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Estimating the Choices of Electric Vehicles: A Random Utility Model

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Abstract
Purpose: This study aims to understand the consumption behaviour of Malaysians on electric cars by utilizing the discrete choice modelling approach. This paper also describes the relationship between the socio-demographic factors of the consumers and their buying decision by utilising the random utility theory.
Design/methodology/approach: Consumers in two major cities in Malaysia were sampled and given a set of choices determined from review of past studies. The choices are made up of three important attributes of electric cars, which are the price of the vehicle, the driving range of the vehicle and the charging time of the vehicle.
Findings: Results show that brand, design and safety features of the vehicles have significant, influential power over the purchase behaviour of electric cars. This study also reveals that Malaysians have little knowledge on electric cars. The willingness to purchase electric cars among the respondents is also very low.
Research Limitations: This study was conducted on consumers living in cities. Thus, future research may focus on consumers living in remote areas of the country.
Originality/value: There is a dearth of literature that applied the utility theory in understanding consumers choices of electric vehicles. It is against this background that this study fills the literature gap through the attempt to examine the choice of electric cars, and the preferred attributes of electric cars among Malaysians using stated preference data.

Keywords Electric vehicles, discrete choice model, stated preference, experimental survey, sustainable consumption

1 Introduction

The gasoline powered car has been the most important mode of transport for more than 130 years. The market is huge, especially for countries with less comprehensive public transportation services and extreme geographical environment. In 2016, the global auto population was 1.32 billion, doubled the total number of vehicle two decades ago (Petit, 2017). In 2019, global annual vehicle sales were recorded at 65.5 million units (Bekker, 2020).

Before the outbreak of Covid19, the popularity of the sharing economy was an emerging trend of resource mobility; whereby, sharing of cars was projected to replace personal vehicle ownership in some hectic cities. During the pandemic episode, a personal car beats every type of shared conveyance. Personal vehicles become the obvious extension of safe zones and secure transport to the still-open stores and pharmacies.

A gasoline-powered car is like a double-edged sword. It benefits the human well-being, but bring huge damages to the environment. Transportation sector is the largest greenhouse gas contributor. A passenger vehicle emits nearly 5 metric tons of carbon dioxide (CO_2) yearly (EPA, 2018). The heat trapped by the gases within the atmosphere causes the rise of sea levels, severe weather calamities, and droughts that prompt wildfires and crop failures (Tan & Hong, 2018). Meanwhile, the fluctuation of international oil prices affects the total expenditure on vehicle users. Transportation accounted for more than half of the share of global crude oil and petroleum products consumption (EIA, 2020; Prambudia & Nakano, 2012). The need to address environmental and economic issues associated with gasoline-powered vehicles has prompted electricity to become an alternative transportation powered solution.

The impacts to the environment, CO_2 emission and recycling efficiency have been fully considered in producing electric vehicles. Studies show that the technology could reduce 40 percent of CO_2 emission (Adnan et al., 2018). In particular, the core of the electric car, the battery, can be recharged and reused for up to eight years (Cagatay, 2019), while retired batteries can be recycled. This is adhering to the goal of circular economy, which emphasises the higher rates of technological development, environment improvement and higher profit opportunities (Pagliaro and Meneguzzo, 2019).

Low CO_2 emission initiates a positive chain reaction, whereby a clean air improves human health, leads to the saving in the public finance (Lemille, 2017). Besides, using of electric vehicles can reduce dependence on oil imports. If gasoline-powered vehicles are being replaced by electric vehicles, countries that rely heavily on personal transports can reduce the consumption of foreign exchange reserve and household expenditures. The saving from the personal transport expenditure could potentially accumulate wealth in the local economy in a long run. Nevertheless, electric vehicles seem less popular in southeast Asia. Public acceptance and recognition of electric vehicles are relatively low, notwithstanding the rise of interest in the electric vehicles globally (Adnan, Vasant, Rahman, & Noor, 2016).

In the case of Malaysia, lack of a comprehensive public transportation system has resulted its population listed as one of the highest car owners and use rates in Asia; in addition, 23.9 per cent of Malaysians' monthly household income are expenditure for gasoline consumption (Abas & Ooi, 2016). Malaysia's annual CO2 emission by car is 110 million metric tons, it is equal to total electricity used by 18.6 million households per year, or 1.8 billion tree seedlings grown for ten years[1] (based on the quantity of CO2 emission by a passenger car per year, which is about 4.6 metric tons).

