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ACCEPTABILITY OF ELECTRIC VEHICLES: FINDINGS FROM A DRIVER SURVEY

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Abstract

Plug-in Electric Vehicles (EV) offer a clean and cost effective means in the long run of driving short to medium distances within the city, even with the current high purchase cost. In Australia EV may be attractive as a second car in the multicar household. The acceptance of EV requires a change in behaviour – instead of re-fuelling, this vehicle requires battery charging each 140-160km, either at home or at specialised charging stations.

A limited number of EVs are being driven in Perth as part of the Western Australia Electric Vehicle trial (WA EV trial). The trial monitors the performance, benefits, infrastructure and practical implications of EV fleet. This paper explores the opinions and experiences of 43 of the participants. Factor analysis and multiple regression are applied to identify the main motivators and barriers in purchasing and using an EV.

Ninety per cent of respondents are confident about driving the EV; more than 45% take trips of more than 30km. While zero tailpipe emissions is the most desirable feature of EV, followed closely by home charging, the limited range of the vehicle is regarded as the most serious barrier to EV uptake. The overall satisfaction with the EV performance is high (an average score of 3.96 out of 5), although 13 participants experienced at least one technical difficulty, when driving the EVs in the trial.

Two latent constructs reflecting *environmental concerns, and technology learning,* along with EV benefits and technical difficulties experienced while driving an EV explain 59.2% of the variability of the willingness to purchase an EV as the next vehicle.

Key words: *Electric vehicle, multivariate analysis, drivers' attitudes.*

1. Introduction

The increased demand for fossil fuels requires investigation of other energy sources in transport planning. The plug-in Electric Vehicle (EV) is driven by electricity, using an electric motor instead of a petrol or diesel engine. EV has distinct characteristics, for example limited driving range, battery re-charging and zero tailpipe emissions. In addition, EV brings benefits in terms of low running costs. People's acceptance of new fuels and vehicles are determinants of the EV's place in the ensemble of vehicle technologies. The number of kilometres travelled on one charge and the need for frequent charging are factors influencing the purchase and use of an EV, along with the efficiency of the vehicle (weekly $ amount spent on travelling) and comfort. Individuals are likely to trade-off these features and their decision is also affected by attitudes, preferences, and habits.

Many Australian households use more than one car (ABS, 2008) so that the range limitation of EV may not be considered an issue when there is a second car available for long distance trips. With the low travel cost, EVs have the greatest potential for short trips within the city, but the charging requires good trip planning.

A limited number of EVs are in use as part of an EV trial in Perth, Western Australia. The trial monitors the performance, benefits, infrastructure, and practical implications of EV fleets. This study aims to find the perceived barriers to the purchase and use of both converted and commercially manufactured EV. A questionnaire was presented to the drivers in the WA EV trial. Because the vehicles in the trial are all converted EVs, only four respondents use manufactured EVs, with one having experience with both converted and commercially available EV. In terms of sample size, number of manufactured EV drivers is small due to the limited availability of EV in the Western Australian market.

In general, most of the drivers are confident in operating the EV, although 13 participants experienced at least one technical difficulty when driving the converted EVs in the trial. The overall satisfaction with the EV performance is still high with average score being 3.96 out of 5.

The two techniques used in this study include factor analysis and multiple linear regression. The results of the survey are analysed by testing a set of hypotheses through the regression model.

1.1 Aims of the Study

This study explores the drivers' behaviour through a survey with the following aims:

- Identifying drivers' perceptions about EV, and their willingness to purchase an EV;
- Ascertaining participants' attitudes towards the environment and adoption of new technologies;
- Informing the research program and assisting in refining the design of the questionnaire for the household survey that will be conducted separately. The EV driver survey serves thus as a pilot, testing two sections of the household questionnaire: a stated choice experiment and household attitudes towards EV. This study will assist in distinguishing the most relevant characteristics for EV purchase, as well as testing the reliability of several latent constructs necessary in capturing households' preference heterogeneity.

The next section discusses the literature about EV uptake, followed by a conceptual model for the adoption of EV (Section 3), and the data and methodology (Section 4). The findings of this research are discussed next (Section 5) and the last section conveys the conclusions of the study.

2. Previous Studies on the Uptake of Electric Vehicle

Considerable literature on the operating characteristics of EV (e.g. Voelker, 2009) and the work at UWA (Mullan *et al.*, 2010) has established that standard car models converted to EV can give excellent performance.

