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RESEARCH ON FACTORS AFFECTING DEMAND FOR ELECTRIC BIKES IN VIETNAM

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ABSTRACT

The widespread change in means of fuel-consumption vehicles is creating traffic pressure in urban areas, leading to dire consequences for the area's environment. Faced with this challenge, Vietnam has set the goal of controlling the emissions. Hence, using electric vehicles in general and electric bicycles in particular is becoming a sustainable and environmentally friendly consumption trend. With survey data collected, the survey analyzed factors affecting the demand for electric bikes in Vietnam in the green fuel era. Results from the analysis show that Price, Income, Price of related goods, and a number of factors about vehicle characteristics and demographics have high statistical significance, affecting people's decision to own electric bicycles. From there, businesses that produce, sell, and distribute electric bikes can refer to research results; they can make more precise production plans, business decisions, market strategies, and innovative product quality to meet the market demand.

KEYWORDS: Demand, electric bikes, E-Bikes, green energy, pollution.

1. INTRODUCTION

In Vietnam, gasoline cars are fairly popular, the main cause of dense traffic. Vehicle quality is decreasing, causing vehicles to operate less efficiently and consume more fuel, increasing emissions, and directly causing environmental pollution. Toxic emissions from motorbikes such as CO2, NOx, and some other toxic emissions not only cause the greenhouse effect, which is a global problem, but also directly affect the quality of life of residential community (Linh, T.T, 2018).

Two-wheeled electric vehicles become the solution to this problem because their electric motors do not release any toxic smoke and do not make noise. Accordingly, with the electric motor and power pedals, electric bikes have become a vehicle with great potential to replace gasoline-powered vehicles.

An **electric bike** is a two-wheeled bicycle, operated by a DC electric motor or operated by a foot pedal-assisted by a DC electric motor, with a maximum motor capacity of not more than 250 W, has a

maximum design speed of not more than 25 km/h and a mass (including battery) of not more than 40 kg. (According to Circular 41/2013/TTBGTVT)

Each individual using an electric bike can save up to 225kg of CO2 per year (McQueen, MacArthur & Cherry, 2020). Awareness about environmental protection is increasing, contributing to an increase in the number of cars sold in Vietnam. In addition, the market has many cars with different designs produced domestically and imported from abroad at relatively low prices. Previously, the price of an imported electric bike ranged from 18 - 20 million VND, but today, the price of each model has decreased significantly.

The trend of using electric bikes (E-Bikes) in Vietnam has recently been growing. In 2019, there were a total of about 5 million electric bikes in use (Huu & Ngoc, 2021) and the growth rate in the number of electric bikes sold annually is high (Thuy & Hong, 2019). Electric bikes are suitable for many ages, in the past they were mostly used by students (Chu, 2017), but today the trend is increasingly expanding, attracting many older customers, or those with disabilities, or employers.

The electric bike market in Vietnam has many opportunities to develop. Thanks to the government's sustainable development goals on reducing emissions, taxes are placed on gasoline vehicles and a number of policies are introduced to subsidize electric vehicles. Furthermore, development cooperation with EU countries promotes technology transfer projects, which is a premise for businesses to innovate electric bike products. The high rate of urbanization helps people to improve their quality of life, thus prioritizing the use of environmentally friendly vehicles such as electric bikes. In the context of the energy crisis causing oil prices to increase from 2022, the cost of operating gasoline vehicles increases significantly, people gradually switch to two-wheeled electric vehicles to save costs.

Realizing the significance of the field, the research team carry out the "***Research on factors affecting the demand for electric bikes in Vietnam***". The research objective is to synthesize the characteristics of electric bikes, take an overview of the market, and analyze factors affecting the demand for electric bikes in Vietnam, thereby implicate possible solutions for businesses to make decisions and at the same time, support the government in planning policies and legal corridors, preparing for the growing of this mode of transport.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Theory of Demand and factors affecting demand

The theory of demand for goods and services has been presented and applied in many scientific research works and textbooks on Microeconomics. In this study, in order to evaluate the factors affecting the demand for electric bikes, the research team applied the theory of demand in the documents of (Anh & Duong, 2021), (Huong & Duong, 2020) and (Duong, 2012).

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Demand (D) is the quantity of goods or services that buyers are able and willing to buy at different prices in a certain time, under the condition that other factors remain unchanged.
Quantity demanded (Q^D) is the quantity of goods and services that buyers are willing or able to buy at a certain price in a certain period of time, under the condition that other factors remain unchanged.

The quantity demanded of a certain type of good or service tends to increase when the price of that good or service decreases and vice versa (with other factors remaining constant).

