step in the data analysis was to group the respondents into two categories: Tesla and non-Tesla owners to resemble high-end and low-end adopters. Table 1 shows the different EV makes owned by the respondents. Around 63% of the respondents are Tesla owners, followed by Hyundai (15%), Nissan (9%) and Mitsubishi (7%). Tesla models have a better range and battery that justifies somewhat its high retail price compared to the non-Tesla group. This shows a clear trade-off between cost and quality.

Table 1: Tesla and Non-Tesla models

Make	Model	Recommended retail price (RRP) $ [a]	Battery range (Kilometre) [b]	Battery (kWh) [b]	Number of respondents
Tesla	Model S Long range	133,175	600	100	219
	Model X Long range	157,875	597	100	
	Model 3 Standard	66,900	423	50-75	
Nissan	Leaf	49,990	270	40	32
Hyundai	Kona Elite	60,740	305	39.2	53
Mitsubishi	iMieV [c]	48,800	160	16	24
	Outlander (PHEV)	52,490	54 [d]	12	
BMW	I3	68,700	260	42.2	8
Others [e]					12
Total					348

[a] Redbook prices 2020. Recommended retail price is determined by the manufacturer and excludes stamp duty and other government charges. [b] EV battery and battery range are from https://www.evspecifications.com/en/model/2bc417 . [c] No longer available for sale. [d] Source: https://www.mitsubishi-motors.com.au/vehicles/outlander-phev/faqs.html. [e] Others include Audi, Jaguar, Renault, Toyota, Vectric and Volvo.

To explain the variation in the sociodemographic characteristics between Tesla and non-Tesla owners, simple descriptive analysis and chi-squares tests were carried out. Several sections in the survey covered a number of attributes of the adopters such as their social and economic characteristics, demographic features and risk and preferences for adopting technologies such as EV. Given that not all respondents answered all of the questions, a Chi-square analysis was used to test the measurement of association between ownership of Tesla and non-Tesla vehicles with individual socio-economic factors. For continuous variables, the Kolmogorov-Smirnov test was conducted. However, such analysis could not consider the multiple factors simultaneously.

A regression estimation that considers the effect of multiple variables was used to explain what determined Tesla ownership. A logistic regression format was used where the dependent variable is a binary variable indicating whether a respondent is a Tesla owner or not. The model is given in the following form:

$$p = Pr(y = 1|x) = \frac{e^{\beta_0+\beta_1 x}}{1 + e^{\beta_0+\beta_1 x}}$$

where p is the probability of observing an outcome, i.e., in our analysis the probability of a respondent owning a Tesla. The probability depends on the estimation of regressor vector $\boldsymbol{x}$ and parameter vector β_1 and an intercept β_0 .

To understand which factors could influence Tesla ownership, we have included several variables in the model. The selection of variables was guided by the existing literature and the availability of good-quality responses in the survey. Since not all 348 respondents answered all of the questions, we used information from 265 respondents for which we had complete data on the relevant variables.

The main explanatory variables we considered were income, age, level of education, number of adults in the household, dwelling types, residential location and source of influence. In the existing literature, income and age have been identified as significant factors of EV ownership. We have included both of these variables after appropriate conversion. The income variable was created using the annual gross income of the respondents which is recorded as a categorical variable. The mid-point of each of the categories was used to convert the variable to a continuous variable. For the highest income category, an increment the same as the previous category was added to the minimum value for that category. The age variable was also collected as a categorical variable with a range. The mid-points were taken to convert this into a continuous variable. However, the existing literature suggests that both income and age might have a non-linear effect on EV ownership (Hardman and Tal, 2016). Therefore, both variables have been included as a logarithm to capture the non-linear effect.

Education is a dummy variable to indicate if the respondent had received education at bachelor degree level and above. The household composition was included in the form of the number of adults to approximate the expenditure related to family size. Dwelling type and the residential location were included to understand the effect of dwelling type and location.

