



# **Factors affecting the willingness in purchasing electric vehicles in Thailand**

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## **Abstract**

This research paper examines the significant factors that affect the intention to buy electric vehicles. The adoption rate of electric vehicles in Thailand is still low but dramatically increasing. Current government policies on electric vehicles are mostly based on tax reductions and exemptions for certain periods of time. Theory of planned behaviour and technological acceptance model are applied in this paper to analyze the possible factors, what consumers take into consideration of EVs, what supports the willingness and what constrains the adoption intention. Analyzing significant factors, the research adopts the binary regression analysis along with the marginal effect of the binary regression model. The result shows that age, education level, environmental awareness, kilometers driven and car years have significant effects on willingness to buy electric vehicles. This paper also contains recommendations for both car companies and the government of Thailand.

## **Introduction**

In the past one hundred years, the majority of automobiles used for transportation are internal combustion engine vehicles which predominantly consume petrol not electricity. It is undeniable that the rise of electric vehicles (EVs) is not only the result of technological advancement but also changes in several aspects.

Firstly, the fluctuation of oil price has created instability for car manufacturers making alternatives more attractive in the manufacturers' visions. Secondly, the terms of "climate change" and "global warming" have been used more and more as there are enormous scientific results indicating a worrying sign for the planet. Many countries around the world have paid close attention to the problem and are implementing actions to tackle such an effect. Domestic territories have introduced subsidies and incentives for both car manufacturers and citizens to support the use of eco-friendly vehicles. Moreover, urban air pollution from exhaustion of the majority of vehicles also provokes the government to mitigate the negative impact. Furthermore, adaptation of humankind with the incoming of technology has made technological advancement to continuously progress including to the car manufacturing industry.

In recent years the word "electric vehicles" have become more commonly used and referred to the vehicle that consumes proportionally different amounts of electricity according to each type of electric vehicle. As plenty of people can observe when going to places around the country, the growth of charging stations in malls, filling stations or specifically made charging stations built by car companies themselves or by other companies are apparent indications of the rise in the industry. In this paper, the word EVs will be used mainly to describe electric cars.

## Objective

The first purpose of this research is to discover factors that significantly affect the willingness of people in Thailand to purchase electric vehicles; the research also discovers what persuades and dissuades their decisions. The second objective is to identify the attitude of people in Thailand towards electric vehicles whether in terms of environmental awareness, effectiveness of government policies etc.

The findings demonstrate the perspective of people in Thailand and observe information of factors that possibly affect the willingness in purchasing electric vehicles in Thailand which can provide guidelines and facilitate car manufacturers, companies and the government to implement materials, strategies and policies that are beneficial to all parties. Development and improvement from these parties is also able consumers to receive higher living standards and convenience from facilities.

There are five sections in the research, the first goes to introduction, the second one with literature review, followed by the theoretical framework, findings and conclusion. The next part demonstrates the background of the EV industry, timeline of the industry and overview of the industry around the world and in Thailand. The second part, literature review, will mention findings from various literature, factors that can be adapted for suitability of the research. The third part, theoretical framework, will explain what theory can be adapted to the decision of consumers and factors applied in this research. The fourth section, findings, will demonstrate methodology and result of the finding. Lastly, conclusion will discuss the result of the finding and demonstrate what can be improved from the research.

## Brief background

The history of EVs can be dated back to the 19th century. The first EV was first introduced in 1832 in Britain by Robert Anderson. In 1899, La Jamais Contete became the first vehicle to reach the speed of 100 kilometres per hour; the vehicle was named and developed by Camille Jenatzy, a Belgian race-car driver. In 1900 -1910s, electric cars became widely used by US citizens contributing to one-third of all vehicles on the roads powered by charging stations (Gertz & Greiner, 2019). However, the discovery and large-scale production of oil during the 1920s had led the EVs significantly lost their competitiveness to internal combustion engine vehicles (ICEVs) until the 1970s oil crisis in the Middle East that led to a revival of EVs again (Chan, 2013). Mass production of hybrid cars in the 1990s from many car brands such as Toyota, Nissan and Honda using lithium-ion batteries and the first battery electric vehicles with lithium-ion batteries was introduced in 2008 by Tesla (Gertz & Greiner, 2019).

There are several types of EVs but in this research three main types of EVs are mentioned which are hybrid electric vehicle (HEV), plug-in electric vehicle (PHEV) and battery electric vehicle (BEV) (Septon, 2017).

- 1) HEV is run by an internal combustion engine (ICE) and electric motor that consumes energy from a battery. Some HEVs use electric power alone when driven at low speed which helps lower emission compared to conventional vehicles; the reason is batteries are charged from regenerative braking and from the ICEs. However, HEVs are not rechargeable through plugging.
- 2) PHEV is run by both fuels and batteries that transfer energy through electric motors. The size of the battery is larger than HEV, PHEVs are chargeable through charging stations or at houses; batteries can also be charged through ICE and the process of regenerative braking. When the batteries run out, ICE will run PHEVs when batteries are low.

3) BEV does not consist of ICE and is solely run by at least one electric motor consuming energy from the battery. The battery size is the largest out of all three types. BEVs are chargeable at charging stations or at homes and through regenerative braking. BEVs produce no on-road emissions.