To be able to grasp and predict the consumption of goods, businesses need to profoundly understand the influence of factors on demand for their products. Theoretical analysis of factors affecting demand helps businesses make production and business decisions and supports the government in planning appropriate policies for each specific market. For each group of goods and services, the factors affecting demand will be different. However, there are a number of key factors that can affect the demand and quantity of goods demanded:

Table 1: Factors affecting demand and quantity demanded

Factors	Effect	Correlation
Px: Price of goods	Px ↑→ Q^Dx↓	Negative
	Px ↓ → Q^Dx ↑	
I: Income	Common goods: I↑ → Dx↑	Positive
	Low-quality goods: I↑ → Dx↓	Negative
N: Population	N↑ → Dx↑	Positive
	N↓ → Dx↓	
Py: Price of related goods	Subsitute goods: Py↑ → Dx↑	Positive
	Complementary goods: Py↑ → Dx↓	Negative
T: Trend	T↑ →Dx↑	Positive
E: Expectation	E↑ → Dx↑	Positive

Dx: Demand for X

Q^Dx: Quantity demanded for X

Source: Based on (Anh & Duong, 2021)

2.2. Literature review

According to McQueen, MacArthur & Cherry (2020) electric bikes are considered a promising solution to reduce the impact of the greenhouse effect. The study used data from a survey in Portland, USA of e-bike owners. Estimated results show that if 15% of people cycle more than 1 mile (equivalent to 1.6km), the percentage of people traveling by car will decrease from 84.7% to 74.8%. From there, it is possible to reduce the number of people traveling by car per mile from 28.9 million to 25.5 million people in the total number of people traveling by car in a day. These estimates show that e-bikes have the potential to help cities and regions achieve climate sustainability goals through significant reductions in per capita emissions.

Research results of (Linh, T.T, 2018) shows that using electric vehicles in general and electric bikes in particular is a popular trend in the future and is environmentally friendly. The number of electric bikes in recent years has increased rapidly with the main customers being students. The average interviewee is 42 years old, most of the interviewees are students with an average income of 4.8 million VND/month. Analysis results show that the electric bike brand preferred by consumers is Honda, most purchases of electric bikes are referred mainly from friends, colleagues, neighbors or people who have used them. The descriptive results also show that respondents rated electric bikes as having no engine noise when in use and the majority were satisfied with their purchasing decision. However, in reality, the majority of respondents said that electric bikes are not a means of traveling long distances, and the charging time is long.

Duc, N.H. (2017) started the problem from the fact that the traffic situation was not well managed. Traffic jams occur continuously during rush hours, air quality in the city is greatly affected by dust from gasoline-powered vehicles such as cars and motorbikes, creating many serious problems for the elderly, health of the community. Therefore, with a large number of people participating in traffic, mainly students, and commuters, if they use electric bikes instead of gasoline cars to serve their transportation needs, air quality and pollution will be affected. Urban noise will be significantly improved. The main reasons for promoting the use of e-bikes include environmental factors, operating costs and natural resources. Increased use of e-bikes could reduce emissions from fossil fuel motor vehicles, improve air conditions and reduce noise in densely populated areas. Furthermore, the operating fuel cost for electric motors will be lower than the cost of gasoline and oil for motorbikes and cars. Replacing gasoline vehicles also contributes to reducing pressure on the supply of gasoline and oil from domestic exploitation and imports.

Khanh (2018) focused on analyzing factors affecting electric bike consumption behavior of customers, mainly high-school students and university students. The study proposed a structural model of the relationship between the model's components and behavioral intentions. Factor analysis (EFA) was performed to test the construct validity, and confirmatory factor analysis (CFA) was used to test the significance of the proposed hypothesized models. The results show that the factors Subjective Norm, vehicle price, impact of Government policies, and usefulness of using electric bikes are factors that

affect behavioral intention to consume electric bikes; in which Subjective Norms and Vehicle Price have the greatest impact on behavioral intention to use electric bikes. Environmental awareness factors are not predictive variables for students' behavioral intention to consume electric bikes.

Yannick, R. (2023) took a new approach to limited range of travel. Theoretically, electric bikes do not have the problem of range to the desired destination because the rider has the option of pedaling the bike instead of the electric motor. Furthermore, some manufacturers integrate driver assistance modes with varying intensities based on previous energy consumption and actual battery charge. However, these modes are based on past historical data. So in many different situations, drivers will have difficulty calculating the power demand for routes and deciding when to use a specific assistance intensity accordingly. In fact, they face the challenge of adjusting the mode and constant power usage throughout the entire trip so that both electric driving and cycling can be done properly, at various points until reaching the destination.

Research by Dinh, D.D & Nam, V.H (2023) on the factors that determine the driving behavior of e-bike drivers at school age has shown a common problem when using e-bikes; and in Vietnam is traffic safety. Students are the main consumers of the electric bike market. According to research results, currently, students using electric bikes are fully equipped with knowledge about traffic safety and said that the majority of other people riding electric bikes also obey traffic laws. Furthermore, families' commitment to complying with traffic safety laws is also a positive factor in students' driving behavior.

