Effectiveness of policy incentives on electric motorcycles acceptance in Hanoi, Vietnam

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A R T I C L E   I N F O

A B S T R A C T

Electric vehicles are considered a possible alternative for the reduction of CO_2 emissions produced by gasoline-powered vehicles. Hence, various incentive policies have been implemented internationally; however, the effectiveness of these incentives for Vietnamese transport users has not been investigated and recognized. This study conducted stated preference surveys of actual electric motorcycle (EM) users to evaluate their opinions regarding incentives for EMs. The survey results show that the recharge duration and driving range are the most inconvenient factors for EM users who presented dissimilar perceptions of different incentive policies. In particular, EM users showed a greater preference for operating subsidies, such as reduction in electricity purchase price and road-use tax over subsidies for purchasing or setting up of charger stations. The study results provide empirical evidence for transport planners and authorities to provide sufficient strategies for long-term EM development.

1. Introduction

The transport sector is a significant source of air pollution, especially of particulate matter and nitrogen dioxide, and is the main source of environmental noise in many cities (Liao et al., 2017). Therefore, the production of electric vehicles (EVs) that including electric cars (ECs) and electric motorcycles (EMs) has expanded in the mobility market. Previous studies have revealed that an EM uses 72% less energy than a typical internal combustion engine (ICE) motorcycle and produces 6.16 tons less CO_2 equivalent than greenhouse gas (or 45% less) over its 8-year lifespan (Kumar and Alok, 2020). EMs can gradually replace gasoline-powered motorcycles in many Asian cities and can be considered a potential solution for air quality improvement and noise mitigation (de Assis Brasil Weber et al., 2019; Hernandez et al., 2019). Different incentive policies have been implemented in Asian cities to promote the adoption of EVs (Zhang et al., 2014). These incentives include purchasing and operating cost subsidies, free parking, low electricity rates, and access to bus lanes.

The transport sector is one of the main causes of air pollution in Hanoi, Vietnam, with nearly 3 million motorcycles in circulation in 2018 (Transport Development and Strategy Institute, 2018). A study showed that approximately 46% of the dust nanoparticles in Hanoi came from the transport sector (Nghiem et al., 2020). The Vietnamese government has announced a vision for developing green vehicles in

Vietnam. Encouragement for green vehicle development was mentioned in Decree 57 in 2020 and has been in effect since July 10, 2020 (Vietnamese Government, 2020). This decree attracted businesses to invest in the production of EVs, hybrid vehicles, and vehicles using biofuels and natural gas in Vietnam. Specifically, components imported for the production of 'green cars' were entitled to a 0% tax, and the zero tax applies to companies that manufacture components and spare parts and not solely automobile manufacturers as before. Although there was great support, only 283,000 EMs were sold in 2019, a decrease of 26.7% from the previous year's record.

Compared with the EM market in other cities in Vietnam, EM sales in Hanoi have declined in the past three years, particularly in 2020, because of the Covid-19 pandemic which resulted in a reduction in travel demand. However, the major reason for EM sales reduction is that the local government has not actively expanded the charging infrastructure, and there is a lack of incentives for Hanoi residents to purchase EMs. For subsidies, the government has primarily focused on four-wheel vehicles via import tax reductions and the production of automotive spare parts. In addition, there is no subsidy for operating costs such as road-use tax, electricity rate, and annual vehicle tax.

Although incentive policies have been applied internationally, the level of satisfaction with each policy differs. In particular, incentive policies for EM acceptance have not been fully captured. A prior EM adoption survey conducted in Vietnam showed that technological

improvements and economic incentives, particularly sales tax, significantly affect the adoption of EVs (Jones et al., 2013). However, this study focused only on subsidies at the time of an EM purchase. Therefore, this study aimed to examine EM users' satisfaction with incentives offered for the entire life cycle of EM ownership, which is important to better formulate policy measures. For this purpose, experienced EM users were selected for the survey to assess the influence of policy measures on EM purchases and operations. The next section examines previous studies on incentive policies to promote EVs. The experimental design and data collection are described in Section 3. Section 4 explains the data analysis and discussion, and the conclusions are presented in Section 5.

