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Article

Factors Influencing the Behavioural Intention towards Full Electric Vehicles: An Empirical Study in Macau

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Abstract: This study examines the factors that influence individual intentions towards the adoption of full electric vehicles. A sample including 308 respondents was collected on the streets of Macau. The collected data were analysed by confirmatory factor analysis and structural equation modelling. The results demonstrate that environmental concerns and the perception of environmental policy are antecedent factors of the perception of full electric vehicles, which influences the behavioural intention to purchase full electric vehicles. This study also finds that the perception of economic benefit is one of the key factors influencing the adoption of full electric vehicles. Vehicle operators seek economic benefits from future long-term fuel savings, high energy efficiency, and cheap electricity. Thus, a government striving to promote low-carbon transportation needs to scale up its efforts to enhance citizens' environmental concerns and to establish proper environmental policy as well as to provide long-term financial and strategic support for electric vehicles.

Keywords: consumer acceptance; environmental concern; environmental policy; electric vehicles

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1. Introduction

Transportation ranks second after electric power as the largest source of carbon emissions in the world [1]. Over the past few decades, research has been conducted to investigate various aspects of the development of sustainable low-carbon transportation technologies to reduce carbon emissions. As a result, there are already a number of potential alternatives to the conventional diesel/petrol combustion engine [2]. An important development that can improve fuel efficiency and decrease emissions is the introduction of hybrid electric vehicles [3]. However, hybrid electric vehicles are equipped with diesel engines that generate carbon dioxide and cause air pollution. Another alternative is full electric vehicles (energy provided by a battery), which have a zero-emission potential when electricity is produced with the use of renewable energy sources [4]. In fact, powering electric vehicles through solar charging stations could reduce the greenhouse gas (GHG) emissions of these vehicles by up to 34% [5]. Although full electric vehicles have been available since the dawn of motoring, they were not popular. Due to contemporary environmental concerns, full electric vehicles have been making a comeback in the 21st century. Mass-produced full electric vehicles are being introduced into the market by many car manufacturers. For example, the Renault-Nissan alliance sold its 200,000th electric vehicle in early November 2014, approximately four years after the launch of the Nissan LEAF [6]. To support the widespread adoption of full electric vehicles, there is a need to examine the factors influencing the consumer acceptance of these vehicles because consumer acceptance is a key to the commercial success (or failure) of full electric vehicles [7].

There are many factors that influence car-purchasing behaviour, including actual situational factors such as regulatory environments [8]. In addition to the actual situational factors, psychological factors, such as personal attitudes, are equally important [9,10]. Although some empirical studies of the consumer acceptance of hybrid vehicles have been conducted (e.g., [11,12]), there is little research that considers the perception of an expected situation; in particular, there has been little focus on the perception of full electric vehicles.

This study addresses the need for an empirical study that analyses the psychological factors with the situational factors that impact the consumer acceptance of full electric vehicles, and tests the relationships among these factors. This research will identify the factors that influence the consumer acceptance of full electric vehicles and thus might influence policies designed to promote the adoption of full electric vehicles to reduce carbon emissions from transport.

2. Literature Review

2.1. Full Electric Vehicles

Full electric vehicles have been around since before the turn of the twentieth century, and they were popular until approximately 1918 [13]. The continued improvement of the gasoline-powered internal combustion engine vehicles led them to be too competitive [14], and by 1933, full electric vehicles were totally phased out of the transportation market. After a hundred years of evolution, most major vehicle manufacturers are currently developing compact full electric vehicles, usually for short-range city driving (e.g., [15–18]).

Full electric vehicles have an all-electric drivetrain powered from a battery that is recharged from the electricity supply. The previous generation of full electric vehicles were typically small cars (termed "superminis" in the U.K. and "compacts" in the USA) with a limited range (e.g., 100 km), requiring hours to recharge [19]. Therefore, Cheron and Zins [20] reported that range, speed, recharging time, and dead battery problems were the factors discouraging the purchase of full electric vehicles. In general, the purchasing price of full electric vehicles is higher than that of conventional cars. Past studies concluded that among these disadvantages, limited range is the overwhelming drawback of full electric vehicles [21–24]. However, this shortcoming has been overcome. Currently, electric vehicles can reach 250 km, have an attractive appearance, and come in a range of sizes. Gerssen-Gondelach and Faaij [4] forecasted that once future Li-ion and ZEBRA batteries could provide sufficient power at a very low cost, full electric vehicles would become competitive with gasoline vehicles. Although the sales of full electric vehicles to date are very low, Weiss *et al.* [25] forecasted that approximately 145 million full electric vehicles will have been produced worldwide by 2035.

2.2. Factors Influencing Alternative Fuel Vehicles Purchasing Behaviour

Twenty years ago, Ellen *et al.* [26] identified the key factors that motivate environmentally conscious behaviours. These factors consist of personal values, such as a concern for the environment and a belief that an individual could make a difference. This study aims to identify the factors that affect the acceptance of full electric vehicles through understanding the factors that influence individual's purchase intentions for other alternative fuel vehicles. In 2001, the Electric Power Research Institute found that gas prices greatly impact expressions of purchase interest in hybrid electric vehicles [27]. Other customer preferences for hybrid electric vehicles included reduced maintenance, better handling, and reduced air pollution.

