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Article

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The Analysis of Consumer Preference on EV Adoption Barriers and Policy Stimulations in Thailand

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ABSTRACT

This study analyzes consumer preferences for EVs[1] using the discrete choice experiment and explores the attitudes toward possible policies on EV stimulation. The 362 participants with a driving license and living in Bangkok participated in the questionnaire survey. The information on the questionnaire includes their characteristics, car usage behavior, environmental preference, and preference for policies on EV stimulation. The logistic regression analysis reveals that the number of vehicle possessions, ownership of parking space, the price of EV, and fuel cost per month affect the decision to purchase EVs. On the other hand, being female, income, years of car use, maximum driving range of EV, and coverage area of chargers increase the probability of EV purchase. Environmental preferences have a strong positive correlation with EV purchases. Policies involving personal interest and EV sustainability also positively correlate with EV purchases. However, the extreme ecological perspective has an adverse effect. The analysis of the preferences for policies on EV stimulation reveals that monetary policies are the most preferred choice since the participants prioritize the policies favorable to their benefits.

Keywords: Electric Vehicle, Discrete Choice Experiment, Consumer Preference, Logistic regression Model, Willingness to Pay
JEL Classifications: C25, O31, O38

1. INTRODUCTION

In the 2015 Paris Agreement, Thailand pledged to reduce greenhouse gas (GHG) emissions by 20% from the projected business-as-usual (BAU) level in 2030. "The level of the contribution could increase up to 25%, subject to adequate and enhanced access to technology development and transfer, financial resources, and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change (UNFCCC)" (INDC, 2015). Following this commitment, the country applied many policies to fulfill this pledge, including the formulation of long-term plans, such as Alternative Energy Development Plan (AEDP, 2015) and Energy Efficiency Development Plan (EEDP, 2011). The former is a plan to find an alternative source for cleaner energy production (renewable energy), while the latter aims to seek an alternative way to use energy more efficiently to reduce the total energy consumption.

The transportation sector is the second highest energy-consuming sector and the third highest emission-producing sector in Thailand, only behind the electricity and industry sector (EPPO, 2019). To reduce the energy consumption, the promotion of electric vehicles (EVs) could therefore help the Thai government achieve the Paris Agreement target by means of the reduction of GHG emissions. In the Energy Efficiency Development Plan (EEDP, 2011), the Thai government includes a scheme for promoting EVs to reduce energy consumption and CO_2 emissions in the transportation sector. The target is set to have 1.2 million electric vehicles by 2030 (EEP, 2015). Moreover, the government also plans to establish the EV

1 EVs in this paper, we only focus on Battery Electric Vehicles (BEVs)

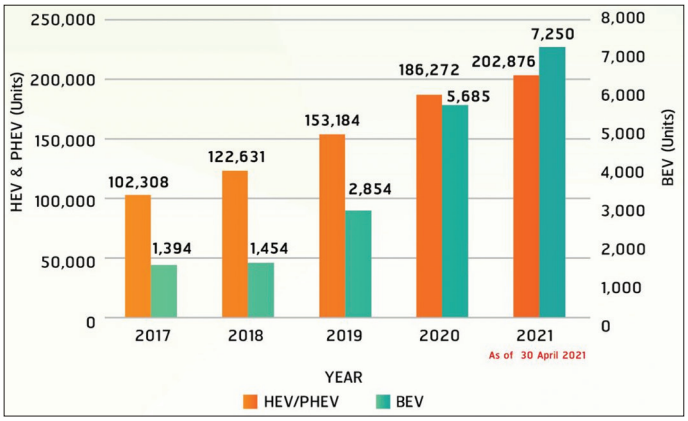
industry in the country, with the goal of becoming one of the major EV manufacturing centers. The plan seeks to sell only EVs in the country from 2035 onward as EV sales have increased markedly all over the world in recent years (IEA, 2019). Thus, Thailand is also expected to be an EV hub in Southeast Asia in 2025.

In 2017, the Thai government approved tax exemption for EV manufacturers to promote the EV industry in Thailand, included in the EV supply-side policy (EVAT, 2020). However, there is currently no direct demand-side policy to support EV penetration. Only indirect policies, such as tax reduction for low-emission vehicles, are applied to all EV types. Consequently, the rate of EV penetration in Thailand remains low. The numbers of electric vehicles in 2015 and 2020 were 71,000 and 200,000 respectively (EPPO, 2021). Only 130,000 new electric vehicles have been reported in the last 5 years (EVAT, 2020). The accumulated XEV in Thailand is shown in Figure 1. In this regard, it is interesting to investigate the barriers to EV adoption in Thailand. Therefore, the government, manufacturers, and associated parties can adapt to this change to help increase the EV penetration rate. Not only the barriers from EVs themselves but also the attitudes of people toward the policies could help stimulate EV use. They can be beneficial to the government in understanding public views on EVs and introducing effective policies that stimulate EV adoption in Thailand. This study aims to investigate the barriers to EV adoption by using stated preference (SP) as a discrete choice experiment (DCE) survey.