The studies to explore the potential demand for EV have started in different regions of the world. Most of the research work for EV uptake is in the USA. Kurani and Turrentine (1996) compared petrol and CNG with the hybrid and "neighbourhood" EVs (for 454 households) and found *home-recharging* will be successful. Half of the households mentioned that they would buy EV as their next new vehicle in *multi-vehicle households.* Kurani and Turrentine (1996) were also amongst the first researchers to incorporate attitudinal data in their modelling.
Golob and Gloud (1998), with 69 individuals, applied regression analysis comparing petrol and EV, and found EV likely to be used if average vehicle mileage is less than 28 miles/day. Another study in California (Hess *et al*., 2006) comparing internal combustion engine vehicles, EV and hybrid vehicles, suggested that EV can only compete in the market if they have a range greater than 353 miles – thus recommending increased driving range for EV acceptance.
Bolduc *et al*. (2008) conducted an experiment in Canada with 866 individuals, comparing petrol, alternative fuel, hydrogen fuel cell vehicle and hybrid EV. They used hybrid choice models including *perceptions and attitudes* and the structural and measurement equations for latent variables were simulated together. The hybrid choice model demonstrated its capabilities to capture: i) the environmental concerns; and ii) the appreciation of new car features. The behaviour towards charging of electric vehicles was not discussed; however, the latent constructs enriched the model's explanatory power.

Recent study by Lieven *et al.* (2011) in Germany applied correspondence analysis to rank eight types of cars (city, small, van, sports, luxury, etc.) for six types of uses (first vehicle for all uses, second for leisure, etc.). Their findings tell that *price* is the top priority for both conventional and EVs, with *range* ranked second. Performance, durability, environment, and convenience are given less priority. Only 4.2% of first car buyers chose EV and they rated price and range as a lower priority than non-EV potential buyers. Another recent research in vehicle type choice modelling is by Kuwano *et al.* (2012) in Japan, they designed a two stage model. In the first stage of decision making respondent was given a brief overview of EV features, and then asked whether to keep EV as one of the available choices. If the respondent decided to keep EV in the choice sets, a set of scenarios containing gasoline, hybrid-electric, and EV in the choice sets was displayed to the respondent; otherwise scenarios with only gasoline and hybrid-electric vehicle were given to the respondent. In this way social conformity was reflected in their model, and heterogeneity in the preferences was explained by the use of latent class models. In addition to the attributes that were considered by similar studies (such as purchase price, range, charging time, and operation costs), Kuwano *et al.* (2012) had market share as an attribute in their stated preference choice sets. With 384 respondents in Japan, Kuwano *et al.* (2012) found that *10% of respondents prefer to own an EV*, while 20.2% considered EV as an alternative in the choice experiments. They obtained three latent classes: *EV share rise, EV purchase price reduction, and EV performance improvement* (Kuwano *et al.,* (2012); page 7).

In summary, studies of EV acceptance have been increasing since their start more than ten years ago (Kurani and Turrentine, 1996; Brownstone *et al.,* 2000; Ahn *et al*., 2008), with the most recent research in this area being in the USA (Hidrue, 2010), Switzerland (Ziegler, 2010), Germany (Lieven *et al*., 2011), and Japan (Kuwano *et al*., 2012). The technology at the core of this study embodies significant advances and the study has the task of assessing how much these advances will improve acceptability of EV.

2.1 Consumer Behaviour Models on the Adoption of New Technologies

EV is a significant new technology; this makes it pertinent to explore EV adoption as "*new technology*" adoption. In the literature we find that technology adoption research includes variations for market inventions, in the field of information technology (IT), or both.

2.1.1 Technology Acceptance Model

Davis (1989) theorizes in the Technology Acceptance Model (TAM), that behavioural intention to use a system is determined by two factors: perceived usefulness and perceived ease of use. The term system here was taken as any *Information System*, and perceived usefulness is the extent to which an individual believes that the system will help to enhance his performance. The ease of use similarly indicates the extent to which an individual believes that using the system will not require extra effort to learn first. A theoretical extension of this model as TAM2 is defined (Venkatesh and Davis, 2000); it contributes by adding social influence constructs and also explores how perceived ease of use can be increased by helping the user to learn the system. This model has been used in different studies, as Lee *et al*. (2003) summarises its use in literature from 1986 till 2003.