Özlem, S., Christian, A.K (2019) built a linear structural model (SEM) to analyze data collected from an online survey to evaluate the impact of psychological factors and other factors. Demographic factors for electric bike demand. The results show that the majority of electric bike users and non-users believe that weather and road conditions are a major problem affecting the driving process. In addition, factors such as range of travel and infrastructure such as charging stations for electric bikes are important factors in choosing to use electric bikes. However, the motivation for people willing to buy electric bikes is to contribute to environmental protection and improve their own health through cycling. A limitation of the study is that the survey was conducted on a Facebook post, thus reducing the representativeness of the group of e-bike users, causing the sample to be biased.

Yasir, A and partners (2022) also applied linear structural modeling (SEM) with data collected from the spread survey method (Snowball sampling) to evaluate psychological, financial and economic factors. Individual capacity for electric bike demand in China. The factor of cost savings during use has the greatest influence on the decision to buy a car. Besides, an increase in price has a negative impact on the intention to use a car. Meanwhile, low travel speed (20 to 30km/h) is a positive factor for the demand for electric bikes due to ensuring traffic safety and saving energy when traveling. However, psychological factors, awareness of electric bikes and the benefits that this vehicle brings, do not have much influence on people's purchasing decisions.

Popovich and partners (2014) conducted a qualitative study, based on interview data from 27 electric bike owners, to study factors affecting the experience of using the vehicle. Speed and acceleration are higher than conventional bicycles which is a positive factor affecting the demand for electric bikes. This is a feature that promotes the decision to buy a bike for people with physical limitations or who want to cycle with less effort, giving them more experience, ignoring difficulties in terms of distance and weather conditions. details. However, the study results showed some negative aspects stemming from safety concerns, difficulty of use, and limited range of movement. In addition, awareness of the role of electric bikes in protecting the environment has not been raised and some people who do not use bicycles consider the price and maintenance costs of bicycles to be a major barrier.

Fishman & Christopher (2015) concluded that e-bikes have been shown to provide physical benefits to riders with sedentary lifestyles, allowing them to use them more frequently and for longer periods of time than riders of regular bike. Furthermore, the ability to maintain speed with less effort than traditional cycling is said to be a driving force behind the use of e-bikes, especially in poor weather conditions. As electric motors replace gasoline-powered motor vehicles, electric bikes bring clear environmental benefits. Traveling by electric bike emits much less carbon dioxide from the power plant than a gasoline vehicle traveling the same distance. The practicality and utility of electric bikes are also very important to vehicle users.

Sarmad & Johan (2020) pointed out that in developing countries such as Vietnam, China or India, the power grid structure is mainly based on thermal power, produced from fossil fuels. Therefore, in reality, electric bikes are not completely environmentally friendly, but it can be said that electric bikes save more greenhouse gas emissions than gasoline-powered vehicles. The study also shows that positive factors affecting the demand for two-wheeled electric vehicles are energy saving, low infrastructure construction costs, low operating costs, and reasonable prices. In addition, some major barriers to the demand for this product are the government's lack of subsidy policy and people's awareness of the role of electric bikes has not been raised.

3. RESEARCH METHODS

Theoretical research methods

The research team carried out desk Research to clarify the theoretical basis of Demand; Factors affecting demand for electric bikes (E-Bikes).

The article reviews researches on Demand for goods and services and on E-Bikes through academic databases, including: the Researchgate, ScienceDirect, IEE Explore, Scopus, Emerald, Insight, Taylor & Francis Online, in addition to the Google Scholar search engine and information pages about electric vehicles in general and electric bikes in particular.

From there, the team identified factors affecting the demand for E-Bikes and specific conclusions were made about the degree of influence of each factor.

Practical research methods

Based on the factors affecting the demand for E-Bikes, the research team developed a survey questionnaire. After completing the form, a test survey was conducted.

Then, the forms were sent to individuals via the Google Form platform (https://docs.google.com/forms/d/e/1FAIpQLSf1MPZPLSqlJ--d8US8cBVufZT0IcGsxU2O8kdiTop6mo4YXw/viewform), the total number of forms collected was 326.

Based on the factors, along with the market demand analysis method on the econometric model, the project estimates the demand for E-Bikes. Specifically: With 2 price factors of E-Bikes (P_{XMD}), the price of related goods, includes the price of substitute goods - electric motorbikes (PXMD) and the price of complementary goods – battery/accumulator price (P_{AQ}), the research team formulated a regression equation to identify the relationship between these factors and the demand for E-Bikes.

