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College students' potential purchase intention of electric two-wheeled vehicles

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Due to the rise of renewable energy/green energy issues in recent years, many countries have agreed to adopt the forms of environmental protection, cleanliness, and no impact on the environment for the sources and composition of energy. They have also drawn up relevant international agreements (i.e., Kyoto Protocol, Paris Agreement) to strictly limit and manage CO₂ emissions. The newly advocated electric vehicles have gradually been regarded as a method to improve the environment by all countries. Through the introduction of new electric transport modes, the innovation and reform of the energy structure are promoted, and traditional transportation has also changed. In recent years, Taiwan has promoted the policy of replacing traditional fuel two-wheeled vehicles with electric two-wheeled vehicles (ETWVs), and gradually increased the number of ETWVs in Taiwan by replacing old fuel vehicles and subsidizing the purchase of ETWVs. This study is aimed at college students to explore the important factors that affect their willingness to buy ETWVs. As college students are the first group to buy ETWVs, if their willingness to buy ETWVs can be increased, environmental sustainability may be enhanced. Through a questionnaire designed to investigate the two-wheeled vehicle use preferences of college students in Taiwan, this paper explores the significant factors affecting college students' purchase of ETWVs. This study applies Logistic Regression and Ordered Logit models, and the results of model estimation show that household income, gender, environmental awareness, recognition of ETWVs, the fuel costs of existing vehicles, number of people in each household, operational efficiency of ETWVs, and subsidy and incentive measures will all positively affect the purchase intention of college students.

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Introduction

All parts of the world are severely impacted by extreme weather, and Taiwan is no exception. From 1900 to 2012, the increase of the average temperature in Taiwan is higher than the global average (The News Lens, 2020). In July 2020, the Taipei Weather Station measured the highest temperature ever recorded in Taiwan at 39.7 °C. As more than 90% of Taiwan's energy depends on oil, coal, natural gas, and other fuels, less attention was paid to the development of green/renewable energy in the past. Thus, in the recent five years, under rapid changes to the climate and environment, Taiwan attached importance to the use and layout of green and renewable energy. At present, the Taiwanese government has set energy transformation goals for 2025, including reducing coal-fired power generation to 27%, and increasing the use of natural gas to 50% and renewable energy to 20%. In addition, Taiwan is committed to promoting electrical two-wheeled vehicles (ETWVs). Taiwan's promotion and subsidy measures can be divided into two categories: central and local governments. The central units include the "Industrial Development Bureau" and "Environmental Protection Administration", while local county and city governments cooperate with their respective budgets and targets to promote the amount of ETWVs purchased, and the related subsidy measures.

Taking the cities investigated in this study as an example, in recent years, in order to improve mobile pollution sources, the Taichung City Government has implemented measures to subsidize the replacement and control the number of old fuel vehicles and promote people to buy ETWVs when replacing vehicles; therefore, the performance of promoting the growth of ETWVs in recent years has been outstanding. The subsidy of the local environmental protection bureau (Taichung City) is divided into two schemes: subsidy for eliminating old fuel vehicles and subsidy for newly purchased ETWVs. One is the maximum subsidy for replacing old ETWVs with US \$685.7¹, and the other is the maximum subsidy for newly purchased ETWVs with US \$360.9, ranking first in Taiwan. In addition to the cash subsidy for replacement and new purchases of ETWVs, a number of preferential policies have been introduced, including free parking of ETWVs. Moreover, exemption from fuel tax and vehicle license tax allows people living in Taichung City to embrace more potential incentives to buy ETWVs.

However, due to the high penetration rate and low use cost of fuel vehicles in Taiwan, the proportion of college students using vehicles to and from school is quite high. Moreover, most schools are located in the suburbs, and bus routes and service frequency in urban areas are insufficient, and while Taichung City Government has actively coordinated the continuous driving of passenger routes into the campus since 2016, it is still impossible to reduce students' dependence on vehicles due to insufficient public transport services around the campus. Thus, fuel vehicles are still the main means of transportation used by students.

In Taiwan, while the promotion measures of ETWVs are mainly led by the government, such as giving consumers vehicle subsidies, manufacturers incentives, and parking incentives, there is still a lack of overall planning and consideration, such as charging requirements and a friendly ETWV use environment. Thus, as there is a relative lack of research regarding the behavior of ETWVs purchase, this study further explored the important factors affecting the purchase of ETWVs from the perspective of users. This study took college students as the research subjects, as they are the main potential group who may buy ETWVs as transportation for the first time, which means that they can cultivate their cognition and attitude towards environmental sustainability. Thus, if we can understand the willingness of college students to buy ETWVs to increase the market share of

ETWVs, a contribution to environmental carbon reduction can be expected. Therefore, the questionnaire situation designed by this study (including subsidy measures, such as rebate, exemption of fuel tax/vehicle license tax, reduced parking fees) can explore the influence of subsidy measures on college students' choice of ETWVs types.

This study aimed at the factors that affect college students' willingness to buy ETWVs. The Logistic Model and Ordered Logit Model were used as the analysis models, and the influences of the two models on college students' willingness to buy ETWVs under different factors were compared. Meanwhile, the marginal effect was analyzed by analyzing the odds ratio and elasticity of each factor of the two models, and corresponding promotional strategies were put forward according to the analysis results. In short, college students are often the first group to buy ETWVs, and the results of exploring the tendency, attitude, and willingness of college students to buy ETWVs can be used to understand the effective measures to promote ETWVs and serve as a policy reference to promote the purchase of ETWVs.

The main contributions of this study can be divided into several parts: (1) The first research on college students' willingness to buy ETWVs in Taiwan; (2) Understand the important factors affecting college students' purchase of ETWVs through the odds ratio; (3) Develop marketing and promotion strategies for specific groups of college students, such as those who consume higher fuel costs for vehicles and college students of different ages. Subsequent sections are arranged, as follows. In the next section, the relevant literature was reviewed to understand the factors affecting the use and purchase of ETWVs, the driving measures of related electric vehicles, and the degrees of influence. Then, the questionnaire was designed, and the important factors and promotional measures, as obtained by literature review, were added as the basis of the questionnaire design. Then, the data collected from the questionnaires were analyzed, calibration and analysis were carried out with the Logistic Model and Ordered Logit Model, and finally, conclusions and suggestions were put forward.

