The Effects of Environmental Policy and the Perception of Electric Motorcycles on the Acceptance of Electric Motorcycles: An Empirical Study in Macau

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Abstract

Air pollution is a serious environmental issue across the world and has drawn attention from researchers with different backgrounds. The carbon exhaust from gasoline vehicles is one cause of air pollution. One solution for reducing carbon emissions is to provide green vehicles, such as electric motorcycles, for drivers and passengers, which can help the sustainable development of the environment in an ecological way. This research discusses the market response to electric motorcycles in Macau by focusing on the effects of environmental policy. An environmental technology acceptance model was developed, based on which 325 valid questionnaires were collected. The research demonstrates the impact on motorcyclists’ acceptance of electric motorcycles by considering their perceptions of environmental policy, pollution reduction, the saving of energy, and driving performance; the results can lead to valuable discussions on the environment–technology–society ecosystem in further studies. The research results could help relevant government bodies to develop appropriate environmental policies to encourage motorcyclists to adopt electric motorcycles. Furthermore, the electric motorcycle industry could identify key success factors for developing or promoting electric motorcycles using the study variables.

Keywords

environmental policy, pollution reduction, energy-saving, driving performance, electric motorcycles

Introduction

Macau is a small tourist city with an area of 32.9 km² (Macau DSCC, 2019). It is one of the most popular tourist destinations in the world, with 33 million visitors per year (Macau Dataplus, 2019). Macau is faced with the same problem as many other tourist cities: the threat of environmental pollution. Since the scale of industrialization in Macau is very small, the main source of air pollution is vehicle exhaust. As with many Asian cities such as Ho Chi Minh, where, depending on the traffic conditions, it may take a very long time to catch a bus (Nguyen et al., 2019), motorcycles/scooters are popular in Macau. Motorcycles and scooters have advantages of mobility, parking, ease of riding, and low operating costs (Badami & Iyer, 2006; Iyer & Badami, 2007; Lu et al., 2008). However, people in Macau believe that the widespread use of motorcycles has resulted in serious issues with environmental pollution (Zhu et al., 2019). Owing to their long history, many Asian cities have a high population density and highly mixed land use, which creates a suitable platform for motorcyclists (Amsden, 1991; Chiu & Tzeng, 1999). However, most motorcycles are powered by highly polluting two-stroke engines, which make an important contribution to air pollution from transport on a passenger-kilometer basis (Badami, 2004). The CO₂ emission rate from motorcycles is 64 to 128 g/pax-km, and the energy use for motorcycles is 21 to 42 kWh/100pax-km (Cherry et al., 2009). A recent study indicated that electric motorcycles consume approximately eight times less energy and emit approximately half the equivalent CO₂ of gasoline motorcycles (Koossalapeerom et al., 2019). In addition to the emissions problem, there is high noise pollution from motorcycles (Wang et al., 2000). Thus, motorcycle pollution is worthy of public attention (Rose, 2012) especially in small tourist cities such as Macau.

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As a potential alternative to gasoline motorcycles, zero emissions (in the sense that it uses recycled energy), low-noise, and highly energy-efficient solution have appeared: electric motorcycles or electric motorized two-wheeled vehicles (Hsu & Lu, 2010; Redman, 2015). Electric motorcycles are a good environmental solution, as they are powered by electricity so they have no exhaust emissions (Chiu & Tzeng, 1999). The diffusion of electric motorcycles is important in the reduction of air pollution in densely populated metropolitan areas (Huang et al., 2018). As well as in Asian countries, electric motorcycles are promoted in many other regions by both the public sector and industry because of their environmental features. However, as with other issues within the environment–technology–society ecosystem, there is a concern among motorcycle riders about performance issues. Electric motorcycles are promoted by policies and advertising, which may focus on environmental or convenience issues (Wang et al., 2000), but the driving performance of an electric motorcycle, in particular, is an important factor that is considered as part of the consumer’s purchasing decision, and this is also part of the industry’s ongoing efforts (Wu et al., 2015). Motorcyclists will compare the environmental protection features (the reduction of pollution and the saving of energy) with driving performance when they consider whether to use an electric motorcycle (Weinert et al., 2008). Although these three factors related to performance (the reduction of pollution, the saving of energy, and the driving features) have been identified in previous studies, no study has been made to compare the effects of these three factors on the acceptance of electric motorcycles. Thus, this study attempts to fill the gap by examining how these three factors influence motorcyclists’ acceptance of electric motorcycles.

In addition, Kang and Park (2011) stated that the experience and perception of government policy will affect the perception of alternative fuel vehicles. In Kang and Park’s (2011) study, the perception of hydrogen fuel cell vehicles is measured by the perception of the driving performance of such vehicles. However, the perception of alternative fuel vehicles should include the perception of the environmental protection performance of such vehicles, because the environmental concern is one possible reason for purchasing an alternative fuel vehicle (Badami, 2004). Consumers are not solely economic animals, but they are also concerned about environmental issues (Hsu & Lu, 2010). Thus, there should be a link between the experience and perception of environmental policy and the perception of the above performance factors. However, no study has considered this relationship. This study considers the experience and perception of environmental policy as two antecedent factors of the three performance factors; these ultimately influence motorcyclists’ acceptance of electric motorcycles, and this study thereby covers the existing research gap.