General model:

$$\mathbf{Q = a*P + b \ (1)}$$

In which: **P** is the price of E-Bikes; **Q** is the demand for E-Bikes (representing the survey subjects' willingness and ability to afford). a, b are coefficients.

$$\mathbf{Q_{XDD} = c*P_{XMD} + d \ (2)}$$

In which: $\mathbf{P_{XMD}}$ is the price of electric motorbikes (a substitute for E-Bikes); $\mathbf{Q_{XDD}}$ is the quantity demanded of E-Bikes (representing the survey subjects' willingness and ability to afford E-Bikes when there is a change in the price of substitute goods). c, d are coefficients.

$$\mathbf{Q_{XDBS} = e*P_{AQ} + f \ (3)}$$

In which: $\mathbf{P_{AQ}}$ is the price of complementary goods of E-Bikes; $\mathbf{Q_{XDBS}}$ is the demand for electric bikes (representing the survey subjects' willingness and ability to afford electric bikes when there is a change in the price of additional goods). e, f are coefficients.

The procedure for analyzing is taken as follows:

Step 1: Use EViews 8 software to run the model with collected secondary data.

Step 2: Check the statistical significance of the regression coefficients with the explanatory variables and the statistical significance of the regression model with a significance level $\alpha=0.05$. A regression coefficient is statistically significant if:

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- Prob < α=0.05
- Prob(F-statistic) < α=0.05

Step 3: Check the explainability of the model through the coefficients R–squared and Adjusted R–squared. A model is explanatory (fit) if:

- R–squared > 0.6
- Adjusted R–squared > 0.6

Step 4: Check the model's defects with α=0.05.

A model is good (can be used for analysis) when the regression coefficients in the model are statistically significant, and the R–squared, Adjusted R–squared should not have autocorrelation and heteroskedasticity. At the same time, the residuals of the model should follow the standard normal distribution.

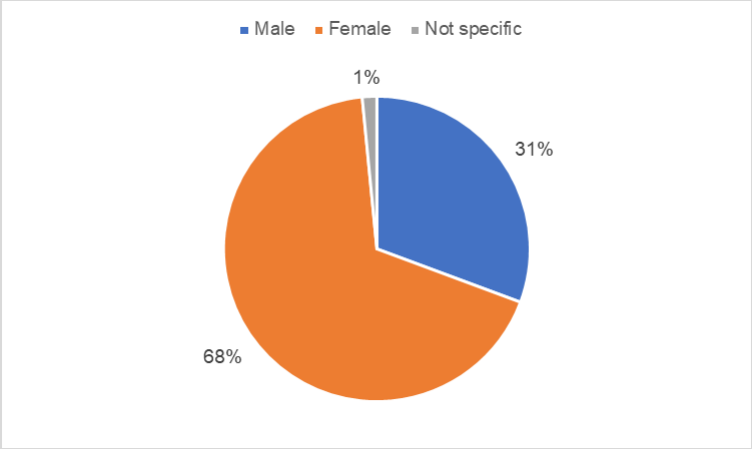
In the study, the authors used tools on Eviews8 to check these refractive errors. Specifically: Applying the Breusch-Godfrey test to check for correlated disabilities; Applying Breusch-Pagan-Godfrey method to test the variable error method; Applying Test Jarque - Bera to check whether the residuals of the model follow the normal distribution or not.

When the above conditions are met, the survey results will be put into estimation and analysis in the model.

4. RESEARCH RESULTS

4.1. Description of survey participants

Figure 1. Gender of survey participants



Source: Survey results

Among 326 people participating in the survey, 221 were female (68%), 100 were male (31%) and 5 people did not want to be specific (1%).