2. LITERATURE REVIEW

There have been many studies that investigate the barriers to EV adoption around the world. Willingness to pay is one of the popular methods for analyzing consumer preferences on interested subjects (Chinh et al., 2021; Ferguson et al., 2018; Tanaka et al., 2014). The summary of the literature review on EVs is shown in Table 1. Most studies adopt a discrete choice experiment (DCE) survey to explore consumer preference toward EV adoption. Their results are somewhat different, even though they are mostly in the same direction. The price of the vehicle, maximum driving range, charging station availability, and fuel price are the attributes that concern EV adoption.

Figure 1: Accumulated xEV in Thailand between 2017 and 2021



Source: EVAT (2020)

In Thailand, Tangnaku (2016), Suanmali and Tansakul (2019) and Vongurai (2020) used the contingency valuation (CV) method in their survey to explore the attitudes of Thai people toward the attributes of the EVs. Vongurai (2020) estimated that Thai peoples' WTP for EVs was THB910,000 (USD29,320). However, Tangnaku (2016) estimated the EVs additional willingness to pay (WTP) from current internal combustion engine vehicles (ICE) to be THB307,341 (USD9,903).

2.1. EV Attributes

According to the literature review, the EV attributes are listed below.

a. Purchase price
This attribute is included in most studies. It is found in all studies that the purchase price has a negative impact and is highly significant on EV utility. Several studies compare the EV purchase prices with the purchase prices of ICE in the market by charging an extra price to the referenced vehicle price or giving a discount to the referenced vehicle price (Hackbarth and Madlener, 2013; Hidrue et al., 2011; Tangnaku, 2016). Some studies use specific prices explicitly designed for their work (Glerum et al., 2014; Helveston et al., 2015; Kim et al., 2019).

b. Fuel cost.
This attribute also appears in most of the studies, albeit only in different forms. Most studies use fuel cost as the cost per 100 km or both fuel efficiency and fuel price. It is reported to have a negative effect on decisions over vehicle purchase. This attribute is advantageous to EVs as it incurs lower fuel costs than ICE.

c. Maintenance cost
Many studies include this attribute in their works. The high price of the battery is one of the consumers' concerns. It is found to have a negative impact on EV utility (Glerum et al., 2014; Potoglou and Kanaroglou, 2007; Tangnaku, 2016).

d. Charging station availability
All the studies use the density of charging stations relative to the number of current gas stations, varying from 10% to 100% (Hackbarth and Madlener, 2013; Potoglou and Kanaroglou, 2007; Tanaka et al., 2014). In most studies, it is found to have a significant and positive effect. This effect occurs because more charging stations can relieve people's range anxiety (Hackbarth and Madlener, 2013).

e. Performance
This attribute is usually represented by engine power, acceleration time, or maximum speed. In all studies, consumers are found to prefer better performance. Potoglou and Kanaroglou (2007) found that males significantly prefer faster acceleration, while females prefer slow acceleration. They also found that single people value shorter acceleration time than married people do.

f. Maximum driving range
The relatively short travel range is considered one of the most

Table 1: The summary of literature review in EVs

Author (s) (year)	Country	Time of data collection	Number of respondents	Type of survey	Survey method	Choice task per respondent	Attributes	Estimation model
Potoglou and Kanaroglou (2007)	Canada	2005	482	DCE	Internet	8	PP, FC, MC, CA, PF	Nested logit Model
Hidrue et al. (2011)	USA	2009	3,029	DCE	Internet	2	PP, DR, FC, CT, PF	Latent class model
Hackbarth and Madlener (2013)	Germany	2011	711	DCE	Internet	8	PP, FC, DR, CA, CT,	MNL
Glerum et al. (2014)	Switzerland	2012	593	DCE	F2F	5	PP, FC, MC	HCM
Tanaka et al. (2014)	US/Japan	2012	4,202/4,000	DCE	Internet	8	PP, FC, DR, ER, CA	MXL
Tangnaku (2016)	Thailand	2016	383	CV	F2F	14	PP, CH, CT, MC, DR	Censored Regression
Helveston et al. (2015)	USA/China	2012-2013	582/384	DCE	F2F	15	VT, BR, PP, CA, FC, PF	MXL
Kim et al. (2019)	South Korea	2017	1,000	DCE	F2F	4	PP, FC, VT, ER, CA	MXL
Vongurai (2020)	Thailand	N/A	400	CV	F2F and Internet	N/A	BR, ER, FC	SEM
Suanmali and Tansakul (2019)	Thailand	N/A	400	CV	F2F and Internet	11	BR, PF, FC, MC	Multiple Regression