Along with these socio-economic variables, and to understand the source of influence that facilitates the purchase of EVs, responses to the following question were included: 'What encouraged you to purchase an electric vehicle?'. A categorical variable depicting seven types of responses was included: (i) pro-technology enthusiast; (ii) peer influence; (iii) received information from media; (iv) researched on the internet; (v) researched on the green vehicle guide; (vi) had a test drive; and (vii) other reasons such as climate concerns, costs, previous experience with an EV, high torque, etc.

Given that it is difficult to interpret the coefficients from logistic regressions directly, a common practice is to estimate the marginal effect of individual variables, which captures the probability of observing an outcome given a unit change in a continuous regressor. For discrete variables, it is the change in the probability due to moving from the base level to the alternative level. The marginal effect of a variable takes the following form:

$$\partial y/\partial x_j = \Lambda(x'\beta)\{1 - \Lambda(x'\beta)\}\beta_j$$

where $\Lambda(\cdot)$ is the logistic cumulative distribution function (CDF). Stata 16 was used to analyse the data.

4. Results and Discussion

The results section has been divided into four parts: (a) socio-demographic, economic and psychographic features of adopters; (b) motivating factors when purchasing an EV; (c) combined effect of socio-economic factors on Tesla ownership; and (d) EV use and experience.

4.1. Socio-demographic, economic and psychographic features of adopters

Based on the results of the survey, Table 2 presents the socio-demographic characteristics of the sample. The third and fourth columns show statistics relevant to non-Tesla and Tesla groups while the fifth column shows sample statistics. The final column shows Queensland statistics, where available, for benchmarking against regional values. The number of observations related to each question and the test statistics examining the association between vehicle ownership and socio-economic factors are also presented. The frequency distributions have been presented as a percentage of the respective group for easier comparison among non-Tesla, Tesla, sample and Queensland groups.

It can be seen that early adopters are predominantly male (83%), which is in contrast to the Queensland statistics. However, a similar imbalance was observed between males and females in other studies. For example, a survey of early adopters of EVs in Sweden (247 respondents) had a similar gender distribution to Queensland (Vassileva and Campillo, 2017). Between the two samples, the Tesla group has more males (88%) than the non-Tesla group (76%); however, there is no statistically significant association between ownership type and gender.

The sample group has an average age of 48 years, which is older compared to the Queensland statistics. The average age of the non-Tesla group is slightly higher (52 years) than the Tesla group (46 years); however, the difference is not statistically significant. The average household income in the sample is substantially higher than the Queensland median income. The Tesla group has significantly higher household income than the non-Tesla group.

The level of education for the sample is also substantially higher compared to the Queensland statistics, with 66% of respondents having a bachelor or higher degree. However, there is no statistical variation between Tesla and the non-Tesla groups indicating that early adopters are generally more highly educated.

The majority of the respondents are employed (60%), a small group is self-employed (19%) and the remainder are retired (18%). There is a slight variation in employment between the Tesla (65% employed) and non-Tesla (54% employed) groups. This results in a weak statistically significant association between EV ownership and employment status.

The number of adults in the household follows a similar pattern to the Queensland statistics and there is no variation between Tesla and non-Tesla groups. Dwelling type is similar and there is no significant variation between Tesla and non-Tesla groups. It is interesting to note that most of the respondents (68%) live in suburban areas as opposed to city and rural areas, which is in contrast to the Queensland statistics. This could be a reflection of the purposive nature of our sampling. Finally, the vehicle ownership rate is higher in the sample group compared to the Queensland statistics, even though there is no variation between Tesla and non-Tesla groups.

In summary, EV owners in Queensland are predominantly male, slightly older, better educated, predominantly living in detached houses in suburban areas and possess more vehicles on average compared to the Queensland population. We observed some variations between Tesla and non-Tesla groups in terms of gender, age, income, and employment. These differences were explored more comprehensively through regression analysis.