Since environmental pollution not only prevents tourists from visiting destinations but also affects people’s lives (Lai et al., 2015; Sunlu, 2003), the Macau government has established a roadmap for environmental management, with the aim being “to build a low carbon Macau, creating green living together” (Macau DSPA, 2019). However, the effectiveness of this environmental policy has been questioned. This study contributes a research model on the environment–technology–society issues by looking at the relationships between the experience and the perception of environmental policy, the perception of different aspects of electric motorcycle performance, and the acceptance of electric motorcycles. This study provides a contribution to the theory of the acceptance of environmental technology by considering an environmental policy. The results of this research will help relevant government bodies to understand the influence of environmental policy on motorcyclists’ acceptance of electric motorcycles. This study could also help the electric motorcycle industry to formulate strategies to address different performance issues and thereby sway potential customers’ purchase intentions in favor of electric motorcycles.

**Literature Review**

To understand the factors that influence motorcyclists’ acceptance of electric motorcycles, previous studies on the factors affecting the acceptance of electric motorcycles are reviewed first. Since environmental policies may influence motorcyclists’ behavioral intentions toward electric motorcycles, the establishment and perception of environmental policies are discussed. Before accepting an electric motorcycle, motorcyclists would consider its performance, so the perceived performance of the electric motorcycle is explored.

**Factors Affecting the Acceptance of Electric Motorcycles**

Previous studies have used different theories to identify the factors affecting the acceptance of new technology. The most common theory is the Technology Acceptance Model (TAM), which was developed by Davis (1989) on the basis of the theory of reasoned action (TRA) (Fishbein & Ajzen, 1975). The TAM consists of two relevant beliefs: perceived usefulness (PU) and perceived ease of use (PEOU). PU is defined as the extent to which an individual believes that using the system will enhance the performance of the job (Davis, 1989), while PEOU concerns the degree to which an individual believes that the use of a particular technology will be free of effort (Davis, 1989). Researchers have reported that TAM plays a crucial role in the acceptance of novel technologies (Ashfaq et al., 2019; Huseynov & Yildirim, 2019; Siyal et al., 2019). As it should not be hard for motorcyclists to drive electric motorcycles, this study borrows the concept of PU and explores the potential performance factors affecting the acceptance of electric motorcycles. To enhance the power of prediction and in keeping with the research setting,
and after reviewing the literature, this study classifies three major performance aspects as set out below.

Electric motorcycles have a clean, energy-efficient power source (Wang et al., 2000) because their batteries can be recharged from a standard electrical outlet (Weinert et al., 2007). As early as 1999, Chiu and Tzeng (1999) studied the market acceptance of electric motorcycles in Taiwan by investigating consumers’ attitudes toward emission levels and environmental friendliness. Many later studies have also shown that environmental concern is a factor that affects motorcyclists’ behavioral intentions toward electric motorcycles (Cherry et al., 2009; Steg et al., 2001; Weinert et al., 2008). As regards environmental concerns, as electric motorcycles mainly contribute to the reduction of air pollution (Huang et al., 2018), one of the reasons why a motorcyclist would consider an electric motorcycle would be the perception of its performance in reducing pollution.

Previous studies have also shown that motorcyclists consider the driving performance of electric motorcycles (Cherry & Cervero, 2007; Chiu & Tzeng, 1999; Hsu & Lu, 2010; Sheu, 2007; Weinert et al., 2007; Wu et al., 2015). The series of large-scale surveys conducted by Cherry and his colleagues (Cherry & Cervero, 2007; Cherry et al., 2009) identified that consumers are concerned with safety issues in relation to electric motorcycles. Weinert et al. (2007) and Rose (2012) also noted that motorcyclists are concerned with travel times, comfort, safety, infrastructure, and mobility. Most recently, Zhu et al. (2019) found that driving speed is a factor that influences consumers’ willingness to buy and pay for electric motorcycles. Therefore, the perception of driving performance, including safety, speed, and comfort, would influence motorcyclists’ acceptance of electric motorcycles.

From the perspective of the economic benefits, previous studies have shown that energy efficiency is a factor influencing motorcyclists’ decisions to purchase electric motorcycles (Cherry et al., 2009; Lu et al., 2008). Recently, Wu et al.’s (2015) study in Taiwan found that saving energy is an important factor when motorcyclists are considering whether to purchase an electric motorcycle. Huang et al.’s (2018) study also indicated that motorcyclists evaluate the benefits of energy efficiency and pollution reduction when replacing gasoline-powered motorcycles with electric motorcycles. They concluded that electric motorcycles offer a significant energy saving benefit for a high fuel economy. Therefore, the perception of energy-saving should influence motorcyclists’ acceptance of electric motorcycles.