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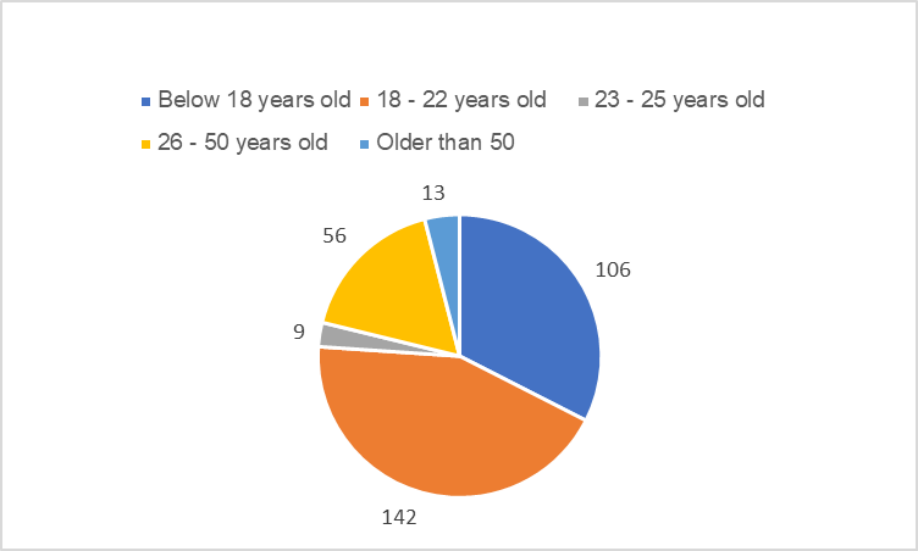
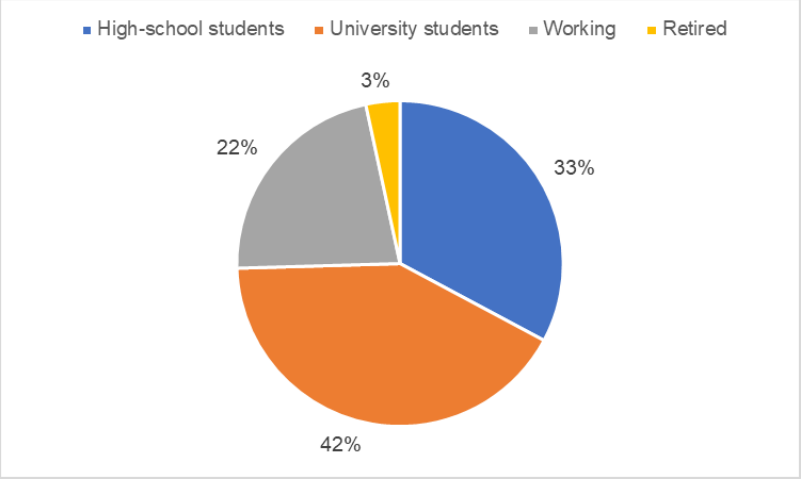
Figure 2. Age of survey participants



Source: Survey results

There were 326 respondents, of which the most were 142 people aged 18 - 22 years old (44%), followed by 106 people under 18 years old (32%), 65 people aged 23 - 50 years old (20%), and 13 people over 50 years old (4%).

Figure 3. Education level of survey participants



Source: Survey results

The majority were students, with 136 respondents (accounting for 42%), followed by 107 high school students (accounting for 33%), 72 working people (accounting for 22%) and 11 retired people (3%).

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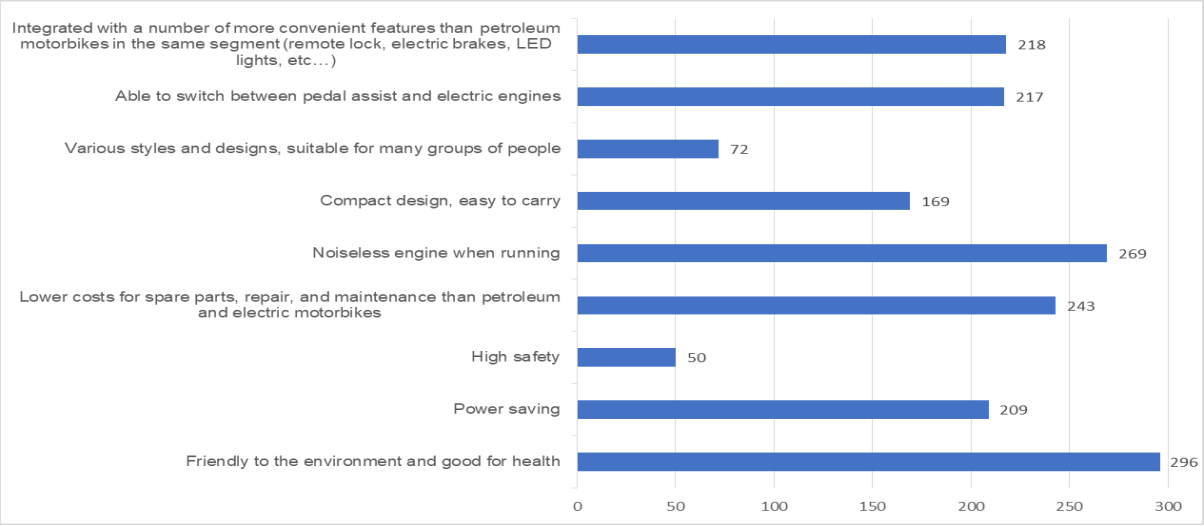
4.2. Survey results for respondents' awareness of general information about E-Bikes

Of the 326 survey participants, 320 people knew about E-Bikes (accounting for 98%) to respond, only 6 people did not (accounting for 2%). The survey results also recorded many advantages of E-Bikes that were highly appreciated by survey participants. (Figure 4).