According to Azmi & Tokai (2017), registration of electric cars accounts for 5,403 units as of March 2019, although an estimation for passenger vehicle market is 12 million units in year for 2030 (accounting for only 4 percent of the environmental-friendly vehicles), and will increase further to 43,000 units in 2040. These number reveals that the attempt to replace the gasoline-powered car with the electric car remains challenging in this country. Hence, consumer preferences

[1] 8.89 × 10-3 metric tons CO2/gallon gasoline × 11,484 VMT car/truck average × 1/22.3 miles per gallon car/truck average × 1 CO2, CH4, and N2O/0.989 CO2 = 4.63 metric tons CO2E/vehicle /year

for and factors that may hinder electric vehicles adoption in Malaysia should be identified and minimised as a strategy in promoting the consumption of electric vehicles in the country.

Review of the local literature identifies use of Theory of Planned Behaviour (TPB) and examination of purchase intention from the attitudinal perspective in past studies (Adnan et al., 2017, 2018; Yong et al., 2017). Observed however is lack of available research applying the utility theory in investigating on the attributes of electric car that the market prefers, which is also linked to consumers' socio-demographic characteristics. It is against this background that the current study fills the literature gap through the attempt to find the determinants of electric cars consumption and the preferred attributes of electric cars among Malaysians. Apart from contributing to vehicle consumption literature, the findings from this study are may make valuable recommendations for the government in developing practical policies on environment protection and for the vehicle industry in devising effective marketing strategies that can promote electric vehicles consumption of and profit-making in the country.

This paper is organized as follows. After the introduction, a brief review literature on utility theory, attributes of an electric car that contributes to the buying behaviour and factors that influence consumers' buying behaviour of environmental-friendly vehicles follow suit. A conceptual model is then proposed to determine the relationship between the attributes of an electric car and the purchasing behaviour. Subsequently, an empirical study is developed to validate the proposed conceptual framework. The results and findings are discussed afterwards. Finally, the conclusion and limitations of this study are presented.

2 Literature Review

In market economics, the consumer demand theory plays a fundamental role in witnessing the insight of the market demand. This theory assumes that all consumers are rational. According to the theory, a rational consumer makes choices based on individual preferences, and will always attempt to maximize the utility or satisfaction subject to a budget constraint (Medema, 2008). In the context of a car purchase, a rational consumer will consider to maximize the utility through attributes of a car and some personal factors, including the social-demographic factors before purchasing. Thus, the demand for electric vehicles depends on the added value that it could offer to the consumer over fossil fuel vehicles.

In identifying attributes of goods that can maximise the utility of consumers, the random utility model (RUM) is often used. RUM is a choice model that researchers use to model the choice of the decision maker on a set of choices which are mutually exclusive (Walker & Ben-Akiva, 2002). It utilizes indicators such as the stated preference and revealed preference to help researchers estimate the consumption behaviour.

2.1 Attributes of electric vehicles that contributes to its consumption behaviour

The literature has identified many attributes that have been associated with electric vehicles (EVs) consumption behaviour of the consumers in the marketplace. Amongst them include price, driving range, charging time and charging facilities.

2.1.1 Price

According to the law of demand, price plays a fundamental role in consumer demand. The Marshallian demand function specifies that consumers would solve their utility maximization problem by buying at each price, and in each wealth condition, namely income. Similarly, price is the major concern of adopting alternative fuel vehicles (Campbell, Ryley, & Thring, 2012; Hidrue,

Parsons, Kempton, & Gardner, 2011). The price premiums imposed on energy efficient products have turned it to be less attractive (Tan, Ooi and Goh, 2017). The exceptional cost should be reduced for electric-fuel-vehicles to be affordable (Campbell et al., 2012). A study by Tamor, Gearhart, & Soto (2013) show that consumers who adopt EVs are much affected by the short-term cost of owning an EV compared to the long-term savings that they can accumulate. In other words, consumers will be more fascinated by the savings of lower purchase price of the EV. This discovering bolsters by an investigation led in Los Angeles, which claim that by expanding in the driving range of the EVs alone is deficient to improvement for it, but the decrease in the cost upon buying will stimulate the demand (Adepetu & Keshav, 2017).