Table 1 summarizes the results of previous studies on the factors that influence motorcyclists’ behavioral intentions toward electric motorcycles. These studies were mainly conducted in Asian regions such as China, Taiwan, India, and Indonesia. Other than the above three major psychological factors, researchers have identified some situational factors that are not considered in this study; these include price (Cherry et al., 2016; Weinert et al., 2006, 2008) and carrying capacity (Steg et al., 2001; Weinert et al., 2007). Although these scholars studied the market response to electric motorcycles by analyzing various factors, the lack of a systematic discussion on the effects of environmental policy appears as a research gap. In fact, Badami (2004) provided an in-depth discussion on environmental policy with electric motorcycle owner networks. Moreover, Cherry et al. (2009) noted the importance of the perception of environmental policy on the diffusion of electric motorcycles. Policies are required to address not only air pollution but also transport impacts, welfare, land use, and cost issues. However, there is no further empirical study that discusses the effects of the experience and perception of environmental policy on motorcyclists’ acceptance behavior. The impact of environmental policy on the diffusion of electric motorcycles thus remains unclear.

**Environmental Policy**

Since environmental policy making is crucial for achieving a sustainable future for our society (S. Chen, 2017), environmental policy has the potential to influence both motorcycle riders’ activity and innovation in the industry (Rose, 2012). In recent years, vehicles have contributed increasingly to air pollution (Guo et al., 2007). In the context of electric motorcycles, the relevant policy objectives include improving the efficiency of the transport system, improving safety standards, reducing the use of non-renewable energy, reducing environmental impacts, and maximizing accessibility and mobility capacity (Rose, 2012). An effective environmental policy relies on effective information generation, enforcement, and monitoring to improve people’s experience and perception (Badami, 2004).

An environmental policy can also have financial benefits for electric motorcycle users. The cost of green energy is a key factor that affects motorcycle drivers’ and passengers’ purchasing behavior (Salmela & Varho, 2006; Wu et al., 2015). Many studies have discussed the impact of financial benefits on customers’ acceptance of alternative fuel vehicles. Egbue and Long (2012) noted that the initial cost of an alternative fuel vehicle is significantly higher than that of a gasoline-powered vehicle. Karplus et al. (2010) also agreed that the costs of alternative fuel vehicles could be a significant barrier to market entry, particularly in the absence of environmental policy. Other studies have recommended that governments establish environmental policies to subsidize the initial costs of owning an alternative fuel vehicle, such as by providing incentive schemes (Gallagher & Muehlegger, 2011).

In order to fulfill different purposes, different countries have developed different blueprints and issued different types of environmental policies. Developed countries have also implemented economic instruments, such as taxes on fertilizer, gasoline, and other polluting inputs (Bercik & Helfand, 2010). Developing countries usually start with market-based instruments to relax the trade-off between the goals of economic growth and environmental quality.
Table 1. Previous Studies in the Acceptance of Electric Motorcycles.

| Author(s)          | Factors                                                                 | Vehicles                      | Country     |
|-------------------|-------------------------------------------------------------------------|-------------------------------|-------------|
| Chiu and Tzeng (1999) | Zero-emission, noise level, energy efficiency, gender, air pollution, purchase price, maximum speed, operating cost, emission level, cruise distance, style, environment friendliness, and the preference score | Electric motorcycles          | Taiwan      |
| Wang et al. (2000)     | Clean, energy-efficient power source                                    | Fuel cell motorcycle         | Taiwan      |
| Steg et al. (2001)      | Reliability, speed, safety, carrying capacity, comfort, power, driving behavior, media image, and policy limitation | Motorcycles                   | Netherlands |
| Badami (2004)            | Environmental policy                                                     | Motorized two-wheeled vehicle | India       |
| Weinert et al. (2006)    | Carbon-intensive, energy use, mobility, environmental impact, cost, performance, bans, policy, and battery | Electric two-wheelers, electric vehicles | China       |
| Sheu (2007)                   | Electric power and pollution                                            | Electric scooter              | Taiwan      |
| Weinert et al. (2007)    | Travel times, range, carrying capacity, comfort, ease of use, performance, and safety | Electric bikes, electric scooter | China       |
| Cherry and Cervero (2007)| Speed, safety, pollution, infrastructure, parking, mobility, and policy limitation | Electric bikes, electric scooter | China       |
| Iyer and Badami (2007)   | Market forces, environmental regulation, industry R&D efforts, vehicle price, emissions, and noise | Two-wheeled motor vehicle     | India       |
| Lu et al. (2008)         | Emission and energy efficiency                                           | Motorcycles                   | Taiwan      |
| Weinert et al. (2008)    | Policy, safety, battery quality, and energy costs                        | Electric bicycles, e-scooters | China       |
| Cherry et al. (2009)     | Perception of environmental policy, reduce-pollution performance, battery, energy efficiency, and public health | Electric bikes, electric Scooter | China       |
| Hsu and Lu (2010)        | Easy to park, mobile, fast, electric power, and pollution                | Electric motorcycle, air-powered motorcycles | Taiwan      |
| Rose (2012)              | Policy environmental impacts, mobility, safety, and battery             | E-bikes                       | Australia   |
| Jones et al. (2013)      | Price, range, refuel/recharge time, operating cost, maintenance cost, acceleration, speed, license requirement, and sales tax | Electric scooter              | Vietnam     |
| Wolf and Seebauer (2014) | Energy use, air pollution, noise reduce, carbon-intensive, and environmental benefits | Electric bicycles, e-scooters | Austria     |
| Wu et al. (2015)         | Consumer demand, price, perceived usefulness, image, and energy saving | Electric motorcycles          | Taiwan      |
| Cherry et al. (2016)     | Congestion, safety, emissions, and household income                      | Electric bikes                | China       |
| H.-S. Chen et al. (2017) | Product knowledge, perceived quality, perceived risk, and perceived value | Hydrogen-electric motorcycle  | Taiwan      |
| Gueera (2019)            | Motorcycle attributes: monthly payment, fuel price, charge time, max speed, and max range Preference attributes: smokes, has an electric-specific motorcycle, thinks e-bike quality is high, thinks e-bike quality is low, thinks a lot about the environment, rarely thinks about the environment, and has a gas-specific motorcycle | Electric motorcycles          | Indonesia   |
| Huang et al. (2018)      | Energy-saving benefit and environmental benefit                         | Electric motorcycles          | Taiwan      |
| Thuy and Hong (2019)     | Economic benefit, usage convenience, convenience in replacing components, size-weight, usage safety, environmental friendliness, and environmental pollution | Electric two-wheeled vehicles | Vietnam     |
| Zhu et al. (2019)        | Sale price, charging fee, repair fee, battery lifetime and cost, battery endurance, tax incentives, environmental benefits, charging convenience, fuel price, driving speed, and load capacity | Electric motorcycles          | Macau       |
(Huppes, 2001). Therefore, the effects of environmental policies depend on policy instruments, which influence people’s perception of them.