DCE: Discrete choice experiment, CV: Contingent valuation method, F2F: Face to face interview, PP: Purchase price, FC: Fuel cost, MC: Maintenance cost, CA: Charging availability, PF: Performance, DR: Drive range, ER: Emission reduction, VT: Type of vehicle, BR: Brand, CT: Charging time, MXL: Mixed logit model, HCM: Hybrid choice model, SEM: Structural equation modelling

significant barriers to EV adoption. All studies that include this attribute use a range per full battery charged. Maximum driving range is found to have a positive and significant effect on decisions over EV adoption in all studies. People with a lower average annual mileage have a lower preference for the maximum driving range (Hidrue et al., 2011). Also, a household with multiple cars is likely to be less concerned about a relatively low EV range (Tanaka et al., 2014).

g. Emission reduction
Many studies include this attribute regarding emission reduction relative to ICE. This attribute shows a positive and significant effect on EV adoption in all studies.

h. Charging time
This attribute proves significant in all studies. None of the studies distinguish between the slow and fast charge. For daily purposes, electric vehicles use longer charging time at home or work, which takes around 6-8 h for a full charge. As to the recharging during longer trips, a fast charger could fill up 80% of the battery within 15-30 min. As a result, charging time varies depending on the conditions.

In conclusion, purchase price, maximum driving range, and charging availability are the top three significant attributes for all EV consumer preferences worldwide. Most studies on EV consumer preference include these three attributes in their survey.

2.2. Data Survey and Analysis

There are two main approaches for the stated preference in the literature: (1) discrete choice experiment (DCE) and (2) contingent valuation method (CV). Nonetheless, most of the studies apply a DCE survey to study EV attributes and the effects of policies on EV adoption (Bansal et al., 2021; Hackbarth and Madlener, 2013; Hidrue et al., 2011; Ma et al., 2019; Molin et al., 2012). Although the initial methodology of applying a DCE survey in transportation was first introduced by Train (2009), only Suanmali and Tansakul (2019); Tangnaku (2016); Vongurai (2020) applied it to investigate EV attributes. Bjerkan et al. (2016) and Tangnaku (2016) used CV to analyze the policies' effects on EV use.

There are two survey methods to approach respondents in the literature. (1) internet-based survey and (2) face-to-face (F2F) interview survey. The result shows that the internet-based survey attracts more respondents than the F2F survey. The internet-based survey is primarily employed as it is cheap, less time-consuming, and more convenient, compared with the F2F.

Regarding the DCE survey, the early works use either Nested Logit Model, Latent Class Model, or Ranked Order Logit to analyze the data (Hidrue et al., 2011; Potoglou and Kanaroglou, 2007). However, most of the recent studies employ either Multinomial Logit (MNL), Mixed Logit Model (MXL), or Hybrid Choice Model (HCM) as a tool for analyzing the data (Bansal et al., 2021; Hackbarth and Madlener, 2013; Helveston et al., 2015; Kim et al., 2019; Ma et al., 2019; Wang et al., 2017). There is an advantage of MXL over MNL as it does not require a restrictive assumption of independence from irrelevant alternatives (IIA), which are adopted in MNL. The MXL model gives the coefficients a probability distribution for the population, reflecting individual preference heterogeneity (Kim et al., 2019). For the CV survey type, regression methods, such as multiple regression, logistic regression, and censored regression, are employed to analyze the data (Bjerkan et al., 2016; Tangnaku, 2016; Vongurai, 2020).

According to the literature review, many researchers adopt the DCE survey to study EV attributes. However, only the CV method is employed in Thailand to study EV's consumer preference and WTP (Suanmali and Tansakul, 2019; Tangnaku, 2016; Vongurai, 2020). Moreover, the attitudes of Thai people toward policy stimulation have not yet fully studied. The DCE is a better choice for EV consumer preference as its advantage is appropriate for

multi-attribute goods, while the CV method is more suitable for single-attribute goods (Kim et al., 2019). Electric vehicles, which present several attributes concerning people, should therefore be studied through the DCE survey.

2.3. Stimulation Policies

Stimulation policies can be categorized into different types depending on their purposes. Eriksson et al. (2008), Keizer et al. (2019) categorize policies into two types—push intervention and pull intervention. Push intervention policies are made to reduce the benefits or utility of ICE, which lead to burdens of consumers needed to increase EV adoption, such as increasing ICE tax, restricted areas for CV in the city center, parking fee of ICE. On the other hand, pull intervention policies are made to increase the benefits of EVs, such as reduction of EV tax, EV lanes, and free battery charging. Another method categorizes the policies into 2 types (Gilbert, 2002; Graham-Rowe et al., 2011; Gross et al., 2009): Structural intervention and psychological intervention. Structural intervention includes policies that alter structural contexts to change peoples' behavior, such as fuel tax, ICE restricted areas, and subsidies. Psychological intervention includes policies that employ information to convince people to change their behavior, such as information on GHG reduction from EVs and financial benefits if they opt for EVs. In this study, the policies are categorized into 3 types: Infrastructure (structural) intervention, monetary intervention, and psychological intervention.