Figure 4. Advantages of E-Bikes



Source: Survey results

Of the 320 people who have known about E-Bikes, the number of respondents who believed that E-Bikes are eco-friendly and good for riders' health was 296 people, followed by 269 people who believed that E-Bikes do not make noise when running. Notably, 243 respondents thought an advantage of E-Bikes is "The cost of spare parts, repair, and maintenance is lower than that of petroleum and electric motorbikes". In addition, some other advantages include but not limited to: Integrating more modern features compared to petroleum modes of transport in the same segment (Remote lock, electric brakes, LED lights...); Being able to switch between pedal assist and electric running; Saving power...

Of the 320 people who have known about E-Bikes, there are 134 owning/using the products and 186 people not using/owning ones (58%). The reasons for not owning/using E-Bikes are recorded in Figure 5.

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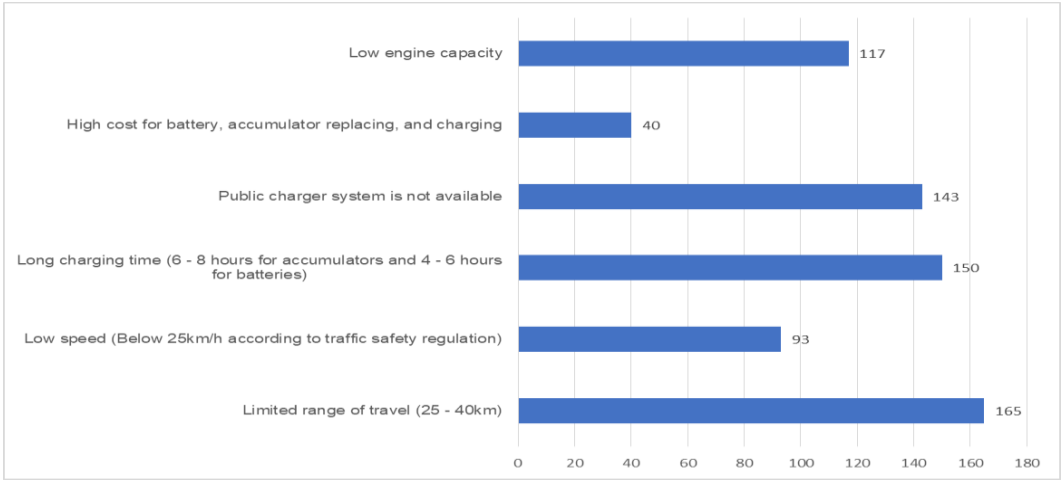
Figure 5. Reasons for not owning/using E-Bikes



Source: Survey results

Survey results indicate that the most popular reason is "Limited range of travel (from 25-40km)" with 165 choices, followed by "Long charging duration (4 - 8 hours)" with 150 choices from respondents. Facility is also critical for the development of E-Bikes' market, as 143 respondents believed the public charger system is not popular. Other significant barriers for E-Bikes relate to low engine capacity, limited travel speed, or high cost of replacing batteries...

Of the 186 people who were not using E-Bikes, there are still 149 people who wanted to learn more about E-Bikes (78%), only 43 people who did not (22%). Thus, with 134 people using E-Bikes and 149 people wishing to learn about them, the total number of people continuing the survey on factors affecting the demand for E-Bikes was 283 people.

4.3. Analyze the influence of factors on demand for E-Bikes

4.3.1. Price of E-Bikes

The survey results show that there is an inverse relationship between the price of E-Bikes (P) and the quantity demanded of E-Bikes (Q), shown in Table 1 and Figure 6, which is consistent with the Theory of Demand.

Table 2. E-Bikes price (P) and E-Bikes quantity demanded (Q)

P (million VND)	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
Q (pcs)	267	258	261	246	219	155	90	55	37	34

Source: Survey results

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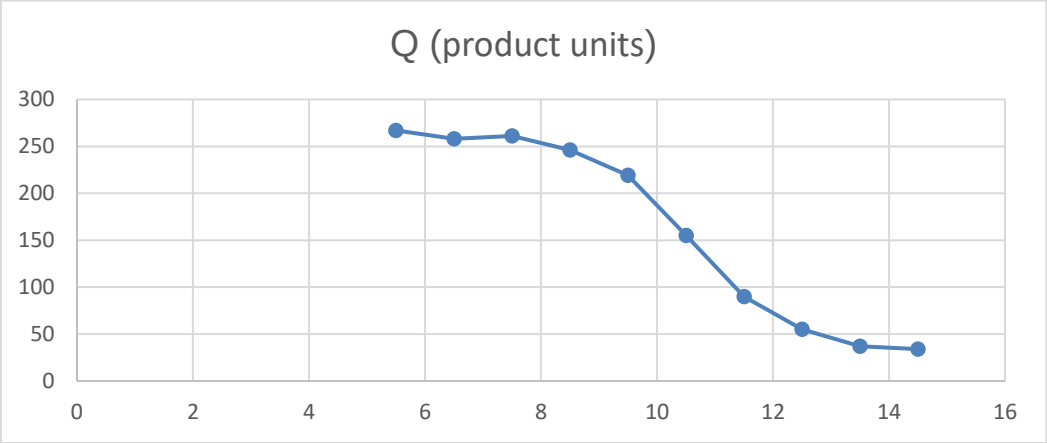
Figure 6. Demand curve for E-Bikes