**Perception of Environmental Policies**

Government policies play an important role in promoting the use of energy-efficient appliances (Ma et al., 2011). For example, the Chinese government has attempted to invest in electricity infrastructure to reduce the price of electric vehicles; in this way, using environmental policy as a tool (Weinert et al., 2008), this has caused a rapid expansion of the rural e-bike market. The effects of environmental policies arise from two elements: the experience of environmental policies and the perception of environmental policies (Kang & Park, 2011).

The experience takes into account the impact of past events on people’s current perception and behavior (Rajapaksa et al., 2018). Schulte et al. (2004) also stated that a person’s experience influences the development of his or her perceptions of a product. According to Cherry et al.’s (2009) research, motorcyclists’ experience of environmental policy could have an impact on their perceptions of the policy. The results of Kang and Park’s (2011) study also indicated that a person’s perception of government policy is directly influenced by his or her own experience of the policy. People who are highly experienced in a given area should have detailed knowledge of a range of relevant cases in that area (Keeley & Scoones, 2003). Therefore, a motorcyclist who does not understand the instruments of an environmental policy that has been announced cannot have a perception of the policy.

**Hypothesis 1 H1**: A motorcyclist’s good experience with an environmental policy has a positive impact on the motorcyclist’s perception of the policy.

**Perception of Electric Motorcycles**

Table 1 shows the factors that influence the acceptance of electric motorcycles. As mentioned in the above literature review, the perception of electric motorcycles can be assessed under three categories of performance – (a) performance in reducing pollution, (b) energy-saving performance, and (c) driving performance. Motorcyclists consider purchasing electric motorcycles because of their pollution reduction performance, which can effectively address air and noise pollution problems (Cherry et al., 2009; Hsu & Lu, 2010). Furthermore, the fuel economy (kilometers per unit of energy) of electric motorcycles is four times higher than that of gasoline-powered motorcycles (Huang et al., 2018). Therefore, the fact that electric motorcycles save energy (both in terms of cost and with respect to energy sources) can influence motorcyclists when they are considering electric motorcycles (Weinert et al., 2007). As most motorcyclists are unfamiliar with electric motorcycles, they may worry about their driving performance (Egbue & Long, 2012). Speed and range matter substantially (Guerra, 2019). The driving performance of electric motorcycles is therefore a factor when motorcyclists consider purchasing electric motorcycles.

In the industry, a typical instrument of environmental policy is emission standards, which can provide guidance and practice for fuel injection, three-way catalysts, and electronic engine management (Iyer & Badami, 2007). For motorcyclists, policy instruments should relate to the performance factors affecting their perception of electric motorcycles. If a motorcyclist has a good experience with environmental policy, he or she should understand how these instruments of environmental policy can help to solve environmental issues by encouraging the adoption of electric motorcycles. Therefore, the experience of environmental policy may influence motorcyclists’ perception of the three performance factors of electric motorcycles.

**Hypothesis 2a (H2a)**: A motorcyclist’s good experience with an environmental policy has a positive impact on the motorcyclist’s perception of the performance of electric motorcycles in reducing pollution.

**Hypothesis 2b (H2b)**: A motorcyclist’s good experience with an environmental policy has a positive impact on the motorcyclist’s perception of the energy-saving performance of electric motorcycles.

**Hypothesis 2c (H2c)**: A motorcyclist’s good experience with an environmental policy has a positive impact on the motorcyclist’s perception of the driving performance of electric motorcycles.