Table 2: Socio-demographic characteristics of the groups

Characteristics	Feature	Non-Tesla		Tesla	Sample	Queensland
Gender	Female	22		12	16	51 [a]
	Male	76		88	83	49 [a]
	Other	1		0	1	
	Prefer not to answer	1		0	0	
	No. of observations	128		219	347	
	Chi square	10.39	**			
Age	Mean ± SD	52 ± 14		46 ± 12	48 ± 13	Median age: 37 [a]
	No. of observations	109		191	300	
	Kolmogorov-Smirnov	0.19	***			
Annual income [c]	Mean ± SD	$133,325 ± $67,600		$175,398 ± $73,222	$159,932 ± $73,946	Median income: 72,904 [a]
	No. of observations	118		203	321	
	Kolmogorov-Smirnov	0.27		***		
Education	Some high school	2		3	3	34 [b]
	High school graduate, certificate or equivalent	8		10	9	18 [b]
	Trade/technical/vocational training	16		16	16	NA
	Professional degree	7		6	6	10 [b]
	Bachelor's degree	41		47	45	13 [b]
	Master's degree	12		12	12	3 [b]
	Doctorate degree	14		7	9	1 [b]
	No. of observations	129		219	348	
	Chi square	5.41				
Employment	Employed – working ≥ 40 hours/ week	30		45	39	58 [a]
	Employed – working 1 – 39 hours/week	24		20	21	30 [a]
	Self-employed	21		18	19	NA
	Not employed – looking for work	1		1	1	8 [a]
	Not employed – not looking for work	1		0	1	5 [a]
	Retired	23		15	18	NA
	Other (Please specify)	1		0	1	NA
	No. of observations	129		219	348	
	Chi square	11.47	*			
Number of adults in the household	< 2	10		11	11	24 [a]
	2-4	85		83	84	67 [a]
	> 4	5		6	5	10 [a]
	No. of observations	129		218	347	
	Chi square	0.47				
Dwelling Type	Apartment/Unit	5		8	7	11 [a]
	Detached House	90		84	86	77 [a]
	Townhouse	5		7	6	11 [a]
	No. of observations	129		219	348	
	Chi square	2.07				
Location	City Dweller	14		17	16	69 [b]
	Rural	19		14	16	9 [b]
	Suburban	67		68	68	22 [b]
	No. of observations	129		219	348	
	Chi square	2.00				
Number of vehicles (including EVs)	1	31		22	26	29 [b]
	2	40		43	42	32 [b]
	3	17		20	19	10 [b]
	More than 3	12		15	14	5 [b]
	No. of observations	129		218	347	
	Chi square	3.16				

Note: [a] 2016 Census QuickStats: Queensland (abs.gov.au). [b] Census TableBuilder - Log in (abs.gov.au). [c] Sample average income was calculated by taking the mid-value in each income category used in the survey. '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

4.2. Motivating factors when purchasing an EV

It is important to understand the motivating factors behind purchasing an EV as this will provide insight into the future uptake of EVs. The respondents were asked to express their agreement with a set of statements relating to the motivating factors behind purchasing an EV, ranging from purchase cost, saving on ownership costs, latest technology, driving range on a single charge, low or zero CO2 emissions, fuel efficiency, vehicle performance in terms of acceleration and speed, and ability to charge their EV at home. The respondents were asked to indicate their level of agreement on a 7-point Likert scale on what they considered relevant when purchasing their EV: Strongly disagree, Disagree, Somewhat disagree, Neither, Somewhat Agree, Agree, and Strongly Agree. However, for simplicity, the responses have been grouped into "Agree", "Neutral" and "Disagree" groups in Table 3 as they reflect the general trend in responses.

Table 3: Motivating factors that encouraged early adopters to purchase an EV

Factors	Level	Non-Tesla	Tesla	Sample	Chi square
EV emits low or zero carbon dioxide emissions	Agree	95	86	92	2.71
	Neutral	3	3	3	
	Disagree	3	10	5	
Ability to charge my EV at home	Agree	86	100	90	4.34
	Neutral	9	0	7	
	Disagree	4	0	3	
Savings on ownership costs (fuel, repairs and maintenance)	Agree	86	90	87	0.23
	Neutral	8	7	8	
	Disagree	5	3	5	
Driving range on a single charge	Agree	80	97	84	4.60*
	Neutral	15	3	12	
	Disagree	5	0	4	
Latest new and exciting technology	Agree	77	90	81	2.13
	Neutral	8	3	7	
	Disagree	15	7	13	
Fuel efficiency	Agree	81	76	79	1.52
	Neutral	16	24	19	
	Disagree	3	0	2	
Purchase cost	Agree	77	66	74	2.46
	Neutral	14	14	14	
	Disagree	9	21	13	
Vehicle performance in terms of acceleration and speed	Agree	59	97	70	14.03***
	Neutral	19	0	14	
	Disagree	22	3	17	
No. of observation		74	29	103	