The market of EVs in Thailand has performed well. The growth of both accumulated EVs and sales of EVs in the past three years has been dramatic. In this scenario EVs include all types of transport such as cars, motorcycles, trucks etc. accumulated EVs. Accumulated HEVs and PHEVs have grown by more than 50% from 102,308 in 2017 to 186,272 in 2020 while accumulated BEVs have grown more than four times from 1,394 in 2017 to 5,685 in 2020. In terms of sales, the number in 2020 is 32,264, almost three times of 11,945 in 2017 for HEVs and PHEVs while the number for BEVs have skyrocketed to 2,999 in 2020 from only 165 in 2017 (Electric Vehicle Association of Thailand, n.d.).

Government in Thailand has launched policies to help promote the use of EVs, mostly on taxes. There are currently two three main tax policies; excise tax, import tax and income tax.

1) Excise tax rates of EVs are lower than cars with ICEs only. For HEVs PHEVs, the excise tax rate range for cars with engine capacity of less than 3,000 cubic centimeters (CC) is from 8 to 26 percent and is from 4 to 13 percent for cars under investment promotion measures from Board of Investment (BOI) while the rate for ICE cars at same level of engine capacity is from 25 to 40 percent. Excise tax rate for BEVs is 8 percent and is exempted from January 1, 2020 to December 31, 2022 before the rate will increase to 2 percent under investment promotion measures from BOI (Eco Sticker, n.d.).

- 2) Two-year import tax expense reduction by 90 percent for raw materials used in production of battery cells and battery modules. The raw materials must not be available in Thailand and battery cells and battery modules must be manufactured locally (Board of Investment, 2020).
- 3) Income tax exemption for PHEV and BEV manufacturers by 3 years for investment packages less than 5 billion Baht. The exemption of BEV can be extended if the project meets certain requirements. Income tax exemption for PHEV and BEV manufacturers by 3 years and 8 years respectively for investment packages more than 5 billion Baht. The exemption of BEV can be extended for additional research and development (R&D) expenditure (Board of Investment, 2020).

### **Literature review**

This section mentions and explains research related to this research paper identifying factors that affect the willingness in purchasing EVs and to construct models for testing.

Carley et al. (2013) conducted an online survey asking factors affecting intention to purchase EVs. The survey was conducted in the United States with all of respondents over 18 years old. The authors used logistic regression to determine relatedness of purchase intention and factors applied in the survey. The result shows that age does have a negative significant effect on the intention of buying EVs at the 0.01 level; the older the person, the lower interest in purchasing EVs.

Survey, created by Lin and Wu (2018), was distributed to respondents in 4 major cities in China discovering the reason for purchasing EVs. An (2002) explained the application of logistic regression for survey results with categorical variables. Maximum likelihood estimation (MLE) is considered to be more applicable than Ordinary Least Squares (OLS) in logistic regression

because higher level of flexibility and lower restrictions. In this survey, the authors conducted dummy variables for gender and marital status. The result does represent a positive significant impact of marital status on purchasing willingness of EVs; if the respondent is married, the higher the probability of intention to purchase EVs.

Kim et al. (2019) observed the purpose to buy EVs in South Korea as Zhang et al. mentioned factors that have consequences on decision purchasing BEVs, including education level. This paper adopts a binary probit choice model. The authors distributed the survey to respondents of at least 18 years who travel by one's own cars at least one time per week. The authors classified education level as a dummy variable with high school level as a benchmark. The result is educational level has a negative significant effect at the 0.01 level; if the respondent has a higher education level than high school, the lower chance of respondents purchasing BEVs.

Chen et al. (2020) inspected socio-demographic factors that have an impact on selecting EVs in Nordic countries. The authors applied hierarchical regression analysis and data from empirical surveys. Families that own several cars tend to earn more which links to higher probability of purchasing BEVs that are costly (Dargay et al., 2000; Jong et al., 2004). The authors used standardized regression using F-statistic to measure significance levels. The result shows that income has positive correlation with adoption of EVs at the 0.001 level: the higher the respondent earns, the higher intention of purchasing EVs.

Kim et al. (2015) tested factors that impact the attitude of people in South Korea to car ownership of EVs. There is a high level of popularity using ordered probit models when the dependent variable in a regression model is ordinal (Erdem et al., 2010; Li et al., 2012). The authors created three models but the model mentioned in this paper is the authors' Model 2 which is the "Willingness to purchase an EV". The result is car ownership has a positive impact

on EVs ownership at 0.05 level; the more cars respondents own, the higher the intention of buying EVs.

Joo et al. (2018) found that price and charging stations show significant relationship to EVs adoption consequences. A study of penetration effect on EVs by Byun et al. (2018) shows that consumers take the number of charging stations and vehicle prices into consideration. The authors factored charging risks and affordability in terms of vehicle prices and maintenance costs as variables applying a moderating effects approach with the adoption of a structural equation model. The results are that both charging risks and affordability have significant effects on EVs adoption at 0.001 and 0.01 levels, respectively.

Wang et al. (2017) analyzed the impact of policy from the government in terms of EVs adoption in China. The result shows the effectiveness of electromobility incentives in terms of both increasing motivation of purchasing EVs in Europe and growing EV market share (Fearnley et al., 2015). Financial incentive approach does help lower the price of EVs thus encouraging the motivation of purchasing EVs (Li et al., 2016; Kanaroglou and Potoglou, 2007). The authors adopted hierarchical moderated regression analysis. The result shows that financial incentives do have a positive significant impact to purchase intention EVs at the level of 0.01; the higher the incentive effectiveness in consumers' perspective, the higher likelihood of EVs adoptions.