Literature review

Ali et al. (2017) further collected the impact and effectiveness of ETWVs promotion measures, and pointed out that electricity price will directly affect the use and market share of ETWV; Guerra (2019) studied the feasibility of ETWVs as an alternative to fuel vehicles, and pointed out that the main key factors for ETWVs to increase market share include price, performance, endurance, and charging time. Based on the above, it can be known that the vehicle characteristics of ETWVs are directly related to the market share, thus, if the characteristics of the above factors can be appropriately or continuously improved, the use and market share of ETWVs should be improved.

Since the advent of the Internal Combustion Engine (ICE), modern transportation operations have undergone fundamental changes, and it is impossible to imagine life without the internal combustion engine, and Powered Two-Wheelers (PTWs) are the representatives of this kind of vehicle. In recent years, the gradual trend of switching to electric two-wheeled vehicles (ETWVs) means there is no excessive exhaust emissions or noise problems, which has effectively alleviated the increasingly serious traffic problems in Europe. Hardt and Bogenberger (2018) conducted a travel survey on 38 users who use such vehicles in Munich, Germany, and the survey results pointed out that the attributes affecting use can be divided into objective and subjective factors. The objective factors include whether the basic charging facilities are sufficient and convenient to use; subjective factors include safety awareness, weather conditions, and luggage restrictions.

Bakker (2018) further discussed the policy planning, advantages, and disadvantages of electric two-wheeled vehicles, and the results showed that this kind of new transport equipment has a decisive influence on urban transportation planning. As ETWVs receive little attention at present, traditional traffic planning often ignores the traffic demands and specifications of ETWVs on the road, which leads to traffic conflicts on the road. That study collected the promotional policies in China, Vietnam, the Netherlands, and other countries, and pointed out that the utilization rate of ETWVs can be effectively improved if appropriate measures are adopted, such as implementing low emission restriction zones, phasing out traditional motorcycles, and improving the traffic-related legal framework. One of the main principles of urban planning is to increase the attractiveness and safety of ETWVs.

Ferrara et al. (2019) studied the usage preference of fuel vehicles and ETWVs in India, and designed five schemes for face-to-face interviews. The results showed that the price and performance of ETWVs are the most direct influencing factors for individual users, and when the price and performance of ETWVs (such as battery charging technology) reach a certain level, they will be attractive enough for individual users. Other environmental factors, such as the integrity or improvement of the charging infrastructure, are factors that influence the choice of ETWVs by individual users. Eccarius and Lu (2020) studied the supporting measures of ETWVs and fuel vehicles, and pointed out that although the popularization and application of ETWVs are still not as large as that of traditional fuel vehicles, it provides a great advantage for the sustainable development of the environment in the future. At the initial stage, it was suggested that policy development for ETWVs should be encouraged and restrictions on the use of fuel vehicles should be gradually adjusted.

Thuy and Hong (2019) adopted the Theory of Planned Behavior (TPB) and analyzed the willingness and attitude preference of high school students in Ha Noi, Vietnam to use ETWVs, in order to determine the factors that affect students' willingness to use ETWVs. The results showed that the attitude and preference factors of high school students' tendency to use ETWVs included perceived economic benefits, the convenience of use, friendly environment feeling, and fashionable appearance design. However, high school students' willingness or purpose to use ETWV is influenced by three factors: individual subjective norms, attitude tendency to use ETWVs, and the attractiveness of such vehicles to high school students.

Zhu et al. (2019) used the contingent evaluation method (CVM) to discuss consumers' willingness to buy (WTB) and willingness to pay (WTP) for Electric Motorcycles (EM). The results showed that respondents pay more attention to the actual cost of ETWVs, such as selling price, charging rate, warranty fee, and tax incentives, and the highest speed and load of EM are not the main reasons to attract consumers to buy. However, the education level and the number of family members of the respondents will affect the WTB and WTP for EMs, and the WTP amount for an EM is estimated to be 1,315.54 patacas (Mop 1 = USD 0.13).

Brückmann et al. (2021) analyzed the promotion policy of Battery Electric Vehicles (BEV), and found that individuals are more inclined to use BEV if there are relatively perfect BEV facilities near their homes. This phenomenon clearly indicates that the integrity of facilities around ETWVs and the influence degree of policy promotion can directly affect individuals' willingness to use ETWVs.

Lee et al. (2021) probed into E-Scooter Sharing (ESS) and compared two groups of users: the group that tends to use ESS for commuting and the group that tends to use ESS only in the first

mile and the last mile. The results showed that the socioeconomic characteristics of individuals tend to be younger and have higher income, and those who prefer green energy and are less satisfied with the quality of current public transport services tend to use ESS.

Patil and Majumdar (2021) investigated the decisive factors that will affect the utilization rate of ETWVs in urban areas of India, and used the Analytic Hierarchy Process (AHP) to analyze the opinions of experts and scholars. In addition, Relative to an Identified Distribution and Transformation (RIDIT) was used to analyze the preferences of respondents. According to the research results, about 32% of greenhouse gas emissions from urban transportation in India come from motorized two-wheelers (M2W), and replacing M2W with Electric Two-Wheelers (E2W) can effectively reduce exhaust emissions. The results also showed that "purchase cost", "operating cost", "endurance mileage", "charging efficiency", and "carbon emission reduction" are all key factors affecting the use of E2W. Therefore, the study also suggested developing vehicles with higher endurance, higher charging efficiency, lower purchase cost, and providing sufficient charging and parking facilities, which is very important for the promotion of E2W in India.