2. Literature review

Various incentive policies have been implemented to promote electric cars (ECs). In many countries, incentives have been widely applied to EC ownership and usage, such as tax savings, insurance charges, highway tolls, and parking costs. Since 2016, ECs have been exempted from annual sales tax in Germany for 10 yrs. To counteract the upfront purchase price of an EC, Germany announced direct subsidies of €5,000 for private EC buyers and €3,000 for commercial EC buyers in 2016. Similarly, France designed a subsidy scheme in 2008 to encourage people to buy ECs (Plötz et al., 2014). In 2017, France proposed a bonus of €10,000 to encourage the removal of diesel cars greater than 10 yrs. old. The United States has offered tax credits between $2,500 and $7,500 based on the battery volume of an EC since 2008. In 2014, more than 37 states established incentives, and EC purchases were tax-free (Jang and Cassidy, 2012; Jenn et al., 2018). Other benefits such as unrestricted parking and priority access to high-density lanes were also offered to EC owners. In addition, the US government has committed to funding EC technological development, new EC manufacturing facilities, and EC charging stations (Gass et al., 2014; Mersky et al., 2016). The UK government issued a policy to increase the use of bicycles and ECs. These changes stemmed from the state of environmental pollution and sedentary habits that threaten health. Under the current scheme, EV buyers can receive a maximum of £4,500 through the government subsidy program (Kumar and Alok, 2020).

Unlike the purchase costs of EMs, the high price of ECs is seen as one of the key barriers to their adoption (Larson et al., 2015). Consequently, EC users have been offered many incentives to encourage EC market adoption (Yang et al., 2016). Previous research has assessed the effectiveness of various incentives and can be divided into two groups. One group examined how the market share of ECs changed over time as incentive strategies were implemented, and the other group used survey data to assess consumer behavior towards ECs.

Many studies have shown that incentive policies encourage the adoption of ECs (Gong et al., 2020; Jenn et al., 2018; Meisel and Merfeld, 2018; Wang et al., 2017) and EMs (Huang et al., 2018; Jones et al., 2013; Zhu et al., 2019). However, the effectiveness of such incentives varies depending on the measures applied. A policy was more effective when offered as a financial incentive (purchase price reduction, tax reduction) than when offered as a non-financial benefit (parking unrestricted, access to priority lanes) (Hardman et al., 2017; Münzel et al., 2019; Sierzchula et al., 2014). Furthermore, various studies (see Table 1) have examined EV adoption and the effects of incentive policies for both ECs and EMs. Stated preference surveys were widely utilized because the revealed preferences were hardly adopted because of the small EV market (Asghar et al., 2021; Kumar and Alok, 2020; Meisel and Merfeld, 2018).

Compared with ECs, incentives for promoting EMs have rarely been examined. Recently, studies on EM adoption have focused on Taiwan, Indonesia, Vietnam, and Macau. In Taiwan, the environmental and energy concerns of motorcycle use in urban areas have fostered the rapid development of EMs and significantly contributed to their market acceptance (Chiu and Tzeng, 1999). Regarding incentive policies, a

Table 1
Summary of studies on EV adoption and incentive policies.

Author(s)	Country	Analysis model	Factors
(Chiu and Tzeng, 1999)	Taiwan	Multinomial logit	purchase price, maximum speed, emission level, operating cost, cruise distance
(Jones et al., 2013)	Vietnam	Mixed logit	price, range, refuel/recharge time, operating cost, maintenance cost, acceleration speed, license requirement, sales tax
(Silvia and Krause, 2016)	USA	Agent-based model	purchase price subsidy, development of charging installation, development of city EV fleet
(Bjerkan et al., 2016)	Norway	Logistic regression model	exemption from purchase tax, exemption from vat, vehicle license fee reduction, exemption from road tolling, free parking, bus lane access, free ferry tickets
(Wang et al., 2017)	China	Multinomial logit	purchase price, cruise range, purchase restriction rescission, driving restriction rescission, access to bus lane, public charging fee exemption, road toll exemption, parking fee exemption, purchase tax exemption, insurance charge exemption
(Jenn et al., 2018)	USA	Generalized model, knowledge model, lagged-dependent model	individual credit, fleet credit, HOV lane access, time of use rate, inspection exemption, registration fee reduction, EV charging subsidies
(Guerra, 2019)	Indonesia	Mixed logit	monthly payment, charge time, maximum speed, maximum range, socio demographic, fuel price
(Zhu et al., 2019)	Macau	Binary logit	sale price, charging fee, repair fee, battery life and cost, battery endurance, environmental benefits, charging convenience, fuel price, driving speed, load capacity, tax incentives
(Gong et al., 2020)	Australia	Nested logit	vehicle body type, price, set-up cost, operating cost, recharge time, range of a single recharge, access to bus lane, rebates on upfront costs, rebates on parking fees, energy bill discount, stamp duty discount
(Liu and Lai, 2020)	Macau	Partial least squares structural equation modeling	perceptions of environmental policy, pollution reduction, saving of energy, driving performance