Source: Survey results

On Eview8, the research team examined the relationship between E-Bikes' prices and demand for E-Bikes, the estimated results are shown in Table 3.

Table 3. Estimation results of the relationship between E-Bike prices and quantity demanded

Dependent Variable: Q

Method: Least Squares

Date: 09/21/23 Time: 11:09

Sample: 1 10

Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P	-31.55152	3.235458	-9.751791	0.0000
C	477.7152	33.66276	14.19120	0.0000

R-squared	0.922404	Mean dependent var	162.2000
Adjusted R-squared	0.912704	S.D. dependent var	99.46390
S.E. of regression	29.38751	Akaike info criterion	9.775873

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Sum squared resid	6909.006	Schwarz criterion	9.836390
Log likelihood	-46.87937	Hannan-Quinn criter.	9.709486
F-statistic	95.09743	Durbin-Watson stat	0.749670
Prob(F-statistic)	0.000010		

Source: Model estimation results

From the estimation results, we see that there is an inverse relationship between the price (P) and quantity of E-Bikes demanded (Q), which, specifically, is expressed by the equation:

Q = -31.55152*P + 477.7152

Based on the price and demand equation, we can calculate the price elasticity of demand:

$Q_P^{D'}$ = -31.55152

In the considered price range of 5.5 - 14.5 million VND, the quantity demanded decreases from 267 to 34 product units.

$E^{D}{}_{P}$ = [(34-267)/(34+267)] / [(14.5-5.5)/(14.5+5.5)] = - 1. 72

This shows that when the price of E-Bikes increases by 1%, the demand for E-Bikes decreases by 1.72%. In this case E = $|E^{D}{}_{P}|$ = 1.72 > 1. **Elasticity of demand is deemed**, which means demand for E-Bikes is more sensitive to an increase in price.

For revenue to reach its maximum value when E = $|E^{D}{}_{P}|$ = 1, based on the determined regression equation, we can calculate:

E = |-31.55152 x [P / (-31.55152 x P + 477.7152)] |= 1

The price to achieve maximum revenue is approximately 7.57 million VND

Checking model if fits:

+ All coefficients are statistically significant as Prob coefficient (P)=0.0000 < 0.05; Prob (C)=0.0000 < 0.05;

+ The regression model fits the data, because the Prob coefficient (F-statistic) = 0.000010 < 0.05;

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+ The coefficient of determination R-squared and Adjusted R-squared are 0.922404 respectively; 0.912704 > 0.6.

The results of testing for autocorrelation defects are given in Table 4.

Table 4. Autocorrelation defect test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	4.236136	Prob. F(3,5)	0.0771
Obs*R-squared	7.176483	Prob. Chi-Square(3)	0.0665

Source: Model testing results

According to Table 4, the values of Prob. F and Prob. Chi-Square are all greater than 0.05. The model does not have from autocorrelation defects.

Results of testing for heteroskedasticity are given in Table 5. According to Table 5, the values of Prob. F and Prob. Chi-Square are all > 0.05. The model is not flawed with heteroskedasticity errors.

Table 5. Heteroskedasticity test

Heteroskedasticity Test: White

F-statistic	0.811195	Prob. F(2,7)	0.4821
Obs*R-squared	1.881601	Prob. Chi-Square(2)	0.3903
Scaled explained SS	0.385773	Prob. Chi-Square(2)	0.8246

Source: Model testing results

The residuals of the model follow normal distribution, as Prob (Jarque-Bera) values in the model are greater than 0.05 (Figure 7)