Chen, Zarazua de Rubens, Noel, Kester, & Sovacool (2020) found that while young people are more interested in EVs, their purchasing power is low. This indicates that the demand for EVs will rise if the market can offer more economic prices of EVs. An interesting finding by Habich-Sobiegalla, Kostka, & Anzinger, (2018) shows that there is a strong relationship between the EV's price and its demand. However, the reason behind it is not stated. Lin & Wu (2018) found that due to Chinese government subsidies, lower electric vehicle prices promoted people's willingness to buy cars. This finding however is found conflicting with Xu, Zhang, Bao, Zhang, & Xiang's (2019) study whereby the price of EVs has no effect on the purchase intention. Some Malaysians are willing to pay extra for electric vehicles looking at the economic value in the long run (Khazaei, 2019).

2.1.2 Driving Range

Besides price, the driving range of an EV is another major concern of consumers. The driving range is defined as the distance the EV is able to operate until the battery runs out. Adepetu & Keshav (2017) show that most people purchase EVs for the use in short distance only because it is solely relying on the battery for its power source and alternative energies are kind of impossible. Consumers feel insecure and anxiety to use EVs for a long distance.

Consumers prefer a higher driving range of EVs due to accustomisation to the high range of fossil fuel cars (Franke & Krems, 2013). In reality, the preferred range that consumers expect from an EV is more than the actual needs. In an experiment conducted by Franke and Krems (2013), consumers' range preference decreases over a period of three months after a practical driving experience on EVs. If the range anxiety of the consumer can be overcome, the consumer will be more willing to purchase EVs (Daziano, 2013). However, Chen et al. (2020) found no significant correlation between driving range and EV adoption.

2.1.3 Charging Time and Charging Facilities

A study carried out in China by Yang, Long, Li, & Rehman (2016) identified long charging time and limited charging infrastructure as the main barriers of the EV adoption in China. Most consumers prefer the fossil fuel cars compared to EVs, because it is more time consuming and troublesome to recharge the EV than to fill the fuel at the petrol station. Similarly, Zhang, Bai, & Shang, (2018) also find that longer charging time will affect future EV use. This is supported by Chen et al., (2020), that shorter charging time will lead to higher EVs adoption. The time needed to recharge may sometimes disturb the daily routines of the users (Jensen, Cherchi, & de Dios Ortúzar, 2014). The charging time is one of the major inconveniences of owning an EV (Ko & Hahn, 2013). Unlike the convenience and refuelling speed of fossil fuel cars, EVs will have to be recharged by using electric cable after usage. Caperello & Kurani (2012) states that EV owners sometimes fail to charge their vehicles with the facilities outside of their homes. Users found to be

safer to recharge at home for the safety of both the vehicle and the power cord. EVs may be more attractive if the battery is swappable (Ko & Hahn, 2013).

2.2 Determinants of choice

2.2.1 Demographic Factors

Consumer demographic factors namely age, gender, monthly income, educational level and marital status are proven to influence consumers' purchasing decision. About age, Lin & Wu (2018) found that age shows a significant relationship between age and consumer purchase decision. As explained by Chen et al. (2020), while young people are more interested in buying electric cars, it is the elders consumers that have higher real purchasing power. Habich-Sobiegalla et al. (2019) for instance found that consumers aged 35-49 are those who have the highest desire to buy electric cars. These findings are supported by Sovacool et al. (2019), but they emphasized that when cost and other motivations were added into the model, the relationship between age and purchase decision will be limited. Interestingly, Habich-Sobiegalla et al. (2018) holds an opposite review as the research in China shows that older consumers have a higher purchasing desire than young people.

In terms of gender, the male is said to be more reserved when it comes to the acceptance of new technology compared to females, surprisingly (Dagsvik, Wennemo, Wetterwald, & Aaberge, 2002). In other words, females are more open to newer technologies and have a higher likelihood to pay more for cleaner vehicles (Daziano & Bolduc, 2013; Lin & Wu, 2018). Chen et al.'s (2020) study however show the opposite result. Habich-Sobiegalla et al. (2018) found that respondents of different nationalities produced different results. Women in Russia are more likely to buy electric cars which is not found in countries like China and Brazil. Sovacool et al., (2019) shows that there is no noteworthy link between age and purchase decision.