Perception of government policy is particularly affected by trust in the policy-making process, policy consistency, and policy efficiency (Kang & Park, 2011). Both economics-based and market-based instruments of environmental policy should deal accurately with environmental issues. As the performance of electric motorcycles is directly related to environmental improvement, if a motorcyclist perceives an environmental policy to be useful for encouraging the adoption of electric motorcycles, he or she should perceive the performance of electric motorcycles to be better. A perception that government policy is useful may have a positive impact on the perception of the three performance factors of electric motorcycles.

**Hypothesis 3a (H3a)**: A motorcyclist’s positive perception of environmental policy has a positive impact on the motorcyclist’s perception of the performance of electric motorcycles in reducing pollution.

**Hypothesis 3b (H3b)**: A motorcyclist’s positive perception of environmental policy has a positive impact on the motorcyclist’s perception of the energy-saving performance of electric motorcycles.
Hypothesis 3c (H3c): A motorcyclist’s positive perception of environmental policy has a positive impact on the motorcyclist’s perception of the driving performance of electric motorcycles.

Acceptance of Electric Motorcycles

A positive perception of a product can make a customer more likely to purchase the product (Viardot, 1998). In Kang and Park’s (2011) study, it was found that the perception of the driving performance of hydrogen fuel cell vehicles is important to the perception of hydrogen fuel cell vehicles. Oliver and Rosen (2010) also stated that consumers are concerned with vehicle fuel efficiency when they consider purchasing a hybrid electric vehicle. Chiu and Tzeng’s (1999) study indicated that driving performance is an important factor in persuading people to buy an electric motorcycle. Other than the driving performance, the fact that electric motorcycles protect the environment makes motorcyclists avoid purchasing gasoline motorcycles (Kurani et al., 1996). Electric motorcycles could achieve energy-saving targets through their energy-efficient equipment (Ma et al., 2011). In addition to their recognition that electric motorcycles reduce pollution, motorcyclists would select electric motorcycles if they understood that the overall energy efficiency of electric motorcycles is higher than that of gasoline scooters and cars (Cherry et al., 2009). Therefore, the perception of these three elements may influence the motorcyclists’ acceptance of electric motorcycles.

Hypothesis 4a (H4a): A motorcyclist’s perception that electric motorcycles reduce pollution has a positive impact on the motorcyclist’s acceptance of electric motorcycles.

Hypothesis 4b (H4b): A motorcyclist’s perception that electric motorcycles save energy has a positive impact on the motorcyclist’s acceptance of electric motorcycles.

Hypothesis 4c (H4c): A motorcyclist’s perception that the driving performance of electric motorcycles is good has a positive impact on the motorcyclist’s acceptance of electric motorcycles.

In summary, the environmental policy may affect the perception of the three aspects of motorcycle performance, and then the perception of these three aspects of performance may affect the acceptance of electric motorcycles. Figure 1 shows the research model, which is based on the hypotheses that have been discussed.

Research Method

Questionnaire Design and Survey Instrument

The research question for this study is as follows: what factors influence motorcyclists’ acceptance of electric motorcycles in Macau? A questionnaire survey with two sections was used. Section 1 contained six sets of questions relating to a total of 18 items for the six constructs of the research model. A 7-point Likert-type scale was used, with “1” set as “strongly disagree” and “7” as “strongly agree.” Section 2 contained general background information.

The measurable items for the experience of environmental policy, perception of environmental policy, and the acceptance of electric motorcycles are based on Kang and Park’s (2011) study, with certain modifications to suit the electric motorcycles setting. There are three aspects of performance: performance in reducing pollution, energy-saving performance, and driving performance. The items used to measure the perception of the performance in reducing pollution cover air pollution, noise pollution, and environmental pollution. The items used in the measurement of the perception of energy-saving performance include items covering the saving in energy resources, renewable energy, and energy efficiency. The items used...
to measure the perception of driving performance are based on Kang and Park’s (2011) research. The measured items are listed in Table 3.

### Data Collection

The content validity was checked by two academic colleagues to assess any misunderstandings or ambiguity of expression in the questionnaire. To evaluate the readability of the questionnaire, a pilot study with 20 students who owned motorcycles was performed. The feedback from the respondents was that the questions in the questionnaire were easily understood and could be answered easily. In the study, the interviewer-administered survey was conducted on the street at eight different locations in Macau, including business and residential zones, from December 2018 to January 2019. The target respondents were motorcyclists. Conventional sampling was employed. The interviewers invited motorcyclists to complete the questionnaire before they rode away on their motorcycles or after they had parked their motorcycles. A total of 350 completed questionnaires were collected. As it was an interviewer-administered survey, the response rate was 100%. However, 25 questionnaires were eliminated (e.g., for providing similar ratings for all items), leaving 325 questionnaires as valid for analysis. The ideal N:q ratio (observations/parameters to be estimated) is 20:1 or, at the very least, 10:1 (Kline, 2011). In this study, 18 items for six constructs were measured. The N:q ratio is greater than 10:1 and, therefore, the sample size of the study is adequate.

