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Impact of government incentives on the market penetration of electric vehicles in Australia

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ABSTRACT

Incentives to buy and use electric vehicles (EVs) may influence individuals' decisions to do so. To examine these impacts, a latent class discrete choice model is developed to analyse consumer preferences related to EV attributes and related government incentives. Data was collected from a stated preference survey of 1,076 residents of New South Wales (NSW), Australia. According to the results, the proposed latent constructs classify respondents into five segments. The segments are then used to distinguish respondent behaviours regarding EV attributes and related government incentives. The results show that rebate on the upfront cost of an EV is the most preferred one-off financial incentive, because EVs are expected to be expensive, especially in Australia which has a very small EV market at present. Furthermore, rebates on energy bills and parking fees are also well-received, as these things are expensive in Sydney, Australia. Thus, operational incentives for discounts on energy bills and parking fees may facilitate the success of EVs in NSW.

1. Introduction

Electro-mobility and electric vehicles (EVs) are seen by many in developed countries to be the future of mobility (Harrison and Thiel, 2017) because of their many potential economic and environmental benefits. Examples of these benefits include lowering the daily travel costs of consumers, reducing greenhouse gas emissions and minimising dependence on oil. Despite these potential advantages, major barriers remain to the adoption of EVs, which only represent a small market share of vehicles currently in service. The low market penetration of EVs in Australia is more apparent than in other developed countries such as those in the European Union and North America (Hall and Lutsey, 2017). Previous research suggests that some of the major obstacles to the widespread adoption of EVs are purchasing costs, lack of public charging infrastructure, battery technology limitations and high battery costs (Egbue and Long, 2012), as well as a lack of consumer confidence in EV technology (Lévay et al., 2017; Matteson and Williams, 2015). As a result, many studies have considered using incentive mechanisms to help increase the acquisition of EVs and overcome some of the existing barriers (Axsen et al., 2015; Hao et al., 2014; Holtsmark and Skonhoft, 2014). Currently, in New South Wales (NSW) and the city of Sydney in particular, only two types of incentives are available to encourage the purchase of low-emission vehicles such as EVs: minor motor tax reductions and discounted parking permits (ClimateWorks Australia, 2017). This level of incentive is quite negligible compared to what is being offered around the world to promote sustainable modes of transport. The limited existing incentivisation schemes and low market penetration in NSW indicate that there is a knowledge gap regarding how incentives can improve market penetration and encourage individuals to acquire an EV. Thus, more studies are needed to understand consumer preferences and attitudes towards EV acquisition.

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This study investigates how residents evaluate various properties of EVs when considering purchasing one. Current studies (Egbue and Long, 2012; Jenn et al., 2013; Shao et al., 2017; Sierzchula et al., 2014) of EV incentive policies mainly focused on the types of incentive to be applied instead of their effectiveness in terms of net present value of monetary equivalent of them. Thus, no such study exists on when and how the incentives should be applied by the policymaker. The main objectives are understanding individual preferences regarding governmental incentives, exploring how the decision-making process varies among different segments of the population when incentives are provided, and measuring how much the effectiveness of each incentive to a sample population varies based on the NPV equivalent of the expenses associated with the policy over the next 5–6 years. This study contributes to the literature by providing information that governmental and municipal managers can use to inform their decision making as they formulate policy to sustainably and efficiently help residents adopt EVs and increase EV market penetration.

The remainder of the article proceeds as follows. Section 2 reviews some of the literature on EV-related policies and incentives that have been implemented worldwide. This is followed by a description of the data and method used for the study. In the penultimate section, we report the results of our detailed empirical analysis of consumer preferences for different incentives. We conclude with a discussion of the implications of our findings.

2. Literature review

Demand studies have explored the financial, technical, essential and political concepts of EVs to help governments and car manufacturers evaluate consumer preferences (Liao et al., 2017). Driving range, refilling time and owning costs have been identified as some of the factors influencing EV purchasing decisions (Ghasri et al., 2019; Sierzchula et al., 2014). Some studies have used stated preference techniques to explore heterogeneity in consumer preferences when deciding to purchase an EV (Hidrue et al., 2011). Cherchi (2017) notified the significant of social conformity and market penetration on consumers' behaviours when purchasing. Some argue that financial incentives can trigger EV market penetration due to the purchase price and consumer acquisition strength (Lévay et al., 2017). Consensus exists among current economic studies that government support is needed to trigger the uptake of EVs (Kong and Hardman, 2019).

Various financial schemes have been considered by the federal governments of many countries to support the uptake of EVs (Yang et al., 2019). Examples include subsidies for charging infrastructure, operating costs, and EV supply chains. In general, government support can be categorised into two major types: non-financial and financial. Non-financial government support does not incur a direct cost to the government and includes, for example, granting EVs access to bus lanes and licence plate controlling (Zhang et al., 2018). Wolbertus et al., 2018 reported that the evidence that granting EVs access to bus lanes increases EV purchasing intent is mixed; however, the cost of doing so is less than that of providing direct rebates on purchasing costs. Financial government support, such as cashback schemes, can be further divided into one-off and on-going incentives. One-off incentives are subsidies given once, such as rebates on upfront costs, stamp duty discounts and tax waivers. On-going incentives are subsidies with absolute limit amount; for example, rebates on parking fees and energy bills. Larson et al. (2014) surveyed consumer attitudes to EVs in Manitoba, Canada from late 2011 to early 2012 and revealed that consumers are unwilling to pay substantial premiums for EVs. Investigations of the Chinese Electric Vehicle Subsidy Scheme (EVSS) show that financial incentives are essential if EVs are to be cost-competitive with conventional internal combustion vehicles (ICVs) (Hao et al., 2014). Germany, a leading country in EV usage, announced a national purchase subsidy of €4,000 for PHEVs in 2011, which significantly increased their sales (Kong and Hardman, 2019). A study by Diamond (2009), conducted in the US, found a strong relationship between fuel prices and EV adoption: higher prices increase EV purchasing intent. In the same study, they concluded that rebates on up-front costs or stamp duty discounts are more effective than delayed rebates or tax credits. Furthermore, Yang et al. (2019) identified the subsidy be allocated to consumers rather than manufacturers, and also stated that greater subsidies to manufacturers should be expected if the subsidy budget increases.

Currently, in Australia, the state of Victoria provides a $100 discount on registration fees for an EV, while the Australian Capital Territory offers a stamp duty waiver, which could be worth $1,350 on a $45,000 EV purchase. However, in NSW and the city of Sydney in particular, only two types of incentives are available to encourage the purchase of low-emission vehicles, including EVs. The NSW Government provides a minor reduction (around $20–30) in annual motor vehicle tax if the vehicle has CO_2 emissions of less than 150 g/km in its combined driving cycle. The City of Sydney offers a discount for residential parking permits based on the Green Vehicle Rating, as measured by tailpipe CO_2 emissions for the combined driving cycle. For vehicles with emissions less than 112 CO_2 g/km, an annual parking permit costs $41, which increases to $159 for vehicles that emit 260 CO_2 g/km or above. This level of incentive is negligible compared to what is being offered elsewhere around the world, which is one of the reasons why Australian governments have not been successful in increasing EV market penetration and sales (ClimateWorks Australia, 2017).

As discussed earlier, stated preference (SP) surveys and multinomial logit (MNL) models have been used to explore individual behaviours and consumer preferences toward purchasing an EV. To capture the variation in preferences, three main modelling methods can be used to identify different segments of the population (Liao et al., 2017): (1) Traditional segmentation, (2) hybrid choice modelling and (3) latent class modelling. However, some scholars recognise that it is difficult to apply these models in policy-making because it is a challenge to categorise people into various classes (Boxall and Adamowicz, 2002). Therefore, there is limited knowledge about consumers' preference segmentations for purchasing EVs with government support.

In this paper, a latent class model is used to investigate the homogeneity of preferences within heterogeneous segments of the population regarding government support and EV characteristics. The latent class modelling method used for this study is similar to the method used by Hidrue et al. (2011) in their study on EVs. However, the main focus of consumers' preferences is on government support. They studied consumers' willingness to pay (WTP) based on five EV attributes: driving range, charging time, fuel cost savings, pollution reduction and driving performance. More specifically, in this study, we also explore the impacts of different governmental incentives, such as the availability of fast-charging stations, rebates on upfront costs, rebates on parking fees, energy bill discounts, and stamp duty discounts. Our assumption of government support is very much aligned with Liao et al. (2017) review, which stated that the effectiveness of various types of government support (financial or non-financial) varies according to demographics.