study indicated that emerging energy technologies have achieved competitive advantages via economies of scale owing to government subsidies (Huang et al., 2018). Taiwanese government subsidy policies have gradually phased out the market and transferred finite budgets to other emerging energy technologies that need to achieve economies of scale. The key motivation of transport users in Macau to purchase EMs was their perception of environmental policy, pollution reduction, and energy savings (Liu and Lai, 2020). Consumers in Macau often pay more attention to an EM's actual cost, such as sale price, charging fee, repair fee, and tax reduction incentives, while the driving speed and load capacity of EMs attract very little attention (Zhu et al., 2019). Similar findings have been reported on users' willingness to adopt EMs in Indonesia. The driving speed, range, charge time, and purchase price were of significance to Indonesian transport users (Guerra, 2019).

Furthermore, charge time was particularly important, suggesting that improvements in battery-charging technology and charging infrastructures could substantially impact consumers' willingness to adopt EMs.

In previous research, incentives have been combined as a single variable. As a result, the impact of a single incentive has hardly been examined. Moreover, the majority of people interviewed lacked experience with EMs or ECs and incentives because they did not own one (Azarafshar and Vermeulen, 2020; Gong et al., 2020; Jenn et al., 2018). People who have experience with an EV have a better level of awareness and understanding of EVs than that of the general public. Therefore, it is recommended to recruit survey respondents with EV experience (Kurani et al., 1994).

3. Data and methodology

3.1. Experimental design

The implementation of incentive policies has been rather limited in Vietnam; therefore, investigating the preference of transport users for different levels of incentive measures was not possible. Thus, choice modelling by using surveys and discrete choice models were applied in our research to study stated preferences on alternative policy incentives. The application of discrete choice methods on stated preference data from EM users with EM experience provide helpful insights in characterizations of potential EM adopters and their needs. A stated preference survey was conducted to examine EM users' perceptions of possible incentive policies.

To investigate consumer adoption of EMs, an EM was described as a product including three attributes: purchase price, cruise distance, and recharge duration. The study also focused on the possible impact of incentive policies on EM adoption. Therefore, incentives for EMs are described by five attributes: purchase subsidy, battery guarantee, charger equipment subsidy, electricity cost, and road maintenance subsidy. While purchase subsidy and charger equipment subsidy are provided once during EM purchasing, subsidies for electricity rates and road maintenance fees are provided during the entire operating cycle of an EM. Finally, eight attributes were selected and designed for the choice sets. We designed different levels of each attribute that were close to real values for the sake of the survey respondents' understanding. Each attribute had three or four levels. Table 2 lists these attributes, levels and experiment set they are included.

A long list of attributes makes it difficult for respondents to select their choice. An earlier study recommended that no more than five

Table 2
Attribute descriptions and levels.

Attribute (unit of measurement)	Description	Level	Experiment
Purchase price (0.1 M VND)	Total EM consumer cost	200/400/600	Both
Purchase subsidy (0.1 M VND)	Tax reduction of EM purchase	40/60/80/100	Both
Cruise distance (km)	Total riding distance with fully charged battery	60/80/100/120	Set 1
Battery guarantee (1000 km)	EM battery-life performance guarantee	100/120/140/160	Set 1
Charger equipment subsidy (0.1 M VND)	Total government cost to install an EM charger	20/30/40	Set 1
Electricity cost (0.1 M VND/yr)	Cost of charging an EM battery over 1 yr of use	4/6/8/10	Set 2
Recharge duration (min)	Time required to recharge EM battery from empty to full	10/20/30/40	Set 2
Subsidy for road maintenance (0.1 M VND/yr)	Amount of reduction in road maintenance fee for 1 yr of EM ownership	1/2/3/4	Set 2