Note: '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

The table shows that environmental concern was the most relevant factor for early adopters when purchasing their EV. Overall, about 92% of respondents supported the statement "EV emits low or zero carbon dioxide emissions" as one of the motivating factors that influenced purchase of an EV. This supports the literature findings that early adopters who are highly educated are usually environmentally sensitive (Hardman et al., 2016); and those who are more concerned for the environment are more likely to adopt EVs (Vassileva and Campillo, 2017).

Burs et al. (2020) also made a similar observation that environmental concerns were a strong driver of EV adoption. More non-Tesla owners agreed with the statement compared to the Tesla group even though such difference was not statistically significant. Hardman et al. (2016) also found that non-Tesla owners (low-end adopters) were more motivated by environmental concerns compared to Tesla owners (high-end adopters).

Convenience was the second most supported statement; all of the respondents in the Tesla group and 86% of non-Tesla group agreed with the statement. This could be supplemented by the fact that a high percentage of early adopters live in detached houses (86%), with only 6% living in townhouses and 7% living in units/apartments (Table 1). Charging at an apartment/unit is recognized as a barrier to the widespread uptake of EVs; the owners need to have the ability to charge at home to increase the uptake of EVs (Grote et al., 2019). The existing literature also found that the majority of adopters have a strong preference to charge their vehicles primarily overnight at home, instead of using public or workplace infrastructure (Anable et al., 2014; Grote et al., 2019; Plötz et al., 2014).

The next important consideration for EV adopters was saving on ownership costs (87%) with both groups placing similar importance on this factor. Financial savings have been cited as one of the strongest motivators of consumer interest in EVs (Breetz and Salon, 2018). It was expected that low running and maintenance costs would offset the high purchase cost of an EV (Hardman et al., 2016), meaning that these savings area significant contributor to the likelihood of continuing with EV ownership. If the net cost over the lifespan of an EV is not less than that of an ICEV, current EV owners may switch back to ICEVs.

The statement about the driving range on a single charge also received relatively strong support (84%) and provided a statistically significant association between EV ownership and the level of agreement. This was more important for Tesla owners than non-Tesla owners (97% vs 80%)

because Tesla as a brand focuses on long-range EVs (Long et al., 2019) and this was reflected in our survey responses.

The statement about the latest new and exciting technology also received strong support (81%), even though there was variation between the two groups. Ninety percent of Tesla owners and 77% of non-Tesla owners supported the statement. Tesla's brand has played an important role in the perception of EVs, and conveys an image of “high performance” and an “image of intelligence for the future” with societal benefits of helping to reduce climate change and air pollution (Long et al., 2019).

Fuel efficiency is slightly more relevant for non-Tesla (81%) owners than Tesla (76%) owners. Although EV purchase price has been identified as a barrier in surveys with the general population (Nicholson, 2020), only 74% of early adopters ranked it as a relevant consideration. de Rubens (2019) also made a similar observation about the low priority of EV purchase cost to early adopters. Finally, vehicle acceleration and speed was very important for Tesla owners with more than 97% of respondents agreeing with the statement compared to only 59% of respondents in the non-Tesla group. This showed a strong statistical relationship between EV ownership and the importance of acceleration and speed. In summary, while there is general agreement between the two groups, preferences for two performance-related attributes—driving range and acceleration and speed—set the non-Tesla and Tesla groups apart.

The statements discussed above mainly refer to vehicle attributes. However, respondents could also be influenced by social factors such as friends and families, social networks, etc (Table 4). The largest influencing factor for motivation and/or information was the internet. Overall, 35% of respondents in both Tesla and non-Tesla groups researched EVs before purchasing them. Self-identifying as a pro-technology enthusiast was a contributory factor with 33% of the respondents in the Tesla group and 22% in the non-Tesla group stating this influenced their purchase. Test driving an EV also facilitated its purchase, particularly for Tesla owners.

