# Identifying the Factors Affecting the Preference of College Students Towards Electric Motorbikes[1]

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## Introduction

With the development of science and technology, people tend to attach importance to environmental protection and the electric motorbike is becoming more and more popular due to the low emissions (Song et al., 2017a, Song et al., 2017b). Compared with traditional vehicles, the most advantages of electric motorbike are that it will help reduce the emissions of automobile exhaust, reduce urban noise pollution and save energy (IEA, 2009). Hence, the electric motorbike is becoming a very important alternative to improve air quality in urban areas.

To promote the use of the electric motorbike, relevant policies' establishment and implementation require a clear understanding of the consumers' attitudes and the significant effect factor of consumers for purchasing the electric motorbike. However, there is less of the researches on consumers' attitudes and their purchase intention and preference and willingness to pay (WTP). Zhang et al. (2011) indicated that the consumers' awareness of electric vehicle and examined the factors that are most likely to affect consumers' choice for EV in China. Bjerkan et al. (2016) described the role of incentives for promoting battery electric vehicle (BEV) and determined what incentives are critical for deciding to buy a BEV in Norway. As people attend to accept high-quality incentives (Gneezy and Rustichini, 2000), to capture the satisfy motivation of people expectations will improve the behavior change(Cameron et al., 2001; Cameron and Pierce, 1994)。

limited by the real market data available, stated choice experiments as a current popular tool to study the factors influencing of electric vehicles. The participants were presented with a set of vehicle and other alternatives vehicle and then choosing their preferred alternative by trading-off key attributes such as purchase price, running costs, environmental performance, safety, range, and recharging considerations (Hess et al., 2006; Lieven et al., 2011; Ziegler, 2012; Bühler et al., 2014).

It is worth pointing out that the study explores the influencing factors or incentives that could encourage families to purchase electric motorbike is very important. we tend to focus exclusively on the strategy that is targeted at promoting electric motorbike adoption through incentives such as providing the monetary subsidy, tax, parking policy, and warranty difference of the motorbike to propose a more realistic choice situation that potential college students are thinking about and comparing policies that affect the utility of all the alternatives. The results obtained in the study will help policy makers and managers to better understand the purchase behaviors and preferences of young people and can provide some effective supports for policies designed to promote electric motorbike in Taiwan.

## Model Methodology

Refer to Yen and Jones (1997) indicated the IHS transformation on a random variable $v$ is defined

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over all values of parameter $\theta$ as below:

$$T(\nu) = \log\left[\theta\nu + \left(\theta^2\nu^2 + 1\right)^{1/2}\right]/\theta \\ = \sinh^{-1}(\theta\nu)/\theta \tag{1}$$

Because the transformation is symmetric about zero in 0, one can consider only $\theta > 0$. The transformation is linear when $\theta$ approaches zero and behaves logarithmically for large values of $\nu$; it is scale invariant and is well suited for handling extreme values (Burbidge, Magee, and Robb). To introduce the IHS transformation into the double-hurdle model, consider latent participation $d_i^*$ and latent consumption $y_i^*$ as linear functions of the first-hurdle regressor $z_i$ and second-hurdle regressor $x_i$:

$$d_i^* = z_i^{'}\alpha + \nu_i \\ y_i^* = x_i^{'}\beta + \varepsilon_i \tag{2}$$

where $\alpha$ and $\beta$ are conformable parameter vectors, and the random errors $[\nu_i, \varepsilon_i]'$ are normally distributed with zero mean and variance-covariance matrix:

$$\sum_i \begin{bmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_i^2 \end{bmatrix} \tag{3}$$

The standard deviation $\sigma_i$ is allowed to vary across observations, accommodating heteroscedasticity of $\varepsilon_i$. The observed dependent variable $y_i$ related to the latent variables such that

$$T(y_i) = y_i^* \text{ if } d_i^* > 0 \text{ and } y_i^* > 0 \\ = 0 \text{ otherwise} \tag{4}$$