Yin et al. (2017) studied factors behind the purpose of adoption of new energy vehicles in China. Kahn (2007) represented a solid correlation between environmental awareness and purchasing rate of neighborhood electric vehicles (NEVs). Citizens living with green lifestyles have higher probability of owning and driving NEVs (Ozaki and Sevastyanova, 2011). The authors applied error correction models setting the hypothesis of environmental concern towards

purchase intention. The result is that the hypothesis is accepted; the higher environmental awareness, the more intention of buying NEVs.

Testing difference in attitudes toward EVs is what Krems et al. (2017) observed through test drives in Germany. The authors conduct the attitudes of respondents both before and after test drives. Arbuckle (2014) mentioned and recommended the use of t-test for independent variables for analysis in the research paper. The variable for safety consists of the attitude and trust in safety and reliability of BEVs. The result shows significant difference between before and after test drives; respondents are more likely to believe in trust after test drives.

In this research some additional factors will be included in the paper. These factors are related to driving behaviour and preferences.

- 1) The first factor is driving locations, where respondents prefer to drive their vehicles; in urban areas, in rural areas, or in the mountain areas.
- 2) The second factor is the driving distance per car in the unit of kilometers.
- 3) The third factor is the length of keeping the cars, measuring how long each respondent keeps their cars in a unit of years.

### **Theoretical Framework**

Theory of Planned Behaviour (TPB), Ajzen (1991), introduced by psychologist Icek Ajzen in 1985 is a theory that has been widely accepted to study the attitude and influence of attitude that have effects on behavioral changes. TPB is a theory developed from the Theory of Reasoned Action (TRA) by (Ajzen and Fishbein, 1977) with a restriction of TRA in dealing with conducts in which people do not entirely possess volitional control, TRA is useful when there are no important barriers which do affect performance of the behaviour. TPB suits better in reality,

compared with TRA, by including perceived behavioral control because there are many constraints affecting ones' decisions and behaviour. TPB explains complexity and relationships between human and related factors. Ajzen (1991) mentioned that human behaviour is the result of intention. TPB model explains how the intention is directly affected by three factors; attitude, subjective norm and perceived behavioural control.

### 1) Attitude

Kim and Han (2010) described the attitude as an evaluation of one's behaviour. The attitude of EVs is related to beliefs of consumers' perspectives in terms of environmental friendliness, efficiency in costs, effectiveness of government policies and types of pollution such as air and noise.

### 2) Subjective Norm

Ajzen (1991) defined the subjective norm as a perspective of an individual towards the customs of the society that lead to conduct in certain ways. The subjective norm of EVs is related to beliefs of consumers' perspectives in terms of subsidies from the government, deduction of tax. How the media publishes the images of EVs, and word of mouth from friends and families are also parts of the subjective norm.

### 3) Perceived Behavioural Control

Ajzen (1991) described perceived behavioural control as the challenges and difficulties of one's perspectives with a focus of achieving conduct. The level of perceived behavioural control is positively correlated with opportunities and resources possessed by one's insight. The opportunities and resources in EVs can be an individual's wealth and charging stations availability of places one usually travels.

Technology acceptance model (TAM) was introduced by Davis et al. (1989) as a model developed from social psychology which is extended from TRA and TPB. TAM has been widely accepted in prediction and explanation of technological acceptance consisting of two factors, perceived usefulness and perceived ease of use. The two affect the attitude and intention of individuals towards the use of new technology.

1) Perceived usefulness is the attitude of belief of individuals towards the use of technology to increase their skills and knowledge (Davis, 1989). Perceived usefulness is analysis and awareness of the benefits expected to receive from technologies and lead to the use of such technologies if found to be beneficial and acceptance.

2) Perceived ease of use represents the simplicity of technology for use to increase their skills and knowledge (Davis, 1989). Davis (1989) defined the simplicity as uncomplicated and effortless.

Liang et al. (2018) applied TAM for prediction and explanation of EVs' technological acceptance of consumers by focusing on perceived usefulness more than perceived ease of use because EVs are brand-new and most consumers have had no experience with the use of EVs. Perceived usefulness consists of reduction of carbon dioxide emissions and mitigation of energy shortage and reduction of transportation expenses; these affect EVs' technological acceptance of consumers. Wu et al. (2019) used TAM to study technological acceptance when consumers consider environmental benefits and ease of use of EVs which affects acceptance. Moreover, Schluter and Weyer (2018) adopted TAM in their research to demonstrate features of EVs' technology which affects awareness of benefits including experience of the use of EVs influencing the acceptance of EVs among consumers.

## Methodology

This section consists of three sections; variables, data collection and statistical treatment. Variables mentioned in this paper are dependent and independent variables are the first part. The second part, data collection comprises data collection and questions in the questionnaire. Data cleansing and model selection fall under the statistical treatment part.

### Variables

Dependent variable in this research paper is the “willingness to purchase EVs” which will be affected by nine factors: demographics, charging station, price, government policies, environment, driving locations, safety, kilometers and car years; dependent variable (Y) is the binary option. Independent variables (Xs) influence the decision of consumers’ willingness to purchase EVs developed from these nine factors.

There are a total of 27 independent variables, 6 variables from demographics, 4 from charging stations, 4 from price, 4 from government policies, 3 from environment, 3 from driving locations, 2 from safety, 1 from kilometers and 1 from car years.