3. Data description

To capture people's beliefs, preferences and attitudes toward electric vehicle (EV) acquisition, a detailed questioner was developed and fielded which contained two major components, where this paper is only based on the first component. These components were:

(a) An EV purchasing choice component ($n = 1076$ of 1180 completes). A sample of NSW residents was debriefed with respect to their revealed preference (RP) for actual vehicle acquisition, including vehicle type, vehicle size, cost, etc. plus a stated preference (SP) discrete choice experiment (DCE) that elicited preferences for EVs from a presentation of hypothetical options. In this component, the monetary valuation of EV characteristics was based on the price of the vehicle.
(b) Electric vehicle charging infrastructure investment component ($n = 1180$ completes). All respondents (EV owners, EV considerers and non-EV considerers) participated in a hypothetical referendum that imposed household levies (which had a value and a duration) for investment in an EV charging infrastructure that would provide greater accessibility.

Survey participants were classified according to their disposition towards EV acquisition. If respondents did not own any vehicles or were not considering purchasing/leasing a car in the near future, they were considered as *non-vehicle owners* and were directed to the referendum task. Alternatively, if respondents reported that they currently owned a vehicle or were considering purchasing or leasing a vehicle in the near future, they were considered as *vehicle owners* and were directed to the referendum task with EV purchasing task. Thus, all surveyed respondents participated in the referendum task, but only *vehicle owners* participated in the EV purchasing task. Fig. 1 presents the survey structure.

Overall, the questionnaire consisted of six sections. Firstly, respondents were screened out if they were not from NSW and were below the age of 18 years in the first section. Secondly, respondents were asked to provide details regarding any cars they had owned or will own in the near future in the second section. Thirdly, a subsection of the respondents was presented with eight discrete choice experiments to determine their EV purchasing behaviour and preferences in the third section. Then, respondents were given questions answered on a five-point Likert scale as well as attitudinal questions to elicit their perceptions and beliefs regarding the EV concept in general in the fourth section. After that, all respondents were given eight hypothetical scenarios to vote in an official referendum to pay a household levy up to a time horizon, for governments to provide better access to charging facilities throughout NSW in the fifth section. Finally, respondents were asked to report their demographic information, such as their age, gender, education, employment, income or number of cars in the last section.

As discussed earlier this study only focuses on the first component of the data collection which comprises 1,076 respondents from NSW residents. The survey was administered online between 26th October and 7th November 2018 via the internet. Respondents were selected to represent the NSW population in terms of key socio-demographic variables, such as age, gender and income. An overview of the sample’s geographical distribution is provided in Fig. 2.

As presented in Table 1, the distribution of gender in the sample was very much aligned with the NSW population at 49% male and 51% female. The *age* structure of the sample was skewed towards the middle rather than the tails, such that the survey sampled more people between 25 and 64 years old (1–2.5% more) than those aged below < 25 years or > 65 years. More than 66% of the households contained couples with or without children. The third-largest household type in NSW, Australia was those with single residents. The respondents’ average education level was higher than that of the general population: postgraduate and undergraduates comprised 11% and 8.4% more, respectively, than in the general population. The majority of the respondents (62%) were employed

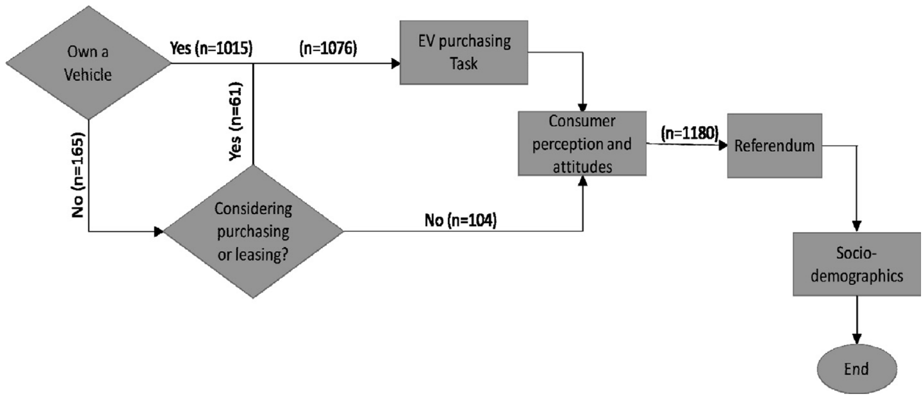


Fig. 1. Survey structure for the present study.

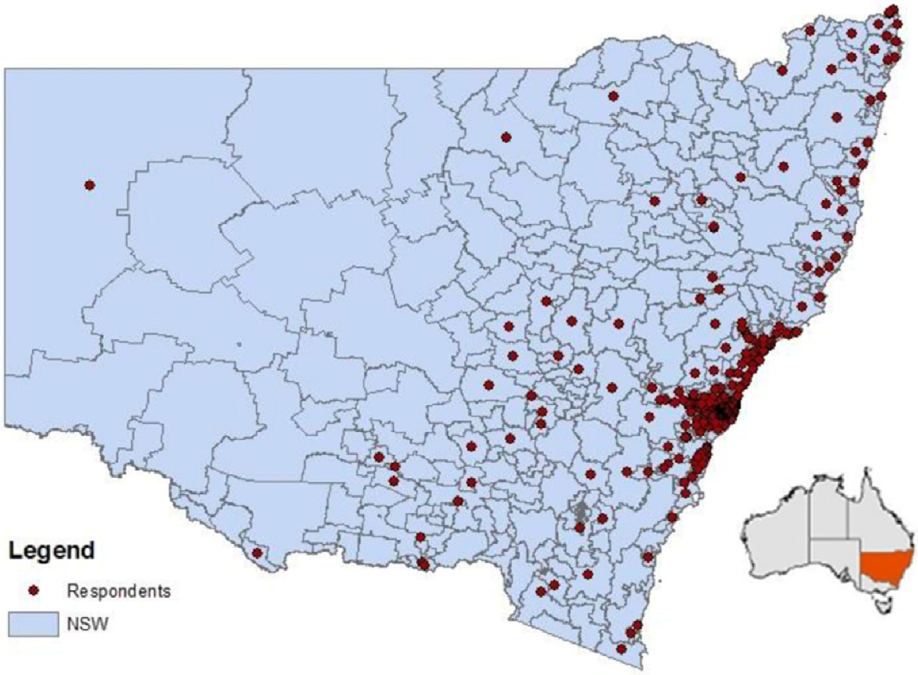


Fig. 2. Sample distribution in NSW, with respondent locations shown at their postal code centroid.

either full-time or part-time. As a result, the fourth and fifth (highest) income quantiles had the largest proportion of the sample within them. Moreover, 67.1% of the respondents lived in a house and 21.9% liven in an apartment. Some 36.1% of the respondents owned their own properties completely and 62% were paying mortgages or renting. Overall, the sample was considered representative of the NSW population.

4. Methodology

Consumer choice behaviours are normally analysed by discrete choice experiments (DCE) (Louviereet al., 2000). The random utility theory framework (McFadden, 1973) and Lancaster (1966) utility maximization model are used to model consumer behaviours in most choice studies. DCE has a foundation that allows quantitative analysis of the relative values of multiple attributes of consumer behaviour. While links between individual consumer attitudes, preferences and actual purchasing decisions are complex (McEachern et al., 2005), DCEs and the use of consumer panels open up the possibility of exploring multiple policies influencing EV purchasing decisions across populations of consumers. For a typical DCE exercise, different methods are available for choosing the right attributes, such as literature review, focus group discussions and online surveys. For this research, an online survey was designed and implemented based on feedback received through a focus group and expert opinions. Then, a latent choice model was applied to analyse consumer behaviours.