Plötz, Schneider, Globisch, & Dütschke (2014) state that consumers who are engaged in technical professions are more likely to buy EVs while Hackbarth & Madlener (2016) show that younger and higher educated people are more implausible to purchase EVs. This is supported by Habich-Sobiegalla et al. (2019), but applicable only in China, not Russia and Brazil (Habich-Sobiegalla et al., 2018). Sovacool et al. (2019) did not find any relationship between education level and purchase decision. In addition, while income turns out to be a less influential factor as compared to age, gender and educational level (Bjerkan, Nørbech, & Nordtømme, 2016), Chen et al. (2020) and Habich-Sobiegalla et al. (2018), found that there is positive relationship between higher-income individual and purchase decision. Nonetheless, studies are showing that income can be a prominent factor when come to the purchase of greener products. Income for instance is an indicator of strength to tolerate the rise in the marginal cost when buying an environmentally friendly goods (Newell & Green, 1997). Hence, demographic factors have an influence on the choice of electric car.

2.2.2 Brand

Brand is an indicator of trust. Brand reflects the design and performance of automobiles. At the aggregate level, the essence of global brands- quality, reliability, and trust remain important (Rosenbloom & Haefner, 2009). Brand information and country-of-origin information are often used by consumers to reduce the complexity of task involved in information processing (Supanvanij & Amine, 2000). A general assumption in the branding literature is that a favorable brand image will have a positive impact on consumers' behaviour towards the brand, especially

the trust in the quality (Hong and Kamaruddin, 2020). Brands from countries with the strong brand image gain higher chance of being assumed to be a good product (Nielsen, 2016). Hence, brand has an influence on the choice of electric car.

2.2.3 Environmental Concern

Chen et al. (2020); Lin & Wu (2018); Roberts & Bacon (1997) and Xu et al. (2019) state that the environmental behaviour has a positive relationship with the environmental knowledge of an individual (Habich-Sobiegalla et al., 2018) in Brazil, China and Russia. It is also proven that the willingness to pay for green products is highly associated with the degree of individual's awareness of the consequences of using those goods, environmental problems, and their willingness to solve the problems (Bang, Ellinger, Hadjimarcou, & Traichal, 2000; Laroche, Bergeron & Forleo, 2016; Sang & Ali Bekhet, 2015). When consumers understand further about the environmental benefits of electric vehicles, they will reduce their concerns about perceived risks (Zhang et al., 2018). However, no relationship was found between environmental concern and intention to own an EV (Habich-Sobiegalla et al., 2019). Hence, encironemnt concern attitude has an influence on the choice of electric car.

3 Method and Data

3.1 Stated preference experiment design for discrete choice modelling

The stated preference discrete choice approach, also recognised as stated preference experiment design (Hong, Sun, Beg and Zhou, 2020), is employed for the study to investigate, explain, and estimate choices from alternatives (the combination of attributes) that have been pre-determined for electric cars based on the literature review. Stated preference discrete choice is a self-reported decision protocol, where a sample is asked about his/her choices that made under hypothetical situations, regardless of the use or purchase experience, or the presence of goods and services in the market. It is an efficient method to be applied when there are unavailability of data due to new products/services, or the insufficiency of choice varieties that enable the examination of attributes of interest (Viney, Lanscar, and Louviere 2002).

3.2 Conceptualising and designing the alternatives

Designing the alternatives/choice is a vital process of discrete choice modelling, and the determination of the choice alternatives, attributes and elements has been recognised as an important yet difficult task (Holmes and Adamowicz, 2005). The decision-making context of the study objectives is investigated through this process, by using a product or service, and its attributes. The methods of presenting choices to respondents, how respondents would interpret the alternatives, and factors that are likely to be significant in the choice-making process would have to be carefully considered.