*VND: Vietnam Dong.

attributes should be included in a survey questionnaire to allow participants to make choices more easily (Kim, 2006; Walker et al., 2002). Therefore, the eight attributes listed in Table 2 were separated into two groups. We made two distinct estimations using two datasets and then combined them into an equation in the post-estimation process. Then, in each group, two common attributes were selected, which were later utilized to aggregate the estimated findings from the two datasets. Purchase price and subsidy are two typical features. Finally, two sets of attributes were obtained: Set 1 contained cruise distance, charger equipment subsidy, and battery guarantee, and Set 2 included electricity cost subsidy, recharge duration, and subsidy for road maintenance fee in addition to two common attributes.

Different alternatives were created based on the two sets of attributes allowing interviewees to make decisions. A full factorial design was used to account for all possible combinations of attributes and levels. However, this combination generated a large number of choice scenarios for survey respondents, including 576 choice scenarios for Set 1 and 768 choice scenarios for Set 2. Consequently, an orthogonal array was used to reduce the correlation between attributes as indicated in (Hensher, 2005). Finally, the number of choice scenarios was reduced to 50, with 20 from Set 1 and 30 from Set 2. The questionnaires were designed based on three randomly chosen choice scenarios from a pool of 50 possibilities. Fig. 1 shows an example of the decision scenario.

3.2. Data description

The survey participants were recruited from June 6 to 21, 2020, when the Covid-19 pandemic was well controlled in Vietnam. This new normal status was applied to shopping malls, office buildings, schools, universities, and public areas. All survey participants were EM owners with prior driving experience and access to a home charging utility. Furthermore, we gathered responses via face-to-face interview surveys so that the questions can be explained properly. This sample approach improved the survey's quality, resulting in greater completion rates and replies from participants with better comprehension of the subjects. At the completion of the survey, 581 respondents had been selected, of which 557 responses were utilized for the analysis because 24 responses were incomplete or inconsistent. Table 3 summarizes the attributes of the respondents.

There was an equal distribution of male and female respondents, and their ages were primarily 18–39 (above 60%). Educational status and household income were also assessed. EM ownership and usage are correlated with a medium-income young age group (Jenn et al., 2018; Plötz et al., 2014).

3.3. Multinomial logit model

A multinomial logit model was used to analyze the data collected from the stated preference survey. For this purpose, a utility function was constructed containing EM characteristics and subsidies. The utility of the i_{th} customer selecting the j_{th} option from J options is $U_{ij} = \beta \cdot x_{ij} + \varepsilon_{ij}$, where β is a coefficient vector, x_{ij} is an input vector, and ε_{ij} is the error term. For the logit model, the error term was assumed to be an independent identically distributed extreme value. The selection probability was given as the logit probability because the selection was made for the option with more utility than for the other options, $P(U_{ij} > U_{ik}$ for $\forall i \neq k) = \frac{e^{\beta' x_{ij}}}{\sum_{k=1}^{J} e^{\beta' x_{ik}}}$. The maximum likelihood technique was utilized to estimate the coefficient vector β to determine the values that maximized the likelihood of the choice probability (Train, 2003).

As indicated in Section 3.1, the survey used two independent datasets that differed from surveys using standard logit probability. Consequently, the coefficients for each dataset were estimated separately and subsequently aggregated using a post-analysis process. V_{Set1} and V_{Set2} are the utilities analyzed using the standard logit probability composed of Set 1 and Set 2, respectively. The functions are

Scenario 1: Set 1

Choice	Purchase price	Purchase subsidy	Cruise distance	Battery guarantee	Charger equipment subsidy
	40 million VND	4 million VND	100 km	100 thousand km	2 million VND
	60 million VND	6 million VND	80 km	120 thousand km	3 million VND

Scenario 2: Set 2

Choice	Purchase price	Purchase subsidy	Recharge duration	Electricity cost	Subsidy for road maintenance fee
	40 million VND	6 million VND	20 minutes	0.4 million VND/year	0.6 million VND/year
	20 million VND	4 million VND	40 minutes	0.6 million VND/year	0.8 million VND/year

Fig. 1. Selection examples.

Table 3
Respondent description.