Let $\phi(\cdot)$ and $\Phi(\cdot)$ be the univariate standard normal probability density function and cumulative density function, respectively, and let $\psi(\cdot,\cdot,\cdot)$ be the bivatiate standard normal cumulative density function with correlation coefficient $\sigma_{12}/\sigma_i$. Using equations (1), (2), (3) and (4), the sample likelihood function for an independent sample pf $n$ observation can be written as:

$$L = \prod_{i=1}^{n}\left[1 - \Psi\left(z_i^{'}\alpha,\ \frac{x_i^{'}\beta}{\sigma_i},\ \frac{\sigma_{12}}{\sigma_i}\right)\right]^{1-I_i} \times \left\{\left(1+\theta^2 y_i^2\right)^{-1/2}\frac{1}{\sigma_i}\phi\left[\frac{T(y_i) - x_i^{'}\beta}{\sigma_i}\right]\Phi\left[\frac{z_i^{'}\alpha + (\sigma_{12}/\sigma_i)\left[T(y_i) - x_i^{'}\beta\right]/\sigma_i}{\left[1-(\sigma_{12}/\sigma_i)^2\right]^{1/2}}\right]\right\}^{I_i} \tag{5}$$

Where $I_i$ is a dichotomous index such that $I_i = 1$ if $y_i = 1$ and $I_i = 0$ otherwise. Detailed derivation of the likelihood function is available from the authors.

The likelihood function (5) nest a range of interesting specifications considered in the literature. First, when $\theta = 0$, the model reduces to the dependent double-hurdle model (Blaylock and Blisard, Blundell and Meghir, Jones). Second, setting $\sigma_{12} = 0$ leads to the HIS double-hurdle model with independence. Third, zero restrictions on both $\theta$ and $\sigma_{12}$ reduce the model to the double-hurdel model with dependence (Atkinson, Gomulka, and Stern; Blundell and Meghir; Cragg). Forth, seting $\Phi\left(z_i^{'}\alpha\right) = 1$ in the independence HIS double-hurdle model leads to the HIS Tobit model (Reynolds and Shonlwiler). Finally, setting $\theta = 0$ in the HIS Tobit model leads to the Tobit model. Tests of the full model against these nested models can be done by regular means.

To accommodate heteroscedasticity of the error term $\varepsilon_i$, the standard deviation $\sigma_i$ can be specified as:

$$\sigma_i = \exp\left(w_i\gamma\right) \tag{6}$$

Where $w_i$ is a vector of exogenous variables and $\gamma$ is a conformable parameter vector.

**Data Analysis**

The survey had a little difference between male and female respondents, with a slightly the higher percentage of males (55.1%) than females. The large part of college students' age of the survey is between 19 and 22 years (80.2%). The average household monthly income of students is about NT$40,000-80,000 (38.3%). A majority of students in the survey come from short-term trip every day (84.3%). Most of the travel distance is between 1 and 3 kilometers (32.4%). The average of a trip time is 6-15 minutes (51.8%). The average travel speed is 51-60km/hr and follows by the 61-70km/hr and 41-50km/hr. the price of the current riding scooter of most students is NT$60,000-80,000, secondly is NT$40,000-60,000. The average maintenance cost every year is NT$1,000-1,999 (32.7%). Table 1 shows that the WTP of college students' to purchase the electric motorbike. We divided three part to discuss. Such as the willingness to replace the original motorbike, do not willingness to replace the original motorbike, but assume to purchase the motorbike in the future, and the total sample of replacing or assuming to purchase the motorbike. Generally speaking, the students' true intentions of purchasing or replacing the electric motorbike have higher willingness to pay.