There are two main reasons of using the stated preference choice modelling for the study. Firstly, electric vehicles are not common products to Malaysians. Many may have heard or seen it; however, only a few have actually used it. In stated preference choice modelling approach, the investigator decides, plans and designs the data that need to be collected, based on the contextual situation of the market. Hypothetical questions could be asked to respondents even if they have not consumed the product. Secondly, with its strong theoretical foundation, stated preference choice model is effective in yielding predictions that are consistent with economic theories (Louviere et al., 2008).

As per McFadden (2001), observing or measuring every single characteristic that effects behaviors is kind of impossible, because randomness exists across individuals. With the available information, it only allows prediction and explanation of choices of consumers, up to the probability of an alternative being chosen. Therefore, random utility hypothesis is applied to resolve randomness in the choice model (Brown and Walker, 1989).

In the random utility choice model, choice is assumed to be a discrete event, and utility towards a product varies across individuals as a random variable. Random utility theory is applied with the assumption that, given a set of alternatives *j=1, 2, ..., J*, a rational consumer will choose the alternative that provides the highest utility. Utility cab be estimated by observing individuals' choices through data. In this study, Malaysians' choices of electric cars are related to their characteristics and product attributes through random utility choice modelling with the stated preference data.

Choices of electric cars are also determined by the features that attached to it, such as the performance of the car, design and brand. Choices of electric cars is also influence by intangible factors that impossible to be observed or quantified directly, such as environment concern related values. These intangible characteristics can be captured by using the stated preference approach.

3.3 Construction of choices (alternatives)

There are three distinct attributes of electric cars (price, driving range, and charging time) identified based on the literature review, illustrated in Figure 1.

Attribute 1: Price

Price of the car is defined as the monetary value the consumer needs to pay in order to own the car. Basically, the price of a conventional vehicle can be divided into three main segments in Malaysia. First, price range less than RM100000, which is the budget segment that make out most of the vehicles on the road. Second, the segment between RM100000 to RM200000, which is the middle segment whereby the consumers are willing and able to pay a bit more for the vehicle will be. Third, the luxury segment is more than RM200000. This research will study the response from the consumer towards the electric car at these three different price ranges.

Elements 1:< RM100k
Element 2: From RM100k – RM 200k
Element 3: > RM200k

Attribute 2: Driving range

Driving range of the electric car is defined as the distance the electric car is able to travel before its battery runs out and needs to be recharged again. According to Oxley et al. (2013), motorcyclists who travel more than 200km per week has a higher percentage amongst other distance. Hence, this research has chosen 200km as the benchmark. If an electric car had a driving range of 200km, it will most probably suffice the commuter for one week of daily routine commuting. Tesla, one of the leading EVs manufacturers in the world claimed that its car has a driving range of more than 500km. Hence, in the real world's situation, a 200km range per week will be an appropriate measure for the usability of EV.

Element 1: >200km
Element 2: ≤200km

Attribute 3: Charging time

Charging time of the car is defined as the time required for the car to be recharged from zero percent to 100 percent. EVs manufacturer such as Tesla has invented the supercharger technology, which can significantly reduce the charging time of an EV. However, the supercharging can only be done at the recharging station set up by the company. Using the conventional 3-point plug that is available at common household, it will require a longer time. A conventional electric car such as the Nissan Leaf will require 4 hours to be fully recharged using the conventional 3-point plug. Hence, 4 hours is chosen as the reference point as the user of electric cars can recharge the vehicle by plugging it in before work and the car will be ready after work. Similarly, users can plug in the car at home before they go to bed and the car will be ready in the morning.

Element 1: > 4 hours

Element 2: ≤ 4 hours

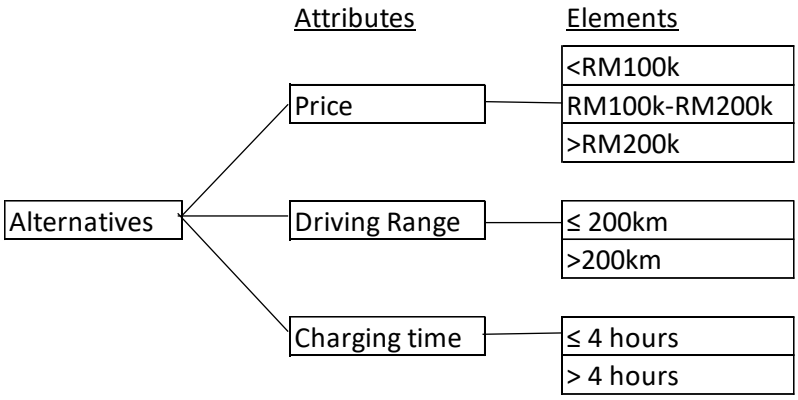

Figure 1: Attributes and elements of electric cars

Table 1 presents the list of alternatives for electric cars (combination of attributes). A rational individual will evaluate and compare all available alternatives and choose the one that yield the highest utility.