### Findings

Structural equation modeling (SEM) is a powerful statistical technique that combines multiple regression and factor analysis procedures into a single method (Bentler, 1995). Partial least squares structural equation modeling (PLS-SEM) is a second-generation SEM technique and was used to test the research model in the present case because PLS-SEM is capable of maximizing the variance of the dependent variables that are explained by the independent ones in place of reproducing the empirical covariance matrix (Haenlein & Kaplan, 2004). In addition, PLS-SEM is able to test a number of interaction terms with minimal restrictions on measurement scales, sample size, and residual distribution (Chin et al., 2003). Therefore, PLS-SEM was performed using SmartPLS 3 to analyze the data (Ringle et al., 2015).

### Demographic Characteristics

The backgrounds of the respondents are shown in Table 2. This shows that the majority of the respondents were male (55.4%) and had achieved a university level of education (55.4%); 33.2% fell within the 26 to 30 years age group; 34.2% fell within the US$1,255 to US$1,618 monthly income bracket; they had 3 to 5 years of experience of riding motorcycles (28.0%); they rode a motorcycle 5 days a week (28.3%); and they worked in a service industry (23.4%). The distribution of the sample is close to the distribution of Macau’s motorcyclist population.

| Gender | Frequency | % |
|--------|-----------|---|
| Male   | 180       | 55.4|
| Female | 145       | 44.6|
| Age    |           |   |
| 21–25  | 26        | 8.0 |
| 26–30  | 108       | 33.2|
| 31–35  | 87        | 26.8|
| 36–40  | 46        | 14.2|
| 41–45  | 30        | 9.2 |
| 46–50  | 15        | 4.6 |
| Above 50 | 7    | 2.2 |
| Above 60 | 6     | 1.8 |
| Monthly income (US$) | | |
| Under 871 | 46      | 14.2|
| 871–1,244 | 57      | 17.5|
| 1,255–1,618 | 111    | 34.2|
| 1,619–1,991 | 64     | 19.7|
| 1,992–2,489 | 28     | 8.6 |
| 2,500–3,111 | 10     | 3.1 |
| 3,112–3,734 | 3      | 0.9 |
| More than 3,734 | 6      | 1.8 |
| Education | | |
| Primary | 4         | 1.2 |
| Secondary | 135    | 41.5|
| University | 180   | 55.4|
| Postgraduate | 6     | 1.8 |
| Driving age (year) | | |
| Under 1 | 40       | 12.3|
| 1–3    | 80        | 24.6|
| 3–5    | 91        | 28.0|
| 5–7    | 39        | 12.0|
| 7–10   | 30        | 9.2 |
| More than 10 | 45      | 13.8|
| Driving frequency (per week) | | |
| 1 day  | 15        | 4.6 |
| 2 days | 18        | 5.5 |
| 3 days | 33        | 10.2|
| 4 days | 48        | 14.8|
| 5 days | 92        | 28.3|
| 6 days | 58        | 17.8|
| 7 days | 61        | 18.8|
| Career |           |   |
| Student | 46       | 14.2|
| Education | 38      | 11.7|
| Trading | 43        | 13.2|
| Art & Design | 28     | 8.6 |
| Service | 76        | 23.4|
| Manufacturing | 54     | 16.6|
| Government | 26     | 8.0 |
| Others | 14        | 4.3 |
Reliability and Construct Validity

Reliability concerns the accuracy of measurements and reflects the extent to which the respondent answers the same questions, or close approximations thereof, in the same manner each time (Straub et al., 2004). Table 3 shows the means, standard deviations, and PLS loading. Table 4 shows the Cronbach’s alpha, construct reliability (CR), and average variance extracted (AVE). The value of Cronbach’s alpha for all components is higher than 0.6, and all PLS loadings are higher than the cross-loadings. Thus, the reliability and validity of the study are satisfactory.

Table 4 also shows the correlation matrix of the five constructs. All of the correlation values among the constructs of the model are significant ($p$-value < .01). The square root of the construct’s AVE exceeds its correlations with other constructs in the model. This is a necessary aspect of the discriminant validity of the latent constructs.

Results of PLS-SEM Analysis

As recommended by Hair et al. (2010), bootstrapping was performed using 325 cases and 5,000 samples to assess the significance of the path coefficients. Figure 2 shows the results of the PLS-SEM analysis. The minimum value of $R$-squared in the model is 0.350; therefore, the model can be described as “substantial” (Hair et al., 2010). Table 5 indicates that H1, H2, H3, and H4 are supported.

Moderating Effect of Gender

The demographic data and the driving information were used to test for any moderating effects between the performance factors and the acceptance of electric motorcycles, using PLS-SEM analysis. The results do not show any moderating effects, except that gender moderates the effect of driving performance on the acceptance of electric motorcycles. Table 6 shows the results of the PLS-SEM analysis. Figure 3 shows the results of the simple slope analysis, demonstrating that male motorcyclists are more concerned with driving performance than females.