Recently, Gallagher and Muehlegger [11] studied the consumer adoption of hybrid electric vehicles in the USA and found that groups with strong preferences for environmentalism and energy security prefer hybrid electric vehicles. Their results indicate that rising gasoline prices and certain social preferences result in maximum sales. Musti and Kockelman [12] found that the top three attributes that buyers look for when seeking a new vehicle purchase are price (30%), fuel economy (28%), and reliability (21%). In general, car use and car ownership are typically associated with instrumental, hedonic, and symbolic attributes [28]; Schuitema *et al.* [29] found that instrumental attributes are largely important for the adoption of electric vehicles and that people's pro-environmental self-identity has a positive effect on the perception of electric vehicles. Zhang *et al.* [30] analysed the factors impeding the development of electric vehicles and found these factors to include deficient electric vehicles subsidy policies, embarrassed electric vehicles market, local protectionism, and unmatched charging infrastructure. Although Steg *et al.*'s [31] survey in the Netherlands suggested that socio-economic and socio-demographic variables are motivational factors for car use, the results of Delang and Cheng's [32] survey in Hong Kong indicated that people recognize the environmental benefits of electric cars but not the economic and social benefits.

For the negative factors, EPRI [33] found that consumers identified the following to be barriers to electric vehicles purchase: lack of electric vehicle infrastructure; potential increases in electric rates; and lack of choice in vehicles. The results of Tan *et al.*'s [34] survey of customer preferences and acceptance of electric vehicles indicated that purchasing behaviours are affected by four factors: charge inconvenience, short battery range, cost, and psychological factors. Bockarjova and Steg [35] claimed the most important barriers for electric vehicle adoption were perceived high monetary and non-monetary costs of electric vehicles and benefits associated with the use of a conventional vehicle. Liu and Santos [36] had similar findings in China that when deciding whether to buy a hybrid electric vehicle, a consumer will consider the cost of the vehicle and the cost of operations such as battery capacity and possible speeds. Other than the price concern, Carley *et al.* [37] argued that range and charge time are barriers to deciding to purchase an electric vehicle in the U.S.A. However, Skippon [38] stated that the future dynamic performance and cruising performance of electric vehicles might partially offset the reduced utility of low range, long recharge times, and higher costs.

However, Klockner *et al.* [39] found that psychological determinants show a high correlation between the purchase and use of electric vehicles in Norway. Nayum *et al.* [40] and Nayum and Klockner [41] further tested the effects of socio-psychological and psychological factors on the normative and intention processes of purchasing an electric vehicle. Klockner [42] further identified the psychological determinants in different stages (goal, behavioural, and implementation stages) of the decision-making process. Their findings confirmed that personal norms, attributes, perceived behavioural control, and planning abilities affect the intention of purchasing an electric vehicle.

Hydrogen fuel cell vehicles (HFCV) are another type of alternative. HFCV and full electric vehicles use electric motors, the only difference is the power source: hydrogen fuel cells *versus* batteries, respectively. Recently, Kang and Park [43] reported that experience with HFCV, policy experience, perception of HFCV, perception of policy, values, and psychological needs are the factors that influence consumer acceptance of HFCV. Tarigan *et al.* [44] and Tarigan and Bayer [45] argued that environmental attitudes and knowledge are important factors for the acceptance of HFCV.

Table 1 summarizes the results of previous studies on the factors influencing purchasing behaviour for alternative fuel vehicles. Some factors are psychological, such as environmental concerns [19,46–48] and the negative perception of electric vehicles [19,43], whereas other concerns include actual situational factors, such as tax reduction [49,50] and changes in gasoline prices [11,48,51]. However, little research has been conducted on the effect of the perception of expected situations on the consumer acceptance of alternative fuel vehicles and investigated the interrelationships among them.

Table 1. Factors influencing alternative fuel vehicles purchasing behaviour.

Author(s)	Factor	Vehicles
Cheron and Zins [20]	Expectancies: comfort, reliability, durability, power, road handling, safety, economy, and fair price of parts; Perceived risks: out of power, having an accident, a mechanical breakdown, not being able to start up, being stuck in a traffic jam, and having a flat tire	Full electric vehicles
Chiu and Tzeng [52]	Purchasing price, reliability, maximum speed, emissions level, operating cost, style, agility, safety, cruise distance, and acceleration	Full electric motorcycles
Lipman and Delucchi [53]	Manufacturing costs, retail prices, and lifecycle costs	Hybrid electric vehicles
Sallee [50]	Tax credits	Hybrid vehicles
West [54]	Gasoline prices	Sport utility vehicles
Chandra *et al.* [49]	Tax rebates	Hybrid vehicles