Table 4: Source of information

	Non-Tesla	Tesla	Sample
I am a pro-technology enthusiast	22	33	29
I have a friend with an EV	2	4	3
I read about EVs in the media (e.g. social media)	1	2	2
I read/researched EVs on the internet	37	33	35
I read/researched about EVs in the Green Vehicle Guide	2	1	1
I test drove an EV	6	13	10
Other	30	13	20
No. of observation	132	205	337
Chi square	23.35***		

Note: '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

4.3. The combined effect of socio-economic factors on Tesla ownership

The combined effect of key socio-economic variables on Tesla ownership has been modelled through a logistic regression (Table 5). The signs of the coefficients indicate whether a variable has a positive or negative effect on the ownership. The associated marginal effects of the discrete variables indicate the extent of the impact. Both income and age have been included as a logarithm to capture the non-linear effect. Therefore, their impacts have been predicted over relevant ranges and are presented in Figure 1.

Table 5: Results of the regression model

	Model			Margin		
	Estimate	P	SE	Estimate	P	SE
Income (log)	1.55	***	0.32			
Age (log)	-1.00	*	0.57			
Education (Bachelor and above = 1, otherwise = 0)	-0.06		0.32	-0.01		0.06
Number of adults (Base = 2 and less)						
From 2 to 4	-0.81		0.55	-0.14		0.08
More than 4	-0.77		0.88	-0.13		0.15
Dwelling (Base = Apartment)						
Detached	-1.16		0.76	-0.19	*	0.10
Townhouse	-0.38		0.96	-0.05		0.14
Residential location (Base = City Dweller)						
Rural	0.19		0.58	0.03		0.10
Suburban	-0.12		0.46	-0.02		0.08
Source of influence (Base = Other)						
I am a pro-technology enthusiast	3.89		0.00	0.35	***	0.08
I have a friend with an EV	2.59	**	1.16	0.45	***	0.13
I read about EVs in the media (e.g. social media)	2.32	*	1.23	0.42	**	0.15
I read/researched EVs on the internet	0.76	*	0.41	0.16	*	0.08
I read/researched about EVs in the Green Vehicle Guide	-0.35		1.34	-0.07		0.26
I test drove an EV	2.00	***	0.64	0.37	***	0.10
Constant	-13.18	**	4.73			
Number of observations	265					
LR Chi square	67.93	***				
AIC	314.31					