4.1. Underlying attributes

Based on the literature review and focus group discussion (with experts in strategic transport planning and policymaking from academia and the state government[1]), a set of core attributes that describe EV alternatives were identified. These attributes can be divided into three groups: vehicle properties (such as price and technical features), potential government support schemes, and EV market share. Table 2 presents these attributes and their corresponding levels. Vehicle attributes are investigated based on previous studies (Beggs et al., 1981; Brownstone et al., 2000; Caulfield et al., 2010; Hess et al., 2012; Ou et al., 2018; Sierzchula et al., 2014) and include body type, purchase price, set-up cost, operating cost, recharge time, and single-recharge range. For example, Sierzchula et al. (2014) considered cost, range and recharge time to be three of the technological barriers to EV adoption. Ou et al. (2018) found that the setup cost of a home charging facility is an important determinant. Vehicle body type was found to be a significant component of consumers' preferences for EVs (Brownstone, 2001). In addition, Hess et al. (2012) developed several nested and cross-nested logit models to capture the correlation between alternatives with similar body type or fuel type.

The government support schemes considered were primarily adopted from previous studies with consideration of their

[1] The Office of Environment and Heritage in New South Wales.

Table 1
Descriptive statistics of respondent characteristics.

Variable		Sampled population Statistics	NSW population statistics
Total Participants		*1076*	*7,480,228*
Gender			
	Male	49.0%	49.3%
	Female	51.0%	50.7%
Age			
	18–24 years	9.3%	11.72%
	25–34 years	21.6%	18.63%
	35–44 years	18.3%	17.31%
	45–54 years	17.3%	16.68%
	55–64 years	17.5%	15.14%
	65 plus	16.0%	20.53%
Household type			
	Couple family with no children	30.8%	26.6%
	Couple family with children	35.8%	32.7%
	One parent family	5.4%	11.5%
	Single person household	17.4%	23.8%
	Group household	7.6%	4.2%
	Other Family	3.1%	1.2%
Education			
	Postgraduate	21.0%	10%
	Undergraduate	39.4%	31%
	TAFE Certificate or equivalent	31.9%	46%
	Other	7.7%	13%
Household annual income			
	Lowest quintile ($1-$33,800)	6.5%	7.3%
	Second quintile ($33,801-$47,580)	13.3%	11.8%
	Third quintile ($47,581-$62,190)	12.5%	16.6%
	Fourth quintile ($62,191-$122,520)	31.4%	21.7%
	Highest quintile ($122,521 and more)	26.2%	42.7%
	Prefer not to answer	10.1%	NA
Dwelling type			
	House	67.1%	69.31%
	Apartment	21.9%	29.83%
	Other	11.0%	0.86%
Is this dwelling…?			
	Owner	36.1%	29.9%
	Owner with mortgage	32.5%	33.9%
	Renter	29.5%	34.4%
	Other	1.9%	1.8%
Employment			
	Full-time	42.8%	47.10%
	Part-time	19.3%	21.50%
	Retired	17.9%	15.50%
	Un-employed	3.4%	3.20%
	Not in the labour force	2.2%	2.10%
	Student	6.1%	5.70%
	Household duties	8.2%	4.90%

applicability to NSW, Australia. These schemes include access to bus lanes, availability of fast-charging stations, rebates on upfront costs, rebates on parking fees until 2025, energy bill discounts until 2025, and stamp duty discount until 2025. The year 2025 was selected because government supports are normally given in five-year periods (Harmel and Robertson, 1986). The supports can be reviewed by the state or federal government when the changes are not widely accepted; thus, the supports could be terminated if they have a catastrophic impact on society.

The last section pertains to market share. The proportion of registrations that are EVs communicates a signal from peers regarding EV performance. Higher proportions of EV registration suggest that higher number of drivers trust this new technology, which provides an encouraging signal for those who are awaiting peer confirmation before adopting the new technology themselves (Rogers, 2010).

4.2. Experimental design and implementation

Individual perceptions of and preferences for EVs and policy are measured using the discrete choice modelling framework. The attribute level values used in the specific choice tasks were defined in an efficient experimental design generated using NGENE software based on the D-efficiency design (Ali Ardeshiri and Rose, 2018; Scarpa and Rose, 2008). D-efficiency design strategies produce significantly better relative efficiency results, in a statistical sense, than the more traditional orthogonal designs (Scarpa and

Table 2
Alternatives' attributes and levels in the SP task.

Attribute	Min	Max	Number of levels	Level(s)
Vehicle Property				
Vehicle body type	–	–	6	Small Hatchback; Small Sedan; Large Sedan; Small SUV; Large SUV; Minivan
Price (condition on available budget)	$25,000	$55,000	4	$25,000; $35,000; $45,000; $55,000
	$55,000	$100,000	4	$55,000; $70,000; $85,000; $100,000
	$100,000	$160,000	4	$100,000; $120,000; $140,000; $160,000
Set up cost	$1,000	$3,250	4	$1,000; $1,750; $2,500; $3,250
Operating cost	3c/km	12c/km	4	3c/km; 6c/km; 9c/km; 12c/km
Recharge time	0.5 hr	7.5 hr	8	0.5 hr; 1.5 hr; 2.5 hr; 3.5 hr; 4.5 hr; 5.5 hr; 6.5 hr; 7.5 hr; 8.5 hr
Range in a single recharge	120 km	540 km	8	120 km; 180 km; 240 km; 300 km; 360 km; 420 km; 480 km; 540 km
Support Scheme				
Availability of fast charging station (Distance between the stations)	5 km	20 km	4	5 km; 10 km; 15 km; 20 km
Access to bus lane			2	Yes; No
Rebate on upfront cost	$3,000	$10,000	4	NA; $3,000; $6,500; $10,000
Rebate on parking fee until 2025	$100	$400	4	NA; $100; $250; $400
Energy bill discount until 2025	25%	100%	4	NA; 25%; 75%; 100%
Stamp duty discount	5%	25%	4	NA; 5%; 15%; 25%
Market penetration				
Current portion of EVs sold	1 out of every 100	90 out of every 100	4	1; 30; 60; 90

Rose, 2008).

The final design had a D-error of 0.0092 and included 144 choice tasks in 18 blocks, providing each participant with eight repeated choice scenarios. Each individual was given eight hypothetical tasks to complete and was urged to treat each task independently of the others. In each task, participants had the option to choose between two EVs. The "opt out" option was also available as the third alternative. Participants were also reminded to keep in mind their vehicle purchasing budget, as well as their household income and all other expenses. To ensure that participants took the survey seriously, a short "cheap talk" script was developed using guidance from Morrison and Brown (2009). Cheap talk is a technique used in SP surveys to remind participants that they should make choices as if they really had to pay. Cheap talk has been shown to be effective at reducing the potential for hypothetical bias in choice experiments (Ardeshiri et al., 2019; Ali Ardeshiri et al., 2018; List et al., 2006; MacDonald et al., 2015; Tonsor and Shupp, 2011). Fig. 3 presents an example of the DCE task.

4.3. Data analysis

The underlying theory of the LCM assumes that individual preferences are based on observable attributes, while latent variables are unobservable for the analyst. The latent variables, which determine how respondents can be segmented, are captured through a model of discrete groups varying across individuals who are implicitly sorted into a set of S classes. However, no information is available to the analyst about which class contains which particular individual. In each latent class, consumers will select the EV they will purchase that is associated policies they prefer. The utility on the EV preference is labelled "utility" (U), and can have a range of values for individual i, with k EV options belonging to the latent class s in a t choice situation (Eq. (1)).

$$-\infty < U_{it.k|s} < +\infty \tag{1}$$

To establish the components required to build the model, we assume that a choice scenario presents alternatives in the choice set C_k, $k = 1, 2, \ldots, K$, where K is the number of choice alternatives (in this case, EVs) in a choice experiment. Each alternative k for individual i has a utility of:

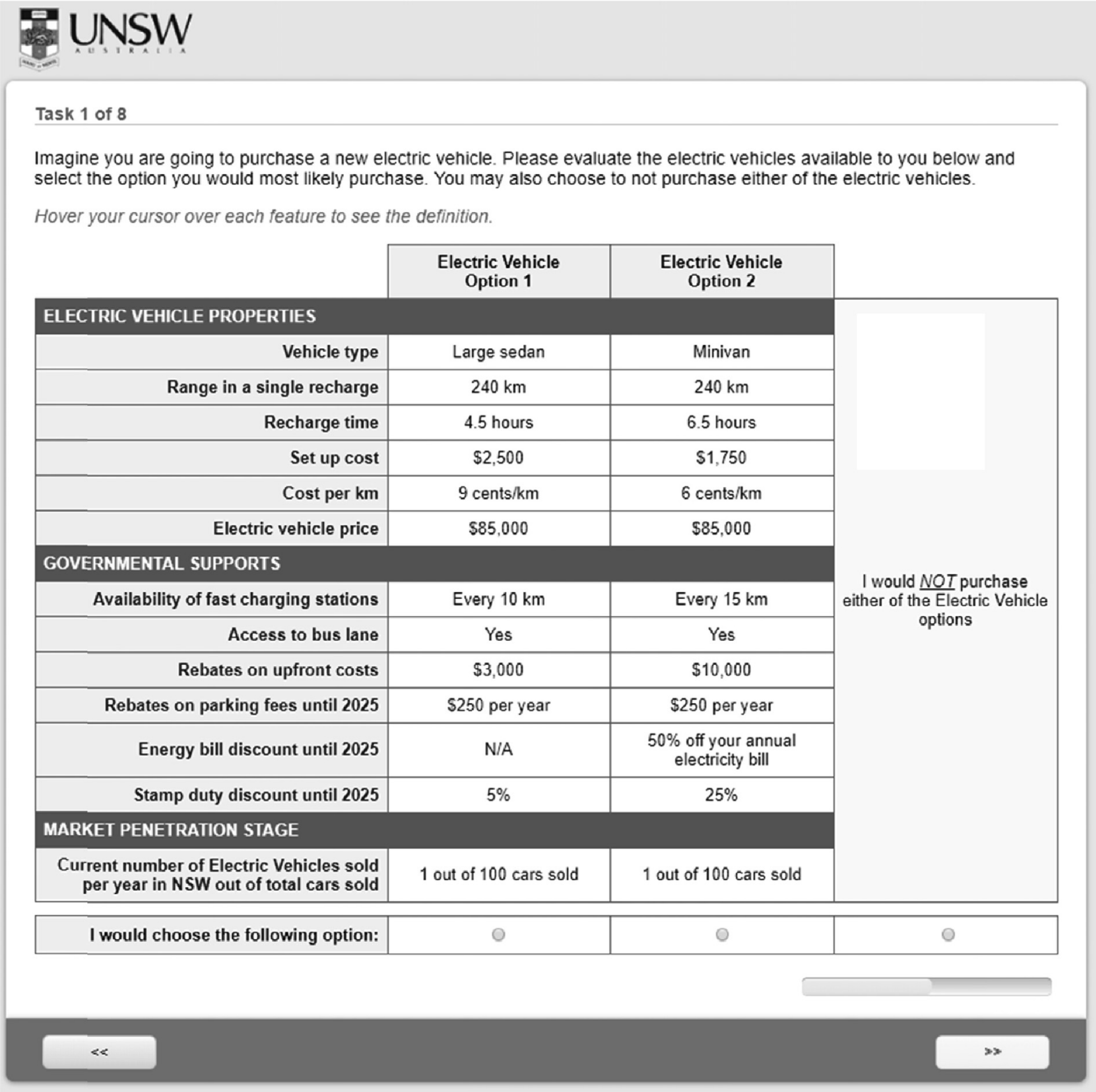
$$U_{it.k|s} = V_{it.k|s} + \varepsilon_{it.k|s} \tag{2}$$

where $V_{it.k|s}$ is the systematic utility for alternative k, conditional on belonging to class s with a set of attributes on the EV attributes β_s, where $\varepsilon_{it.k|s}$is the stochastic component of the utility of the alternative and it is assumed to be independently and identically Gumbel-distributed.

$$V_{it.k|s} = \beta_s X_{it.k|s} \tag{3}$$

Then, the class conditional choice model is a multinomial logit formulation:

$$P_{it.k|s} = \frac{\exp(U_{it.k|s})}{\sum_{k\in C_k}\exp(U_{it.k|s})} \tag{4}$$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Task 1 of 8

Imagine you are going to purchase a new electric vehicle. Please evaluate the electric vehicles available to you below and select the option you would most likely purchase. You may also choose to not purchase either of the electric vehicles.

Hover your cursor over each feature to see the definition.

	Electric Vehicle Option 1	Electric Vehicle Option 2	
ELECTRIC VEHICLE PROPERTIES			I would *NOT* purchase either of the Electric Vehicle options
Vehicle type	Large sedan	Minivan	
Range in a single recharge	240 km	240 km	
Recharge time	4.5 hours	6.5 hours	
Set up cost	$2,500	$1,750	
Cost per km	9 cents/km	6 cents/km	
Electric vehicle price	$85,000	$85,000	
GOVERNMENTAL SUPPORTS			
Availability of fast charging stations	Every 10 km	Every 15 km	
Access to bus lane	Yes	Yes	
Rebates on upfront costs	$3,000	$10,000	
Rebates on parking fees until 2025	$250 per year	$250 per year	
Energy bill discount until 2025	N/A	50% off your annual electricity bill	
Stamp duty discount until 2025	5%	25%	
MARKET PENETRATION STAGE			
Current number of Electric Vehicles sold per year in NSW out of total cars sold	1 out of 100 cars sold	1 out of 100 cars sold	
I would choose the following option:	○	○	○

<< >>

Fig. 3. Example Task used in the Survey.

To simplify, allow y_{it} to be the specific choice made, so the previous equation provides:

$$P_{it|s} = Porb(y_{it} = k|\ class = s) \tag{5}$$

Thus, for the given class assignment with a number of tasks, T_i events are assumed to be independent. This is possibly a strong assumption, especially given the nature of the sampling design used in the choice analysis where the individual answers a sequence of survey question. In fact, there might exist some correlations in the unobserved parts of the random utility. The latent class model does not readily extend to autocorrelation. Thus, for the given class assignment, the contribution of individual i to the likelihood is the joint probability of the sequence $P_i = [P_{i1}, P_{i2}, \ldots, P_{ik}]$, which is:

$$P_{i|s} = \prod_{t=1}^{T_i} P_{it|s} \tag{6}$$

The class assignment is unknown. Let G_{is} denote the probability for class s, including individual i. The multinomial logit form is:

$$G_{is} = \frac{\exp(z_i^{'}\theta_s)}{\sum_{s=1}^{S}\exp(z_i^{'}\theta_s)} \tag{7}$$

where z_i denotes the set of observable characteristics of the class membership, which is entered into the model. The likelihood for individual i is the expectation (over classes) of the class-specific contributions:

$$P_i = \sum_{s=1}^{S} G_{is}P_{i|s} \tag{8}$$

The final log-likelihood for the entire sample can be formulated as:

$$LnL = \sum_{i=1}^{N}\ln P_i = \sum_{i=1}^{N}\ln\left[\sum_{s=1}^{S} G_{is}\prod_{t=1}^{T_i} P_{it|s}\right] \tag{9}$$

Maximisation of the log-likelihood function with respect to the S structural parameter vectors, β_s, and the $S - 1$ latent class parameter vectors, θ_s, is a conventional problem in maximum likelihood estimation. All our models were estimated using PythonBiogeme, an open source freeware designed for the estimation of discrete choice models using maximum simulated likelihood methods (M Bierlaire, 2016).

5. Research findings

A latent class model was used to estimate individual policy preferences for EVs. Due to the fact that the number of the latent classes is unknown, a trial on the number of classes (2, 3, 4, 5 and 6) was examined to define the number of segments of participants. Five segments of participants were found to be sufficient to properly explain the data, as this produced the minimum Akaike information criterion (AIC) and Bayesian information criterion (BIC) values (lower AIC and BIC values indicate better model fit). Trends in AIC and BIC values are presented in Fig. 4.

The estimated parameters for the five-class latent model are presented in Table 3. Section 4.1 describes the five household classes identified by the final model and how they correlate with EV properties and governmental incentives.

5.1. Household EV acquisition styles and choice patterns

5.1.1. Lower-quartile middle-income families (Class 1)

The lower-quartile middle-income class constituted 12% of the sample population and consisted mainly of double-income households. They tended to belong to traditional families (65.4% were a family or couple with no children). The majority of these households were in the middle-income category, with an average total household income of $65,630. The average age of the household members in this class was 53.3 years. Most of them (55.4%) were working fulltime or part-time and had a bachelor or advanced diploma degree. Interestingly, 63.9% of these households did not have a car. In terms of their dwelling settings, 35% of households were more likely to live in semi-detached houses; 70% of them were owner-occupiers, and 26% were renting the property. Moreover, in relation to their driving preferences, they had a tendency to save costs on fuel and drive safely. In fact, more than 72% of people in this class agreed or strongly agreed with the following statements: “Saving on fuel makes me happy” and “Saving fuel is important”. “Driving more safely” was the other factor they considered important when driving.