Table 1. *Cont.*

Author(s)	Factor	Vehicles
Diamond [55]	Incentive, income, high occupancy vehicle, gas, VMT (annual cost of fuel), green planning capacity	Hybrid vehicles
Berensteanuand and Li [51]	Gasoline prices, government support	Hybrid vehicles
Gallagher and Muehlegger [11]	Government incentives (tax incentives), changes in gasoline prices, and preferences for environmentalism	Hybrid vehicles
Kang and Park [43]	Experience with HFCV, experience of policy, perception of HFCV, perception of policy, values, and psychological need	Hydrogen fuel cell vehicles (HFCV)
Zhang *et al.* [46]	Understanding of AFVs, vehicle performance, government policy, environmental requirement, opinion of peers, vehicle price, tax reduction, fuel price, fuel availability, maintenance costs, and vehicle safety	Alternative fuel vehicles (AFVs)
Graham-Rowe *et al.* [19]	Cost minimization, vehicle confidence, vehicle adaptation demands, environmental beliefs, impression management, and perception of electric vehicles	Full electric vehicles and hybrid electric vehicles
Tarigan *et al.* [44]	Knowledge, personal profit, and environmental attitude	Hydrogen vehicles
Tarigan and Bayer [45]	Pro-environmental attitudes and hydrogen knowledge	Hydrogen vehicles
Ziegler [47]	Purchase price, motor power, fuel costs, CO_2 emissions, and service station availability	Alternative energy vehicles
Carley *et al.* [38]	Environmental views index, owns a hybrid, appearance, charging stations, range, vehicle price, charge time, car for the environment, innovation, independent on foreign oil	Plug-in electric vehicles
Jensen *et al.* [48]	Purchase price, fuel costs, driving range, carbon emissions, top speed, battery stations, battery life, charging, environmental attitude	Internal combustion *vs.* electric vehicles
Klockner *et al.* [39]	Awareness of need, ascription of responsibility, social norm, descriptive norm, introjected norm, personal norm, perceived behavioural control, awareness of consequences, attitude, intention	Normal *vs.* electric vehicles
Nayum *et al.* [40]	Socio-demographic factors, norm-related items, specific attitude, environmental attitude, intention, perceived behavioural control, brand loyalty, car type class, CO_2 emission levels	Environmental friendly cars
Schuitema *et al.* [29]	Instrumental, hedonic, symbolic, pro-environmental identity, car-authority identity	Normal vehicles, hybrid electric vehicles, and fully electric vehicles
Bockarjova and Steg [35]	Severity (env. & energy), vulnerability (env. & energy), rewards, self-efficacy (env. & energy), resp-efficacy, costs	Electric vehicles
Klockner [42]	Awareness of need, responsibility, personal norms, attitudes, perceived behavioural control, knowledge, planning ability, intentions	Electric vehicles
Nayum and Klockner [41]	Perceived behavioural control variables, importance of car attributes, norm activation constructs, norm-related items, ecological worldview, attitudes, intention, knowledge of environmental impacts, extended socio-demographics	Internal combustion engine *vs.* electric vehicles
Peters and Dutschke [56]	Relative advantages, compatibility, ease of use, trialability, observability, social norm	Electric vehicles
Skippon [38]	Dynamic performance, cruising performance	Electric vehicles

2.3. Full Electric Vehicles in Macau

Macau is a tourism city. Air quality is a pivotal factor in people's travel decisions. Macau does not have power stations. It imports electricity from the China Southern Grid (CSG) supplied by coal generation in Guangdong, so vehicles are the major source of carbon emissions that cause air pollution in Macau. Macau citizens perceive the advantage of a reduction in air pollution and carbon emissions from vehicles. Thus, promotion of alternative fuel vehicles, especially full electric vehicles, has become part of the Macau government's environmental policies [57,58]. This study focuses on the consumer acceptance of full electric vehicles in Macau.

Limited range is one of the weaknesses of full electric vehicles [55]. However, Macau is a small city (total area = 31.3 km^2) with narrow roads and streets (total length = 413.4 km). There were 240,107 vehicles among the population of 636,200 on 31 December 2014 [59], and therefore, one of every 2.65 citizens has a vehicle. Compared with other Asian cities, this ratio is high. The typical driving range of vehicles in Macau is less than 40 km (private usage: 8 km; business usage: 20 km; special usage such as fast-food delivery: 40 km) [60]. Therefore, full electric vehicles are highly suitable for Macau's topography and environment. After visiting Macau, many experts have affirmed the city's suitability for full electric vehicles and have invariably said that Macau is a role model for the implementation of full electric vehicles [61]. The adoption of full electric vehicles could also become an eye-catching way to enhance and re-brand the tourist experience in Macau. Companhia de Electricidade de Macau (CEM) acquired a full electric car and built the first public electric vehicle charging station in early 2010. There are two companies importing full electric vehicles, Mitsubishi and Tesla. BMW plans to announce its full electric vehicle (Mini E) in the coming years. Compared with other tourism cities, Macau appears to have a great potential market for full electric vehicles. The experience of adopting full electric vehicles in Macau could provide guidance for the governments of other cities in developing policies to promote the adoption of full electric vehicles. Although Macau is a small city in Asia, the results of the study could provide insights for comparable cities elsewhere.

3. Research Model and Hypotheses

Some authors have indicated that the effect of tax incentives increases hybrid vehicles' sales (e.g., [11,49,50]). Some authors concluded that the effect of gasoline prices (future fuel savings) affects hybrid vehicles sales (e.g., [11,51,62–64]). Recent studies indicated that the perception of government policy and vehicle drivers' environmental attitude affect consumer acceptance of hybrid electric vehicles and HFCV (e.g., [43,45,54]). Most of the previous studies focused only on the acceptance of hybrid electric vehicles and HFCV, but this research investigates the consumer acceptance of full electric vehicles. However, the importance of environmental factors compared with other factors and the relationship between these factors for the adoption of alternative fuel vehicles have not been well studied. Because the market for the full electric vehicle is too new for collecting data to measure actual purchasing behaviour, there may be a gap between intentions and actual behaviour [65]. Thus, this research studies individual intentions towards the adoption of full electric vehicles. In this study, environmental concern and perception of environmental policy are combined with perception of economic benefits, perception of electric vehicles, and behavioural intention towards electric vehicles to form a research model as shown in Figure 1.