Table1 Descriptive statistics for WTP and mobility characteristics

| Item | Number | WTP | Year |
|---|---|---|---|
| Willingness to replace the original motorbike | 278 | 57,527 | 5.7 |
| scooter I | 10 | 48,500 | 5.0 |
| scooter II | 86 | 53,977 | 5.3 |
| motorcycle | 24 | 53,750 | 4.6 |
| electric moped | 5 | 57,000 | 9.2 |
| electric scooter I | 48 | 57,354 | 5.7 |
| electric scooter II | 105 | 62,261 | 6.1 |
| Do not willingness to replace the original motorbike, but assume to purchase the motorbike in the future | 624 | 51,105 | 6.5 |
| scooter I | 42 | 45,595 | 7.1 |
| scooter II | 304 | 48,023 | 6.4 |
| motorcycle | 156 | 54,202 | 6.1 |
| electric moped | 6 | 43,667 | 5.4 |
| electric scooter I | 34 | 55,088 | 8.3 |
| electric scooter II | 82 | 58,354 | 7.3 |
| The total sample of replacing or assuming to purchase the motorbike | 902 | 53,084 | 6.3 |
| scooter I | 52 | 46,154 | 6.7 |
| scooter II | 390 | 49,336 | 6.1 |
| motorcycle | 180 | 54,142 | 5.9 |
| electric moped | 11 | 49,727 | 7.1 |
| electric scooter I | 82 | 56,415 | 6.8 |
| electric scooter II | 187 | 60,548 | 6.7 |

* The horsepower of scooter I is between 7 and 8; the horsepower of scooter I is between 5.2 and 8.8; the horsepower of motorcycle is between 8.5 and 18.4; the horsepower of electric moped is less than 1.34; the horsepower of electric scooter I is between 1.35 and 4.9; the horsepower of electric scooter II is between 5 and 8.5

The survey instrument comprised a questionnaire designed to capture traditional motorbike college students' travel behavior, use characteristics of the motorbike, choice decisions of the electric motorbike, socio-demographic characteristics, and attitudinal information. The choice component of the questionnaire was designed to explore the electric motorbike purchase decisions using a scenario design. Approximately more than 900 college students completed two choice scenarios of long term and short term trips were designed by considering six purchasing alternatives with various incentive attributes and fully responded to the questions. Six motorbikes alternatives: scooter I, scooter II, motorcycle, electric moped, electric scooter I, and electric scooter II were given in each scenario. Attributes identified against each alternative, along with their levels, are given in Table 2. The Attitudinal component of the questionnaire included 26 items measuring the six attitudinal dimensions (environmental concerns, EC;

purchasing and using intention, UPI; use confidence, UC; price, PX; policy, POL; Perceived Usability and ease of use, PU) presented in Table 2.

Table2 Attributes and attribute levels for design of the choice experiments

| Vehicles types | scooter I | scooter II | motorcycle | electric moped | electric scooter I | electric scooter II |
|---|---|---|---|---|---|---|
| *General characteristics* | | | | | | |
| License style | written in black on a white background | written in black on a white background | written in black on a white background | written in red on a white background | written in black on a green background | written in black on a white background |
| Maximum capacity (people) | 2 | 2 | 2 | 1 | 2 | 2 |
| *operational efficiency* | | | | | | |
| Horsepower (hp) | 7~8 | 5.2~8.8 | 8.5~18.4 | <1.34 | 1.35~5 | 5~8.58 |
| Top speed (km/ hr) | 90~100 | 105~110 | 120 | 45 | 40~50 | 90 |
| Driving range (km) | 100 | 140 | 150 | 65 | 100 | 110 |
| Recharge time (hr) | - | - | - | 2~3 | 4~6 | replacement |
| *Vehicle cost* | | | | | | |
| Purchase price (NT$ 10000) | 4.8~7.8 | 4.9~8.4 | 7.4~15.8 | 5.7~6.8 | 7.2~8.2 | 7.4~12.9 |
| Maintenance cost (NT$/year) | 2,000 | 2,500 | 3,000 | 1,000 | 1,000 | 1,100 |
| Fuel cost (F), Recharge cost (R), The rental price of battery (B) (NT$/year) | Short trip[*1]: 2500(F) Long trip[*1]: 5000(F) | Short trip: 2800(F) Long trip: 5500(F) | Short trip: 3000(F) Long trip: 5800(F) | Short trip: 120(R)+5000(B) Long trip: 250(R)+5000(B) | Short trip: 160(R)+6500(B) Long trip: 350(R)+5000(B) | Short trip: 6000(B) Long trip: 7200(B) |
| *Incentive*[*2] | | | | | | |
| Incentive money (NT$) | 0 | 0 | 0 | +25% base[*3] +50% base +75% base | +25% base[*3] +50% base +75% base | +25% base[*3] +50% base +75% base |
| Parking fee (NT$/hr) | +25% base[*4] +50% base +75% base | +25% base[*4] +50% base +75% base | +25% base[*4] +50% base +75% base | 0 | 0 | 0 |
| Battery warranty | Unlimited, NA | Unlimited, NA | Unlimited, NA | 30,000 km/3 yr 60,000 km/5 yr 90,000 km/8 yr | 30,000 km/3 yr 60,000 km/5 yr 90,000 km/8 yr | 30,000 km/3 yr 60,000 km/5 yr 90,000 km/8 yr |
| Tax (NT$/year) | +25% base[*5] +50% base +75% base | +25% base[*5] +50% base +75% base | +25% base[*5] +50% base +75% base | 0 | 0 | 0 |