2.1.2 Technology Readiness

The concept of *technology readiness* (Parasuraman, 2000) refers to the *people's propensity to embrace and use new technologies for accomplishing goals in home life and at work*. Parasuraman (2000) in collaboration with a company in the United States developed a Technology Readiness Index (TRI) as part of a technology readiness research program. Focus groups and interviews were conducted with the customers of companies from a variety of different technologies (e.g., financial services, e-commerce, online services, and telecommunications). After a number of analyses, a technology readiness scale was designed with four dimensions. The two positively supporting dimensions: *Optimism* and *Innovativeness* were classified as drivers, whereas the other two *Discomfort* and *Insecurity* were classified as inhibitors. The items in this TRI were further used by many researchers as a scale to measure self-service (e.g., ATM, bank by phone, and online banking) technologies adoption (James *et al*., 2005, Meuter *et al*., 2003), and also to explore the Internet home usage (Matthing *et al*., 2006). Both TAM and TRI consider the positive drivers of technology, however, in addition to TAM, TRI incorporates constructs with a negative effect in the adoption of new systems.

2.1.3 Technology Adoption Propensity

Ratchford and Barnhart (2011) reported on the assessment of consumer propensity to adopt new technologies. This research primarily considers the adoption of new technology by consumers in the market, while TRI focused mainly on specific technologies (for example, computers, or Internet). When buying a new technology the decision is made based on the benefits, and the time and effort consumers spend in learning and absorbing the new technology (Ratchford and Barnhart, 2011). The precise forecasting of technology products requires measurement of both positive and negative attitudes towards the technology. Ratchford and Barnhart (2011) recently developed a Technology Adoption Propensity (TAP) index containing 14 items, significantly shorter than TRI with 36 items.

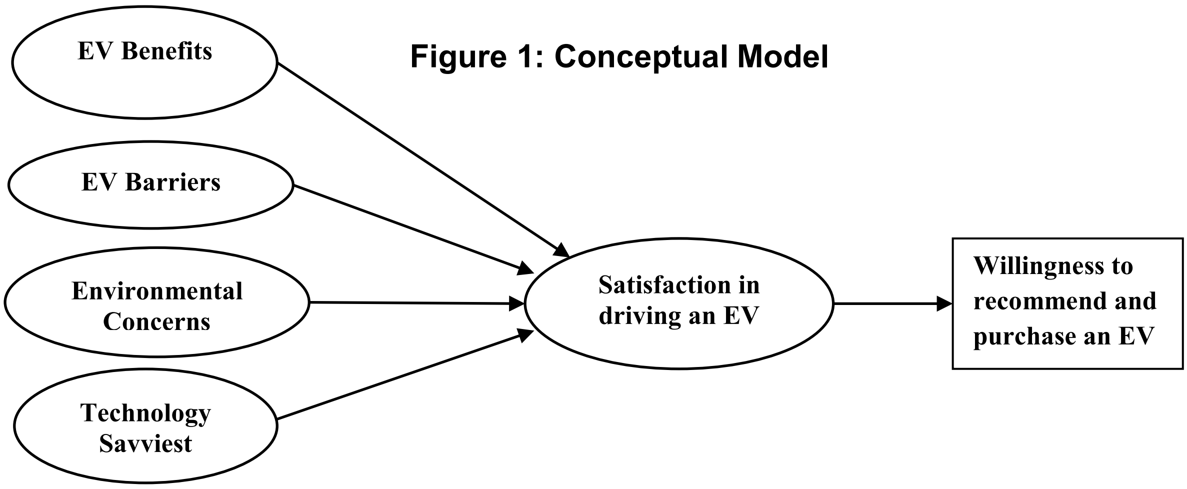
2.1.4 Post Adoption Behaviour

Huh and Kim (2008) studied the role of post-adoption behaviour and experimented with young people and early adopters. On the other side, Son and Han (2011) indicated that technology readiness of the consumer (i.e. how well a consumer is prepared for the new technology) has an impact on the post-adoption behaviour. Gatignon and Robertson's (1985) suggested that diffusion of technological innovations will depend on consumers developing new knowledge and new patterns of experience.