Respondent attribute	Description	Percentage of total respondents
557 respondents		
Gender	Male	49.1%
	Female	50.9%
Age	18–29	28.3%
	30–39	32.6%
	40–49	18.5%
	50–59	19.4%
	60 and over	1.2%
Education	College/associates	26.2%
	Undergraduate	59.2%
	Graduate	14.6%
Monthly household income	<3 M VND/mo	7.2%
	3–6 M VND/mo	16.5%
	6–10 M VND/mo	29.6%
	10–20 M VND/mo	29.8%
	20–40 M VND/mo	12.6%
	>40 M VND/mo	4.3%

$$\widehat{V}_{set1} = \widehat{\beta}_1.x_{1ij} + \widehat{\beta}_2.x_{2ij} + \widehat{\beta}_3.x_{3ij} + \widehat{\beta}_4.x_{4ij} + \widehat{\beta}_5.x_{5ij} \tag{1}$$

$$\widehat{V}_{set2} = \widehat{\beta}_1.x_{1ij} + \widehat{\beta}_2.x_{2ij} + \widehat{\beta}_6.x_{6ij} + \widehat{\beta}_7.x_{7ij} + \widehat{\beta}_8.x_{8ij} \tag{2}$$

where x_1 to x_8 are survey attributes, including purchase price, purchase subsidy, cruise distance, battery guarantee, charger equipment subsidy, electricity cost, recharge duration, and subsidy for road maintenance, respectively, and β_1 to β_8 are the coefficients for the corresponding factors.

Coefficient β_1 had an inverse of cost value unit because the purchase price, x_1, had a cost unit that was inserted into both equations, and the utility was unitless. Consequently, V_{Set1} and V_{Set2} were converted into cost units by dividing the two sides by β_1. Each coefficient had participants' units of willingness to pay. These equations are expressed as

$$\widehat{M}_{Set1} = x_{1ij} + \widehat{\beta}_2/\widehat{\beta}_1.x_{2ij} + \widehat{\beta}_3/\widehat{\beta}_1.x_{3ij} + \widehat{\beta}_4/\widehat{\beta}_1.x_{4ij} + \widehat{\beta}_5/\widehat{\beta}_1.x_{5ij} \tag{3}$$

$$\widehat{M}_{Set2} = x_{1ij} + \widehat{\beta}_2/\widehat{\beta}_1.x_{2ij} + \widehat{\beta}_6/\widehat{\beta}_1.x_{6ij} + \widehat{\beta}_7/\widehat{\beta}_1.x_{7ij} + \widehat{\beta}_8/\widehat{\beta}_1.x_{8ij} \tag{4}$$

By combining Eqs. (3) and (4), a supplementary equation can be expressed, and the selection probability was $P(U_{ij} > U_{ik}$ for $\forall i \neq k) = \frac{e^{(M_{Set1}+M_{Set2})}}{\sum_{k=1}^{J} e^{(M_{Set1}+M_{Set2})}}$. Because neither Set 1 nor Set 2 contained all factors, the coefficients were analyzed according to the factors contained in the

dataset while keeping the other factors unchanged. The coefficients were considered to be mathematical values of the βs from Sets 1 and 2 in this combined equation. The coefficient for the purchase price is $\frac{\widehat{\beta}_1^{Set1} + \widehat{\beta}_1^{Set2}}{2}$, where the superscripts denote the collected data. The coefficient for purchase subsidy appearing in both datasets is $\frac{\widehat{\beta}_1^{Set2}\widehat{\beta}_2^{Set1} + \widehat{\beta}_1^{Set1}\widehat{\beta}_2^{Set2}}{2\widehat{\beta}_1^{Set1}\widehat{\beta}_1^{Set2}}$, and the other coefficients are $\widehat{\beta}_3/\widehat{\beta}_1^{Set1}$, $\widehat{\beta}_4/\widehat{\beta}_1^{Set1}$, $\widehat{\beta}_5/\widehat{\beta}_1^{Set1}$, $\widehat{\beta}_6/\widehat{\beta}_1^{Set2}$, $\widehat{\beta}_7/\widehat{\beta}_1^{Set2}$, and $\widehat{\beta}_8/\widehat{\beta}_1^{Set2}$. Eq. (5) represents the combined utility.