3. METHODOLOGY

The data used for analyzing the consumer preference is usually obtained from the survey. Since electric vehicles are a relatively new invention, people are still unfamiliar with them. Only a fraction of population uses them. Stated preference surveys are the best choice for collecting data from people. Most literatures employ discrete choice experiments (DCE) to explore the barriers to EV adoption. The DCE operates within a framework of rational choices. It is assumed that when confronted with a set of options, people choose the option of maximal utility. From this assumption, the utility of choice is a function of the characteristics of the possible choices, with the characteristics of the person making the choice. Choice models characterize that function for a population, thereby allowing for the statistical inference about the functional parameters. In this study, the DCE is applied to collect the data.

According to the literature, two survey methods are used: internet-based and face to face (F2F) interviews. The advantages of the internet-based interview include cost effectiveness. By this method, several surveys can be collected quickly from different locations, proving convenient for participants. On the other hand, there are still some disadvantages, such as the lack of respondents' attention to the questions, leading to poor results, survey fraud, limited sampling, respondents' availability, and the lack of a trained interviewer to clarify and probe data. The advantages of the F2F survey include in-depth data collection and comprehensive understanding, longer interview length (compared with an internet-based survey), and the ability of the interviewer to clarify and probe explanations given by respondents. However, it also has disadvantages, such as more resource and time consumption, relatively higher cost, and incompleteness of interviews. In this study, the F2F survey is adopted as it provides more in-depth data collection and a more comprehensive understanding. Despite being time-consuming and costly, it could yield better results than the internet-based survey.

3.1. Survey Design

The locations where data are collected are randomly chosen in the Bangkok Metropolitan Region because of the budget and time limitations. As electric vehicles are a relatively novel invention, the early adoption of these vehicles is likely to be found in the Bangkok Metropolitan Region as public facilities (charging stations) are more suitable. In this study, we only focus on battery electric vehicles (BEV), since they have the most potential to reduce GHG emissions in the transportation sector, compared with the others. Target respondents include those who can afford a car and have a driving license.

The survey is comprised of three sections. The first section includes a set of questions inquiring about the respondents' socio-demographics and checking whether they have any knowledge or experience with EVs. The second section requires the respondents to opt for EV choices, which have random attributes, or not. The EV attribute level of each choice will be random from the attributes shown in Table 2. The computer program will be used for making a choice set by random attributes. The possibility of the choice set is equal to 27. A pretest of the survey will be conducted to cut limited choices from the survey. Each respondent takes nine choice tasks for this section. This part is used to collect consumer preferences on EV attributes.

The last section requires the respondents to rank the EV stimulation policies from Rank1 to Rank3. Rank1 means this policy is the most effective policy to motivate them to buy EVs from all six policies. Rank2 is the second most effective policy to motivate them, and Rank3 is the third most effective policy. The total of six policies on EV stimulation in this section is presented in Table 3.

3.2. Method of Data Analysis

MNL or MXL is the method used to analyze the nominal dependent variables with more than two categories. Since this study is interested in the attributes of only BEV, MXL cannot be used, even though many studies employ MXL to analyze their data. Logistic regression is often used to model the association of a categorical outcome with independent variables for survey data (An, 2002). The logistic regression is therefore employed to analyze the data obtained from the survey in this study. In general, a logistic regression function (McFadden, 1973) with more than one explanatory variable can be presented in the following equation.

$$P(Y_i = 1) = F(Z_i) = \frac{1}{1+e^{-z_i}} \quad \text{for } s = 1, 2, 3, \ldots, n \tag{1}$$

$$P(Y_i = 0) = 1 - P(Y_i = 1) = 1 - \frac{1}{1+e^{-z_i}} = \frac{e^{-z_i}}{1+e^{-z_i}} \tag{2}$$

Where,

Table 2: The EV attributes level in this study

Attributes	Level
Purchase price	THB635,000 (USD20,460)
	THB835,000 (USD26,905)
	THB870,000 (USD28,033)*
	THB905,000 (USD29,160)*
	THB970,000 (USD31,255)*
	THB1,050,000 (USD33,833)
	THB1,150,000 (USD37,055)*
	THB1,170,000 (USD37,700)*
	THB1,305,000 (USD42,050)*
Maximum driving range	150 km
	300 km
	400 km
Charging availability (% of the current gas station)	10%
	30%
	50%