3 A Conceptual Model for the Adoption of Plug-in Electric Vehicles

Drawing on the above literature, a set of latent constructs were identified through which the acceptability of Plug-in Electric Vehicles by the drivers' in the WA EV trial can be assessed. Thus, the objective of this study is to determine what contributes for the drivers' attitudes and perceptions of EV, and also to find which EV driving experiences can affect their propensity to adopt EV.
The specific questions we explore in this research refer to: the direct impact of EV benefits, technical difficulties experienced while driving EV, along with effects of the attitudes towards environment and technology adoption (measured using latent constructs) on the willingness of the drivers to recommend and purchase an EV. The survey instrument was designed according to the conceptual model given in Figure 1. While the purpose of the overall research is to test a mediating model (EV benefits and barriers, environmental concern, and technology learning impact on the overall satisfaction while driving an EV, which in turn allows predicting the willingness to recommend and purchase an EV) for this paper, we test a direct model with all predictors affecting the willingness to recommend and purchase an EV.

Figure 1: Conceptual Model



The primary hypotheses of this study include:

H1: Drivers confident in the environmental performance and efficient use of energy of EV are more likely to recommend and purchase an EV.

H2: Drivers showing concerns for environmental changes are more likely to recommend and purchase an EV.

H3: Drivers ready to adopt and learn new technologies are more likely to recommend and purchase an EV.

H4: Perceived EV benefits influence positively the willingness to recommend and purchase an EV.

H5: Experienced technical difficulties while driving an EV influence negatively the willingness to recommend and purchase an EV.

H6: Overall, drivers' satisfaction with EV reflects the willingness to adopt EV as a future car. For this paper the satisfaction with driving an EV is tested as one of the independent variables, as this is not mediating model rather a direct model is tested with all predictors affecting the willingness to adopt EV as a future car.

4 Data and Methodology

In order to design the survey questionnaire, a focus group was conducted in November 2011 with 11 EV drivers at The University of Western Australia. The drivers discussed their EV driving experiences and perceptions towards EV as a new technology. Overall, they were satisfied with the trial EV performance and showed confidence towards its acceptance. The participants indicated the pros and cons of EV in the trial. The advantages of EV as discussed in the focus group include: *smooth and quiet operating drive, good torque, resource management, sustainability, being a new technology (innovative) but appearing or driving like a normal car, clean energy with no emissions, low running cost, minimal service cost or no need to go for oil-checks, free reserved parking, efficiency.* The drivers also discussed the drawbacks and concerns that they had while driving EV: *limited range, finding a charging station, recharging time, trip planning, range indicator problems, and technical problems like regenerative braking, acceleration etc*. These barriers also affected the willingness of other drivers to become part of the trial, when presented in the induction process for EV usage. The participants also indicated the factors that might affect EV performance in the market, such as *range, performance, place and time required for recharging, substantial price, limited choice of EV models, and their resale value*.

In December 2011, an online survey was deployed and sent to all EV drivers in Perth, WA. The experiences of the drivers in the focus group helped the design of the questionnaire. The instrument included four sections: 1) EV characteristics; 2) drivers' experiences; 3) attitudinal questions; and 4) background questions. The socio-demographics in the survey included the age, sex, education of the respondents, and number of cars at home. Since the drivers in the trial did not purchase the EVs themselves, the income variable was deemed irrelevant. The questionnaire also asked drivers about the technical problems encountered when driving the EV, as well as what do they perceive the most and the least desirable features of EV. The vehicles in the trial are all converted EVs, thus only a limited number of drivers outside the trial had experiences with manufactured EVs. The overall satisfaction of driving EV was also included in the questionnaire.

4.1 Survey Design and Data Collection

The drivers in the EV trial filled in *an online* survey, with 43 respondents completing all questions. Although this is a small number of respondents, the response rate was high (and the sample appropriate for representing the EV drivers in WA) considering that only few organisations in the trial have started to use EV, with not all the respondents using it on a regular basis. Among these 43 respondents, four respondents experienced driving commercially manufactured EV, while rest of respondents are drivers of the converted EV..

The socio-demographics in survey (Table 1) show that the majority of respondents are male drivers (67.4%), and a number of respondents (73%) own 2 or more cars. Twenty-two respondents are over 40 years and 28 have tertiary education.

More than 80% of drivers showed satisfaction in driving EV, with 34.1% being extremely satisfied. This is a positive indication towards EV acceptance in the WA EV trial, where 24% of respondents drive more than 50km, 39% drive 21-50km, 27% drive 10 to 20km, and only 11% drive less than 10km in a single trip.