Class 1 household members had a strong preference for small-sized vehicles such as small sedans, hatches and SUVs. After Class 2, members of Class 1 had the highest sensitivity towards *single-recharge range*. These respondents were indifferent to *recharge time* and, thus, no significant parameter was estimated. The coefficient for *Cost per km* had a negative and significant value of − 0.76, which implies that every one-dollar increase in the cost of driving an EV will decrease consumer utility of purchasing the EV by 0.76. The main factor in EV purchasing decisions was the vehicle cost. Members of Class 1 were extremely sensitive to EV price, which could be linked to their demographic backgrounds and budget constraints (middle-income) as well as their beliefs. *Rebates on parking fees* was the only significant influence on Class 1 households considering purchasing an EV. Respondents falling in this class had a strong preference for a higher level of autonomy when driving a vehicle. They also had a negative preference towards purchasing brand new

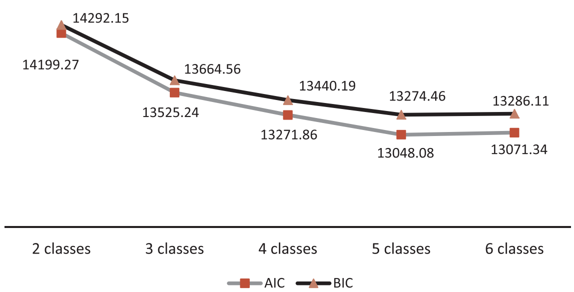

Fig. 4. Relationships between AIC/BIC values vs the number of latent classes.

Table 3
Coefficients of preferences for government support and EV attributes.

		Class 1	*Class 2*	*Class 3*	*Class 4*	*Class 5*
	Utility function Intercept					
	ASC Option1	4.30 (0.63)	−3.56 (0.88)	−1.16 (0.49)	2.66 (0.22)	−2.32 (0.33)
	ASC Option2	4.39 (0.66)	−3.41 (0.88)	−1.16 (0.49)	2.78 (0.22)	−2.28 (0.32)
Electric Vehicle Properties	**Vehicle Type**					
	Large SUV			3.36 (0.34)	0.19 (0.09)	
	Large Sedan		0.72 (0.31)	1.43 (0.27)	0.16 (0.09)	0.52 (0.21)
	Small SUV	2.11 (0.33)		2.97 (0.32)	0.26 (0.1)	0.94 (0.22)
	Small Sedan	2.30 (0.33)			0.24 (0.1)	1.68 (0.23)
	Small Hatch	1.86 (0.32)			0.36 (0.09)	1.86 (0.22)
	Range in a single recharge (km)	0.29 (0.09)	0.42 (0.13)	0.20 (0.07)	0.09 (0.02)	0.16 (0.04)
	Recharge time		−2.05 (0.69)	−1.54 (0.37)	−0.34 (0.11)	−0.68 (0.25)
	Cost per km	−0.76 (0.31)		−0.93 (0.26)	−0.42 (0.08)	
	Electric Vehicle price	−18.9 (1.72)	−4.57 (1.41)	−2.59 (0.45)	−0.94 (0.17)	−1.14 (0.48)
GovernmentalSupports	Access to bus lane					0.18 (0.11)
	Rebates on upfront costs			0.85 (0.24)	0.22 (0.07)	0.44 (0.15)
	Rebates on parking fees until 2025	0.14 (0.07)		0.10 (0.06)	0.04 (0.02)	
	Energy bill discount until 2025		0.70 (0.52)	1.12 (0.32)	0.35 (0.09)	0.78 (0.21)
	Stamp duty discount until 2025		0.13 (0.15)			
Market Penetration Stage	The current number of Electric Vehicles sold per year in NSW out of total cars sold			0.74 (0.27)	0.40 (0.08)	0.40 (0.17)

		Class 1	*Class 2*	*Class 3*	*Class 4*	*Class 5*
Socio-demographics	Class Membership Intercept	−2.23 (0.78)	−0.33 (0.58)	−4.21 (0.92)	5.07 (1.33)	Base
	Household type					
	Single person household	−0.59 (0.39)			−0.67 (0.25)	
	Couple family with no children			1.43 (0.54)		
	Couple family with children			1.67 (0.53)	0.55 (0.2)	
	One parent family			1.86 (0.68)		
	Age					
	Continues Age		0.02 (0.01)		−0.08 (0.02)	
	age between 18 and 30 years	−1.44 (0.56)		1.37 (0.74)	−1.62 (0.87)	
	age between 31 and 45 years	−0.76 (0.42)		1.64 (0.68)	−1.31 (0.66)	
	age between 46 and 65 years			1.60 (0.64)	−0.99 (0.42)	
	Household Total Income (Per annum)					
	Continues Income				−0.07 (0.02)	
	Income below $52K			−0.84 (0.43)		
	Income between $52 to $104K	0.99 (0.3)				
	Income more than $104k		0.87 (0.24)			
	Level of Education					
	Certificate from TAFE or equivalent			0.73 (0.39)		
	Bachelor's degree or equivalent		−0.7 (0.22)	0.79 (0.35)		
	Master's degree or equivalent		−1.13 (0.33)			
	Gender					
	Female		0.51 (0.21)			
	Employment					
	Employed full time				0.78 (0.19)	
	Dwelling Description					
	Free standing house	−0.78 (0.32)				
	Dwelling Ownership					
	Owned outright		0.63 (0.28)		0.65 (0.22)	
	Being rented		0.51 (0.27)			

		Class 1	*Class 2*	*Class 3*	*Class 4*	*Class 5*
Perception & Attitudes	**Support 2035 ban**					
	Support the Australian government to introduce a ban on production and sales of any cars running on petrol, gasoline or diesel by 2035		−0.97 (0.23)		0.55 (0.19)	

(*continued on next page*)

Table 3 (*continued*)

		Class 1	Class 2	Class 3	Class 4	Class 5
Perception & Attitudes	**Preferred Level of Autonomy**					Base
	Human Only				−0.36 (0.2)	
	Modern Vehicle	1.6 (0.42)				
	Modern Plus	1.06 (0.44)	−0.61 (0.28)		−0.41 (0.23)	
	Full Autonomy (+Human)	2.32 (0.48)				
	Preferred Vehicle Purchase Option					
	Brand New	−0.82 (0.32)			0.49 (0.22)	
	Second hand		0.53 (0.26)		0.91 (0.27)	
	Familiarity with EV					
	Yes			0.52 (0.28)	0.46 (0.17)	
	To consider an EV					
	More affordable pricing	1.74 (0.68)	−1.4 (0.25)		−0.55 (0.22)	
	Improved charging infrastructure			0.84 (0.3)		
Estimation report						
	Number of estimated parameters	**112**				
	Sample size	**8608**				
	Init log-likelihood	**−6840.54**				
	Final log-likelihood	**−6423.82**				

vehicles and believe that for consumers to consider purchasing an EV, prices should be more affordable. Additionally, the *Stamp duty discount until 2025* subsidy had a negative impact on their decisions.

5.1.2. High-income households with bachelor's degrees (Class 2)

Class 2 constituted 8% of the sample population and consisted mostly of households with high annual incomes with bachelor's or master's degree-level educations. More than 70% of these households lived in a family household setting. Moreover, the average household income in Class 2 was over $82,800 per annum and its members had the highest average age (55.5 years old) among all classes. Thus, 35% of respondents were retired. More than 85% of this class resided in a free-standing or semi-detached house (with 78% owning and 19.5% renting), and around 60% owned one or more cars. Moreover, Class 2 respondents preferred second-hand EVs to brand-new ones. Similar to Class 1, fuel efficiency and EV safety were the two most critical concerns of Class 2 residents (70% of respondents indicated concerns about these issues).

Class 2 respondents preferred large sedan vehicles. They had the highest sensitivity to single-charge driving range and recharge time among all classes, with parameter estimates of 0.42 and − 2.05, respectively. Similar to Class 1, vehicle price was the main driver of the EV purchase decision making. Interestingly, *access to bus lanes* had no impact on this group; however, the *energy bill discount* and *stamp duty discount* incentives had positive and significant values for this class. Class 2 was the only segment to have a positive preference for the *Stamp duty until 2025* subsidy. Respondents belonging to class 2 were unlikely to support an Australian Government ban on the production and sale of ICV cars by 2035.