Table 1 : Definition of each variable

| Factors                      | Variables       | Definition                                                                                            |
|------------------------------|-----------------|-------------------------------------------------------------------------------------------------------|
| <b>Dependent Variables</b>   |                 |                                                                                                       |
| Willing to purchase EVs      | Willingness     | Have you ever thought of buying EVs?                                                                  |
| <b>Independent Variables</b> |                 |                                                                                                       |
| 1. Demographics              | Age             | Age of respondents (at least 20 years old)                                                            |
|                              | Marital Status  | Are you single or married? ( <i>0=single, 1=married</i> )                                             |
|                              | Education Level | Respondent's level of education ( <i>Secondary=1, Diploma=2, Bachelor=3, Master=4, Doctorate=5</i> ). |

|                        |                    |                                                                                                                                                                                   |
|------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | Occupations        | Current occupation of respondent (Government Officer, Private Employee, Entrepreneur, Students and Others.                                                                        |
|                        | Salary             | Average income per month in Thai Baht. (1=Less than 15,000 Baht, 2=15,000-30,000 Baht, 3=30,001-45,000 Baht, 4=45,001-60,000 Baht, 5=60,001-75,000 Baht, 6=more than 75,000 Baht) |
|                        | Car Owned          | Number of cars currently owned. (0=0 cars, 1=1 car, 2=2 cars, 3=more than 2 cars)                                                                                                 |
| 2. Charging Stations   | Number of Charging | Reduction of charging frequencies is important. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                           |
|                        | Availability       | There are sufficient charging stations. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                   |
|                        | Distance           | Charging stations are currently suitable for long distance drives.(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                         |
|                        | Charging Speed     | Charging speed is satisfactory. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                           |
| 3. Price               | Affordability      | You can afford an EV. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                                     |
|                        | Reasonability      | Price of an EV is reasonable. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                             |
|                        | Running Cost       | Running cost (oil and electricity) is reasonable. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                         |
|                        | Maintenance        | Maintenance expense is reasonable. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                        |
| 4. Government Policies | Policies Awareness | You are aware of EV policies from the government. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                         |
|                        | Excise Tax         | Excise Tax policies are satisfactory. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                     |
|                        | Import Tax         | Import Tax policies are satisfactory. (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)                                                                     |

|                         |                         |                                                                                                                                                   |
|-------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | Income Tax              | Income Tax policies are satisfactory. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                              |
| 5. Environment (enviro) | Environmental Awareness | You have environmental awareness. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                                  |
|                         | Extra Expenses          | You are willing to pay more for environmentally friendly products. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i> |
|                         | Environment Protection  | EV protects the environment. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                                       |
| 6. Driving Locations    | Urban                   | You drive in urban areas. <i>(0=no, 1=yes)</i>                                                                                                    |
|                         | Rural                   | You drive in rural areas. <i>(0=no, 1=yes)</i>                                                                                                    |
|                         | Mountain                | You drive in mountain areas. <i>(0=no, 1=yes)</i>                                                                                                 |
| 7. Safety               | Trust                   | You trust EV safety while driving. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                                 |
|                         | Charging                | You trust in the safety of EV while charging. <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                      |
| 8. Kilometers (kilos)   | Kilometers              | How many kilometers do you drive per one car? <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                      |
| 9. Car Years (caryears) | Car Years               | How long do you keep your car (in years)? <i>(1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree)</i>                          |

## Data Collection

Observation and collection was achieved by using Google Form method, an online survey). This empirical study was conducted in Thailand. The target population is at least 20 years old. Sample selection is collected from March to May 2021. Distribution of the survey was administered through online platforms such as Facebook, Instagram and Line. There are a total of 290 results from online distribution of surveys.

The questionnaire contains three sections. The first section asks respondents whether they have had consideration of buying EVs. The second section asks demographics of the respondents factors influencing willingness to purchase EVs. The third section asks factors influencing willingness to purchase EVs. In the third section, respondents are required to pinpoint the level of agreement and disagreement and answer yes or no for statements from all factors. There are five choices for agreement and disagreement statements, strongly disagree, disagree, neutral, agree and strongly agree, for all factors excluding demographics and driving locations. There are two choices, yes and no, for the factor of driving location. The questionnaire is shown in the Appendix.

### **Statistical treatment of data**

After data collection from respondents, the data went through the process of transformation into numerical form for the ability to do an analysis using a program called STATA; the numerical form is shown in *Table 1*. Walter (2008) stated that too many variables contained in the regression has the possibility of making the results from prediction worse due to redundancy of data; creating groups of factors is the alternative for avoidance of possible problems.

As the paper consists of nine broad categories of independent variables, which are demographics, charging station, price, government policies, environment, driving locations, safety, kilometers and car years.

- 1) The demographics will be determined by variables of Age, Marital Status (maristat), Education Level (educleve), Occupations, Income and Car Owned (cars).
- 2) The charging stations (charstat) will be determined by variables of Number of Charging, Availability, Distance and Charging Speed.

- 3) The price will be determined by variables of Affordability, Reasonability, Running Cost and Maintenance.
- 4) The government policies (govepoli) will be determined by variables of Policies Awareness, Excise Tax, Import Tax and Income Tax.
- 5) The environment (enviro) will be determined by variables of Environmental Awareness, Extra Expenses and Environment Protection.
- 6) The driving location will be determined by variables of Urban, Rural and Mountain.
- 7) The safety will be determined by variables of Trust and Charging.
- 8) The kilometers (kilos) will be determined by the average number of kilometers driven by each car.
- 9) The car years (caryears) will be determined by the average number of years of keeping a car.