*The price increases in line with the increasing battery size to increase maximum driving range

Table 3: Preference on EV stimulation policies

Please rank the following EV stimulation policies in the order of your preference
1) Free parking and charging space for EVs at public buildings
2) Priority lanes for EVs
3) Fiscal support in R&D of the EV industry
4) Replacement of public buses and government organization's vehicles in favor of EVs
5) Fiscal support in R&D of battery disposal
6) Encouragement to use of renewable energy for EV fuel

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_m X_m + \varepsilon \quad (3)$$

$P(Y_i)$ denotes an probability of purchasing EV of respondent i where $P(Y_i=1)$ is purchase and $P(Y_i=0)$ is not purchase (n is the number of respondents).

$X_1, X_2, \ldots X_n$ denote explanatory variables represent characteristic of respondents, EV attributes and socio-environmental perspectives (list of variables are shown in Appendix 1) (m is the number of explanatory variables)

β_0 denotes an intercept (a constant term)

$\beta_1, \beta_2, \ldots \beta_n$ denote coefficient of the independent variables.

Marginal willingness to pay (MTWP) for a particular attribute implies a representative consumer's WTP for an increase in the level of the attribute. As a result, the MWTP means economic value or economic benefit of consuming a unit of the attribute. MTWP can be calculated by

$$MWPT_j = -\frac{\frac{\partial Z}{\partial X_j}}{\frac{\partial z}{\partial X_{pric}}} = -\frac{\beta_j}{\beta_{pric}} \quad \text{for } s = 1, 2, 3, \ldots, n \quad (4)$$

Where,

$\frac{\partial z}{\partial X_s}$ is a partial derivative of Z with respect to X_j

z denotes a deterministic (observable) component

X_j denotes a vector containing the level of attribute j (for j = 1, 2, 3, …, m).

X_{pric} denotes a vector containing the level of the purchasing price

β_j denotes a coefficient of the attribute j (for j = 1, 2, 3,…, n)

β_{pric} denotes a coefficient of the purchase price.

4. RESULTS

4.1. Summary Statistics

Out of 362 samples, the percentage of female participants (50.6%) in this survey is almost the same as the male participants (49.4%). By looking at the age of the respondents, more than half (59.4%) are below 35. Only 6.1% of the respondents who take this survey are over 55. In addition, 58.6% of the respondents are single, 37% married, and only 4.4% divorced. Regarding education, almost 80% of the respondents have bachelor's degrees. Around three-quarters of the respondents have an income of THB20,000-THB50,000/month, while 16.6% of the respondents have an income of THB50,000-THB100,000/month. Only 6.1% of the respondents have an income over THB100,000. Over 80% of the respondents have their own parking space. Around 65% of respondents never drive EVs, with only 27.3% owning EVs themselves. By examining the information on vehicle use, the respondents have an average of two cars in their possession. The average age of the current vehicle used is 5 years. The respondents pay around THB4,000 monthly for fuel and almost THB13,000 for annual maintenance costs. Details of the demographic profile of the respondents of this study can be seen in Table 4.

4.2. Logistic Regression

The respondents choose "purchase EVs" in 1,651 out of 3,258 scenarios, accounting for 50.7%. The means of purchased EV attributes (price, maximum driving range, and charging availability) are THB1,006,107 (USD32,420), 300 km, and 30% charging availability. The result of binary logistic regression is shown in Table 5. *Gender*, *Inco*, *Car*, *Use*, *ENV1*, *ENV4*, *ENV5*, *ENV6*, *Price*, *Dist*, *Charg*, *POL1 POL4* are the 95% significant level variables. Moreover, the 90% significant level variables are *Park and Fuel*. *Gender*, *Inco*, *Use*, *ENV1*, *ENV4*, *ENV5*, *Dist*, *Charg*, *POL1*, and *POL4* have positive coefficients, while *Car*, *Park*, *Fuel*, *ENV6*, *and Price* have negative coefficients. *Gender*, *ENV1*, and *Inco* are the top three highest odd ratios (Exp[β]) with 1.399962, 1.368166, and 1.317993 respectively.

4.3. EV Stimulation Policy

In the last section of the survey, respondents are asked to rank the EV stimulation policies that induce them to purchase EVs. The result is shown in Table 6. The total score column is the sum score from Rank1, Rank2, and Rank3, where Rank1 gets 3 points, Rank2 gets 2 points, and Rank3 gets 1 point.