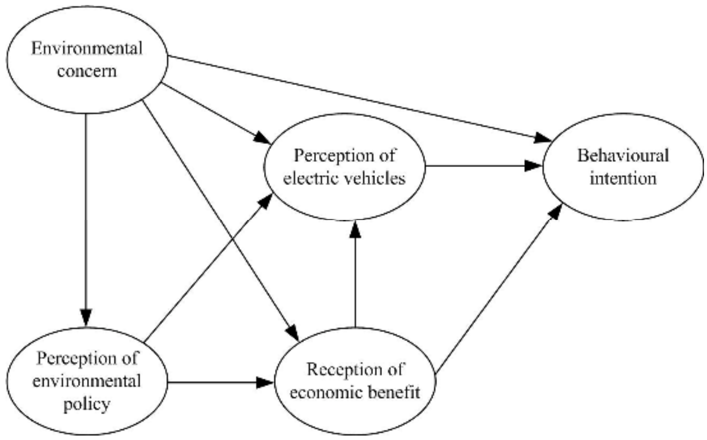

Figure 1. Research model.

Environmental Concern (EC): Environmental concern is usually focused on a perception that the environment is deteriorating in some way [66]. Environmental concern can be defined as the degree to which people are aware of environmental problems and support efforts to solve these problem and/or indicate a willingness to contribute personally to the solution [67,68]. Concern for the environment is significantly related to consumer behaviours such as purchasing ecologically safe products, recycling newspapers, contributing to environmental groups, communication with public officials, and attending public hearings [43]. People with little environmental concern do less work to support environmental policy [69]. Kahn's [70] study indicated that environmentalists are more likely to purchase hybrid electric vehicles than non-environmentalists. Jensen *et al.* [48] argued that environmental concern has a positive effect on the preference for electric vehicles both before and after experiencing an electric vehicle. Peters and Dutschke [56] found that having environmental advantages is a motivator for adopting electric vehicles. Bockarjova and Steg [35] stated that people are more likely to adopt an electric vehicle when they expect electric vehicles to decrease environmental risks. Environmental concern is a psychological factor that should affect user's attitudes towards the acceptance of full electric vehicles.

Hypothesis 1: A user's environmental concern has a positive impact on the user's perception of environmental policy.

Hypothesis 2: A user's environmental concern has a positive impact on the user's perception of economic benefit.

Hypothesis 3: A user's environmental concern has a positive impact on the user's perception of full electric vehicles.

Hypothesis 4: A user's environmental concern has a positive impact on the user's behavioural intention towards full electric vehicles.

Perception of Environmental Policy (PEP): Irwin and Wynne [71] stated that political context affects the validation of new technology, whereas Flynn and Bellaby [72] argued that political circumstance influences the acceptance of products and technology. There are different types of environmental policies such as financial incentives and sales tax waivers on full electric vehicle purchases. Peters and Dutschke's [56] study indicated that financial incentives are considered to be important measures for purchasing an electric vehicle. Gallagher and Muehlegger [11] and Chandra *et al.* [49] found that tax incentives increase hybrid vehicle adoption. An individual's perception of environmental policy should affect the individual's perception of full electric vehicles.

Hypothesis 5: A user's perception of environmental policy has a positive impact on the user's perception of economic benefit.

Hypothesis 6: A user's perception of environmental policy has a positive impact on the user's perception of full electric vehicles.

Perception of Economic Benefit (PEB): The acceptance of a product is often affected by a personal perception of economic benefit. Berensteanu and Li's [51] study indicated that the effect of high gasoline prices increases hybrid vehicles sales compared with gasoline vehicles because the running costs and maintenance costs of full electric vehicles are low. The results of Wang and Gonzalez's [73] study indicated that the energy costs of electric vehicles are approximately eight times less than those of gasoline, diesel, and natural gas vehicles. Expensive gasoline and cheap electricity are great incentives to buy an electric vehicle rather than a gasoline car [74]. Consumers may consider these benefits when they are making a decision regarding purchasing a new vehicle.

Hypothesis 7: A user's perception of economic benefit has a positive impact on the user's perception of full electric vehicles.

Hypothesis 8: A user's perception of economic benefit has a positive impact on the user's behavioural intention towards full electric vehicles.

Perception of Full Electric Vehicles (PFEV): A positive perception of a product can make a customer more likely to purchase the product [75]. Schulte *et al.* [2] supported the view that the perception of a product affects customer acceptance. In this study, "the perception of full electronic vehicles" is the perceived overall driving performance, including the comfortable driving, of electric vehicles. Thus, the perception of full electric vehicles should influence customer's purchasing behaviour.

Hypothesis 9: A user's perception of full electric vehicles has a positive impact on a user's behavioural intention towards full electric vehicles.

4. Research Method

The research question of this study is as follows: what are the factors that affect consumer acceptance of full electric vehicles in Macau? A questionnaire survey was employed that includes two sections. Section 1 contains 5 sets of questions with a total of 15 items for the five constructs of the research model. A 7-point Likert-type scale was employed, with 1 being "strongly disagree" and 7 being "strongly agree". Section 2 provides general background information.