[*1]Short trip means that the scenario of a single travel distance is under 10 km; long trip means that the scenario of a single travel distance is more than 10 km

[*2] In the incentive attribute, the questionnaire of six vehicle types is divided into two scenarios. R2P SC means that the scenario of replacing two-stroke motorbikes and purchase the new scooter; R4P SC means that the scenario of replacing four-stroke motorbikes and purchase the new scooter

[*3]In the R2P SC, the base incentive money of electric moped is NT$24,200, In the R4P SC, the base incentive money of electric moped is NT$13,700; In the R2P SC, the base incentive money of electric scooter I is NT$27,000, In the R4P SC, the base incentive money of electric scooter I is NT$16,500; In the R2P SC, the base incentive money of electric scooter II is NT$29,000, In the R4P SC, the base incentive money of electric scooter II is NT$18,500

[*4]The base parking fee of scooter and motorcycle is fixed at NT$20 in both R2P SC and R4P SC

[*5]The base tax of scooter I and scooter II is NT$450 in both R2P SC and R4P SC; the base tax of motorcycle is NT$1,400 in both R2P SC and R4P SC

## Model Estimation Results

The results of the comparison between the Tobit model with random parameter and the traditional Tobit model are shown in Table 3. The Tobit model with random parameter fit better than the traditional Tobit model based on the AIC value.

The coefficient of the variable means that the variable increases the probability of the willingness to purchasing the electric motorbike of the college students' behavior when the coefficient is positive. The coefficient of standard deviation means the estimation of the standard deviation of the normal distribution that the variable was subjected to. That the corresponding p-value is less than 0.05 indicates that the standard deviation of the normal distribution that the variable was subjected to is not statistically equal to zero. That means the coefficient of the variable was exactly subjected to the normal distribution whose mean value is the estimation of the coefficient of the variable and the standard deviation is the estimation of the coefficient of standard deviation.

Table 3 The estimation of Fixed and Random-Parameters Tobit Model

| | Fixed parameters model | | Random parameters model | |
|---|---|---|---|---|
| Variables | Coef. | t-ratio | Coef. | t-ratio |
| Constant | 4.429*** | 32.720 | 0.260*** | 33.380 |
| *Standard deviation of parameter distribution* | | | 0.803*** | 7.440 |
| The distance of single trip is 5-20 km by using the motorbike. | 0.407* | 1.950 | 0.597*** | 4.070 |
| *Standard deviation of parameter distribution* | | | 0.449*** | 3.780 |
| The average income of household is more than NT$100,000. | - | - | 0.324** | 2.450 |
| *Standard deviation of parameter distribution* | | | 0.148* | 1.890 |
| The expense of gas per week is more than NT$110 by using motorbike. | 0.562*** | 3.280 | 0.420*** | 2.910 |
| *Standard deviation of parameter distribution* | | | 0.082*** | 9.660 |
| The incentive money of purchasing electric motorbike is more than NT$20,000. | 0.414** | 2.000 | 0.289* | 1.740 |
| *Standard deviation of parameter distribution* | | | 0.628*** | 5.170 |
| I believe that the electric motorbike as my main transportation for weekday activities is reliable. | 0.273* | 1.650 | 0.386** | 1.980 |
| *Standard deviation of parameter distribution* | | | 0.846*** | 6.180 |
| I willing to purchase or replace the electric motorbike because of incentive program. | 0.508* | 1.880 | 0.588** | 2.470 |
| *Standard deviation of parameter distribution* | | | 0.668** | 2.160 |
| I agree that the electric motorbike price is reasonable. | 0.392** | 2.200 | 0.297* | 1.930 |
| *Standard deviation of parameter distribution* | | | 0.115*** | 5.480 |
| The parking expense of motorbike per month is more than NT$100. | 0.329* | 1.710 | 0.280* | 1.710 |
| I agree that the incentive policy of government is very attracting me. | 0.286* | 1.730 | 0.337** | 2.380 |
| sigma | 2.220*** | 42.080 | 0.855*** | 43.030 |
| Number of observations | | 902 | | 902 |
| LL(0) | | -2027.8 | | -1989.1 |
| LL(b) | | -1991.7 | | -1933.6 |
| AIC | | 4003.4 | | 3905.3 |