The results of variables of each category, except demographics and driving locations, will be numerically averaged while variables of demographics and driving locations in *Table 1* will be presented. There will be two regression models in this research paper. The first regression model (Model 1) consists of only variables in the category of demographics; the second regression model consists of all categories (Model 2). This research will also include marginal effects of both regression models

Model 1

$$Pr(Y=p) = \beta_0 + \beta_1(age)_i + \beta_2(marstat)_i + \beta_3(educleve)_i + \beta_4(salary)_i + \beta_5(cars)_i + \varepsilon_i$$

$$; i = 1, \dots, 290, p = 0, 1$$

Where :

- $\Pr(Y=p)$  represents the probability of ever have had willingness to purchase EVs, where  $p=0$  when respondents have never thought of buying EVs and  $p=1$  when respondents have thought of buying EVs.
- $\beta_0$  is a constant.
- $\beta_1, \beta_2, \beta_3, \beta_4$  and  $\beta_5$  represent the different probability of each demographic variable affecting willingness to purchase. The factor has higher probability of having intention to purchase EVs if a positive coefficient of each demographic variable is present and vice versa.
- *age, marstat, educleve, salary and cars* are demographic factor variables
- **Model 2**

$$\begin{aligned} \Pr(Y=p) = & \beta_0 + \beta_1(\text{age})_i + \beta_2(\text{marstat})_i + \beta_3(\text{educleve})_i + \beta_4(\text{salary})_i + \beta_5(\text{cars}) \\ & + \beta_6(\text{charstat}) + \beta_7(\text{price}) + \beta_8(\text{govpoli}) + \beta_9(\text{enviro}) + \beta_{10}(\text{urban}) + \beta_{11}(\text{rural}) \\ & + \beta_{12}(\text{mountain}) + \beta_{13}(\text{safety}) + \beta_{14}(\text{kilos}) + \beta_{15}(\text{caryears}) + \varepsilon_i ; i = 1, \dots, 290, p = 0,1 \end{aligned}$$

- $\beta_6, \beta_7, \beta_8, \beta_9, \beta_{10}, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}$  and  $\beta_{15}$  represent difference probability of charging stations, price, government policies, environment, driving locations, safety, kilometers and car years. The factor has higher probability of having intention to purchase EVs if a positive coefficient of each variable is present and vice versa.
- *charstat* represents charging stations.
- *price* represents price.
- *govpoli* represents government policies.
- *enviro* represents environment.
- *urban* represents urban areas.
- *rural* represents rural areas.

- *mountain* represents mountain areas.
- *safety* represents safety of EVs.
- *kilos* represents the number of kilometers per car.

## Results

After the data collection, these are summary results. For the demographics category, the age of respondents, by average, is 30.69 years with standard deviation of 8.315 and approximately 46.55% of respondents are married and the rest, 53.45%, are single.

For other categories, The average results from Likert-scale categories are 2.948, 2.767, 2.841, 3.511 and 3.957 for charging stations, price, government policies, environment and safety, respectively. For dummy variables, almost half of respondents, 48.28%, drive cars in urban areas, 43.1% drive cars in rural areas and 29.3% drive cars in mountain areas. Average kilometers of cars driven by respondents is 70,309 kilometers. Respondents, on average, use their car for 2.76 years.

From the second objective, the attitude of people in Thailand toward readiness and availability of charging stations is somewhat low. Many people in Thailand have the lowest agreement in terms of affordability and price reasonability of EVs. However, compared to other factors, people in Thailand have positive opinions about environmental protection of EVs from 3.517 Likert scores and high trust in safety of EVs.

For the third objective, in terms of government policies, the average Likert results are not satisfactory from medium awareness of policies and tax reduction and exemption approaches.

*Table 2* represents descriptive statistics of both dependent and independent variables.

Table 2 : Descriptive statistics of all variables

| VARIABLES               | MEAN  | S.D.  | MIN. | MAX.   |
|-------------------------|-------|-------|------|--------|
| Dependent Variables     |       |       |      |        |
| Buy                     | 0.345 | 0.476 | 0    | 1      |
| Independent Variables   |       |       |      |        |
| Age                     | 30.69 | 8.373 | 20   | 54     |
| Marital Status          | 0.466 | 0.889 | 0    | 1      |
| Education Level         | 2.397 | 0.891 | 0    | 4      |
| Salary                  | 3.414 | 1.546 | 1    | 6      |
| Number of Charging      | 3.635 | 0.976 | 2    | 5      |
| Availability            | 2.629 | 0.939 | 1    | 5      |
| Distance                | 2.964 | 0.949 | 1    | 5      |
| Charging Speed          | 3.123 | 0.963 | 1    | 5      |
| Affordability           | 2.871 | 1.424 | 1    | 5      |
| Reasonability           | 2.141 | 1.093 | 1    | 5      |
| Running Cost            | 3.185 | 1.023 | 1    | 5      |
| Maintenance             | 3.08  | 1.067 | 1    | 5      |
| Policies Awareness      | 2.945 | 1.064 | 1    | 5      |
| Excise Tax              | 2.875 | 1.105 | 1    | 5      |
| Import Tax              | 2.997 | 1.059 | 1    | 5      |
| Income Tax              | 2.788 | 0.942 | 1    | 5      |
| Environmental Awareness | 3.69  | 1.13  | 1    | 5      |
| Extra Expenses          | 3.431 | 1.285 | 1    | 5      |
| Environment Protection  | 3.517 | 1.246 | 1    | 5      |
| Urban                   | 0.483 | 0.503 | 0    | 1      |
| Rural                   | 0.431 | 0.5   | 0    | 1      |
| Mountain                | 0.293 | 0.442 | 0    | 1      |
| Trust                   | 3.922 | 0.96  | 1    | 5      |
| Charging                | 4.026 | 0.964 | 1    | 5      |
| Kilometers              | 70309 | 70043 | 0    | 310000 |
| Car Years               | 2.759 | 2.467 | 0    | 10     |