Table 1: Information about Respondents

Variable	%	Count
Gender		
Male	67.4%	29
Female	32.6%	14
Age		
17-22	9.3%	4
23-29	20.9%	9
30-39	18.6%	8
40-49	18.6%	8
50-59	20.9%	9
60+	11.6%	5
What is your highest level of education?		
Year 12	9.3%	4
College/Professional qualification	25.6%	11
University Bachelor Degree	48.8%	21
Masters or PhD	16.3%	7
How many vehicles do you have at home?		
1	27.9%	12
2	48.8%	21
3 or more	23.3%	10

"*Zero-tail-pipe emissions*" was considered the most desirable feature suggesting that the drivers are concerned about the environment, followed by *"low running cost"*, then "*reliability*", "*low-maintenance*", and "*home-charging*". *"Low level of noise"* is also suggested as a desirable feature of EV by the drivers in the trial. In terms of perceived barriers for EV uptake, the respondents indicated the "*limited range*" and "*purchase cost*" as the most serious limitations, followed by "*recharging infrastructure*" and "*recharging time*", with "*reliability*" the least serious barrier.

As informed by the focus group, the questionnaire presented a list of technical problems with EV, from which the participants had to select the ones they encountered while driving EV. Forty-two respondents answered this question, 52% respondent indicated "*Power-steering failure*", "*no regenerative braking*" and "*range indicator errors*", while 10 respondents reported other faults that are related to *charging, braking faults, motor overloading, and gearbox* problems.

Recognising the role of attitudes and preferences in explaining behaviours, the survey included a set of latent constructs regarding EV benefits, environmental concerns, adoption of new technologies, and willingness to recommend and purchase an EV. Since the objective of this survey is to investigate and test the role of these latent constructs against the *willingness to purchase an EV*, the analysis included two stages: i) exploratory factor analysis to test the validity of the latent constructs (latent factor scores were derived for use in the subsequent analysis); ii) *multiple linear regression*, for simultaneous assessment of the linear interrelationships between predictors for willingness to purchase EV.

4.1 Exploratory Analysis of Attitudes towards Electric Vehicle

To test the drivers' behaviours and attitudes towards EV, items reflecting several latent constructs were included in the survey. These constructs refer to: EV benefits, environmental concerns, adoption of new technologies, and willingness to recommend and purchase an EV.

The latent constructs' items were designed as a set of five level *Likert-Scale* questions ranging from strongly agree to strongly disagree. After an Exploratory Factor Analysis (EFA) stage, uni-dimensional constructs were tested.
During the analysis of the constructs, it has been found that few construct items were weak and they will be redefined for the household survey. Each construct is discussed in detail below.

4.1.1 Environmental Concern

This construct showed strong relationships among the variables. The basic assumptions of factor analysis are satisfied, with a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of ***0.707*** indicating a strong construct. The *alpha factoring* extraction method was used to maximise the construct reliability; factor loadings of each element in this construct are above 0.5, as shown in Table 2.

The analysis of results showed that 90% respondents agreed that it is now the real time to worry about our environment and this requires our immediate efforts. A large number (69.8%) of respondents believed that climate change is not a myth; this shows that respondents are concerned about climate change and air pollution effects. Approximately 63% of respondents showed willingness to spend extra time or pay more for products and services, only to save the environment.

Table 2*: Environmental Concern* Factor Loadings

Items	Factor Loadings
Now is the real time to worry about the effects of air pollution.	**0.795**
I am concerned that future generations may not be able to enjoy the world as we know it currently.	**0.757**
Saving the environment requires our immediate efforts.	**0.718**
I am willing to pay more for products or services only to save the environment.	**0.714**
I am willing to spend extra time only to save the environment.	**0.622**
Vehicle emissions can destroy our flora and fauna.	**0.534**

For this construct, the reliability coefficient, Cronbach's Alpha has a value ***0.832,*** suggesting consistency of the entire scale (Hair *et al.,* 2010).

4.1.2 Technology Adoption

This is a very important construct, already tested in literature investigating the adoption of EV as new technology (Ewing and Sarigollu, 2000). Our analysis showed that multiple constructs may emerge (the items were not correlated significantly for a unidimensional factor), and we selected here to report the strongest one – *"technology learning"*.

Overall, the survey responses are convincing about the relevance of technology adoption in further uptake of EV. For example, 90% respondents believed that using new technologies makes our life easier, and 70% respondents felt that new technologies give more control over our daily life. Nearly 77% of respondents showed an excitement for learning new technologies, while 80% of the drivers agreed that keeping up with the new knowledge or technologies is necessary.