5.1.3. High-income with college certificate (Class 3)

Class 3 constituted 6% of the sample population and its members had an average age of 45.8 years. Almost 20% of respondents indicated that they were unemployed and were doing domestic duties at home, which is the highest rate among all classes. More than 90% were living in traditional families (i.e. a couple with or without children). The average household income for Class 3 was $88,400, and more than 60% of members were employed. Over 78% indicated they resided in a free-standing or semi-detached house, and more than 20% lived in a flat, unit or apartment. Two-thirds of the class owned their property. Most importantly, this class had a good understanding of EVs and strongly believed that improving the EV charging infrastructure would increase their likelihood of purchasing an EV. In addition, similar to the previous classes, EV efficiency and driving safety were the most two serious concerns of this class.

Class 3 households had strong preferences for large SUVs, small SUVs and large sedans. Class 3 had moderate sensitivity to *single-charge driving range*, with a coefficient of 0.20, which is lower than that for Class 2 but higher than that for Classes 4 and 5. The estimated coefficient of *recharge time* had the second-lowest negative value of − 1.54, which was statistically significant. Furthermore, similar to Class 1, the coefficient for *driving cost* was also significant with a negative value of − 0.93, which further indicates that the class wanted to lower their driving costs by using an EV. Different incentives had different impacts on households in this class. *Energy bill discount* incentives, followed by *rebates on upfront costs* and *rebates on parking fees* had the highest positive impacts on EV purchasing decisions whereas, similar to Class 2, *access to bus lanes* had no impact. Compared to the other classes, market penetration had the most positive impact on EV acquisition for households belonging to this class. Finally, households belonging to this class felt that, in considering purchasing an EV, *improving the charging infrastructure* plays a major role.

5.1.4. Young middle-income families (Class 4)

This class constituted 15% of the sample and consisted largely of couples without children with an average age of 40.3 years, which was the youngest of all classes. The average household income in Class 4 was $76,000 and 63.9% of members were employed. Class 4 households were most likely to have an advanced diploma or above (57.6%). The majority of these households (75%) were in free-standing or semi-detached houses. Some 62.5% were renting or paying a mortgage and 34.18% of owned the property outright. These households were familiar with EVs and favoured second-hand ones, although brand-new ones were also acceptable. Moreover, battery *efficiency* was the most important factor when considering purchasing an EV.

Overall, Class 4 households were less demanding when it came to EV properties. Members belonging to this class do not have a specific preference on EVs types. They had the least sensitivity among all classes to *single-charge range*, *recharge time*, *driving cost* and *purchase price*. Similar to Class 3, *Energy bill discount incentives* followed by *rebates on upfront costs* and *rebates on parking fees*, had the greatest positive impacts on purchasing an EV. Similar to Class 3, market penetration had a positive impact on EV acquisition. Class 4 household members tended to purchase both brand-new and used vehicles with a preference for the latter.

5.1.5. Classic families in Australia (Class 5)

This class constituted 59% of the sample and consisted of a variety of people with an average age of 44.1 years. They were highly likely to be living in a family-oriented household (72.34% were a couple with or without kids) with a median household income of $80,987 per annum. The majority of the class were employed (65.5% were employed full-time or part-time) and were likely to have a bachelor's degree or above (51%). Most (78%) were living in either a free-standing or semi-detached house. Some 35.8% owned the property outright and 61.5% were paying rent or a mortgage. Their key preferences in vehicle acquisition were *save fuel* and *drive more safely*.

Class 5 households had strong preferences for small EVs and large sedans. After Class 4, they had the second-lowest sensitivity towards *single-charge range* and *recharge time*. However, the coefficient for *driving cost* was not significant, as they may have varied tastes in this regard. Unlike other respondents belong to other classes, *access to bus lanes* was an attractive incentive. However, *energy bill discount* had the highest impact, followed by *rebates on upfront costs* for households belonging to this class. Interestingly, *rebates on parking fees* and *stamp duty discount until 2025* were not attractive incentives for these households.

5.1.6. Household perceptions of and attitudes to EVs, and the market penetration stage

Households' perceptions and attitudes were also added into the models for each class to provide insights on their preferences for EVs. Respondents in Class 1 had strong preferences for *EV technology* (*Full autonomy* had the highest estimated coefficient) among all other classes. A ban on the production and sales of ICVs was only supported by respondents in Class 4 and was not favoured by households in Class 2. Finally, households in Class 4 had a positive preference for buying a brand-new EV, but others did not. Respondents belonging to Classes 3 and 4 expressed some familiarity with EVs. Moreover, the current market penetration stage indicated the percentage on consumers with EVs and it is a way on describing the household attitudes to EV within the community; however, such concept may also be indicated by the number of available charging infrastructures in local communities, or the frequency of EV keywords mentioned in the social media.

6. Discussion

Government supports can be applied in many ways and their effectiveness is a major concern of policymakers. In this section, we discuss the effectiveness of the studied government supports on consumer preferences and their probability of purchasing an EV. According to previous literature, the *Access to bus lane* incentive was expected to highly influence EV purchasing decisions; however, its effect was lower than that of other types of support. *Rebates on the upfront cost* was a welcomed subsidy in NSW, which is consistent with many other studies (Lévay et al., 2017; Zhang et al., 2018). *Energy bill discount until 2025* was the most preferred subsidy, which is an innovative support designed to attract EV users that can be extended with other green energy infrastructure, such as domestic solar panels. Both *Rebate on parking fees until 2025* and *Stamp duty discount until 2025* are incentives that have been widely applied in many leading countries with EVs; however, previous studies report that their effectiveness varies (Kong and Hardman, 2019).

A decision support system (DSS) was developed by PythonBiogeme (Bierlaire, 2003) to simulate "what-if" scenarios. In this section of the study, we will investigate the impact of non-financial and financial governmental supports on NSW household members' decisions when considering purchasing EVs. As a base-case study, all sample data were used to simulate the population of NSW and the respondents' preferred EV characteristics. Fig. 5 presents the base scenario when no governmental supports provided. As shown in Fig. 5a and b, Class 4 households (41.99% of the simulated population), had the highest probability of purchasing an EV, at 3.2%. The overall probability of purchasing an EV for the designated segment was 1.6%. In the following subsection, the impacts of introducing different incentives are provided (Figs. 6–9).

6.1. Non-financial government supports

The only significant non-financial government support was the *Access to bus lane* incentive. This policy allows EVs to travel in road lanes normally restricted to buses and is the only subsidy that does not incur a direct cost to the policymaker. It is attractive to consumers because it is perceived to save travelling time, assuming that bus lanes are underused. Nonetheless, it should be noted that this strategy can negatively affect the travelling experience of public transport users. Although this incentive might create a positive public perception of EVs (Wolbertus et al., 2018), its effectiveness was lower than the other incentives. Table 4 shows that only Class

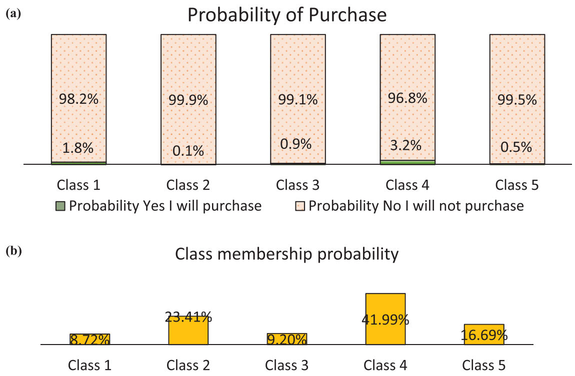

Fig. 5. The probability of purchasing an EV in the base case, and class memberships.