Environmental concern has been treated as an evaluation of or attitude towards one's own behaviour, or other's behaviour with consequences for the environment [76–79]. The measured items of environmental concern cover air pollution [47,52], environmental problems [11,44], and energy conservation [80]. The potential government policies include sales tax waivers [11,49], the subsidization of the construction of charging stations [47], and full electric vehicle programmes [81]. Long-term economic benefits for utilizing full electric vehicles consist of the fuel savings [47], high energy efficiency [47], and cheap electricity [74]. The measured items employed in the construction of the perception of full electric vehicles are based on Kang and Park's [43] study with some modifications to suit the Macau setting. The behavioural intention in this study is measured as the stated likelihood to purchase a full electric vehicle and to recommend full electric vehicles to friends and others in the future. Thus, the measured items are taken from Zeithaml *et al.* [82]. The measured items are listed in Table 3.

The content validity of the measure was checked by two academic colleagues to assess any misunderstandings or ambiguities of expressions in the questionnaire. To evaluate the readability of the questionnaire, a pilot study with 20 students who owned cars was performed. The feedback from the respondents was that the questions in the questionnaire were easily understood and answerable. In the study itself, the interviewer-administered survey was conducted on the streets at five business and residential areas in Macau in March 2012. A filter question "do you drive your own car?" was asked to qualify respondents. A total of 310 completed questionnaires were collected within a month. However, two questionnaires were eliminated (e.g., for giving the same rating for all items), leaving 308 questionnaires as valid for analysis. The minimum, recommended, and ideal N:q ratios (observations/parameters to be estimated) are 5:1 [83,84], 10:1 [83–85], and 20:1 [85], respectively. In this study, there are 39 estimated parameters in the model (as shown in Figure 2), so the N:q ratio is 7.9. Therefore, the sample size of the study is still adequate. Of the sample, 57.8% were male, and 60.7% had a bachelor's or higher education. The respondents in the brackets of 18–29, 30–39, 40–49, and 50 or over accounted for 52.6%, 23.7%, 14.9%, and 8.7% of the total respondents, respectively. The distribution of the samples is similar to that of the population of vehicle owners in Macau because Macau's younger people who work in the tourism sector have a good income and like to drive their own vehicles. Table 2 presents the background characteristics of the respondents.

Table 2. Background characteristics of the respondents (N = 308).

		Frequency	Percent	Cumulative Percent
Gender	Male	178	57.8	57.8
	Female	130	42.2	100.0
Age	18–29	162	52.6	52.6
	30–39	73	23.7	76.3
	40–49	46	14.9	91.2
	50–59	22	7.1	98.4
	≥ 60	5	1.6	100.0
Education	Primary	22	7.1	7.1
	Secondary	99	32.1	39.3
	Undergraduate	169	54.9	94.2
	Postgraduate	18	5.8	100.0
Monthly Income	Less than USD 1875	112	36.4	36.4
	USD1875–3750	171	55.5	91.9
	Over USD 3750	25	8.1	100.0

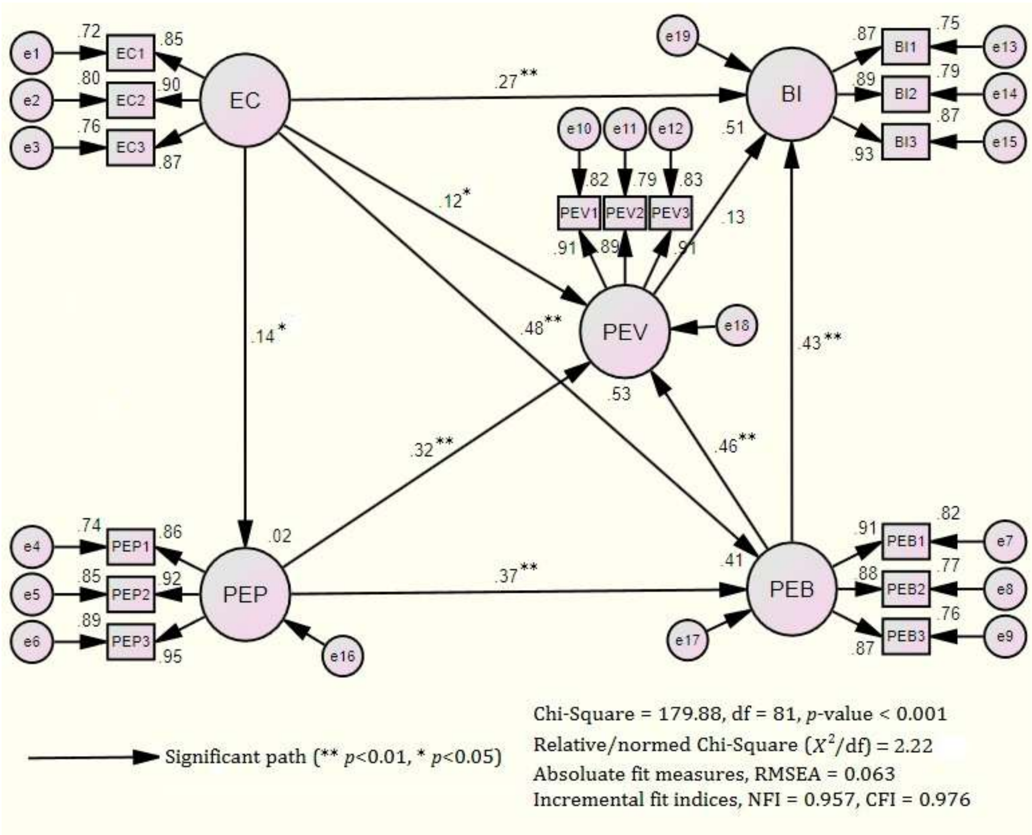

Figure 2. Structural equation modelling results.