Table 1: List of alternatives for electric cars

Alternative	Price	Driving Range	Charging Time
1	< RM100K	≤ 200km	≤ 4 hours
2	> 200K	> 200km	≤ 4 hours
3	RM100K – RM200K	> 200km	≤ 4 hours
4	< RM100K	> 200km	> 4 hours
5	< RM100K	≤ 200km	> 4 hours
6	RM100K – RM200K	> 200km	> 4 hours
7	> 200K	≤ 200km	> 4 hours
8	> 200K	≤ 200km	≤ 4 hours
9	< RM100K	> 200km	≤ 4 hours
10	> 200K	> 200km	> 4 hours
11	RM100K – RM200K	≤ 200km	> 4 hours
12	RM100K – RM200K	≤ 200km	≤ 4 hours

3.4 The model

This study utilizes a multinomial logit model to analyse the response of the target population to the choices given to them. Through maximizing the random utility, the probability of choosing an electric car to individual characteristic factors, are related by using multinomial logit model.

Table 2: List of Variables Used in the Analysis

Variables	**Descriptions**	**Abbreviation**
Gender	1 male; 0 otherwise	*gender*
Income	1 if income < RM5500; 0 otherwise	*income*
Brand	1 if Brand ranked no 1; 0 otherwise	*brand*
Environement concern	1 Yes; 0 otherwise	*concern*
Car performance	1 if Performance ranked no 1; 0 otherwise	*Performance*
Car design	1 if Design ranked no 1; 0 otherwise	*design*

3.5 Data

The non-probability convenience sampling method was applied and a total of 400 respondents were surveyed by using a structured questionnaire in Kuala Lumpur and Penang. Out of the 400, 20 were unusable. The data gathered from the survey was estimated with multinomial logit model using STATA statistical software. Table 3 presents the respondent's profile.

Table 3: Respondent's Profile

Demographic Variables		Frequency	Percentage (%)
Gender	Male	280	73.7
	Female	100	26.3
Age	25-50	355	93.4
	Above 50 years old	25	6.6
Marital status	Single	75	19.7
	Married	305	81.3
Occupation	Self employed	20	5.3
	Others	260	94.7
Monthly income	≤ RM 5,500	220	57.9
	> RM 5,500	160	42.1
Number of respondents willing to purchase an electric car		58	15.3

Among the 380 responses, only 15.3% of the respondents are willing to purchase an electric car. This result is not surprising as the level of awareness of EVs of Malaysians in low, as mentioned earlier. Several reasons have been identified for the low acceptance of EVs in Malaysia, especially electric cars. According to MyCarsearch (2018), Malaysians are concerned about the price of EVs, have misperception of the maintenance fee, inconsistent government policies and the lack of the charging facilities. Adnan et al. (2016) state that the high battery cost of the EVs is the biggest economy obstacle towards the acceptance of EVs in Malaysia. Additionally, there is a comment about the lack of the government's efforts in promoting and assisting the people in owning EVs (Adnan, Nordin, Rahman, & Amini, 2017).

Besides, among the 58 respondents that are willing to purchase EVs, 98% of them own more than one car. Among them, about 98% are aware that the air is polluted by carbon emission, and 87% of them think that the main source of carbon emission is by road transportations. Hence, the result indicates that those who are willing to purchase EVs are those who have experience of owning more than one car and are more environmental concern.