Note: '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

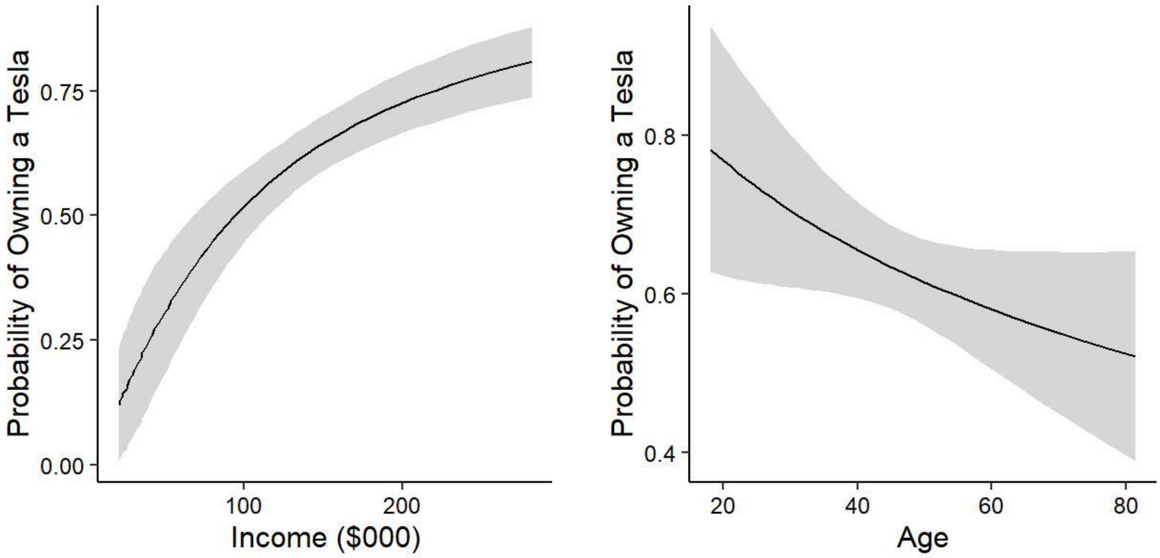

Figure 1: Changes in the probability of ownership with income and age. The shaded area indicates 95% confidence interval.

Table 5 shows that income has a positive effect on Tesla ownership. The probability of owning a Tesla at the lowest observed income level ($20,000) is about 12% which increases to 65% for households with an annual gross income of $155,000 (Figure 1). The observed positive effect of income on Tesla ownership is supported by the existing literature (Hardman, 2017). In contrast to the effect of income, age has a statistically significant negative effect on Tesla ownership. The probability of owning a Tesla drops from 78% at age 18 to 62% at 49 years of age. It seems that older generations do not prefer high-end EVs, which could be linked to the decreased earning capacity of the older adopters.

The remaining explanatory variables do not have much influence except for the variable capturing social influence. It seems peer influence (i.e., having a friend with EV) has the largest influence on purchasing a Tesla. Media influences customers to buy a Tesla. Also, test driving and pro-technology enthusiasm also influence owning a Tesla. Similar evidence was found in studies by Axsen et al. (2015), Hardman et al. (2017), Jansson (2011), and Kurani et al. (2016).

4.4. EV use and use experience

After discussing the socio-demographic profile of early adopters of EVs and examining the key factors influencing Tesla ownership, EV use and use experience in terms of the distance travelled, charging and charging times and the overall level of satisfaction are now summarized.

1.1.1. Distance travelled

Overall, 39% of the respondents, comprising 33% of Tesla owners and 48% of non-Tesla owners, drove on average fewer than 50 kilometres per day during the week (Figure 2). There is a significant association between EV ownership and weekday driving patterns (chi-square = 11.806*). However, there is no statistical association between vehicle ownership and weekend driving patterns (chi-square = 5.18).

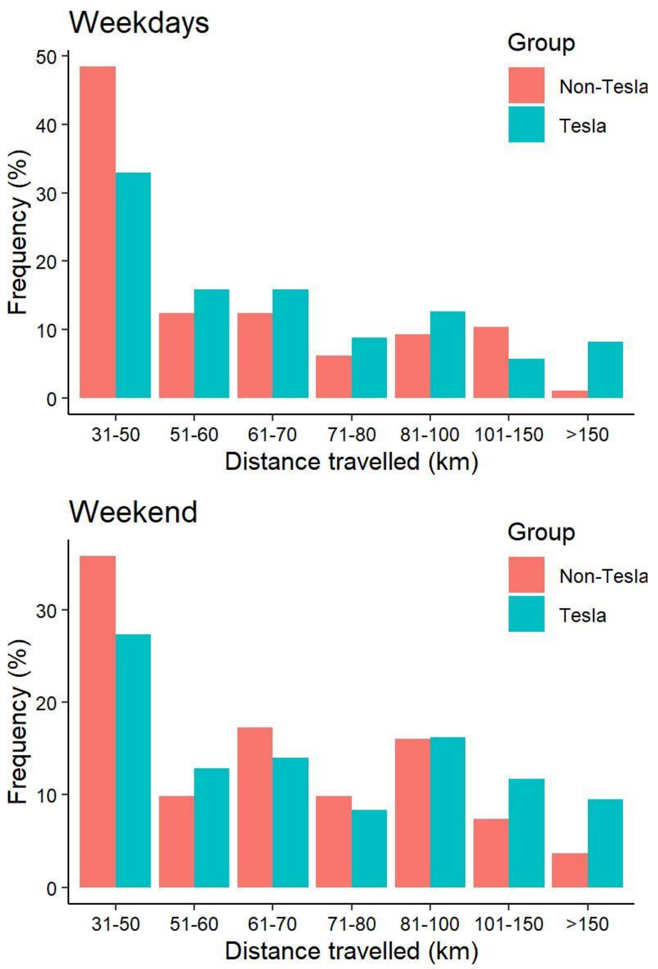

Figure 2: Distribution of respondents by distance travelled per day during weekdays and weekends