Note: *** indicates a significance level of 1%; ** indicates a significance level of 5%; * indicates a significance level of 10%

Maximum likelihood estimates for the double-hurdle model of commuter’ decisions to purchase the electric motorbike are presented in Table 4. The highlights of the estimation results follow: first, the the Gamma is 0.126 means that the IHS parameter is significant at the 0.01 level for all IHS transformed specifications, justifying the transformation; second, Tobit parameterization is rejected and heteroscedasticity of errors is present for all models estimated. In other words, the significance of the IHS parameter suggests non-normality, and significance of income in the heteroscedasticity equation suggests heteroscedasticity of the error terms. Thus, the use of the heteroskedastic and IHS transformed specification is justified. As the above reason, only the results of the HIS Double-Hurdle Model were interpreted in the later

The results from the HIS Double-Hurdle Model show that the following factors have a positive impact on willingness to purchasing the elector motorbike of college students: average income, the price of purchasing the motorbike, the expense of gas per week by using motorbike, the incentive money of purchasing electric motorbike, the tax of motorbike of one year, willing to purchase or replace the electric motorbike because of incentive program, agree using the electric motorbike is contributed to the sustainable development of the environment, agree using the electric motorbike is contributed to the sustainable development of the environment and agree using the electric motorbike is helped to my trip activities outside.

Table 4 The estimation of Independent HIS Double-Hurdle Model

| Variables | Coef. | t-ratio |
|---|---|---|
| *Participation Equation* | | |
| Constant | 2.124*** | 0.890 |
| The distance of single trip is 5-20 km by using the motorbike | 0.763* | 1.720 |
| Both the motorbike and car are the main transportation of weekday activities. | -0.607* | 1.860 |
| I believe that the travel distance of electric motorbike match up to the destination. | 0.746** | 2.050 |
| *Expenditure Equation* | | |
| Constant | 4.239*** | 6.970 |
| The average income of household is more than NT$100,000 | 0.174** | 2.140 |
| The price of purchasing the motorbike was more than NT$50,000 | 0.305*** | 3.560 |
| The expense of gas per week is more than NT$110 by using motorbike | 0.189** | 2.170 |
| The incentive money of purchasing electric motorbike is more than NT$20,000 | 0.236** | 2.120 |
| The tax of motorbike of one year is more than NT$980. | 0.184* | 1.830 |
| I willing to purchase or replace the electric motorbike because of incentive program | 0.278** | 2.010 |
| I agree using the electric motorbike is contributed to the sustainable development of the environment. | 0.174* | 1.820 |
| I agree that the electric motorbike price is reasonable. | 0.160* | 1.830 |
| I agree using the electric motorbike is helped to my trip activities outside. | 0.182** | 2.190 |
| Sigma | 1.133*** | 10.770 |
| *Heteroskedasticity Equation* | | |
| Besides motorbike, the second main transportation of trip activities is the private car. | -0.151** | 2.070 |
| Besides motorbike, the second main transportation of trip activities is the city bus. | -0.092* | 1.710 |
| Rho(u,e) | -0.783*** | 3.260 |
| Gamma | 0.126*** | 3.250 |
| Number of observations | 902 | |
| LL(0) | -1990.4 | |
| LL(b) | -1555.7 | |
| AIC | 3149.5 | |