4 Results

4.1 Respondents choices of alternatives

When given a set of randomized choices on vehicles to purchase (Table 1), 194 out of 380 respondents chose alternative 3 as the most preferred choice of electric cars, whereas alternative 9 has 125 out of 380 respondents. The difference between alternative 3 and alternative 9 is the price. Alternative three has a price of RM100k – RM200K whereas alternative 9 has a price of less than RM100K. Both alternatives have a similar driving range and charging time. This shows that majority of the consumers have a perceived quality based on the price of the vehicle. Even both of the alternatives offer similar attributes of driving range and charging time, consumer tend to perceive that vehicle within the price of RM100K to RM200K are better built than the vehicle that cost less than RM100K. Total of 31 (8%) respondents chosen alternative two as the most preferred choice of electric vehicles.

4.2 Multinomial Logit Model

Discrete choice models analyse individual behaviour related to variable attributes in hypothetical choices. The multinomial logit model (MNL) is a fundamental formulation. Table 4 presents the estimates of the MNL coefficients for the different alternatives. The likelihood ratio (LR), which is chi-square distributed, is 475.55 with a p-value of 0.00 and suggests the model is overall significant. The estimated coefficients of environmental concern and brand are positive and significant at the 5 percent level in alternative C2. In alternative C9, the coefficients of brand is statistically significant. Overall, demographic factors play no role in influencing the purchase behaviour of electric cars.

The estimated coefficients in Table 4 can be interpreted as the relative log odds of choosing alternative *j* against choosing alternative 1 (base set) that occurs due to a change in factors. In C2, the coefficient of brand (a dummy variable) is estimated at -2.198762. In other words, holding everything else constant, a consumer that seeing brand as the most important car purchase criteria will have 2.19% lower log odds of choosing C2 (an electric car price above RM200k with driving range of more than 200km and charging time of ≤ 4 hours) against choosing C3 (an electric car with price between RM100K to RM200K with driving range of more than 200km and charging time ≤ 4 hours).

In C2, the coefficient for environemntal concern (a dummy variable) is estimated at 1.047. In other words, holding everything else constant, a consumer that concern of environment will have 1.04% higher log odds of choosing C2 (an electric car price above RM200k with driving range of more than 200km and charging time of ≤ 4 hours) against choosing C3 (an electric car with price between RM100K to RM200K with driving range of more than 200km and charging time ≤ 4 hours).

In C9, the coefficient of brand is estimated at -1.1498. In other words, holding everything else constant, a consumer that seeing brand as the most important car purchase criteria will have 1.15 lower log odds of choosing C9 (an electric car price below RM100k with driving range of more than 200km and charging time of ≤ 4 hours) against choosing C3 (an electric car with price

between RM100K to RM200K with driving range of more than 200km and charging time ≤ 4 hours).

There is no significant relationship between the demographic factors of the consumers and the purchase behaviour of electric cars. As the majority consumer in Malaysia is still new to the EV technology, the demographic factors such as age, gender, educational level, income and others do not influence their buying behaviour on EV.

Table 4: Multinomial logistic regression

	C2			C9		
Variables	Coefficient		Robust Standard Error	Coefficient		Robust Standard Error
Constant	-11.948		1.7491	1.0006		1.5117
gender	0.9310		0.4692	-0.1912		0.2824
income	-0.3103		0.4170	0.5862		0.2450
brand	-2.1987	**	1.0634	-1.1498	**	0.4895
concern	1.047	**	0.4339	0.2181		0.2831
performance	-1.099		0.7685	-0.6070		0.4206
design	0.6966		1.1923	-1.0417		1.2339
Base Category (C3)			RM100K – RM200K, >200km, ≤ 4 hours			
Number of Observations			380			
Prob > chi^2			0.0000			
Pseudo R^2			0.0512			

Note: * p< 0.1, ** p<0.05, ***p<0.001

In addition to these, respondents were also given a question asking them on what the government could do to increase the purchase and usage of electric cars whereby they can choose from a set of choices provided in the questionnaire. From the results obtained, majority of respondents (60%) thinks that government can motivate the purchase of electric vehicles by offering of monetary incentives and provide subsidy on the price of the car.

The study also found that perceived high battery price a reason that hinders consumers from purchasing electric cars. About 30 per cent of the respondents think that by giving subsidy on the battery price, the purchase of electric cars will increase. Only 28 out of 380 respondents think that improving charging facilities will increase the purchase behaviour of consumer on electric cars. The high price of electric cars in Malaysia is deterring many people from affording to buy the car. Thus, for consumers in Malaysia, improving charging facilities will not have any impact on their purchase behaviour of electric cars. Overall, the nation made electric cars and increase in fuel price has the least impact on motivating the purchase of electric cars.