1.1.2. Charging and time of charging EV: grid and or renewable energy

Early adopters were asked how they sourced their household electricity supply as it could indicate their tendency to adopt new technology and energy conservation behaviour (Table 6). There is a statistically significant association between EV ownership and the source of electricity. Non-Tesla owners (68%) rely much more on solar energy. For example, almost 68% of them rely on a combination of grid and solar PV, which is much higher percentage than for the Tesla group (46%). About 29% of the Tesla owners rely on the electrical grid for their energy which is much higher than the non-Tesla group (11%). On average, 71% of all respondents charge their EVs at home and there is no significant difference between the two groups.

Table 6: Source of household electrical supply and time of charging

		Non-Tesla		Tesla	Sample
Source of electricity supply	Combination of grid and solar PV	68		46	54
	Combination of grid, solar PV and batteries	14		20	17
	Solar Photovoltaic (PV)	7		6	6
	Grid only	11		29	22
	No. of observations	73		122	195
	Chi square	11.83	***		
Place of Charging (first preference)	Charging Infrastructure/Stations	11		19	16
	Home	75		69	71
	QLD Electric Superhighway	7		4	5
	Work	7		7	7
	No. of observations	110		190	300
	Chi square	4.62			
Time of Charging	Morning: 6am to midday	8		12	11
	Afternoon: midday to 6pm	18		15	16
	Early evening 6-9pm	6		7	7
	Late night 9pm-6am	36		39	38
	All of the above	32		27	28
	No. of observations	118		206	324
	Chi square	2.52			
Level of battery charge recharge or 'top up'	< 10% level of charge	4		0	1
	10-50% level of charge	59		47	52
	50%+ level of charge	37		53	47
	No. of observations	120		206	326
	Chi square	15.00	***		
Duration of charging at a charging station/public infrastructure?	20-40 minutes	21		58	47
	More than 40 minutes	74		18	34
	Up to 20 minutes (fast charger)	5		24	19
	No. of observations	19		45	64
	Chi square	18.61	***		

Note: '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

The battery charging time of day varied: 65% charged their batteries during low tariff periods (late night 9 pm – 6 am, 11% from morning to midday, 16% during early afternoon (midday to early evening – 6 pm), and only 7% at peak time from 6 pm to 9 pm. Charging patterns were similar across the two groups. Over half of the Tesla owners recharged their batteries when they were above 50% charge as Tesla batteries have a longer range; thus, Tesla owners spent less time charging batteries. On the other hand, only 37% of the non-Tesla owners recharged their batteries above 50% charge as they required more frequent recharging. They also spent more time charging their EVs.

1.1.3. Overall satisfaction

Finally, early adopters' level of satisfaction concerning their EV driving range, battery charging time, availability of charging infrastructure, and availability of fast charging infrastructure was captured through a series of 7-point Likert scale (ranging from extremely dissatisfied to extremely satisfied) statements. Their responses have been aggregated into three groups: satisfied, neutral and dissatisfied and frequency distribution and relevant test statistics are presented in Table 7.

Table 7: Level of satisfaction in driving range and charging

Feature		Non-Tesla	Tesla	Sample
Overall driving range	Satisfied	76	96	89
	Neutral	8	1	3
	Dissatisfied	16	3	8
	No. of observations	119	206	325
	Chi square	27.70	***	
Battery charging time	Satisfied	81	94	89
	Neutral	12	2	6
	Dissatisfied	7	3	5
	No. of observations	116	204	320
	Chi square	14.83	***	
Availability of charging infrastructure	Satisfied	40	73	61
	Neutral	16	6	10
	Dissatisfied	44	20	29
	No. of observations	119	205	324
	Chi square	34.33	***	
Availability of fast charging infrastructure	Satisfied	29	65	52
	Neutral	23	5	12
	Dissatisfied	48	30	37
	No. of observations	120	206	326
	Chi square	44.44	***	

Note: '***', '**', '*' refer to statistical significance at 1%, 5% and 10%, respectively.