5. DISCUSSION

The variables in this study are categorized into four groups, which are socio-demographic variables (*Gender*, *Age*, *Stat*, *Inco Park*, *Expre* and *Own*), Vehicle usage information variables (*Car*, *Use*, *Fuel*, *Maint*, *Pric*, *Dist* and *Charg*), environmental perspective variables (*ENV1-ENV6*), and policy stimulation preference variables (*POL1-POL6*). According to the binary logistic

Table 4: Socio-demographic characteristics of the respondents (n=362)

Characteristics	Frequency	Percentage
Gender		
Male	179	49.4
Female	183	50.6
Age		
18-25	75	20.7
26-35	140	38.7
36-45	76	21.0
45-55	49	13.5
55+	22	6.1
Status		
Single	212	58.6
Married	134	37.0
Divorced	16	4.4
Education		
<Bachelor	74	20.4
Bachelor	235	64.9
>Bachelor	53	14.6
Income (THB/month)		
<20,000	15	4.1
20,000-50,000	265	73.2
50,000-100,000	60	16.6
>100,000	22	6.1
Parking space		
Not own parking space	63	17.4
Own parking space	299	82.6
EV experience		
Never drive EVs	237	65.5
Have EV experience	125	34.5
EV possession		
Never own EVs	263	72.7
Own EVs	99	27.3
Vehicle usage information	On Average	
Vehicle possession	2 cars	
Current vehicle usage	5 years	
Monthly fuel cost	THB4,069	
Maintenance cost per year	THB12,775	

regression results, the variables with the 95% significant level are *Gender*, *Inco*, *Car*, *Use*, *ENV1*, *ENV4*, *ENV5*, *ENV6*, *Pric*, *Dist*, *Charg*, *POL1*, and *POL4*. Furthermore, the variables with the 90% significant level are *Park* and *Fuel*. Each variable group has a significant variable to represent. Socio-demographics are *Gender* and *Inco*. Vehicle usage information variables are *Car*, *Use*, *Pric*, *Dist*, and *charg*. Environmental perspective variables are *ENV1*, *ENV4*, *ENV5*, and *ENV6*. Policy stimulation preference variables are *POL1* and *POL4*. While *Car*, *Park*, *Fuel*, *ENV6*, and *Pric* have a negative coefficient, the other significant variables have positive effects on the probability of purchasing EVs.

Expectedly, *Car* and *Pric* have a negative effect. The more vehicles people have in their possession, the less motivation for them to purchase a new vehicle. Moreover, the higher the EV price is, the less willing people are to buy. However, *Park*, *Fuel*, and *ENV6* are not variables expected to have a negative impact. For *Fuel*, the respondents who monthly have many travel trips or often take long-distance trips are the ones who have higher monthly fuel costs. They might prioritize maximum driving range as the most significant attribute. The distance of 400 km, which is the highest maximum driving range in this study, might not satisfy them, however. All of the *ENV* are environmental perspective questions which ask respondents for their level of concern regarding environmental issues. All these expected questions would have shown that the high level of environmental concern has positive effects on EV purchase. All significant *ENV* variables provide positive results as predicted, excepted *ENV6. ENV6* is a question inquiring about the importance of participating in environmental activities, such as reforesting and turning off electric lights for 1 h on Earth Day. People who regard these activities as essential tend to be serious about environmental issues. Nevertheless, electric vehicles do not really reduce CO_2 as major sources of electricity in Thailand are generated from fossil fuels. Moreover, electric vehicles also have battery disposal issues, resulting in people not inclined to purchase them. For *Park*, the respondents with a parking space might live in a condominium, making it challenging to install an EV charging station for their use. This reason might be the cause behind unexpected negative impacts.

Gender, *Inco*, *Use*, *ENV1*, *ENV4*, *ENV5*, *POL1*, and *POL4* are the significant positive variables as expected, except *Gender.* It is unexpectedly found that that females have more chances to purchase EVs. A high-income person has a higher chance of buying EVs than a low-income person. The year of the current used vehicle is also found to have a positive impact on EV purchase, since people who use old vehicles are more likely to look for a replacement. *ENV1*, *ENV4*, and *ENV5* prove that people who are highly concerned about environmental activities tend to buy EVs than those who are less concerned. *POL1* (free parking and charging policy) and *POL4* (replacement of public buses and government vehicles in favor of EVs) show that people are concerned about personal interests.

The most purchased combination of EV attributes is an EV with the price of THB905,000 (USD29,160), a 400-km maximum driving range, and 50% charging availability. The second most purchased combination is the price of THB1,150,000 (USD37,055), a 400-km maximum driving range, and 50% charging availability. The third most purchased combination is the price of THB970,000 (USD31,255), a 300-km maximum driving range, and 50% charging availability. The percentage of the respondents who opt for each purchased combination of EV attributes is 81%, 78%, and 77% respectively. On the other hand, the worst purchased combination of EV attributes is an EV with the price of THB1,050,000 (USD33,833), a 150-km maximum driving range and 10% charging availability. The percentage of the respondents who purchase this combination is 23%. According to this result, the respondents prioritize charging availability, maximum driving range, and price as the most significant ones.