5. Findings

Confirmatory factor analysis (CFA) was performed to evaluate the questionnaire's convergent and discriminant validity. Table 3 presents the means, standard deviation, the reliability of the constructs, and the model's standardized factor loadings. The Cronbach's alpha for all components is higher than 0.6, so the reliability of the study is acceptable [86]. All factor loadings are above 0.7 and are highly significant as required for convergent validity ($p < 0.05$). The values of Average Variance Extracted (AVE) of all constructs exceed 0.5, and the values of Composite Reliability (CR) of all constructs exceed 0.7. Based on the guidelines of Hair *et al.* [87], the construct validity of the model is provided. Table 4 indicates the correlation matrix of the five constructs. All of the correlation values among the constructs of the model are significant ($p < 0.01$). The square root of the construct's AVE exceeds its correlations with other constructs in the model, demonstrating a necessary aspect of the discriminant validity of the latent constructs.

The structural equation modelling (SEM) analysis was performed to test the research hypotheses empirically [88,89]. Figure 2 presents the results of the SEM analysis. These results suggest that the model provides an acceptable fit [87,90,91] and that all hypotheses are valid. Table 5 presents the direct, indirect, and total effects of the model.

Table 3. Reliability and validity of the constructs.

		Mean	Std. Dev.	Cronbach's Alpha	Factor Loadings	AVE	CR
EC	Environmental concern:	5.553		0.905		0.763	0.906
EC1	I worry about air pollution.	5.507	0.776		0.854		
EC2	I am concerned about environmental problems.	5.490	0.793		0.893		
EC3	I care about energy conservation.	5.662	0.852		0.873		
PEP	Perception of government policy:	4.321		0.933		0.830	0.936
PEP1	I think that the Macau government would waive sales tax for full electric vehicles.	4.497	1.093		0.864		
PEP2	I think that the Macau government would subsidize the construction of charging stations.	4.234	1.045		0.923		
PEP3	I think that the Macau government would announce a full electric vehicles programme to subsidize the cost of electric vehicles.	4.231	0.966		0.944		
PEB	Perception of economic benefit:	5.128		0.916		0.787	0.917
PEB1	I think that electric vehicles could provide the benefit of fuel savings.	5.166	0.681		0.910		
PEB2	I think that electric vehicles could provide the benefit of high energy efficiency.	5.198	0.678		0.875		
PEB3	I think that electric vehicles could provide the benefit of cheap electricity.	5.020	0.744		0.875		
PFEV	Perception of electric vehicles: Adapted from Kang and Park [43].	4.398		0.929		0.809	0.927
PEV1	I think that the riding comfort of electric vehicles would be good.	4.419	0.897		0.903		
PEV2	I think that the driving performance of electric vehicles would be good.	4.351	0.892		0.886		
PEV3	I think that having an electric vehicle would be good.	4.425	0.967		0.908		
BI	Behavioural intention: Adapted from Zeithaml *et al.* [82].	4.932		0.924		0.786	0.917
BI1	I would speak favourably about full electric vehicles to others.	4.990	0.678		0.853		
BI2	I would recommend my friends to buy a full electric vehicle.	4.873	0.651		0.879		
BI3	I would buy a full electric vehicle in the future (say, in 3 years).	4.932	0.634		0.926		

Remark: AVE—Average Variance Extracted, CR—Composite Reliability.

Table 4. Construct correlation matrix.

	Square Root of AVE	EC	PEP	PEB	PEV
EC	0.873				
PEP	0.911	0.155			
PEB	0.887	0.068	0.439		
PEV	0.899	0.230	0.554	0.621	
BI	0.887	0.371	0.328	0.572	0.496

Table 5. Direct, indirect, and total effects.

	PEP	PEB			PEV			BI		
	Direct	**Direct**	**Indirect**	**Total**	**Direct**	**Indirect**	**Total**	**Direct**	**Indirect**	**Total**
EC	0.140	0.481	0.051	0.532	0.123	0.290	0.413	0.270	0.287	0.557
PEP		0.365		0.365	0.320	0.168	0.448		0.225	0.225
PEB					0.461		0.461	0.435	0.062	0.497
PEV								0.135		0.135

Table 6 presents the comparisons of the measurement model, structural model, and three alternative models. This study assumes that environmental concern is an initial antecedent factor and behavioural intention is the final consequence outcome. The first alternative model contains a new path (PEP → BI) (Model A as shown in Figure 3a). The results reveal that PEP does not significantly affect BI. For validating the structure of the model, two alternative models (Models B and C, as shown in Figure 3b,c) were quasi-randomly generated as recommended by MacCallum *et al.* [92]. The results of the SEM analysis indicate that there is a non-significant path in these two models. The model-fit indices of the structural model are better than the model-fit indices of models A and B. Although the model-fit indices of the structural model is the same as the model-fit indices of the model C, in case the non-significant path is removed to form a model D (as shown in Figure 3d), the model-fit indices of model D are worse than the model-fit indices of the structural model. Therefore, compared with the four alternative models, the structural model is the best model, providing the best explanations of the data.