Previous studies have shown that significant variables include the following characteristics: socio-economic characteristics, such as age and income; ETWV vehicle characteristics, such as "endurance mileage", "charging time", "comfort", and "vehicle appearance"; subsidies and auxiliary measures, such as the "ETWV rebate" and "perfect peripheral charging infrastructure"; attitudes towards ETWVs, such as "support of environmental awareness", "ETWVs can improve the quality of outdoor activities", and "good value for the price of ETWVs". That is to say, users who prefer ETWVs usually have younger age, higher income, higher education level, and certain support attitude towards environmental protection awareness. In addition, they attach great importance to the vehicle characteristics of ETWVs; if several vehicle characteristics can be continuously improved, individual use of ETWVs will be improved. Among the governmental support measures, the ETWV rebate has the greatest influence. Moreover, individuals' identities and attitudes towards ETWVs are mainly "convenience of use" and "ETWVs can improve the quality of outdoor activities", which shows that ETWVs can effectively improve individual experience and perception if their convenience level is enhanced Table 1.

Model

Logistic regression model. The dependent variable of this study is the purchase intention of college students to buy ETWVs. As the relative question of the dependent variable is "If I want to buy a motorcycle now (in the future), I will choose an ETWV", the respondents filled in the degree of their consent. In principle, "Strongly disagree" and "Partially disagree" were recombined into a group of "unwilling to buy ETWVs ($Y = 0$)"; by the same token, "Partially Agree" and "Strongly Agree" were merged into a group of "willing to buy ETWVs ($Y = 1$)".

We assume that the dependent variable Y is a binary variable, where p is the probability of its success (p is between 0 and 1). If p is close to 0, it indicates that Y has a small probability of success; if p is close to 1, it indicates that Y has a large probability of success; and it is influenced by dependent variable x . The relationship between p and x can be expressed, as follows:

$$p(Y = 1|X = x) = \frac{e^{f(x)}}{1 + e^{f(x)}} = \frac{e^{x\beta}}{1 + e^{x\beta}} \quad (1)$$

$$1 - p(Y = 1|X = x) = \frac{1}{1 + e^{f(x)}} = \frac{1}{1 + e^{x\beta}}$$

where the odds ratio is defined as the ratio between the probability of success and the probability of failure of an event,

Table 1 Related Literature Review Summary.

Author	Topics	Impact factors	Research findings
Ali et al. (2017), Guerra (2019)	Effectiveness of ETWVs promotion measures	ETWV characteristics, such as performance, endurance, and charging time	Popularization and refinement of vehicle characteristics can effectively improve the overall market share.
Bakker (2018)	Policy planning and benefits of ETWVs	Traffic engineering design, traffic safety, supporting policies and plans, and restrictive measures	Corresponding traffic safety measures should be designed according to vehicle characteristics.
Eccarius and Lu (2020)	Extension of ETWVs and supporting measures for restriction of fuel	Environmental protection, restrictive measures	If appropriate restrictions can be imposed on fuel vehicles, such as stricter emission regulations, people can be effectively encouraged to buy ETWVs instead.
Ferrara et al. (2019)	Usage preference of ETWVs	Price, performance or operational efficiency of ETWVs, and perfection of external charging facilities	Individuals have the highest sensitivity to the price and performance of ETWVs. If subsidies are given, it will increase the market share.
Hackbarth and Madlener (2013)	Alternatives to fuel vehicles	Young, highly educated, environmentally conscious and endurance	Those who choose electric transport usually belong to younger and more educated groups, and also tend to use more environmentally friendly means of transportation.
Lee et al. (2021)	ESS	ESS	Those who are younger, higher income, prefer green energy, and are less satisfied with the quality of current public transport services will tend to use ESS more
Patil and Majumdar (2021)	Factors affecting the utilization rate of E2W	Purchase cost, operating cost, endurance mileage, charging efficiency, and carbon emission reduction	It is suggested to develop vehicles with higher battery life, higher charging efficiency and lower purchase cost, and provide sufficient external charging and parking facilities, which can effectively improve the utilization rate.
Patil and Majumdar (2021)	Students' willingness and preference for using two rounds of ETWVs	Economic convenience, convenient use, friendly environment feeling, popular fashion appearance design	Economic convenience, use convenience, friendly environment feeling, popular fashion appearance design, and other factors will affect the willingness and perception of use.
Zhu et al. (2019)	Purchase intention of ETWVs	Selling price, charging rate, warranty fee, incentives, or subsidy measures	Users focus on substantial benefits, such as subsidizing the purchase amount of ETWVs, which can effectively encourage users to purchase.

and can be expressed as:

$$\frac{p}{1-p} = e^{f(x)} \tag{2}$$

The logistic regression can be expressed as:

$$\ln \frac{p}{1-p} = f(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_m x_m \tag{3}$$

where m represents the number of independent variables. The logistic regression is estimated by maximum likelihood estimation (MLE) and its likelihood function is expressed, as follows:

$$L(\beta) = \prod_{i=1}^n p_i^{y_i} (1-p_i)^{1-y_i} \tag{4}$$

Ordered Logit Model. This study further used the Ordered Logit Model to explore the important factors that affect college students' tendency to buy ETWVs. The Ordered Logit Model is applicable because there are five orders that depend on the degree of consent among the variables. For the five orders, $k=0, 1, 2, 3$ and 4 . When k equals 0 , this is the minimum threshold, meaning strongly disagree. Furthermore, when assuming that the error term in the utility function is a Gumbel distribution, the Ordered Logit Model can be derived, and its model architecture is:

$$Y^* = x'\beta + \varepsilon, \tag{5}$$

Where Y_i^* is an unobservable strain; x_i^* is an explanatory

variable, and β_i is a parameter to be calibrated; ε_i is an error term. When applied in this study, Y_i^* indicates the degree of consent of purchase intention, and the larger the Y_i^* value, the higher the degree of consent of purchase intention. As Y_i^* is an unobservable variable in the model, the threshold of consent in the model is defined, as follows:

$$Y = k, \text{ if } \mu_{k-1} < Y^* \leq \mu_k, k = 0, 1, 2, 3, 4 \tag{6}$$

When k is equal to 0 , it is expressed as the minimum threshold, that is, the level of strongly disagree, followed by Partially disagree, Neutral, Partially agree, and Strongly agree. In this study, the purchase intention is divided into five levels, thus, the Y_i^* value can be expressed, as follows:

$$Y = \begin{cases} 0, & \text{if } \mu_{-1} < Y^* \leq \mu_0 & (\text{totally disagree}) \\ 1, & \text{if } \mu_0 < Y^* \leq \mu_1 & (\text{partially disagree}) \\ 2, & \text{if } \mu_1 < Y^* \leq \mu_2 & (\text{neutral}) \\ 3, & \text{if } \mu_2 < Y^* \leq \mu_3 & (\text{partially agree}) \\ 4, & \text{if } \mu_3 < Y^* \leq \mu_4 & (\text{totally agree}) \end{cases} \tag{7}$$

where $\mu_{-1} = \infty, \mu_4 = \infty$, by Eq. (5) and Eq. (6), it can be deduced

that:

$$\begin{aligned}
 Y_i &= 0, \text{ if } \varepsilon \leq \mu_0 - x'\beta \\
 Y_i &= 1, \text{ if } \mu_0 - x'\beta \leq \varepsilon \leq \mu_1 - x'\beta \\
 Y_i &= 2, \text{ if } \mu_1 - x'\beta \leq \varepsilon \leq \mu_2 - x'\beta \\
 Y_i &= 3, \text{ if } \mu_2 - x'\beta \leq \varepsilon \leq \mu_3 - x'\beta \\
 Y_i &= 4, \text{ if } \varepsilon > \mu_3 - x'\beta
 \end{aligned}
 \tag{8}$$

The probability of respondents for each ETWV purchase level can be expressed, as follows:

$$\begin{aligned}
 p(Y = 0) &= F(\mu_0 - x'\beta) \\
 p(Y = 1) &= \{F(\mu_1 - x'\beta) - F(\mu_0 - x'\beta)\} \\
 p(Y = 2) &= \{F(\mu_2 - x'\beta) - F(\mu_1 - x'\beta)\} \\
 p(Y = 3) &= \{F(\mu_3 - x'\beta) - F(\mu_2 - x'\beta)\} \\
 p(Y = 4) &= \{1 - F(\mu_3 - x'\beta)\}
 \end{aligned}
 \tag{9}$$

When F is the Logistic cumulative distribution function:

$$F(z) = \frac{e^z}{1 + e^z}
 \tag{10}$$

Where β is the regression coefficient of X . From the above formula, it can be seen that its value is the same in all levels, which means that the slope utility of each independent variable is the same, that is, the parallel lines assumption of the so-called Ordered Logit Model.

Since the dependent variable is ordinal and there is J willingness levels to buy ETWVs, the rating that can be presented as $P(Y \leq j)$, $j = 1, \dots, j - 1$, if $P(Y \leq j) = 1$, then, the Odds Ratio (OR) can be defined as:

$$\frac{P(Y \leq j)}{P(Y > j)}
 \tag{11}$$

The probability of $P(Y > j)$ can also be expressed as $P(Y > j) = 1 - P(Y \leq j)$, then the logarithm of OR is Logit, which can be further expressed, as follows:

$$\log \frac{P(Y \leq j)}{P(Y > j)} = \text{logit}(P(Y \leq j))
 \tag{12}$$

While the intercept of each level is different through the parallel regression assumption, the slope of each level is constant, thus, the Ordered Logit Model can be defined as:

$$\text{logit}(P(Y \leq j)) = \beta_{j0} + \beta_1 x_1 + \dots + \beta_p x_p
 \tag{13}$$

Elasticity analysis. The elasticity analysis of Logistic regression can be used to explore the influence of the change of the attribute value of a specific variable on the change of the probability of consent level, that is, the percentage of the change of the probability of consent level (such as Eq. (14)) when the attribute value of a specific variable changes by 1%.

$$E_x^p = \frac{\partial p}{\partial x} \cdot \frac{x}{p}
 \tag{14}$$

Take Eq. (1) as an example:

$$\frac{\partial p(Y = 1)}{\partial x} \cdot \frac{x}{p(Y = 1)} = \beta x (1 - p(Y = 1))
 \tag{15}$$

Take Eq. (9) Elasticity of Ordered Logit Model as an example:

$$\frac{\partial p(Y_i = 1)}{\partial x} \cdot \frac{x}{p(Y_i = 1)} = (-\beta'_i x) (1 - F(\mu_1 - x'_i \beta_i) - F(\mu_0 - x'_i \beta_i))
 \tag{16}$$

Table 2 Cross-over Analysis of ETWV Ownership and Propensity to Buy ETWVs.

Item\Number of samples		Willingness to buy ETWVs		Total
		Unwilling	Willing	
ETWVs	No	378(46.8)	429(53.2)	807(89.6)
	Yes	28(6.9)	66(13.3)	94(10.4)
Total	Number	406(46.1)	495(54.9)	901(100)

Questionnaire design and data analysis

Questionnaire design. This study aimed at exploring college students' willingness to buy ETWVs for the first time. The questionnaire was divided into four parts: the first part is personal basic data, the second part is college students' main activities and behaviors, the third part is college students' vehicle use characteristics, and the fourth part is college students' perception and attitude towards ETWVs.

The survey contents of personal socio-economic characteristics include (1) Gender: male or female; (2) Age: from 18 to 23 years old or other (uses open answer), with a total of 7 sections; (3) Residential area: 29 districts including Taichung City; (4) Average monthly income of individuals (including petty cash, part-time jobs, and allowance); (5) Monthly income of households: from below US \$720 to above US \$5,038, each US \$720 is a step; (6) Number of people in each household: 1 to 6 or more; (7) Types of vehicles at home: check the number of vehicles and cars, respectively; (8) Preference for the maximum service life of vehicles; (9) Whether there are ETWVs; in the home; (10) Whether an individual has ever used ETWVs. The survey of college students' main activities and behaviors includes (1) Investigate the related attributes of light-duty/heavy-duty motorcycle used by respondents, including purpose, time, starting and ending points, and the number of times for general use; (2) Investigate the interviewee's transfer equipment/use of other mass transportation equipment, except for vehicles.