According to the result, if the willingness to pay for EVs is considered as a mean of "purchased EVs," the willingness to pay for EVs with a 300-km maximum driving range and 30% charging availability (There are charging facilities stationed every 100 km across the country) is THB1,006,107 (USD32,420). The marginal willingness to pay (MWTP) for an increase in the 1-km maximum driving range is equal to THB2,666 (USD86). Meanwhile, the MWTP for the improvement of 50% charging availability (There are charging facilities stationed every 50 km across the country) is equal to THB361,543 (USD11,650).

Table 5: Result of binary logistic regression

Variable	Coef.	Std. Err.	z	P>|z|	Exp(β)	dy/dx
Gender	0.3364	0.0795	4.23	0.00**	1.4000	0.0712
Age	−0.0356	0.0427	−0.83	0.405	0.9651	−0.0075
Stat	0.0313	0.0905	0.35	0.729	1.0318	0.0066
Edu	0.0250	0.0733	0.34	0.733	1.0253	0.0053
Inco	0.2761	0.0748	3.69	0.00**	1.3180	0.0585
Car	−0.0788	0.0324	−2.43	0.015**	0.9242	−0.0167
Use	0.0485	0.0115	4.22	0.00**	1.0497	0.0103
Park	−0.2232	0.1266	−1.76	0.078*	0.8000	−0.0472
Fuel	3.11E-05	1.79E-05	−1.74	0.083*	1.0000	−6.59E-06
Maint	5.04E-06	4.20E-06	1.2	0.23	1.0000	1.07E-06
Expre	−0.1718	0.1150	−1.49	0.135	0.8422	−0.0364
Own	−0.2300	0.1420	−1.62	0.105	0.7946	−0.0487
ENV1	0.3135	0.0561	5.59	0.00**	1.3682	0.0664
ENV2	0.0060	0.0557	0.11	0.915	1.0060	0.0013
ENV3	−0.0190	0.0418	-0.45	0.65	0.9812	−0.0040
ENV4	0.1733	0.0665	2.61	0.009**	1.1892	0.0367
ENV5	0.2345	0.0589	3.98	0.00**	1.2642	0.0496
ENV6	−0.1019	0.0422	−2.41	0.016**	0.9031	−0.0216
Pric	−1.96E-06	2.56E-07	−7.66	0.00**	1.0000	−4.16E-07
Dist	0.0052	0.0005	11.14	0.00**	1.0053	0.0011
Charg	0.0355	0.0024	14.91	0.00**	1.0362	0.0075
POL1	0.2740	0.0927	2.96	0.003**	1.3153	0.0580
POL2	−0.0076	0.0929	−0.08	0.935	0.9924	−0.0016
POL3	0.0905	0.0943	0.96	0.337	1.0948	0.0192
POL4	0.1926	0.0925	2.08	0.037**	1.2124	0.0408
POL5	0.0926	0.0919	1.01	0.314	1.0970	0.0196
POL6	0.0866	0.0928	0.93	0.351	1.0905	0.0183
_cons	−4.5978	0.7279	−6.32	0	0.0101	

** is significant at a 95% confidence level, and * is significant at a 90% confidence level

Table 6: Result of EV stimulation policy ranking

EV stimulation policy	Frequency			Total points
	Rank1	Rank 2	Rank 3	
1) Free parking and charging space for EVs at public buildings (M)	169	57	40	661
2) Promotion of EV lanes (I)	30	55	34	234
3) Fiscal support in R&D of the EV industry (M)	48	53	49	299
4) Replacement of public buses and government organization's vehicles in favor of EVs (I)	46	66	66	336
5) Fiscal support in R&D of Battery disposal (P)	34	68	88	326
6) Encouragement to use of renewable energy for EV fuel (P)	34	60	71	293

I: Infrastructure intervention, M: Monetary intervention, P: Psychological intervention

Almost half of the respondents (46.8%) rank "free parking and charging" as the most motivating reason to opt for an EV policy. This policy also gets the highest total score, compared with the others. The result shows that the respondents value their own benefits the most as this policy is favorable to them in terms of finance. However, the second highest total score is "replacement of public bus and government vehicle in favor of EVs" and the third highest is "fiscal support in R&D of battery disposal." This result also shows that the respondents are concerned about EV sustainable society and environmental perspectives. The "replacement of public bus and government vehicle in favor of EVs" policy could convince people that the infrastructure of EVs will soon develop as the government also invested in this industry. Since the battery disposal is associated with environmental issues, people are concerned about the investment in its R&D. This shows that psychological intervention also affects people's decision to adopt EVs.