In the estimation, the correlations among explanatory variables were checked for a possible multicollinearity issue. The result appears that all variables are modest (less than 0.5). As the survey covers a large sample of different individuals, heteroskedasticity may be present. Therefore, robust standard errors were used in the estimation. Hosmer and Lemeshow's goodness-of-fit test was conducted to check the model fits the set of observations. Results show no significant

difference between the observed proportions and the specified proportions, indicating that the model fits the data well.

5 Implications of the study

The choice model that had been developed based on the review of literature can be used as the theoretical references for future research. Sets of alternatives consist of the attributes of the vehicles that developed through the study could be used for further study on the consumer's choice of EVs. Data gained from this study can help future study to identify the more specific target group of consumers when carrying out future research on consumer buying preferences of EVs.

About 84% of responses show no interest in electric cars, although they are aware of the air pollution caused by greenhouse gases. More than 190 respondents think that the unpopularity of the electric car among Malaysians is due to the high relative cost of clean vehicle/energy technologies that hinders them from buying the car. This is true as the current price of EVs in Malaysia is higher compared to the price of fossil fuel cars. Thus, this study would like to recommend to the policy maker to investigate on the possibility of reducing the overall costs of owning an electric car, from the purchase price to maintenance costs.

Campaign to promote the usage of electric cars can also be organized to educate the public on the benefits of using electric cars in daily commute as the study result shows a relative low-level of people's understanding of electric cars in the country. Campaign could be one way to disseminate knowledge on the technologies and benefits of electric cars.

Policymakers can also study the possibility of categorizing cities into common zone and green zone. Only electric or hybrid cars can enter the green zone. This action not merely to pave the way for reduction in air pollution within cities but could motivate the demand of electric cars. The zoning can be enlarged slowly based on a proper feasibility study on the area and consumer's purchase ability.

Additionally, as many of the respondents think that the cost of electric car battery's replacement is high, this study would like to recommend for the car manufacturers to offer consumers with a longer warranty period for the car battery. It is observed in the marketplace how some car manufacturers, such as Toyota and Mercedes Benz have been offering consumers with eight years warranty on the battery used in their EVs. Other car manufacturers can thus follow the same action as a strategy to increase the confidence of consumers towards EVs as this study also reveals many respondents feel that the cost of the battery replacement is high.

Even though promotion of electric vehicles may bring impact to the traditional car industry, the development of electric vehicles will create many new jobs, especially in advanced batteries sector, and research and development. Research shows that 84,000 jobs that are expected to be eliminated from traditional car industry, but the development of EVs industry are expected to create nearly 200,000 jobs by 2030 (Bannon, 2018).

6 Conclusion

In conclusion, the automotive industry has an important seat in the circular economy. Compared with gasoline cars, electric cars resulted in less pollution, use renewable energy, use eco-friendly materials and increase health benefits. Electric cars are the general trend, and electric cars are likely to replace traditional gasoline cars in the future. This has a great impact on the economy, employment and lifestyle. Therefore, automobile manufacturing industry needs more advanced arrangements to meet future challenges and opportunities.

Among attributes of a car, consumers perceive brand, design and safety features are three of the most important attributes that will significantly influence their buying behaviour on EV. When given a set of choices, the majority of the respondents chooses the choices that give the best attributes of EV in term of driving range and charging time. The only difference is in the price of the EV which is between RM100K-RM200K and below RM100K. The results reveal that the majority of consumer perceived quality based on the price of the vehicle. Even both of the alternatives offer similar attributes of driving range and charging time, consumer tends to perceive that vehicle within the price of RM100K to RM200K are a better built than the vehicle that cost less than RM100K. The study also reveals that majority of the respondents feel that the cost of owning an electric car is expensive. Most respondents are not willing to purchase EVs.

This study acknowledges its limitation as the respondents for this study are only selected from two cities in Malaysia. Thus, the results gathered may be representative the city folks, and additional research may be needed for consumers living in remote areas of the country.

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