|          |       |       |   |   |
|----------|-------|-------|---|---|
| Charging | 4.026 | 0.964 | 1 | 5 |
|----------|-------|-------|---|---|

Table 3:

|           | (1)                  | (2)                  | (3)                  | (4)                  |
|-----------|----------------------|----------------------|----------------------|----------------------|
|           | <i>Model 1</i>       | Order                | <i>Model 2</i>       | Order                |
| VARIABLES | Order                | mf x dydx            | Order                | mf x dydx            |
| age       | -0.102***<br>(0.022) | -0.031***<br>(0.006) | -0.161***<br>(0.038) | -0.021***<br>(0.006) |
| martstat  | 0.311<br>(0.245)     | 0.094<br>(0.074)     | 0.732**<br>(0.047)   | 0.1<br>(0.103)       |
| educleve  | 1.18***<br>(0.190)   | 0.354***<br>(0.049)  | 1.686***<br>(0.369)  | 0.215***<br>(0.055)  |
| salary    | 0.26**<br>(0.114)    | 0.078**<br>(0.034)   | -0.202<br>(0.356)    | -0.025<br>(0.023)    |
| cars      | 0.091<br>(0.166)     | 0.027<br>(0.050)     | 0.476*<br>(0.280)    | 0.061<br>(0.039)     |
| charstat  |                      |                      | 0.133<br>(0.323)     | 0.017<br>(0.040)     |
| price     |                      |                      | 0.556**<br>(0.280)   | 0.071*<br>(0.037)    |
| govepoli  |                      |                      | 0.331<br>(0.326)     | 0.042<br>(0.044)     |
| enviro    |                      |                      | 0.607***<br>(0.188)  | 0.078**<br>(0.031)   |
| urban     |                      |                      | 0.288<br>(0.412)     | 0.037<br>(0.053)     |
| rural     |                      |                      | 0.304<br>(0.476)     | 0.04<br>(0.064)      |
| mounta    |                      |                      | 0.53<br>(0.345)      | 0.08<br>(0.060)      |
| safety    |                      |                      | 0.163                | 0.021                |

|                                                                   |           |     |               |              |
|-------------------------------------------------------------------|-----------|-----|---------------|--------------|
|                                                                   |           |     | (0.343)       | (0.044)      |
| kilos                                                             |           |     | -0.0000358*** | -4.57e-06*** |
|                                                                   |           |     | (0.0000104)   | (0.00000)    |
| caryears                                                          |           |     | 0.673***      | 0.086**      |
|                                                                   |           |     | (0.210)       | (0.035)      |
| Constant                                                          | -1.577*** |     | -6.115***     |              |
|                                                                   | (0.513)   |     | (1.317)       |              |
| Observations                                                      | 290       | 290 | 290           | 290          |
| R-squared                                                         | 0.331     |     | 0.476         |              |
| Robust standard errors in parentheses ***p<0.01, **p<0.05, *p<0.1 |           |     |               |              |

In *column 1*, probit results of *Model 1* demonstrate that salary influences willingness of respondents at 5% level of significance and age and education level affect the willingness at 1% level of significance. The result indicates that the younger, higher income and higher level of education, the higher willingness of the respondent to purchase EVs. However, other demographics variables from *Model 1*, marital status and number of cars are not statistically significant.

*Column 2* represents the marginal effect of *Model 1*. Higher age negatively affects the willingness of purchasing EVs while education level and salary positively encourages intention to buy EVs. Every level of education increases by one unit and increase in income groups increases the willingness to purchase EVs by 35.4% and 7.8% respectively while the intention to buy EVs decreases by 3.1% when the respondents' age increases by 1 year.

Probit results of *Model 2* are shown in *column 3*. Variables of marital status and price influences willingness of respondents at 5% level of significance. Variables of age, education level, environment awareness, kilometers and car years affect the intention to purchase EVs of respondents at 1% level of significance.

Marginal effects of *Model 2* are demonstrated in *column 4*. Environment and car years affects the willingness at 5% level of significance. Age, education level and kilometers influences the intention to purchase EVs at 1% level of significance. The effects of age and education level in *Model 2* become lessened compared to *Model 1* in *column 2* to -2.1% and 21.5% respectively. Every increase in environmental awareness by 1 Likert unit boosts the intention of purchasing EVs by 7.8%. If the respondents have higher car kilometers by 10,000 kilometers, they have a 4.57% lower willingness to purchase EVs. Respondents who keep their cars for one year longer have an 8.6% higher chance of buying EVs.