When exploring the trendy or being fashionable tendency of the respondents, we found that almost 30% of respondents are savvy-trendy adopters, based on their response that "taking up new technologies makes one trendy", and that "being fashionable means having up-to-date knowledge of the techno-world". Approximately 44% of respondents did not agree that new technologies cause more problems than they solve.

As indicated, the EFA suggested more than one dimension, but only three items, with higher commonalities and factor loadings were further retained. They are shown in Table 3.

Table 3: *Technology Learning* Factor Loadings

Items	Factor Loadings
I am excited to learn to use new technologies.	**0.758**
Reverse (Things have become so complicated today that it is hard to understand what is going on in this techno-world)	**0.703**
I love gadgets	**0.601**

The measure of sampling adequacy (KMO) value ***0.669*** and a Cronbach's Alpha of ***0.703*** indicated that this structure for the one-dimensional *Technology Learning* construct is appropriate.

4.1.3 EV Benefits and Challenges

The most important EV benefits, identified by respondents, included: convenience of home battery recharging and reduced average travel cost per trip. The respondents are also comfortable with recharging their EV at public stations, although almost half of the respondents need to do a lot of planning of activities when they drive EV.

In regard to EV technical difficulties, only 20% of the respondents believed that EVs have problems with the acceleration; while 29% disagreed that EVs incur significant maintenance costs.
None of these two constructs, *EV benefits* or *Technical problems associated with EV* had adequate reliability in this sample, and consequently they were not used in this analysis.

4.1.4 Willingness to Recommend and Purchase an EV

This construct showed strong relationships among the variables (KMO=***0.725***). Factor loadings of the elements in this construct (all above 0.8) are given in Table 4. The Cronbach's Alpha had the highest value of all constructs, ***0.910***.

Table 4: *Willingness to recommend and purchase an EV* Factor Loadings

Items	Factor Loadings
I prefer to use EV over any other type of cars.	**0.911**
I would recommend EV to others.	**0.828**
I would buy an EV as my next car.	**0.837**

The results of the analysis show that approximately 65% of respondents would recommend EV to others. Buying an EV as a next car is chosen by 27.9% of respondents, while 35% of respondents would prefer to use EV over any other cars. This percentage of driver's showing a preference to use EV over any other type of cars indicates a positive attitude towards EV and acceptability of the electric car.

5 Regression Model for EV Adoption

Once all the possible factors were identified, the next step was to quantify the effect of different factors in the willingness to adopt EVs. As suggested in the hypotheses, the set of independent variables identified for this model include: environmental concern, attitudes towards technology learning, EV benefits, EV technical problems, being a savvy-trendy adopter, and having confidence in driving EV. The socio-demographics considered in the analysis include age, gender, and education.

The regression model initially tested all the independent variables, but the high correlations among the explanatory variables resulted in multicollinearity issues (Hair *et al.*, 2010). The correlations between independent variables and the willingness to purchase and recommend an EV are given in Table 5.

Table 5: Correlations between Independent Variables and Willingness to Recommend and Purchase an EV

	Independent Variables	***Willingness to recommend and purchase an EV*** Correlation Coefficients	**Significant Cross Correlation Coefficients between potential explanatory variables**
AGE	What is your age (years)?	**0.143**	
HE	What is your highest level of education?	**-0.152**	
TechL	*Technology learning construct*	**0.157**	
EnvC	*Environmental concern construct*	***0.250***	
Conf	How confident are you in the environmental performance and efficient use of energy of EV?	**0.561****	**EV_B1 (0.448*), EV_B2 (0.434*), OvSat (0.475**)**
Tech_B	New technologies give more control over our daily life.	**-0.004**	
TFas	Being fashionable means having up-to-date knowledge of the techno-world.	**0.077**	
LessM	Reverse (I spent a significant amount of money to fix my EV in the last 3 months).	**0.476****	**AccP (0.454*), EV_B1 (0.482**), EV_B2 (0.449*), OvSat (0.441*)**
AccP	I believe EV has no problems with acceleration.	**0.346***	**LessM (0.454*)**
EV_B1	Battery recharging at home is convenient for my EV.	**0.594****	**Conf (0.448*), LessM (0.482**), EV_B2 (0.509**), OvSat (0.552)**
EV_B2	EV driving reduces my average travel cost/trip.	**0.491****	**Conf (0.434*), LessM (0.449*), EV_B1 (0.509**), OvSat (0.560**)**
OvSat	Overall, how satisfied are you driving an EV?	**0.634****	**Conf (0.475**) , LessM (0.441*), EV_B1 (0.552**), EV_B2 (0.560**)**

*** p<.05** **** p<.01**

Table 5 shows that all independent variables (Conf, LessM, EV_B1, EV_B2, OvSat) have moderate correlations with each other. Overall satisfaction in driving an EV (OvSat) is related to EV Benefits (EV_B1, EV_B2), and to being confident in environmental performance and efficient use of EV energy (Conf). Similarly, a lower amount of money spent to fix EV in last 3 months (LessM) has a positive impact on the overall satisfaction (OvSat), and perceived EV benefits (EV_B1, EV_B2).