Discussion

Theoretical Contributions

In most of the previous studies, the researchers discussed the adoption of hybrid or electric cars (Ala-Mantila et al., 2013;
For developing countries such as Vietnam, motorcycles are popular because they are sold at affordable prices. People can ride low-power motorbikes (50 cc) without a license. These motorcycles cause serious air pollution. Thus, investigating the intention to purchase an electric motorcycle for green reasons is essential, but few researchers have discussed the effects of the experience and perception of environmental policy on the acceptance of electric motorcycles. Recently, some researchers have argued that the perception of environmental policy is a psychological factor for the acceptance of environmentally friendly vehicles (e.g., Lai et al., 2015), but the causes and consequences of this psychological factor are still debatable. This study fills the research gap and indicates that the experience of environmental policy is an antecedent factor of the perception of environmental policy. This study further integrates the concept of environmental policy with the perception of three aspects of performance to form a research model for the acceptance of electric motorcycles. This study has developed measurable items for the perception of performance in reducing pollution and saving energy. This integration provides researchers with a new way to study the effects

### Table 4. Reliability, Construct Validity, and Correlation Matrix.

| Construct | Cronbach’s alpha | AVE | CR | Square-root of AVE | EEP | PEP | RP | EP | DP |
|-----------|------------------|-----|----|-------------------|-----|-----|----|----|----|
| EEP       | 0.847            | 0.764 | 0.907 | 0.874                 |     |     |    |    |    |
| PEP       | 0.885            | 0.813 | 0.929 | 0.902                 |     |     |    |    |    |
| RP        | 0.847            | 0.766 | 0.908 | 0.875                 |    | 0.554 | 0.690 |
| EP        | 0.840            | 0.758 | 0.904 | 0.871                 | 0.554 | 0.673 |    |    |    |
| DP        | 0.810            | 0.725 | 0.888 | 0.851                 | 0.527 | 0.545 | 0.556 | 0.596 |
| AEM       | 0.891            | 0.821 | 0.932 | 0.906                 | 0.535 | 0.603 | 0.591 | 0.622 | 0.736 |

Note. All correlations are significant at the 0.01 level (two-tailed). AVE = average variance extracted; CR = construct reliability; EEP = experience of environmental policy; PEP = perception of environmental policy; RP = reduce-pollution performance; DP = driving performance; AEM = acceptance of electric motorcycles.

### Figure 2. Results of PLS-SEM analysis.

Note. PLS-SEM = partial least squares structural equation modeling.
Researchers have studied the effects of various performance factors on the acceptance of environmentally friendly vehicles; for example, Hsu and Lu (2010) discussed pollution reduction factors, Cherry and Cervero (2007) discussed driving performance factors, and Sheu (2007) discussed power consumption issues. In a recent study in Macau, Zhu et al. (2019) found that environmental benefits and safety play a positive role when people consider whether to purchase an electric motorcycle. However, among these three factors, it is still unknown which is the most important in the acceptance of environmentally friendly vehicles. Therefore, this study provides a pioneering analysis by comparing the levels of impact of three performance factors on motorcyclists’ acceptance of electric motorcycles. The results of the PLS-SEM analysis show that the perception of driving performance has a greater effect on the acceptance of electric motorcycles than the perception of the other two performance factors. These findings indicate that speed, comfort, and safety are elements that are considered to be essential by motorcyclists considering the adoption of an electric motorcycle. Macau’s citizens prefer motorcycles because of the road conditions: Macau is a small tourist city with narrow, winding and steep roads. Therefore, people consider driving performance to be the most important.

Table 5. Results of PLS-SEM Analysis.

| Dependent variable | PEP | RP | EP | DP | AEM |
|--------------------|-----|----|----|----|-----|
| $R^2$              | .416| .497| .477| .350| .608|

| Independent variables | Coefficient | Coefficient | Coefficient | Coefficient | Coefficient |
|-----------------------|-------------|-------------|-------------|-------------|-------------|
| EEP                   | 0.645***    | 0.186**     | 0.205**     | 0.301***    | 0.169***    |
| PEP                   | 0.570***    | 0.540***    | 0.351***    | 0.198**     | 0.524***    |
| RP                    |             |             |             |             |             |
| EP                    |             |             |             |             |             |
| DP                    |             |             |             |             |             |

Note. PLS-SEM = partial least squares structural equation modeling; PEP = perception of environmental policy; RP = reduce-pollution performance; EP = energy-saving performance; DP = driving performance; AEM = acceptance of electric motorcycles; EEP = experience of environmental policy. ***p < .001. **p < .01. *p < .05.

Table 6. Moderating Effect of Gender.

| Dependent variable | PEP | RP | EP | DP | AEM |
|--------------------|-----|----|----|----|-----|
| $R^2$              | .416| .497| .477| .350| .621|

| Independent variables | Coefficient | Coefficient | Coefficient | Coefficient | Coefficient |
|-----------------------|-------------|-------------|-------------|-------------|-------------|
| EEP                   | 0.645***    | 0.186**     | 0.205**     | 0.301***    | 0.167**     |
| PEP                   | 0.570***    | 0.540***    | 0.351***    | 0.198**     | 0.524***    |
| RP                    |             |             |             |             |             |
| EP                    |             |             |             |             |             |
| DP                    |             |             |             |             |             |

Note. PEP = perception of environmental policy; RP = reduce-pollution performance; EP = energy-saving performance; DP = driving performance; AEM = acceptance of electric motorcycles; EEP = experience of environmental policy. Gender, RP × Gender, EP × Gender, DP × Gender. ns = nonsignificant. ***p < .001. **p < .01. *p < .05.