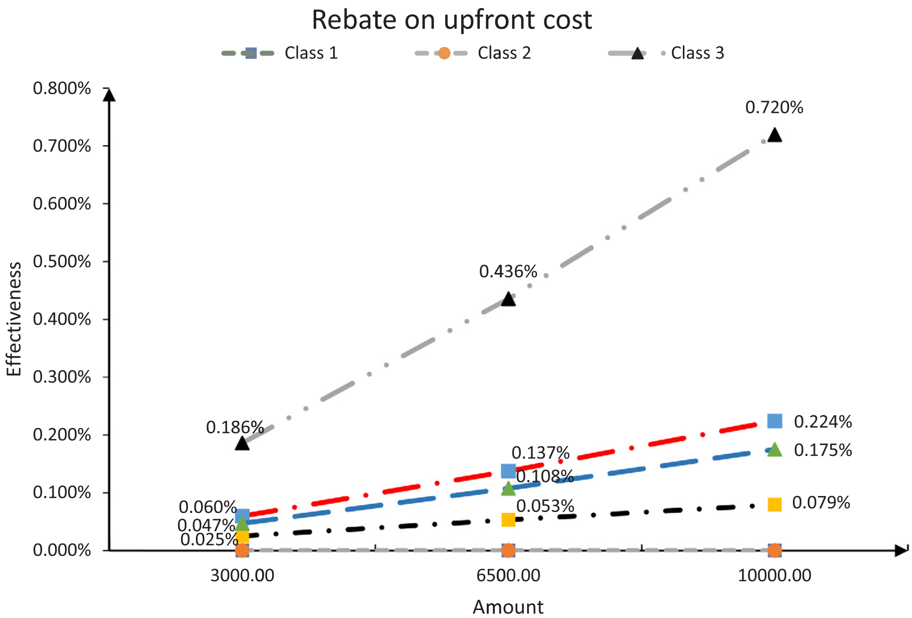

Fig. 6. Effectiveness of the *Rebates on upfront cost* incentive.

5 respondents' EV purchase probability increased by 0.04% when this incentive was applied, but it had no positive impact on the other classes. This might be due to the other major barriers to EV purchase identified in the literature, such as large premiums (Larson et al., 2014), the lack of charging infrastructure at public parking spaces, and limited local transport networks could reduce the perceived benefits of gaining the incentive.

Moreover, the *availability of fast-charging stations* is another government support provided to households, aiming to evaluate the preferred average distance between fast-charging stations. Average distances of 5–20 km were evaluated. Surprisingly this attribute was not significant in any of the classes. This might be attributed to the fact that average distances can be perceived differently and/or people may not fully understand the benefits associated with widely available charging stations. Thus, we recommend further research is required to explore households' preferences towards accessibility to fast charging stations.

6.2. Financial government supports

6.2.1. One-off incentives

Rebates on the upfront cost was the most preferred one-off incentive considered in this study. Customers were very sensitive to the purchase price of EVs. Class 3 shows that the purchase probability increased from 0.186% to 0.720% (Table 4) when a subsidy of $3,000–10,000 was offered. However, this was not observed for Classes 1 and 2. Studies (Liao et al., 2017) show that a subsidy is perceived positively when it decreases the price of a vehicle, which means that a subsidy is more effective when given to consumers rather than manufacturers. Upfront rebates of the maximum $10,000 were most preferred, because the majority of EV models cost more than $60,000 (ClimateWorks Australia, 2017), making them unlikely to be affordable to middle-income families with an average income of $80,000 per annum.

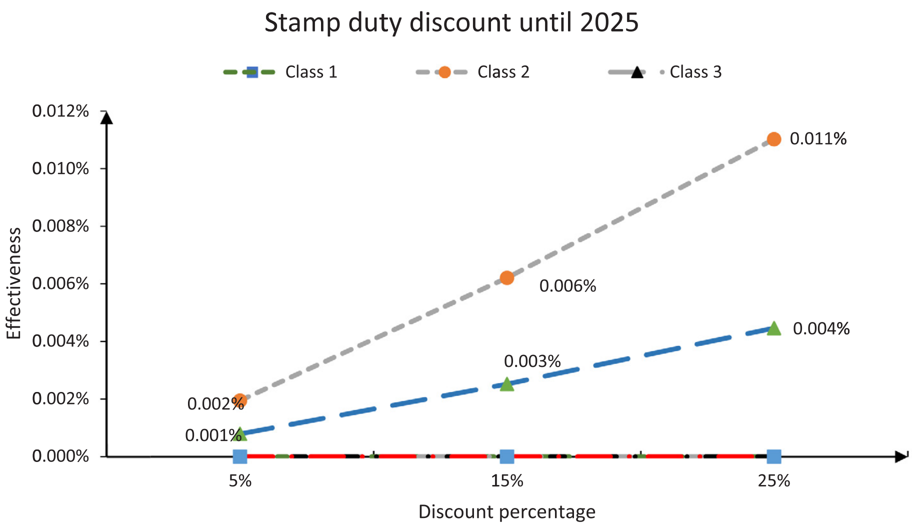

Fig. 7. Effectiveness of the *Stamp duty discount until 2025* incentive.

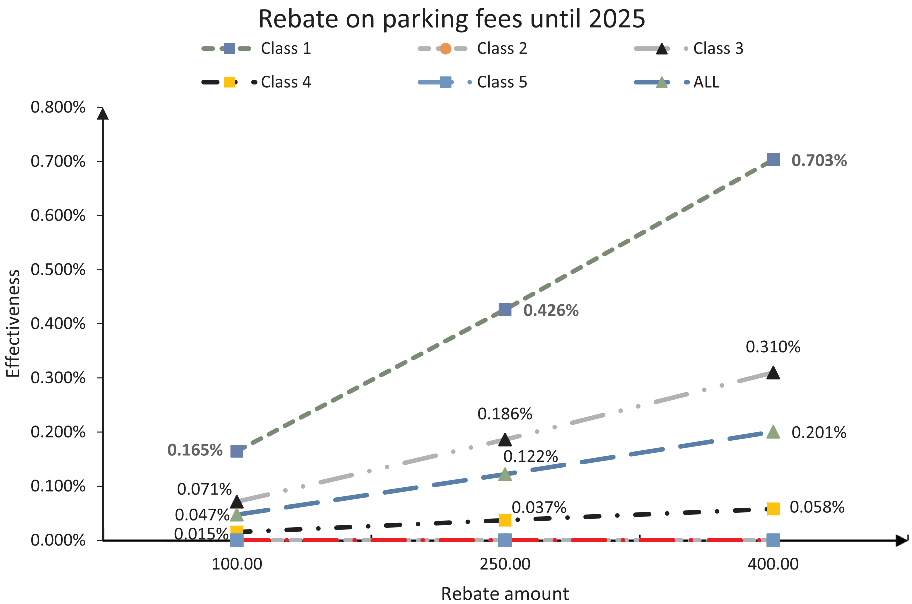

Fig. 8. Effectiveness of the *Rebates on parking fees until 2025* incentive.

Stamp duty discount 2025 is a one-off offset on the stamp duty payable when purchasing an EV. The subsidy was not widely accepted except in Class 2, possibly because the amount of incentive was perceived to be minimal compared to other EV costs and comparable government incentives. Nonetheless, individuals in Class 2 showed a positive reaction to this subsidy, but its effectiveness was lower than those of the other subsidies shown in Table 4. The overall impact on purchasing probability was 0.004% (Negligible) and no impacts on respondents belonging other classes.

6.2.2. On-going incentives (Operating incentives)

One of the suggested operating incentives was *Rebates on parking fees until 2025*, which had a maximum annual amount of $400 that consumers can claim back from the local transport agency. As the results of the simulation show, most consumers perceived a $400 discount on parking fees positively, while respondents belonging to Classes 2 and 5 were unaffected by this incentive (Table 4). One of the major reasons for this incentive being poorly received by Classes 2 and 5 might be that parking fees are rather expensive in NSW, especially in the Sydney CBD ("early bird" parking fees are about $20 per day), such that the proposed subsidy is insufficient to cover parking costs. Moreover, such incentives may cause greater congestion in the CBD as they encourage citizens to drive to work instead of using public transport services.

The most attractive operating incentive was *Energy bill discount until 2025*, which discounts annual electricity bills at certain rates.