On the other hand, <10% of respondents rank "promotion of EV lanes" as the highest motivation to adopt the EV policy. This EV stimulation policy is less preferred, with a total score equal to 234, which is almost one-third of the "free parking and charging policy" score. The respondents might not be convinced of this policy as the roads in Bangkok are limited. Also, people need to see how this policy can be implemented effectively with many limitations in the city.

6. CONCLUSION

The Thai government plans to reduce GHG emissions in the transportation sector by increasing the EV adoption rate in Thailand. Moreover, the Thai government expects the country to be an EV hub in Southeast Asia in 2025. Therefore, understanding consumer preferences for EV attributes could help the government make an effective plan for the adoption of EVs. The objectives of this study are to analyze the consumers' preferences for EVs by using the DCE and to explore the attitudes toward possible EV stimulation policies.

The DCE survey is employed to collect data on the barriers to Thailand's EV adoption and EV stimulation policy preference. There are 363 participants in Bangkok with a driving license and a monthly income of more than THB15,000 (USD485). The survey covers their characteristics, car use behavior, environmental preference, and preference for EV policy stimulation. According to the literature, price, maximum driving range, and charging availability are included in the DCE as they are the most significant EV attributes. It is found that charging availability is the most considered EV attribute among Thai people, followed by maximum driving range and price. The results from logistic regression show that the number of vehicle possessions, ownership of parking space, the price of the EVs, and fuel cost per month are obstacles to the decision to purchase EVs.

On the other hand, being female, income, years of car use, maximum driving range, and the charger's coverage area increase the probability of EV purchase. From an environmental perspective, more significant environmental concerns positively affect the decision to purchase EVs. However, the highest level of environmental concern could have the opposite effect. For the policy stimulation preference, a policy involving personal interests and EV promotion positively affect the decision to purchase EVs.

The willingness to pay (WTP) for EVs is THB1,006,107 (USD32,420). The MWTP for an increased maximum driving range of 1 km is equal to THB2,666 (USD86), and MWTP for the improvement of charging availability is equal to THB361,543 (USD11,650).

"Free parking and charging space" is the most effective policy. Almost half of the respondents value this policy as the highest for EV purchase as it directly involves their benefits. People are also concerned about the infrastructure intervention. "Replacement of public bus and government vehicle in favor of EVs" is ranked as the second most significant attribute. According to the results, people value monetary policies the most, followed by policies on psychological motivation and policies regarding the infrastructure. "Promotion of EV lanes" is the least preferred policy as <10% of the sample chose it as they believe such a plan cannot be implemented.

Even though this study explores the consumer preference of EVs in Thailand in some directions, there are still limitations, which include: (1) The survey is conducted only in the Bangkok Metropolitan Region due to the budget and time limitations. (2) The survey is conducted between December 2021 and February 2022, which was the period after the Covid19 pandemic. The result of the survey could therefore contain some effects from the economic situation caused by the pandemic. (3) Only 2 types of vehicles are considered: BEV and CV, to the exclusion of other alternative fuel vehicles, such as Hydrogen and Hybrid vehicles. The logistic model is employed as a tool to analyze the results in this work. According to these limitations, this study could be improved by expanding the study area with more samples for a better result. Moreover, other types of vehicles should be included in the survey. In addition, the MNL or MXL could be used for analyzing the result to provide a better understanding and direction of BEV in Thailand.

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Appendix 1: Explanation of variables in logistic regression model

Variable	Explanation
Gender	Gender of the respondents
Age	Age of respondents
Stat	Marriage status of respondents
Edu	Highest education level of respondents
Inco	Income per month of respondents
Car	Number of vehicles owned by respondents
Use	Number of years of respondents' current vehicle usage
Park	Parking space
Fuel	Average monthly fuel cost of respondents
Maint	Average annual maintenance cost of respondents
Expre	Respondents' experience in driving EVs
Own	Respondents' ownership of EVs
ENV1	Respondent's perspective on environmental question No. 1
ENV2	Respondent's perspective on environmental question No. 2
ENV3	Respondent's perspective on environmental question No. 3
ENV4	Respondent's perspective on environmental question No. 4
ENV5	Respondent's perspective on environmental question No. 5
ENV6	Respondent's perspective on environmental question No. 6
Pric	Price of EVs in the choice experiment
Dist	Maximum driving range of EVs in the choice experiment
Charg	Charging availability of EVs in the choice experiment
POL1	Score from EV stimulation policies No. 1
POL2	Score from EV stimulation policies No. 2
POL3	Score from EV stimulation policies No. 3
POL4	Score from EV stimulation policies No. 4
POL5	Score from EV stimulation policies No. 5
POL6	Score from EV stimulation policies No. 6
_cons	Constant