This section of the college students' vehicle use characteristics probes into the type of vehicle held (used), whether it is a new car, the service time (year), the mileage (km), and the related variable costs (including fuel, maintenance, and parking costs). The last part asks college students about their perception and attitude towards ETWVs, and college students fill it out according to their actual degree of feeling, which was divided into five scales: "Strongly disagree", "Partially disagree", "Neutral", "Partially agree", "Strongly agree". The other main categories were divided into "pro-environment attitude", "purchase and use intention", "use confidence", "price", "policy factors", and "usefulness and ease of use".

Data analysis. Considering the influence of ETWVs on the willingness to buy ETWVs, the results are shown in Table 2. This study analyzed the samples without ETWVs, with a total of 807²

The number of male vehicle users is higher than that of female users, accounting for 55.6%; the age group is mainly 20 years old, accounting for 25.5%; the monthly income of families is 40,000–60,000 NTD, accounting for 22.1%; the number of people in each household is 4 people, accounting for about 47.0%; the number of vehicles owned by each family accounts for 34.0% at most; most families owned one car, accounting for 51.3%; individual monthly income is mainly US \$360.9–721.8, accounting for 66.3%. Please refer to Appendix A (Table A.1) for more details.

According to the first part of the questionnaire, this study analyzed the main activities of vehicles, and the vehicle use range was mainly outside the school district, at about 67.9%; the main

Table 3 Average Number of Usage Characteristics of the Two Groups.

Item	Never used ETWVs	Prior use of ETWVs	P-value	Significant difference
Average days of use per week	5.6	5.1	0.00***	Yes
Original vehicle purchase price (USD)	2006.8	2012.6	0.78	—
Weekly fuel expenses for regular scooters (USD)	3.5	3.4	0.15	—
Annual vehicle maintenance fee (USD)	59.0	57.8	0.80	—
Monthly vehicle parking fee (USD)	2.6	2.4	0.78	—

Note: *** Significant level 1%.

Table 4 Verification of the Mean of Socioeconomic Characteristics of Two Groups.

Item	Never used ETWVs	Prior use of ETWVs	P-value	Significant difference
Gender	0.57	0.55	0.81	-
Age	20.5	20.8	0.01***	Yes
Individual monthly income (USD)	\$422.0	424.0	0.55	-
Household monthly income (USD)	\$2892.8	2801.2	0.74	-
Number of people in the household	4.38	4.39	0.00***	Yes
Number of two-wheeled vehicles owned in the household	2.60	2.57	0.55	-
Number of cars owned in the household	2.38	2.37	0.82	-

Note: *** Significant level 1%.

purpose of activities was school commuting, accounting for about 79.3%. In addition, the reason to use vehicles for the main purpose of activities was discussed. Most of the college students who can use vehicles selected high mobility as the main reason, accounting for about 56.4%; regarding the frequency and intensity of use, most students use it every day, accounting for about 45%, and the travel time of each trip mainly ranged from 6 to 15 minutes, accounting for about 51.5%. Please refer to Appendix A (Table A.2) for more details.

According to analysis of college students' vehicle usage characteristics, the number of heavy-duty motorcycle vehicles was higher than that of other vehicles, accounting for 62.9%; the purchase cost of the original vehicle was mainly US \$2165.3–2526.2, accounting for 21.9%; the highest rate of weekly fuel expenses on regular scooters was US \$3.3–3.9, accounting for 27.0%; US \$18–36.1 was the most normal maintenance cost of vehicles every year, accounting for 23.8%; the weekly vehicle parking fee was mainly US \$0, accounting for 34.2%. Please refer to Appendix A (Table A.3) for more details.

This study further analyzed college students' perceptions and attitudes towards ETWVs, and set the points as "Strongly disagree" = 1 point, "Partially disagree" = 2 points, "Neutral" = 3 points, "Partially agree" = 4 points, "Strongly agree" = 5 points, and converted the scores of each item in the six dimensions according to these settings. Under the group of college students who are willing to buy ETWVs, the average score was more than 3 points, which shows that if they are interested in buying ETWVs, they will hold positive opinions and attitudes. When the scores of some questions were less than 3 points among college students who are unwilling to buy ETWVs, it showed that they had certain reservations or even negative attitudes towards ETWVs. Please refer to Appendix A (Table A.4) for more details.

This study further discussed whether the experience differences of riding ETWVs will have characteristics different from past vehicle use characteristics, personal socio-economic characteristics, and hypothetical situation scheme selection. This section was divided into three parts to analyze the average test of the two groups, which are discussed, as follows:

This study analyzed the difference between those who have experience in riding ETWVs, and the results show that only the

average number of days per week was different, while other variables showed no significant difference with or without experience driving ETWVs (Table 3). That is to say, a traditional fuel vehicle was used for most past trips, and the reason may be because the battery life mileage of an ETWV is still lower than that of traditional fuel vehicles. Therefore, it is speculated that it is still necessary to take the location of charging facilities in various places into account for route choice when going to the peripheral areas of cities, thus, there are still more restrictions on use than traditional fuel vehicles.

In addition to the analysis of the socio-economic characteristics of the two groups, in terms of age and number of people in each household, those who have or have no experience driving ETWVs showed some differences, while other variables showed no difference (Table 4). In terms of age, the results show that college students who have experience driving ETWVs are usually older, which may be because after passing the freshman stage, they have become familiar with university life and the surrounding environment and know the locations of their charging facilities, thus, they are more confident in using ETWVs than those who do not have experience driving ETWVs. Regarding the number of people in each household, the results show that different numbers of people in each household will have an impact on experience driving ETWVs. The possible reason is that the more people in each household, the less inclined to use ETWVs because of a larger number of vehicles.

Model estimation

Variable specification. The significant variable settings of the model estimation results in this study are shown in Table 5. Among them, the variables of support and attitude tendency were set, and their values ranged from 1 to 5, representing from "Strongly disagree" to "Strongly agree", respectively. The last column is the literature using this variable.