One of the remedies for multicollinearity is to omit one or more highly correlated variables, and identify other independent variables to help the prediction (Hair *et al.*, 2010). To address multicollinearity and given the reduced sample size, a backwards elimination procedure was applied. Two different models were tested, with overall satisfaction and EV benefits being the response variables (Tables 6 and 7).

5.1 Multiple Linear Regressions' Results

With a coefficient of determination R^2 =0.643, the regression model presented in Table 6 confirms a subset of our hypotheses. The standardised coefficients indicate the relative importance of predictors in the same units or standards, regardless of the measurement scale used for the independent variables (Hair *et al.*, 2010). When considering the socio-demographics, age played a significant positive role in the model, with younger people less likely to recommend and purchase an EV (beta for AGE is 0.185). This might be due to the reason that more than 30% of respondents have an age of 50 years or above. The AGE variable has even more significant value in Table 7 where beta is 0.260.

The first hypothesis of this study (drivers confident in the environmental performance and efficient use of energy of EV are more likely to recommend and purchase an EV), is confirmed with the standardised coefficient as 0.262. The third hypothesis shows mixed results with one positive coefficient (technology learning 0.198) and a negative one (control given by technologies -0.287). Hypothesis 5 is also confirmed with a significant negative coefficient and the highest beta in absolute terms (0.367). The satisfaction variable (OvSat) comes next (0.336), confirming hypothesis 6 that overall, drivers' satisfaction with EV reflects the willingness to adopt EV as a future car.

Table 6: Regression Model with Satisfaction Variable as Predictor

	Dependent Variable: *Willingness to recommend and purchase an EV*	**Unstandardized Coefficients**		**Standardized Coefficient**	**Significance**
		B	**Std. Error**	**Beta**	
	Independent Variables				
	(Constant)	-0.716	0.815		0.385
AGE	What is your age (years)?	0.127	0.072	0.185	0.086
Conf (H1)	How confident are you in the environmental performance and efficient use of energy of EV?	0.370	0.177	0.262	**0.044**
Tech_B (H3-A)	New technologies give more control over our daily life	-0.371	0.146	-0.287	**0.016**
TechL (H3-B)	*Technology learning construct*	0.281	0.174	0.198	0.114
Tech_Diff (H5)	I spent a significant amount of money to fix my EV in the last 3 months	-0.387	0.125	-0.367	**0.004**
OvSat (H6)	Overall, how satisfied are you driving an EV?	0.338	0.131	0.336	**0.014**

Note: Parameters significant at 0.05 level in bold.

As discussed in more detail in the next section, satisfaction is a mediator between the EV benefit, EV barriers, and technology learning constructs, and the willingness to recommend and purchase an EV.

The regression model in Table 7 also tests hypotheses of this study, but this time after excluding the overall satisfaction from the list of predictors; independent variables that were not significant were removed from the model, one at a time, while exploring the impact of the rest of the variables. The final model, containing only significant variables, is given below. It has the R^2

value of 0.592, this indicates that variables in this model explain 59.2% of the variability in the willingness to recommend and purchase an EV.

The second hypothesis in this study (drivers showing concerns for environmental changes are more likely to recommend and purchase an EV) is not confirmed by the model, but this may be due to the sample size and limited variability in the construct (the average factor score is 3.71, with a standard deviation of 1.02). Ewing and Sarigollu (2000) found that *the consumers accepted the environmental impact of clean fuel vehicles, but the vehicle's standards cannot be compromised.*

Again, hypothesis 3 does not have full support with the question on technology's control over lives displaying a negative relationship. This negative coefficient was unexpected, however it might be due to the fact that most of the respondents in this study have an experience of driving converted EVs, and not commercially manufactured EVs. Another possible reason might be the word "control". This item needs to be reconsidered for the household survey and perhaps instead of "control over our daily life", the question needs to be reformulated to include "enable us" or another positive phrase (for example "*Using new technologies in our daily lives makes life easier*.")