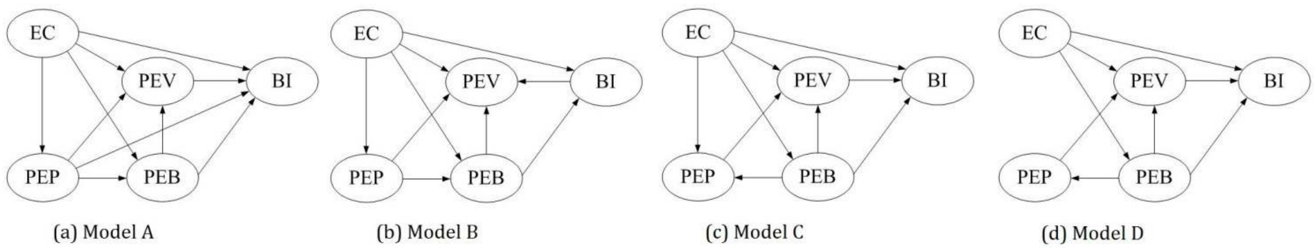

Figure 3. Alternative models.

Table 6. The comparisons of the models.

	Measurement Model	Structural Model	Model A	Model B	Model C	Model D
Chi-Square	179.816	179.879	179.816	180.173	179.879	183.187
Df	80	81	80	81	81	82
χ^2/df	2.248	2.221	2.248	2.224	2.221	2.234
RMSEA	0.064	0.063	0.064	0.063	0.063	0.063
CFI	0.976	0.976	0.976	0.976	0.976	0.975
EC → PEP		0.140 *	0.141 *	0.142 *	−0.126 (ns)	--
PEB → PEP		--	--	--	0.500 ***	0.428 ***
EC → PEB		0.365 ***	0.366 ***	0.480 ***	0.532 ***	0.596 ***
PEP → PEB		0.481 ***	0.481 ***	0.367 ***	--	--
EC → PEV		0.123 *	0.123 *	0.085 (ns)	0.123 *	0.123 *
PEP → PEV		0.320 ***	0.320 ***	0.315 ***	0.320 ***	0.320 ***
PEB → PEV		0.461 ***	0.461 ***	0.394 ***	0.461 ***	0.459 ***
BI → PEV		--	--	0.135 *	--	--
EC → BI		0.270 ***	0.267 ***	0.279 ***	0.270 ***	0.272 ***
PEB → BI		0.435 ***	0.438 ***	0.521 ***	0.435 ***	0.434 ***
PEV → BI		0.135 *	0.142 *	--	0.135 *	0.134 *
PEP → BI		--	−0.014 (ns)	--	--	--

*** $p < 0.001$, * $p < 0.05$.

6. Conclusions and Discussions

6.1. Theoretical Contribution

This paper takes Macau as a case study to investigate the factors that influence individual behavioural intention towards the full electric vehicle. The results of this study prove that environmental concern is an initial factor that finally leads customer's behaviour intention towards purchase of a full electric vehicle. Environmental concern is a psychological factor that directly and indirectly influences four types of perceptions that mediate the link between environmental concern and the acceptance of full electric vehicles (as shown in Table 5).

Unsurprisingly, the results of this study indicate that the perception of environmental policy is positively correlated with the perception of economic benefit linked to full electric vehicles. The perception of economic benefit and the perception of electric vehicles directly affect the acceptance of full electric vehicles. These findings are consistent with the findings of Kang and Park's [43] study that the perception of government policy directly affects the perception of hydrogen fuel cell vehicles and indirectly affects the acceptance of HFCV. The public is aware of the environmental policy and believes that the policy will be maintained continuously to build a low carbon society.

The results of the data analysis indicate that customers' behavioural intention towards full electric vehicles is affected by environmental concern, the perception of full electric vehicles, and the perception of economic benefit. The SEM analysis shows that the direct effect of the perception of economic benefit (β = 0.435) is larger than the direct effects of environmental concerns (β = 0.270) and of the perception of full electric vehicles (β = 0.135). Many studies have argued that environmental concerns are an initial factor that stimulates the need of environmental light vehicles and environmental policy that encourages consumers to take action towards purchasing environmental light vehicles; however, this study highlights a new insight; the perception of economic benefit is an important factor that affects consumer behaviour towards purchase of full electric vehicles. Graham-Rowe *et al.* [19] stated that vehicle operators are more sensitive to fuel economy, and they attempted to calculate likely costs and savings in fuel consumed. The low cost per kilometre is regarded to be the biggest advantage of full electric vehicles [93]. Although the limited driving range is an obstacle to the adoption of full electric vehicles [94], the results of Daziano and Chiew's [65] study indicated that when vehicle operators expected operating cost savings, they would be satisfied with a short driving range (114.8 miles). Therefore, the perception of economic benefit is an important determinant of the consumer acceptance of full electric vehicles in Macau. However, as most of the studies in technology acceptance, this study measured only behaviour intention rather than real behaviour because, at this moment, full electric vehicles are still not commonly adopted in many countries. Further studies should be conducted to obtain additional data to understand how the perception of economic benefits affects the real purchasing behaviour once full electric vehicles are mass produced.