Model estimation results

Logistic regression model (Table 6). The results of Logistic Regression Model estimation show that the factors affecting college students' willingness to buy ETWVs include "ETWVs are

Table 5 Description of Significant Variables.

Explanatory variables	Average	Standard deviation	Minimum value	Maximum value	Description	References
Weekly fuel expenses on regular scooters (USD)	94.56	45.04	30	250	Median	Hackbarth and Madlener (2013)
Age	20.67	1.88	18	45	18 to 45 years old	Hackbarth and Madlener (2013)
Number of people in each household ETWVs are too expensive	4.38 0.35	0.91 0.47	1 0	6 1	1-6 persons Y:1, N:0	Hackbarth and Madlener (2013) Brückmann et al. (2021), Ferrara et al. (2019), Patil and Majumdar (2021)
ETWVs have poor endurance	0.38	0.48	0	1	Y:1, N:0	Brückmann et al. (2021), Ferrara et al. (2019), Patil and Majumdar (2021)
The reason to choose ETWVs is the subsidy	0.24	0.42	0	1	Y:1, N:0	Brückmann et al. (2021), Ferrara et al. (2019), Eccarius and Lu (2020), Patil and Majumdar (2021), Zhu et al. (2019)
Moderate price of the ETWVs	0.05	0.22	0	1	Y:1, N:0	Brückmann et al. (2021), Ali et al. (2017), Guerra (2019), Ferrara et al. (2019)
Exemption of fuel tax/vehicle license tax	0.19	0.39	0	1	Y:1, N:0	Brückmann et al. (2021), Guerra, (2019), Eccarius and Lu (2020), Patil and Majumdar (2021), Zhu et al. (2019)
Outstanding performances (horsepower and distance)	0.08	0.27	0	1	Y:1, N:0	Brückmann et al. (2021), Guerra (2019), Zhu et al. (2019)
I am willing to try or continue to use ETWVs	3.50	1.00	1	5	Level 1-5	Ferrara et al. (2019)
Good value for the price of ETWVs	3.04	0.94	1	5	Level 1-5	Ali et al. (2017), Guerra (2019), Ferrara et al. (2019)
ETWVs can improve the quality of outdoor activities	3.44	0.93	1	5	Level 1-5	Hardt and Bogenberger (2018)
Those who are male, have high household income, and are willing to spend more money to purchase ETWVs for environmental reasons	0.11	0.31	0	1	Y:1, N:0	-
Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future	0.06	0.24	0	1	Y:1, N:0	-

Table 6 College Students' Purchase Intention Pattern Evaluation Results.

Variables	Logistic Regression Model		Ordered Logit Model	
	Coefficient	t value	Coefficient	t value
Constants	-4.56	-9.32**	-	-
Weekly fuel expenses for regular scooters			0.003	2.52**
Age	-	-	0.06	1.73*
Number of people in each household	-	-	-0.14	-1.98**
ETWVs are too expensive	-0.46	-2.43**	-	-
ETWVs have poor endurance	-0.49	-2.61**	-	-
ETWVs rebate	-	-	1.06	4.79**
ETWVs are reasonably priced	1.33	2.29**	-	-
Exemption of fuel tax/vehicle license tax	0.93	3.15**	0.51	2.29**
Outstanding performances (horsepower and distance)	-	-	0.53	1.88*
I am willing to try or continue to use ETWVs	0.81	7.70**	0.28	3.58**
Good value for the price of ETWVs	0.64	6.01**	0.16	2.03**
ETWVs can improve the quality of outdoor activities	-	-	0.16	1.93*
Those who are male, have high household income, and are willing to spend more money to purchase ETWVs for environmental reasons	-	-	0.65	3.06**
Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future	2.63	2.5**	-	-
Threshold value 1	-	-	5.73	3.16**
Threshold value 2	-	-	6.03	3.48**
Threshold value 3	-	-	7.21	4.66**
Threshold value 4	-	-	9.31	6.59**
LL(o)	-557.75		-1168.63	
LL(β)	-399.17		-1061.85	
Pseudo R ²	0.28		0.09	

Note: * Significant level 10%; ** Significant level 5%.

Table 7 Odds Ratio Analysis.

Variables	Logistic Regression Model	Ordered Logit Model
Weekly fuel expenses for regular scooters	-	1.00
Age	-	1.06
Number of people in each household	-	0.86
ETWVs are too expensive	0.62	-
ETWVs have poor endurance	0.60	-
ETWVs rebate	-	2.89
ETWVs are reasonably priced	3.80	-
Exemption of fuel tax/vehicle license tax	2.55	1.66
Outstanding performances (horsepower and distance)		1.70
I am willing to try or continue to use ETWVs	2.26	1.32
Good value for the price of ETWVs	1.91	1.17
ETWVs can improve the quality of outdoor activities	—	1.17
Those who are male, have high household income, and are willing to spend more money to purchase ETWVs for environmental reasons	—	1.92
Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future	13.95	—

too expensive”, “ETWVs have poor endurance”, “ETWVs are reasonably priced”, “Exemption of fuel tax/vehicle license tax”, “I am willing to try or continue to use ETWVs”, “Good value for the price of ETWVs”, and “Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future”. Among them, “ETWVs are too expensive” and “ETWVs have poor endurance” have negative significant effects, while the other factors have positive significant effects .

In the Logistic Regression Model, if the price of ETWVs is too high, the main reason for being less willing to buy ETWVs is that the amount of rebate for ETWVs in Taiwan is limited at present, meaning the price of ETWVs vehicles is still slightly higher than that of traditional fuel vehicles after various rebates. On the other

hand, because the mileage endurance is limited by battery usage and the locations of charging facilities are few, it will also reduce the willingness of people who deem that “ETWVs have poor endurance”.