Figure 3. Simple slope analysis.
In addition to driving performance, motorcyclists in Macau are concerned with the impact of motorcycle emissions on air quality. Around 90% of electricity in Macau is supplied from mainland China. Therefore, the major source of air pollution is from vehicles. Since air pollution affects residents’ life and drives away tourists, the reduction of pollution is important when motorcyclists are considering electric motorcycles.

In relation to energy-saving performance, the results of this study are aligned with the results of previous studies which conclude that vehicle drivers are sensitive to energy costs (Weinert et al., 2007). Since saving energy, as an economic incentive, can motivate people to act for the benefit of the environment, the energy-saving performance of electric motorcycles also influences motorcyclists’ behavioral intentions toward the adoption of these vehicles. The potential savings may not be large enough to motivate people strongly, so, compared with the other two factors, the economic motive of saving energy is less important. This is the case because air pollution is fatal to Macau’s tourism development in the long run, and this ultimately affects the citizens’ incomes and Macau’s economy.

The results of the test for moderating effects showed that male motorcyclists are no more in favor of electric motorcycles than female motorcyclists if the male drivers perceive that electric motorcycles do not have good driving performance. Regardless of their skill and confidence, it is a fact that men drive more aggressively, take more risks, and speed more (Phillips, 2018). This means that the perceived driving performance is a psychosocial factor that has a gender difference because of mental functions. Although this psychological concern is very simple, no previous study has empirically shown these results in research into electric motorcycles. In this way, this study fills the gap in the electric motorcycle literature regarding the behavior of male and female motorcyclists.

**Implications for Practice**

Understanding the market response to electric motorcycles is important for guiding the future of personal mobility in the world (Weinert et al., 2007). Cities in other countries could learn from this case to assist them in addressing the challenge of improving the sustainability of transportation systems, which is heavily dependent on private motorcycles (Rose, 2012). This study indicates that motorcyclists’ attitude to environmental policy encourages them to take action toward the adoption of electric motorcycles. Given this result, the Macau government should establish an appropriate environmental policy to promote electric motorcycles. For example, more charging stations should be built in public car parks, and the Macau government should set a standard that new properties are “electric car ready”—electric car charging stations should be included in every new property. In open-air car parks, solar-powered charging systems should be implemented.

The results of this study also indicate that motorcyclists’ perceptions of pollution reduction and energy-saving performance could influence their attitude toward electric motorcycles. Therefore, the Macau government could consider educating the public regarding the importance of environmental protection and the effect of driving electric motorcycles on the reduction of pollution. Since young people in Macau like to ride motorcycles, the Macau government should conduct workshops in primary and secondary schools to educate students (as potential motorcyclists) about the environmental impacts of electric motorcycles. An individual’s first impression of electric motorcycles can influence his or her future attitude toward them. For existing motorcyclists, the Macau government can send messages about the environmental benefits of adopting electric motorcycles through public media such as TV.

As motorcyclists are concerned with the driving performance of electric motorcycles, and although some electric motorcycle manufacturers have developed high-performance electric motorcycles such as ZERO motorcycles (which have a top speed of 102 mph), there should be a market for more manufacturers to develop different styles of electric motorcycles for men and women.

Motorcyclists also consider the cost-saving advantages of electric motorcycles. Therefore, those who market electric motorcycles should emphasize both the driving performance and the energy-saving performance of electric motorcycles. The marketers should draw a table to show the annual cost savings of electric motorcycles against gasoline ones, to stimulate motorcyclists’ purchasing intention. As recommended above, solar-powered charging facilities in both public and private motorcycle parks can provide cheaper renewable energy. They would enable public and private car parks to provide a free charging service that would save further on the energy costs for electric motorcycle riders.

**Limitations and Further Studies**

This study focuses solely on the citizens of Macau and their acceptance of electric motorcycles. Macau is a tourist city. The per capita income is high. The electric motorcycle market in Macau is different from the markets in India, Taiwan, Vietnam, and other countries. The findings of this study may not be generalizable to other cities. Therefore, further studies are recommended to study motorcyclists’ behavior in developing markets.

This study only examines the effects of psychological factors. However, the literature reveals that there are situational factors such as the cost of gasoline and social factors such as lifestyle (Eccarius & Lu, 2019). Further research may consider including some important situational factors. In addition, further studies can apply this model to study the acceptance of other environmentally-friendly vehicles.

This study has not assessed the environmental impacts associated with electric motorcycles in relation to their
manufacture and disposal in Macau; therefore, future research needs to consider these issues, based on a supply chain context. Furthermore, since energy and motorcycle technologies are evolving fast, future studies may focus on longitudinal data that could help to ascertain the changes in the acceptance of electric motorcycles.

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