Many previous studies evaluated actual situational factors for adopting environmental friendly vehicles. If some situations will be realized soon or we want to test the feedback from consumers in some situations (e.g., electric vehicles could benefit from cheap electricity), employing the expected situational factors could help researchers obtain the outcomes of such situations. It can provide a more realistic feedback for policy makers and commercial marketers to consider before taking actions. This research model tests the situational factors (perception of environmental policy and perception of economic benefit) that consumers are looking for. The results of the data analysis indicate that two expected situational factors play important roles in the adoption of full electric vehicles as discussed above. This study also explores the interrelationships among four factors and the user's behavioural intention towards full electric vehicles (as shown in Figure 2). This study contributes a research model that can be further investigated to explain the causal effects of these four factors for the adoption of other environmental technologies.

6.2. Practical Implications

Air pollution harms the tourism economy and is often raised as a concern in the feedback provided by departing guests. To create a green environment, the general public should adopt full electric vehicles in Macau. This study indicates that environmental concern is an antecedent factor that stimulates interest in full electric vehicles. The Macau government should consider educating the public about the importance of environmental protection and the environmental advantages of driving full electric vehicles. In addition to promoting environmental protection concepts through the mass media, the Macau government could provide financial support for environmental organizations to conduct some environmental protection workshops in primary and secondary schools to educate future vehicles' drivers regarding knowledge of full electric vehicles. The Macau government could also consider sponsoring universities in Macau to develop environmental research and monitoring programmes and let college students practice driving full electric vehicles on their campuses.

The introduction of full electric vehicles requires decisive government environmental policies as the Macau government could play a leading role in changing to full electric vehicles. Although the Macau government offers tax incentives for purchasing light environmentally friendly vehicles, these tax incentives also cover hybrid electric vehicles. Like many Western countries, the Macau government's subsidies are not currently aligned with the goal of decreasing gasoline consumption in a consistent and efficient manner [95]. Thus, the Macau government should do more to promote full electric vehicles. The lack of supporting infrastructure may hinder consumer acceptance of full electric vehicles [55]. Many drivers would be more willing to invest in electric vehicles if there were sufficient charging stations in the community [96]; thus, adding recharging locations could increase the proportion of driving done by electric vehicles [97]. The development of charging infrastructure is essential in supporting the broad-based deployment of electric vehicles [98]. Norway is a successful case of promoting electric vehicles where tax exemption, availability of free public charging stations as well as toll-free roads, ferries and the ability of electric-car drivers to utilize bus lanes are important factors that encourage Norwegian drivers to choose electric vehicles [53]. The Macau government should establish the supporting infrastructure for full electric vehicles, such as providing solar powered charging facilities in public car parks, offering free parking for full electric vehicles charged in public car parks, and offering a full electric vehicles programme to subsidize vehicle owners to replace their existing gasoline vehicles with new full electric vehicles.

This study indicates that the acceptance of full electric vehicles as common transportation equipment would be primarily determined by the perception of economic benefits, that is, the long-term cost advantage of full electric vehicles compared with vehicles that utilize gasoline. Consumers care about long-term lifecycle costs [99]. The Macau government should provide long-term financial support. Battery cost is the most important factor for owning a full electric vehicle [4]. Rechargeable batteries are costly because vehicle owners need to spend money replacing drained batteries every few years. Therefore, the replacement of drained battery would lead to a much higher total cost of ownership [100]. One way around this would be for the Macau government to subsidize full electric vehicle owners for the replacement of drained batteries. However, vehicle maintenance cost is also a long-run cost. Full electric vehicle importers should guarantee that the maintenance costs for full electric vehicles should be competitive with the maintenance costs for vehicles that run on gasoline.

Because Macau does not have a power station, vehicles are one of the major sources of carbon emissions in Macau. Carbon emissions are typically connected to air pollution that poses a threat to the city's main industry—tourism. As a tourist city, the major government income in Macau is from tourism industries. The total income and tax revenues from gaming were above USD17.6 billion and approximately USD 13.4 billion, respectively, in 2013 [59]. The fiscal balance was approximately USD12.4 billion. Since Macau imports electricity from the CSG in Guangdong, so whether both the emissions of greenhouse gases and health-endangering gases could be reduced depends on how the electricity is produced by CSG. The Macau government has relatively large financial reserves and responsibility to support CSG to develop clean energy production, such as building wind energy farms in Hengqin, Zhuhai.

6.3. Limitations and Further Studies

This study focuses only on the citizens and their acceptance of full electric vehicles in Macau. Macau is a small city that is suitable for the adoption of full electric vehicles, and thus, the findings of this study may not be generalizable to other cities with different geographic and economic features. However, the market in Macau is not developed enough to include actual purchase decisions in the model; therefore, further studies are recommended to revise this model for studying the actual purchasing behaviour in a more developed market, for example, in Norway.

As this research investigated only four positive psychological factors, it is suggested that other positive and negative factors such as perceived drawbacks could be added in future studies to widen the scope of this research area. Additionally, there are different types of benefits. This study considers only long-term, personal, direct, and measurable economic benefits that are printed in the catalogues of electric vehicles. However, researchers can consider integrating other benefits such as social and environment benefits in their research.

This study is concerned only with consumer acceptance of full electric vehicles. It may not be generalizable for other environmental transportation technologies. Future studies are suggested to investigate whether a similar concept can be employed with regard to installing other environmental transportation equipment.

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Author Contributions

Ivan K. W. Lai developed the research ideas, conducted the research, analysed the data, and wrote the manuscript. Yide Liu implemented the research programme, was involved in some parts of the data analysis, and helped complete the drafting of this article. Xinbao Sun provided guidance and advice during the duration of the project. Hao Zhang and Weiwei Xu distributed the survey and assisted with the process for the project. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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