$$\widehat{V} = \frac{\widehat{\beta}_1^{Set1} + \widehat{\beta}_1^{Set2}}{2}.x_{1ij} + \frac{\widehat{\beta}_1^{Set2}\widehat{\beta}_2^{Set1} + \widehat{\beta}_1^{Set1}\widehat{\beta}_2^{Set2}}{2\widehat{\beta}_1^{Set1}\widehat{\beta}_1^{Set2}}.x_{2ij} + \frac{\widehat{\beta}_3}{\widehat{\beta}_1^{Set1}}.x_{3ij} + \frac{\widehat{\beta}_4}{\widehat{\beta}_1^{Set1}}.x_{4ij}$$
$$+ \frac{\widehat{\beta}_5}{\widehat{\beta}_1^{Set1}}.x_{5ij} + \frac{\widehat{\beta}_6}{\widehat{\beta}_1^{Set2}}.x_{6ij} + \frac{\widehat{\beta}_7}{\widehat{\beta}_1^{Set2}}.x_{7ij} + \frac{\widehat{\beta}_8}{\widehat{\beta}_1^{Set2}}.x_{8ij}$$

$$\tag{5}$$

4. Results and discussion

The surveys collected three choice scenarios from each respondent. Finally, 1671 acceptable responses were obtained from the 557 participants. Table 4 presents the analysis results for the separate (Set 1, Set 2) and combined (Set 1 + 2) set models.

The results showed that all the analyzed coefficients had a significant

Table 4
Analysis results for Set 1, Set 2, and Set 1 + 2.

Attribute	Separate models		Combined model Set 1 + Set 2
	Set 1	Set 2	
Purchase price	−0.02128***	−0.01623**	−0.01876***
Purchase subsidy	0.00752*	0.01892**	0.01322**
Cruise distance	0.00816***		0.00824***
Battery guarantee	0.00855***		0.00863***
Charger equipment subsidy	0.04384*		0.04378*
Electricity cost		−0.32597***	−0.32604***
Recharge duration		−0.00367***	−0.00374***
Subsidy for road maintenance		0.28696***	0.28704***
Sample size	1002	669	1671
Log-likelihood	−524.120	−351.160	−875.280
Rho-SQ	0.1540	0.1918	0.1729

*p < 0.05, ** p. < 0.01, *** p < 0.001.

level at the 95% confidence level (Table 4). Importantly, the observed signs of the coefficients were in accordance with the expected outputs. Specifically, cost- and time-related variables had negative (-) coefficients, indicating a utility reduction when customers consumed more. By contrast, the coefficient for the variables linked to incentives and subsidies was positive (+), and consumers generally desired greater incentives and subsidies.

Table 4 shows the estimated coefficients for the association between the factors and utility of the participants. Nevertheless, because utility is a unitless measurement of customer satisfaction, the marginal willingness to pay (MWTP) was obtained by dividing the utility coefficient by the purchase price coefficient. The MWTP is simple to explain because it reflects the amount that buyers are likely to pay for a unit increase in the conforming factor. For each MWTP, the 95% confidence level was determined using the method described in (Krinsky and Robb, 1986). Table 5 shows the results of the MWTP analysis and confidence levels for each attribute.

According to the estimates, EM users were likely to pay 19,700 VND to shorten the recharge duration time by one minute and 27,700 VND to extend the driving range by one kilometer. The MWTP for both recharge duration and cruise distance were higher than the values in the range 9,000–18,000 VND to reduce the one-minute recharge duration and the range 6,000–22,000 VND to increase cruise distance resulting from previous studies according to potential customer interviews in Vietnam and Indonesia (Guerra, 2019; Jones et al., 2013). This result is in accordance with previous studies in that driving EMs increased people's anxieties about charges and cruise distance, which were the primary causes of inconvenience (Jensen et al., 2014). EM users were likely to spend 46,000 VND for each 1,000 km extension of battery guarantee.

The investigation considered two forms of EM procurement subsidies: purchase and charger equipment subsidies. EM owners considered charger financial subsidies to be higher than they perceived. The charger equipment subsidy was 3.3 times more than the purchasing subsidy for the same amount of money according to EM owners. This suggests that, for the same money, a charger equipment subsidy would be more effective in motivating the purchase of an EM. The high MWTP for the charger equipment subsidy is owing to the increased charging considerations among EM owners as revealed in a similar study (Guerra, 2019; Jones et al., 2013; Zhou et al., 2016).