Table 7 shows that both groups expressed a high level of satisfaction with overall driving range and battery charging times. However, the availability of charging infrastructure and fast charging infrastructure were major concerns. In general, a higher proportion of Tesla owners expressed satisfaction compared to non-Tesla owners. This is consistent with the findings of Hardman et al. (2016) who showed that Tesla owners have vehicles with a longer driving range, are less likely to charge away from home and have to charge less often. However, non-Tesla owners have a vehicle with a shorter driving range, require more frequent recharge events and are more reliant on the availability of charging infrastructure.

5. Conclusion

For successful transition of the Australian transport sector to a more sustainable energy-efficient industry it is necessary to understand the characteristics and needs of people who have already adopted EVs (Bjerkan et al., 2016). This is one of the first studies to analyse the socio-economic characteristics of the early adopters of EVs in Australia, which has allowed us to develop some observations related to developing policies and strategies.

We have found that the early adopters of EVs in Queensland have socio-economic characteristics that are similar to their international peers. The early adopters are predominantly male, university educated and have higher incomes. Such characteristics are strongly consistent with the observations made in other studies in Austria (Wolf and Seebauer, 2014), Canada (Axsen et al., 2016), Germany (Plötz et al., 2014), the United States (Hardman et al., 2016) and Sweden (Vassileva and Campillo, 2017). This also shows that EV ownership is mostly confined to a specific group and has not reached different socio-demographic groups in Australia. To do so, may require financial policy support such as tax relief, and subsidies to reduce the cost of EVs. As well as social networks and media which have played a significant role in influencing EV ownership, strategic communication and marketing activities should be undertaken to promote EV adoption.

Our study reveals that there are differences between the Tesla and non-Tesla groups. Wealthier households and younger people are more likely to own a Tesla which implies that there is an affordability barrier between Tesla and non-Tesla EVs. Although, with both early adopter groups, reducing CO2 emissions and the convenience of charging were the most relevant considerations in purchasing EVs.

There is substantial heterogeneity between the two groups in terms of use patterns, charging behaviour and source of electricity, whereas there is no variation in the place of charging, with over 70% of the respondents charging their EVs at home. This observation supports the literature that the convenience of charging from home is a key benefit of EV ownership (Grote et al., 2019). However, charging EVs at home may impact and overload the electric grids during peak time. Therefore, integrated load management and tariff structure systems should be developed to prevent overloading the electric grids (Vassileva and Campillo, 2017).

The results of the survey showed a low reliance on public infrastructure by both Tesla and non-Tesla owners, which could be due to a lack of charging infrastructure in public places. If the government wishes to promote EVs they should focus on setting up charging infrastructure to meet the needs of EV owners. This would help to alleviate the range anxiety for potential EV consumers and offer backup when they are planning long trips (Lee et al., 2020).

The current research only focused on one state in Australia, Queensland. Future studies should seek to understand the relevant considerations and charging needs of early adopters across Australia. It is also important to study non-adopters to understand the influence of various factors on their attitudes to EVs more comprehensively.

Declarations of interest: none

Author contributions – AM: Conceptualization; Data curation; Funding acquisition; Writing - original draft; SR: Formal analysis; Writing - review & editing; and MSI: Formal analysis; Writing - review & editing

Acknowledgment

We thank the Queensland Government, Transport & Main Roads and the Energy Queensland Group for their input into the development, review, promotion and distribution of the survey. We gratefully acknowledge the Australian Electric Vehicle Association (Brisbane) and the Tesla Owners Club (Australia) for their help in promoting the survey. Talei Daly-Olm provided research support. The Accounting Finance and Economics Energy Cluster, Griffith University provided financial support. M S Iftekhar acknowledges funding support from the Australian Research Council's Discovery Early Career Researcher Awards grant (ARC DECRA grant number DE180101503).

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