Table 7: Final Regression Model

	Dependent Variable: *Willingness to recommend and purchase an EV*	**Unstandardized Coefficients**		**Standardized Coefficient**	**Significance Level**
		B	**Std. Error**	**Beta**	
	Independent Variables				
	(Constant)	0.411	1.416		0.773
AGE	What is your age (years)?	0.180	0.082	0.260	**0.036**
EnvC (H2)	*Environmental Concern Construct*	0.224	0.172	0.150	0.201
Tech_B (H3-A)	New technologies give more control over our daily life	-0.382	0.172	-0.299	**0.034**
TechL (H3-B)	*Technology learning construct*	0.387	0.178	0.278	**0.037**
EV_B1 (H4-A)	Battery recharging at home is convenient for my EV.	0.266	0.124	0.308	**0.040**
EV_B2 (H4-B)	EV driving reduces my average travel cost/trip.	0.284	0.147	0.268	0.062
Tech_Diff (H5)	I spent a significant amount of money to fix my EV in the last 3 months	-0.305	0.151	-0.289	**0.051**

Note: Parameters significant at 0.05 level in bold.

The fourth hypothesis (H4) of the study (perceived EV benefits influence positively the willingness to recommend and purchase an EV) is confirmed, with EV_B1 and EV_B2 presenting beta coefficients of 0.308 and 0.268, among the highest in the model. Thus, this demonstrates that perceived EV benefits (low driving cost and home-charging) influence positively the willingness to recommend and purchase an EV. This is consistent with the previous literature: e.g., Kurani and Turrentine (1996) identified the "*home-charging*" as a key benefit of EV.

The fifth hypothesis (H5), regarding the relationship between experienced technical difficulties while driving an EV and the willingness to recommend and purchase an EV, is confirmed as well, with a negative coefficient and a beta value of -0.289. Technical difficulties experienced while driving an EV act as a deterrent for EV uptake. This is well supported by the literature. Dagsvik *et al.* (2002) indicated that *alternative fuel vehicles can compete with petrol cars if maintenance and refuelling infrastructures for alternative fuel vehicles are well established*. Again these coefficient values could be different if there were more number of respondents driving commercially manufactured EVs (with less technical difficulties) instead of converted EVs.

5.2 Discussion and Future Research

The independent variables taken into account in this study were derived from literature and were further refined after the focus group. This study primarily explored the behaviours and experiences of the drivers already using the EV, in the WA EV trial. With a limited number of respondents (N=43) a number of hypotheses were tested and confirmed. One of the limitations of this study is that among small set of respondents (N=43) the majority of drivers used converted EVs, only 4 drivers had experience of driving manufactured EVs. Thus, the results would intuitively be different if the number of commercially manufactured EV drivers was larger. At the same time, this limitation does not impact the main objective of the study that is to discover the drivers' perceptions and attitudes towards EVs, and to determine how their experiences might affect acceptability of Electric Vehicles. The weakness of the few constructs was also noted as another limitation and these constructs will be revised for the upcoming household survey.

Since the satisfaction variable seems to be a mediator between perceived EV benefits, EV technical difficulties, attitudes towards technologies constructs and willingness to recommend and purchase an EV, the next step will be to assess these relationships using structural equation modelling (SEM) approach (Meyers *et al*., 2006). On account of small sample size, this was not currently possible, but with a higher number of respondents from the household survey it might be possible in the future.

6 Conclusion

This research explores the EV drivers' behaviour and their perceptions and attitudes towards new technologies. Experiences of drivers in the trial are useful for exploring the impact of EV benefits and of their technical difficulties on the acceptance of EV. The drivers showed confidence in the EV's environmental performance and efficient use of energy. The range is a serious barrier to EV uptake, with almost half of drivers indicating that they require significant trip planning especially for trips longer than 30km.

The analysis of the drivers' survey also aimed to refine the latent constructs such as technology adoption and environmental concern. With the data from the drivers' survey the reliability of the constructs was assessed and items with low value of loadings are being revised. Although the environmental concern appeared non-significant in the regression models, the literature identified it as a key construct, and we will consider it in the household survey. Another supporting argument for environmental concern construct is that the "*Zero-tail pipe emissions*" is ranked as the most desirable feature of EV by the drivers in the trial.
The results of this analysis will inform the household survey, and these constructs will be presented with further improvements, in the pilot household survey.

7 References

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