Therefore, the operational efficiency of ETWVs in Taiwan at this stage has actually reached a certain degree of benefits; for example, the mileage endurance of heavy ETWVs can basically reach 40–60 kilometers, which can meet the existing urban short-distance commuting needs in terms of Taiwan’s urban geography. In addition, most of the subsidy amounts for vehicle purchase fall between US \$145 and US \$721, and after deducting the rebate amount, the amount drops to the point where it is almost the same price as general traditional fuel vehicles, thus, it can still promote certain purchase intentions.

Table 8 Result of Elasticity Analysis.

Variables	Logistic Regression Model	Ordered Logit Model		
		Neutral	Partially agree	Strongly agree
ETWVs are too expensive	-0.06	—	—	—
ETWVs have poor endurance	-0.08			
ETWVs are reasonably priced	0.03			
Exemption of fuel tax/vehicle license tax	0.08			
I am willing to try or continue to use ETWVs	1.19			
Good value for the price of ETWVs	0.82			
Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future	0.07			
Weekly fuel expenses for regular scooters	—	0.01	0.19	0.31
Students' age		0.05	0.74	1.19
Number of people in each household		-0.03	-0.36	-0.58
ETWVs rebate		0.01	0.14	0.23
Exemption of fuel tax/vehicle license tax		0.01	0.05	0.09
Outstanding performances (horsepower and distance)		0.01	0.02	0.04
I am willing to try or continue to use ETWVs		0.04	0.56	0.90
Good value for the price of ETWVs		0.02	0.28	0.45
ETWVs can improve the quality of outdoor activities		0.02	0.32	0.51
Those who are male, have high household income, and are willing to spend more money to purchase ETWVs for environmental reasons		0.01	0.04	0.07

Note: all elasticities are statistically significant at 10% significance level.

Ordered Logit Model (Table 6). The variables of the Ordered Logit Model that affect the degree of purchase intention include “Weekly fuel expenses on regular scooters”, “Students’ age”, “Number of people in each household”, “ETWVs rebate”, “Exemption of fuel tax/vehicle license tax”, “Outstanding performances (horsepower and distance)”, “I am willing to try or continue to use ETWVs”, “Good value for the price of ETWVs”, “ETWVs can improve the quality of outdoor activities”, and “Those who are male, have high household income, and are willing to spend more money to purchase ETWVs for environmental reasons”, in which “Number of people in each household” has negative significant impact and the other factors have positive significant impact.

In terms of weekly fuel expenses on regular scooters, Taiwan’s current ETWV promotion strategy often uses monthly fees as the cost of replacing vehicle batteries. That is to say, if you pay a certain monthly fee every month, you can enjoy unlimited battery replacement services in the contract (but different monthly fees have different total mileage limits). Therefore, the more money spent on fuel vehicles every week, the more attractive the monthly fee scheme of Taiwan ETWVs at this stage. In addition, as the older college students are familiar with university life, the surrounding environment, and the location of charging facilities, they will have more confidence in using ETWVs and their willingness to buy will be higher. Regarding the number of people in each household, due to a large number of vehicles in the household, enough vehicle transport tools have been purchased for their use, thus, they are less willing to buy additional ETWVs. In addition, due to the various governmental subsidy measures, such as ETWVs rebate, exemption of the fuel tax/vehicle license tax, and other measures, the resistance of college students to buy ETWVs can be reduced.

Odds ratio. According to Table 7, the combined variables of “male”, “high household income”, and “regard ETWVs as their first choice when purchasing a vehicle in the future” have the largest odds ratio of 13.95, which indicate that the potential willingness to buy ETWV of those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future, is 13.95 times higher than that of other consumers (due to the large coefficient value, the OR

value is relatively high). The variable of those who think “ETWVs are reasonably priced” are 3.80 times more willing to buy ETWVs than other consumers.

In addition to the odds ratio of the two modes, the significant variables in both modes for “Exemption of fuel tax/vehicle license tax”, “I am willing to try or continue to use ETWVs”, “Good value for the price of ETWVs”, and “ETWVs can improve the quality of outdoor activities”, their willingness to buy ETWVs is 1.17–3.8 times that of other consumers.

Elasticity analysis. Regarding the Logistic Regression Model results (Table 8), when the respondents belong to the four groups of: “ETWVs are reasonably priced”, “Exemption of fuel tax/vehicle license tax”, “Good value for the price of ETWVs”, and “Those who are male, have high household income, and regard ETWVs as their first choice when purchasing a vehicle in the future”, the probability of purchasing ETWVs will increase by 0.03–1.19%; whereas, if they belong to the “ETWVs are too expensive” or “ETWVs have poor endurance” group, the probability of purchasing ETWVs will decrease by 0.06–0.08%. Regarding the Ordered Logit Model results (Table 8), with the exception of “Number of people in each household” every 1% change will reduce the probability of purchasing an ETWV from the neutral to strong range by 0.03–0.58%. Similarly, every 1% change in other variables or those belonging to a specific group will increase the probability of purchasing ETWVs from neutral to strongly agree by 0.01–1.19%.

A further discussion, in terms of weekly fuel expenses for regular scooters, when the user’s weekly fuel costs are higher than a certain amount, the increased probability to buy an ETWV ranges from 0.01 to 0.31%. For example, the basic scheme is designed as the basic consumption (fixed mileage in a single month) with “no regular return to the factory maintenance scheme”; or medium usage (e.g., 300–600 km mileage in a single month) with “regular return maintenance scheme”; or high usage (600–1000 km mileage in a single month) with “regular return maintenance and limited warranty scheme”, which can be achieved through combinations of different warranties and rate schemes, in order to increase the purchase probability of ETWVs.

The older the college students are and the more they agree with buying ETWVs, the probability of buying ETWVs will increase by 0.01–0.31%. This phenomenon shows that the classification of different age groups has an impact on the purchase probability of ETWVs. In the future, when promoting test rides for ETWVs, related experience activities, or marketing strategies, it is suggested to subdivide the age groups of college students; for example, light ETWVs can be promoted among seniors, freshman, and sophomores as short-distance commuting tools for campus, which can allow students to become familiar with the driving mode of vehicles first. At the same time, their first vehicle purchase can be at a cheaper price, which is conducive to the promotion and use of ETWVs.