**Conclusions and Recommendations**

This paper aims to determine the factors influencing college students' decisions to purchase the electric motorbike and how much to spend on the energy saving mode items in Taiwan. Approximately 900 college students completed two choice scenarios of long term and short term trips were designed by considering six purchasing alternatives with various incentive attributes and fully responded to the questions.

The analysis applied random parameter Tobit, IHS double-hurdle methodologies, adjusted for the problems of heteroscedasticity and non-normality, to the college students' decisions to purchase the electric motorbike and how much to spend on the energy saving mode items in Taiwan datasets. This study also demonstrates that the IHS heteroscedastic Double-Hurdle model was statistically superior to the random parameter Tobit model. The IHS double-hurdle model was found to be the most appropriate modeling technique.

The observed decline in the estimated income elasticities accompanied by the significant non-linear relationship between tax, incentive and willingness to pay on purchasing electric motorbike provides evidence. That is, as tax of traditional scooter and the incentive money of purchasing electric motorbike increases, the influence it has on purchasing decisions increase in importance. Understanding the factors shaping purchasing decisions becomes increasingly important with increasing tax and incentive levels.

On the other hand, the results also show that the average income of the household, the purchasing price of the motorbike, fuel expense of using a motorbike, and concerns about the sustainable development, purchase price and help for the travel activities were identified as a significant preference of current motorbike college students. Related agencies can use our study's findings as the basis for determining the electric motorbike price and incentive policy of promotion that can increase the acceptance and usage of urban motorbike college students towards an electric motorbike.

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**References**

Bühler, F., Franke, T., Cocron, P., Schleinitz, K., Neumann, I., Ischebeck, M., Ktrems, J.F., 2014. Driving an EV With No Opportunity to Charge at Home.

Cameron, J., and Pierce, and W. D., (1994). Reinforcement, reward and intrinsic motivation: A meta-analysis. Review

Cameron, J., Banko, K. M., and Pierce, and W. D., (2001). Pervasive negative effects of rewards on intrinsic motivation: The myth continues. The Behavior Analyst, 24, pp. 1-44.

choice. Transp. Res. Part B 40, 147–163.

Gneezy, U. and Rustichini, A., (2000). Par enough or don't pay at all. Quarterly Journal of Economics, 115, pp. 791-810.

Hess, S., Train, K.E., Polak, J.W., 2006. On the use of a modified Latin hypercube sampling (MLHS) method in the estimation of a mixed logit model for vehicle

IEA, 2009. World Energy Outlook 2009. Paris, France.

Lieven, T., Mühlmeier, S., Henkel, S., Waller, J.F., 2011. Who will buy electric cars? An empirical study in Germany. Transp. Res. Part D 16, 236–243.

Song, Q., Li, J., Duan, H., Yu, D., Wang, Z., 2017a. Towards to sustainable energy-efficient city: a case study of Macau. Renew. Sust. Energy Rev. 75, 504–514.

Song, Q., Wu, Y., Li, J., Wang, Z., Yu, D., Duan, H., 2017b. Well-to-wheel GHG emissions and mitigation potential from light-duty vehicles in Macau. Int J. Life Cycle Assess. 1–12.

Yen, S. T. and Jones, A. M., 1997. Household Consumption of Cheese: An Inverse Hyperbolic Sine Double-Hurdle Model with Dependent Errors. American Journal of Agricultural Economics, 79. pp. 246-251.

Zhang, Y., Yu, Y., Zou, B., 2011. Analyzing public awareness and acceptance of alternative fuel vehicles in China: the case of EV. Energy Policy 39, 7015–7024.

Ziegler, A., 2012. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: a discrete choice analysis for Germany. Transp. Res. Part A 46 (8), 1372–1385.