When a subsidy is applied to the operating costs of EMs, the effect on a possible EM adoption is amplified. When EM owners received an electricity cost discount and a subsidy for road maintenance fees, they thought the amounts were 17.3 and 15.3 times greater, respectively, than they actually were. A study reported that Indonesians were willing to pay 250,000 rupiah more (50% of the average purchase price) to reduce fuel prices by 1,000 rupiah (Guerra, 2019). Similar findings were obtained by other researchers in Macau (Zhu et al., 2019) and Taiwan (Chiu and Tzeng, 1999). We adjusted the unit of MWTPs for subsidies during the operating duration to reflect the life period of EMs to examine consumer preferences for subsidies during operation and at purchase. If a normal EM operates for 10 yrs., the volume of subsidies for operation

will accumulate over that time. As a result, the MWTPs for electricity cost and subsidy for road maintenance fee can be translated to 1.738 and 1.530 (1 M VND/10 yrs.), respectively (Table 5). When these values were compared to the MWTPs for purchase subsidies, customers preferred subsidies during operation 2.2 to 2.5 times more.

There are several reasons for this phenomenon. First, EM owners perceive that their benefits increase during the EM ownership period because the operation subsidies are provided cumulatively. Second, EM users recognize that the operating cost of EMs is much higher than the purchase price. Finally, respondents might appreciate the non-monetary benefits, such as CO_2 emissions and noise reduction, which were not included in the survey. This finding reveals that customers are more willing to buy EMs when subsidies are offered to support operating costs rather than purchase prices.

5. Conclusion

Incentive policies have been implemented in many cities to encourage the adoption of ECs. However, such subsidies are rarely applied in motorcycle-dominated countries with a geographical focus on Asia. The results facilitate a better understanding of customer perceptions of incentives for EMs to recommend relevant policies to promote EM expansion. Stated preference surveys were designed for actual EM users to examine their possible selection of EMs with more realistic responses.

Subsequently, the predicted coefficients were transformed into the MWTP, allowing for more understandable interpretations. The MWTP values for increased driving range and reduced recharge duration were significantly higher than those reported in previous studies. This means that the recharge duration and driving range of EMs are the most inconvenient factors for regular EM users.

The study also reveals that purchasing subsidies (purchase and charger equipment subsidies) and those that occurred during the EM ownership period have a positive impact on EM purchasing. The MWTP of EM users for their received subsidies was much higher than they actually had. When MWTPs for operational and purchase subsidies were compared, operational subsidies had higher MWTPs. It is clear that incentive policies that allocate more funding to operational support, rather than purchasing, are more effective. The results of this study will be useful for transport authorities in developing incentive policies to encourage EM adoption.

We acknowledge that our study had some limitations. First, survey information was collected from Hanoi, Vietnam, a metropolitan agglomeration whose features may differ significantly from those of other cities. This is an issue for all vehicle adoption research because geographical location clearly has an impact on travel behavior and mode choice. As a result, other investigations for different locations and nations are required for comparison with the findings of this study. Second, many participants were young. We do not know if this is typical of EM adoption, though it appears to be the case, and further research is needed. Despite the fact that there is a growing body of research on EV adoption in general, the demographic profile of users is likely to be very diverse, and each type of EV may logically attract a different relative advantage, reflecting the differing perceived incentives and adoption barriers. EM adoption research is still in its early stages, and more research on battery technology and charging systems is needed to ensure the long-term viability of the industry.

CRediT authorship contribution statement

Thanh Thi My Truong: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Table 5
Analysis results for MWTP.

Attribute (units)	MWTP (0.1 M VND)	2.5%	97.5%
Recharge duration (1 min)	−0.197	−0.305	−0.126
Cruise distance (1 km)	0.277	0.202	0.409
Purchase subsidy (0.1 M VND)	0.704	0.315	1.230
Charger equipment subsidy (0.1 M VND)	2.336	0.603	4.278
Battery guarantee (1000 km)	0.459	0.235	0.797
Electricity cost (0.1 M VND/yr)	−17.387	−26.966	−10.973
Subsidy for road maintenance (0.1 M VND/yr)	15.307	9.095	24.796

VND: Vietnam Dong.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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