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Regarding the variable of the number of people in each household, the larger the number of people in each household, the less inclined the household is to buy ETWVs, and the probability to purchase ETWVs will decrease by about 0.03–0.58%. In other words, a small family (parents +2 children) is more inclined to buy an ETWV. If detailed planning can be carried out in market segmentation, such as drawing up an exclusive rate scheme for households with small family population, and designing a specific rate to purchase ETWVs, the corresponding discount amount can be obtained, which should effectively enhance the willingness of families with a small population to purchase ETWVs.

The results of this study show the common characteristics of “high income and male”, meaning male, have high household income, and are environmentally conscious, or regard ETWVs as their first choice when purchasing a vehicle in the future. Therefore, it is suggested to plan different exclusive rates and warranty schemes for male and female income groups and household income levels; for example, if the household income is less than US \$2800, use rates and warranty schemes for lightweight ETWVs that feature lower use rates for short-distance use. If the household income is higher than US \$2800, it is suggested to plan a scheme with a high rate or wide warranty scope, in order to provide such groups with short-range or long-range use without worrying about whether the vehicle warranty can meet the corresponding consumption and maintenance needs.

The results of this study also found that specific government incentives may enhance the purchase intention of ETWVs, such as rebates and exemption of the fuel tax/vehicle license tax. However, the corresponding infrastructure around ETWVs is still

not perfect. At present, the charging network for ETWVs in Taiwan is mainly built by the vehicle manufacturers themselves, while the construction progress of charging facilities by the government still lag behind that of private manufacturers. Regarding the ETWV travel behavior, as corresponding engineered traffic support facilities have not been completely planned, very few areas in the six special municipalities of Taiwan have implemented parking spaces exclusively for ETWVs. Providing a perfect use environment for ETWVs users should effectively enhance the purchase intention of ETWVs.

Conclusion and suggestions

With the rapid development of science and technology, people are pursuing convenient and safe new means of transport. In view of the factors of environmental protection and sustainable development, electric transport is an important choice. Due to the high proportion of vehicles used in Taiwan, if people can be encouraged to use ETWVs instead of traditional fuel vehicles, it should be quite helpful for environmental sustainability.

This study used the Logistic Regression and Ordered Logit models to study the purchase intention of college students. The factors that influence purchase intention include “Weekly fuel expenses for regular scooters”, “Age”, “Number of people in each household”, “ETWVs are too expensive”, “ETWVs have poor endurance”, “ETWVs rebate”, “ETWVs are reasonably priced”, “Exemption of fuel tax/vehicle license tax”, “Outstanding performances”, “Those who tend to agree or more agree with ETWVs”, “Those who are male, have high household income, and are environmentally conscious”, and “Those who are male, have high household income, and are willing to purchase ETWVs”. This study analyzed whether the vehicle characteristics of ETWVs will affect the purchase intention, and pointed out that if there are appropriate incentives or subsidies, the purchase intention can be effectively promoted. Further, the study explored the tendency, attitude, and purchase intention of college students to use electric vehicles, in order to understand the effective measures and supporting facilities to promote the purchase of ETWVs, and the results can serve as a policy reference for promoting the purchase of ETWVs.

In terms of weekly fuel expenses for regular scooters, when the user's weekly fuel costs are higher than a certain amount, the more the user tends to agree to buy an ETWV. This phenomenon clearly shows that users have a certain upper limit for the use cost of fuel vehicles. In the future, college students can be attracted to use ETWVs by planning different warranty rate schemes. The older the college students are and the more they agree with buying ETWVs, suggest that marketing strategies for different age groups, which is conducive to the promotion and use of ETWVs. Segment the market for small families, develop an exclusive rate plan and warranty schemes for male and female income groups and household income levels could effectively enhance the willingness to purchase ETWVs. Finally, in order to effectively enhance the purchase intention of ETWVs, in addition to continuous promotions with the existing incentive support measures, it is suggested that the infrastructure, use environment, and the engineered traffic support facilities of the external environment should be coordinated with governmental planning and development.

Since the ETWV is not popular (in fact, very rare) in Taiwan, people are not familiar with the specifications of ETWV, such as battery replacement and rental policies, recharge time, cruising time and relevant subsidy. Therefore, it is our aim to explore the factors that influence the general intention of college students to buy the ETWV. The results obtained from our study can be viewed as, regardless of what specifications of ETWV are, the willingness of college students to buy ETWV under the influence of certain

variables. One can, of course, design a more complex stated-preference experiment to reflect scenarios which are in line with realistic situations. This can be the next move for the future research.

Data availability

The datasets generated during and/or analyzed during the current study adhere to the principle of data confidentiality. Due to the sensitive nature of the data, they are not publicly available. However, interested parties can request access to the datasets from the corresponding author, and appropriate measures will be taken to ensure confidentiality and data protection.

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Notes

1 USD 1 = NTD 27.71.

2 The sample size was calculated according to the following formula: Sample size = $(Z\text{-score}) \times \text{StdDev} \times (1 - \text{StdDev}) / (\text{margin of error})^2$.

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Author contributions

RCJ: conceptualization, data curation, editing-original draft, writing-reviewing and editing, validation, formal analysis, project administration, funding acquisition. CHL: investigation, data curation, writing-original draft, writing-reviewing and editing, formal analysis, software and visualization. TYC: writing-reviewing and editing.

Competing interests

The authors declare no competing interests.

Ethical approval

This research was approved and funded by the National Science and Technology Council, Taiwan (NSTC: 106-2221-E-260-011-MY3). This study does not involve the collection or analysis of data that could be used to identify participants (including email addresses or other contact details). All information is anonymized and the submission does not include images that may identify the person. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent

Informed consent was obtained from all participants. Participants were college students randomly interviewed face to face at selected universities in Taichung city in 2016. All participants were informed about the purpose and aims of this study, voluntarily participated in the study after the researcher assured them of anonymity and that their responses were solely for academic purposes and the ways the data would be used.

Additional information

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