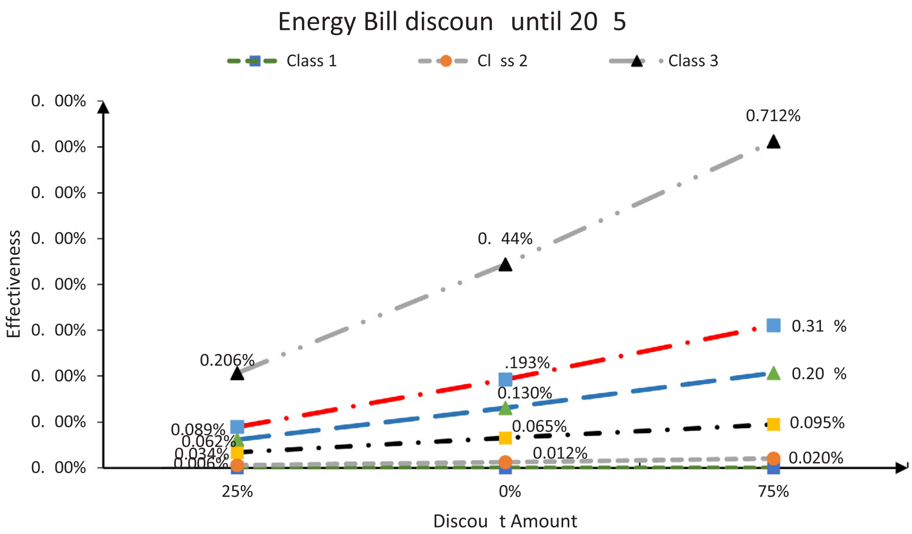

Fig. 9. Effectiveness of the *Energy bill discount until 2025* incentive.

Table 4
Heat map of the effectiveness of government supports.

Government Supports	Class 1	Class 2	Class 3	Class 4	Class 5	ALL
Access to bus lane						
Yes					0.040%	0.009%
Rebates on upfront costs						
3,000			0.186%	0.025%	0.060%	0.047%
6,500			0.436%	0.053%	0.137%	0.108%
10,000			0.720%	0.079%	0.224%	0.175%
Rebates on parking fees until 2025						
100	0.165%		0.071%	0.015%		0.047%
250	0.426%		0.186%	0.037%		0.122%
400	0.703%		0.310%	0.058%		0.201%
Energy bill discount until 2025						
25%		0.006%	0.206%	0.034%	0.089%	0.062%
50%		0.012%	0.444%	0.065%	0.193%	0.130%
75%		0.020%	0.712%	0.095%	0.311%	0.207%
Stamp duty discount until 2025						
5%		0.002%				0.001%
15%		0.006%				0.003%
25%		0.011%				0.004%

Specifically, it increased the EV purchase probability by 0.712% for Class 3 (Table 4), which is a significant change in the probability among all classes by comparing to other incentives. One of the major reasons why energy bill discounts may become attractive in NSW is because electrical energy is expensive in Australia (Bell et al., 2017) and many families pay more than \$1,000 per year for it (ClimateWorks Australia, 2017). Moreover, fossil fuels are costly in NSW; the conservative estimated fuel cost for a family is around \$3,500 per year (Budget Direct, 2019). Thus, if EV users could get discounted electricity, their daily travel expenses could be subsidised because EVs are charged at home by most respondents with free-standing houses. Although researchers have reported that one-off reductions in upfront costs are more attractive than on-going operational cost incentives, the *Energy bill discount until 2025* subsidy may achieve success in Australia.

6.2.3. Scaled effectiveness of government supports

The effectiveness of government supports needs to be investigated along with their financial costs. An assumption is made that the net present value (NPV) of an incentive is almost equivalent to its cost to the government. To compare the effectiveness and NPV of each government incentive, the scaled effectiveness of each incentive is considered as the preliminary evaluation criterion. It is calculated as the effectiveness of the incentive divided by its NPV in ten thousand (Eq. (10)).

$$Scaledeffectiveness_{incentive} = \frac{effectiveness_{incentive}}{NPV_{incentive}/10,000} \tag{10}$$

Moreover, the scaled effectiveness of incentives can be calculated by applying Eq. (10) to each incentive and the overall

Table 5
Scaled effectiveness values of government EV incentives.

Government Supports	Class 1	Class 2	Class 3	Class 4	Class 5	ALL
Rebates on upfront costs						
3,000			0.620%	0.084%	0.199%	0.156%
6,500			0.670%	0.081%	0.211%	0.166%
10,000			0.720%	0.079%	0.224%	0.175%
Rebates on parking fees until 2025						
100	2.565%		1.111%	0.236%		0.737%
250	2.657%		1.159%	0.231%		0.760%
400	2.739%		1.207%	0.226%		0.782%
Energy bill discount until 2025						
25%		0.008%	0.286%	0.047%	0.124%	0.085%
50%		0.009%	0.307%	0.045%	0.133%	0.090%
75%		0.009%	0.329%	0.044%	0.143%	0.095%
Stamp duty discount until 2025						
5%		0.045%				0.018%
15%		0.048%				0.019%
25%		0.051%				0.021%

population based on the NPVs calculated in Table 5. The scaled effectiveness results are shown in Table 6, and demonstrate that *Rebates on parking fees until 2025* is the most scaled effective government incentive for consumers, followed by *Rebates on upfront cost* (the highest scaled effectiveness values of these two incentives are 0.782% and 0.175%, respectively). However, *Energy bill discount until 2025* becomes the second-least effective incentive with a positive impact due to its high NPV values. Lastly, *Stamp duty discount until 2025* has a minimal impact on scaled effectiveness that is less or equal to 0.021%.

7. Conclusions

Respondents' preferences for government incentives were examined in regard to their decision-making in purchasing an EV. Parameters of a latent class model were estimated using a stated choice survey from residents of NSW, Australia. The results of the model demonstrate that respondents can be classified into five latent segments based on their socio-demographic characteristics. The preferences and behaviour of each of the five segments were explored in terms of their decision-making related to purchasing an EV, with consideration of EV performance and technology, and government incentives. The preferences for, and effectiveness of, these incentives differed between the five segments. The study also found that the level of EV acceptance increases with education, employment and income.

The results of the latent class discrete choice model confirm some of the findings of earlier studies; for example, consumers are unwilling to pay a large premium on the upfront cost of an EV, they want it to have an affordable purchase price and low operating costs, and they like strong government incentives.. In addition, the preferences for government supports were analysed based on the targeted group of consumers and the preferred EVs in NSW. The main preferences were for the incentives of *Rebates on parking fees until 2025*, *Rebates on upfront cost* and *Energy bill discount until 2025*. These were the top-three incentives in terms of their positive

Table 6
NPVs of government EV incentives.

Year	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	
Government Supports								**NPV Total**
Access to bus lane								
Yes								
Rebates on upfront costs								
3,000	3,000							3,000
6,500	6,500							6,500
10,000	10,000							10,000
Rebates on parking fees until 2025								
100	100	97	94	92	89	86	84	642
250	250	243	236	229	222	216	209	1,604
400	400	388	377	366	355	345	335	2,567
Energy bill discount until 2025								
25%	1,125	1,092	1,060	1,030	1,000	970	942	7,219
50%	2,250	2,184	2,121	2,059	1,999	1,941	1,884	14,439
75%	3,375	3,277	3,181	3,089	2,999	2,911	2,827	21,658
Stamp duty discount until 2025								
5%	68	66	64	62	60	58	57	433
15%	203	197	191	185	180	175	170	1,299
25%	338	328	318	309	300	291	283	2,166

scaled effectiveness on purchasing probability. Due to fossil fuels and energy being expensive in Australia, energy bill discounts could be a successful incentive in NSW.

However, the preferences for charging infrastructure availability were totally different across segments and the resale value of EVs are still unclear to consumers; thus, the availability of charging infrastructure and the resale values should be explored more in future research. Another limitation of this study is related to the assumption we had made regarding the tasks presented to the individual are independent and no correlation exists among choices of each respondent. The model could be further developed to consider the panel effect in the data.

The outcomes of this study can help policymakers in various ways: (1) The study helps them to correlate the effectiveness and scaled effectiveness of government supports with the probability of EV purchase. (2) It identified the potential cost/NPV of each government support and forecasted the potential cost of on-going incentives for the next six years. (3) The study identified suitable subsidies for households in NSW, Australia, by referencing the incentives used in leading EV-using countries.

CRediT authorship contribution statement

Shuangqing Gong: Writing - review & editing. **Ali Ardeshiri:** Writing - review & editing, Supervision. **Taha Hossein Rashidi:** Writing - review & editing, Supervision, Funding acquisition, Project administration, Resources.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trd.2020.102353.

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