For the second objective, respondents with willingness to buy EVs find prices of EVs more reasonable and have higher environmental awareness than those with no interest in buying EVs. There is no significant effect of charging station safety towards the intention of purchasing EVs.

For the third objective, there is no significant difference in attitude and awareness in terms of effectiveness of government policies between those interested and not interested in purchasing EVs.

## **Conclusion**

This section demonstrates the conclusion of the research paper's findings on factors affecting willingness of consumers to purchase EVs in Thailand.

The result from the analysis found that for category of demographics, age and education level are significant effects on willingness of purchasing of EV. Categories of environmental awareness, kilometers and car years pose significant effects on the intention of buying EVs.

For the second objective, only price and environmental awareness are factors significantly affecting intention buying EVs. Charging stations, driving locations and safety do not show significant effects; the possible reasons can be that EVs' market is considered to be at an initial stage meaning current availability of charging stations is not comfortable in many consumers' perspectives, consumers with willingness to buy EVs drive their cars to locations not different to those who pose no interest in buying EVs and consumers overall trust in safety EVs from the well-known image of EVs no matter if posing the intention to purchase EVs or not, respectively.

For the third objective, there are possible reasons behind the insignificant effect of government policies. The first possible reason is specific personal preferences of consumers interested in EVs no matter what policies the government imposes. The second reason is the effects of policies are indirectly recognized by consumers; the government policies only focus on reducing taxes for the car companies while approaches posing direct effects on consumers such as tax refund or reduction of parking fees are absent.

### Recommendations

These are some of the recommendations the government and car companies can apply for higher benefits of oneselves and the citizens of Thailand.

Car companies can apply these approaches. The first approach is to launch promotions that can attract people in younger age groups using marketing with a combination of psychological tactics. Moreover, car companies can promote their EVs in terms of lifespan and how people can observe the quality of EVs from such promotion.

These are some of the approaches the government of Thailand can apply. The government may consider extending import tax reduction for material used in manufacturing

EVs and income tax with certain conditions to allow companies contribute higher competition in the market. The government should make purchasing EVs to be income tax-deductible for consumers, the government can also exempt or provide reduction in parking fees for EV to increase direct effect and benefits felt by consumers and EV buyers.

These are what both the government of Thailand and car companies can adopt. Both can expand the awareness of the incoming trend of EV by providing messages and improve the convenience and availability of charging stations. Both can also launch messages and develop safety which can encourage those who trust in safety but no intention to have lower hesitation creating more probability of changing this group's opinion to have more willingness and intention to buy EVs.

### Limitations

Similar to any other research papers, there are some limitations this research paper has faced.

- 1) The sample size. Due to the limitation of time, the sample of only 290 respondents, is small compared to millions of Thai citizens in the country.
- 2) The second limitation is the paper does not demonstrate the effect of career to willingness of adopting EVs.
- 3) The third limitation is some factors such as salary and education level. The number of results is, for some people, confusing as the number is not to any extent real numbers of Baht or years for both factors respectively.

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## Appendix

# แบบสอบถามทัศนคติและปัจจัยที่มีอิทธิพลต่อ แนวโน้มในการซื้อรถยนต์ไฟฟ้า

แบบสอบถามจัดทำขึ้นโดยนิสิตวิชาภาคธุรกิจ คณะเศรษฐศาสตร์ มหาวิทยาลัยธรรมศาสตร์ โดยมีจุดประสงค์เพื่อศึกษาเกี่ยวกับพฤติกรรม ทัศนคติและปัจจัยที่มีอิทธิพลต่อการซื้อรถยนต์ไฟฟ้าของผู้บริโภคในประเทศไทย สำหรับงานวิจัยจบการศึกษาปริญญาตรี ขอขอบพระคุณในความร่วมมือในการตอบแบบสอบถาม

**\*จำเป็น**

## ส่วนที่ 1: ข้อมูลเกี่ยวกับพฤติกรรมการซื้อรถยนต์ไฟฟ้า

1. คุณเคยคิดที่จะซื้อรถยนต์ไฟฟ้า \*

- ☐ ใช่
- ☐ ไม่ใช่

2. โดยปกติเมื่อท่านเห็นรถยนต์ ยี่ห้อไหนบ้างที่มักอยู่ในการพิจารณาของท่าน (ตอบได้มากกว่าหนึ่งตัวเลือก)

- ☐ MG
- ☐ Fomm
- ☐ Hyundai
- ☐ KIA
- ☐ Nissan
- ☐ Volvo
- ☐ Toyota
- ☐ Honda
- ☐ Mercedes Benz
- ☐ BMW
- ☐ Tesla
- ☐ อื่นๆ: \_\_\_\_\_

ส่วนที่ 2: ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1. อายุ \*

คำตอบของคุณ \_\_\_\_\_

## 2. สถานภาพสมรส \*

- ☐ โสด
- ☐ สมรส

## 3. ระดับการศึกษา \*

- ☐ มัธยมศึกษา
- ☐ ปวช./ปวส./ปวท./อนุปริญญา
- ☐ ปริญญาตรี
- ☐ ปริญญาโท
- ☐ ปริญญาเอก
- ☐ อื่นๆ: \_\_\_\_\_

## 4. อาชีพ \*

- ☐ พนักงานราชการ
- ☐ พนักงานในบริษัทเอกชน
- ☐ ผู้ประกอบการ
- ☐ นักเรียน/นักศึกษา
- ☐ อื่นๆ: \_\_\_\_\_

5. รายได้เฉลี่ยต่อเดือนของท่านหลังหักภาษีเงินได้แล้ว (ให้ผู้ตอบแบบสอบถามลองประมาณรายได้จากทุกแหล่งในเดือนที่แล้ว) \*

- ☐ น้อยกว่า 15,000 บาท
- ☐ 15,000 - 30,000 บาท
- ☐ 30,001 - 45,000 บาท
- ☐ 45,001 - 60,000 บาท
- ☐ 60,001 - 75,000 บาท
- ☐ มากกว่า 75,001 บาท

6. จำนวนรถที่ท่านมีในปัจจุบัน \*

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ มากกว่า 2

ส่วนที่ 3: ความคิดเห็นต่อปัจจัยที่ส่งผลต่อการตัดสินใจในการซื้อรถยนต์ไฟฟ้า  
กรุณาเลือกที่ตรงกับความเห็นของท่านมากที่สุด 5 = เห็นด้วยมากที่สุด 1 = เห็นด้วยน้อยที่สุด

1. สถานีชาร์จรถยนต์ไฟฟ้า \*

|                                                 | เห็นด้วยมากที่สุด     | เห็นด้วยมาก           | เห็นด้วยปานกลาง       | เห็นด้วยน้อย          | เห็นด้วยน้อยที่สุด    |
|-------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| คุณให้ความสำคัญกับการลดจำนวนการชาร์จรถยนต์ไฟฟ้า | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| สถานีชาร์จที่มีอยู่ตอนนี้เพียงพอ                | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| สถานีชาร์จทำให้รถยนต์ไฟฟ้าเหมาะสมวิ่งทางไกลได้  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| ความเร็วในการชาร์จเป็นที่น่าพอใจ                | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

## 2. ราคา \*

|                                                                                | เห็นด้วยมากที่สุด     | เห็นด้วยมาก           | เห็นด้วยปานกลาง       | เห็นด้วยน้อย          | เห็นด้วยน้อยที่สุด    |
|--------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| คุณสามารถซื้อรถยนต์ไฟฟ้าได้                                                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| ราคารถยนต์ไฟฟ้าสมเหตุสมผล                                                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| ค่าใช้จ่ายในการวิ่งรถยนต์ไฟฟ้า (เช่น ค่าไฟ ค่าน้ำมัน) สมเหตุสมผล               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| ค่าใช้จ่ายในการบำรุงรักษา (เช่น เปลี่ยนแบตเตอรี่หรืออุปกรณ์ภายในรถ) สมเหตุสมผล | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

### 3. นโยบายรถยนต์ไฟฟ้า \*

|                                                    | เห็นด้วยมากที่สุด     | เห็นด้วยมาก           | เห็นด้วยปานกลาง       | เห็นด้วยน้อย          | เห็นด้วยน้อยที่สุด    |
|----------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| คุณทราบถึงนโยบายรถยนต์ไฟฟ้าของรัฐ                  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| นโยบายภาษีสรรพสามิตเป็นที่น่าสนใจ                  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| นโยบายภาษีอากรขาเข้าวัตถุดิบและวัสดุเป็นที่น่าสนใจ | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| นโยบายภาษีเงินได้นิติบุคคลเป็นที่น่าสนใจ           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

#### 4. สิ่งแวดล้อม \*

|                                                       | เห็นด้วยมากที่สุด     | เห็นด้วยมาก           | เห็นด้วยปานกลาง       | เห็นด้วยน้อย          | เห็นด้วยน้อยที่สุด    |
|-------------------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| คุณมีความตระหนักรู้เกี่ยวกับสิ่งแวดล้อม               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| คุณยินดีจ่ายเพิ่มเพื่อสินค้าที่เป็นมิตรต่อสิ่งแวดล้อม | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| รถยนต์ไฟฟ้าลดปัญหาสิ่งแวดล้อม                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

#### 5. พื้นที่ชั้บรถยนต์ \*

|                                     | ใช่                   | ไม่ใช่                |
|-------------------------------------|-----------------------|-----------------------|
| คุณจะชั้บรถยนต์ในตัวเมืองหรือไม่    | <input type="radio"/> | <input type="radio"/> |
| คุณจะชั้บรถยนต์ไปต่างจังหวัดหรือไม่ | <input type="radio"/> | <input type="radio"/> |
| คุณจะชั้บรถยนต์ขึ้นลงภูเขาหรือไม่   | <input type="radio"/> | <input type="radio"/> |

6. ความปลอดภัย \*

|                                              | เห็นด้วยมากที่สุด     | เห็นด้วยมาก           | เห็นด้วยปานกลาง       | เห็นด้วยน้อย          | เห็นด้วยน้อยที่สุด    |
|----------------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| คุณมั่นใจในความปลอดภัยขณะขับรถ               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| คุณมั่นใจในความปลอดภัยของการชาร์จรถยนต์ไฟฟ้า | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

7. ปกติแล้วท่านขับรถกี่กิโลเมตรต่อรถหนึ่งคัน (ให้ผู้ตอบแบบสอบถามลองประมาณค่าเฉลี่ย) \*

คำตอบของคุณ

8. ปกติแล้วท่านเปลี่ยนรถที่ขับทุกกี่ปี (ให้ผู้ตอบแบบสอบถามลองประมาณค่าเฉลี่ย) \*

คำตอบของคุณ