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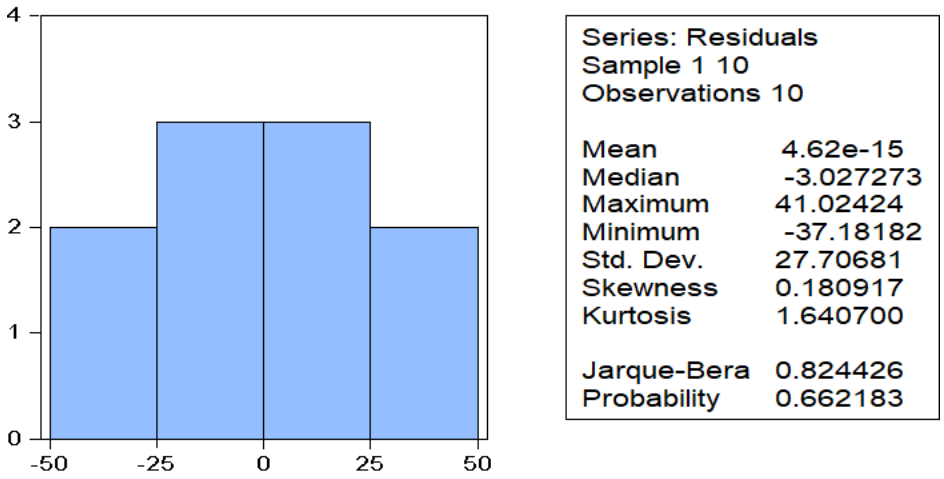
Figure 7. Normal distribution residuals

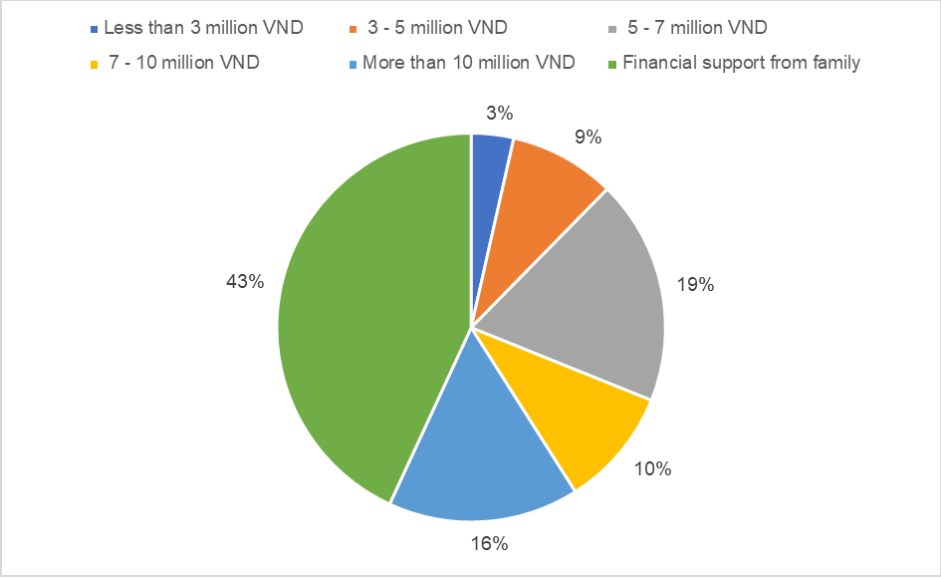


Source: Model testing results

4.2.2. Income

The income of the survey subjects is determined in Figure 8 and Figure 9.

Figure 8. Income of survey participants



Source: Survey results

Because the survey participants were mainly students from high schools and colleges, the survey results on the income showed that 122 respondents still received support from their families (43%). 19% have income from 5 - under 7 million VND, while 16% have income over 10 million VND, 10%

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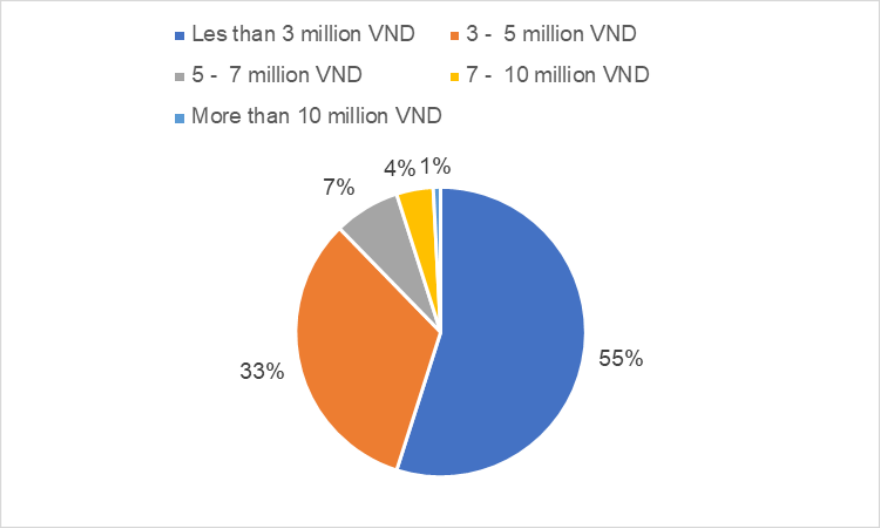
have income from 7 - 10 million VND, 9% have income from 3 - under 5 million VND, and few have an income of less than 3 million VND.

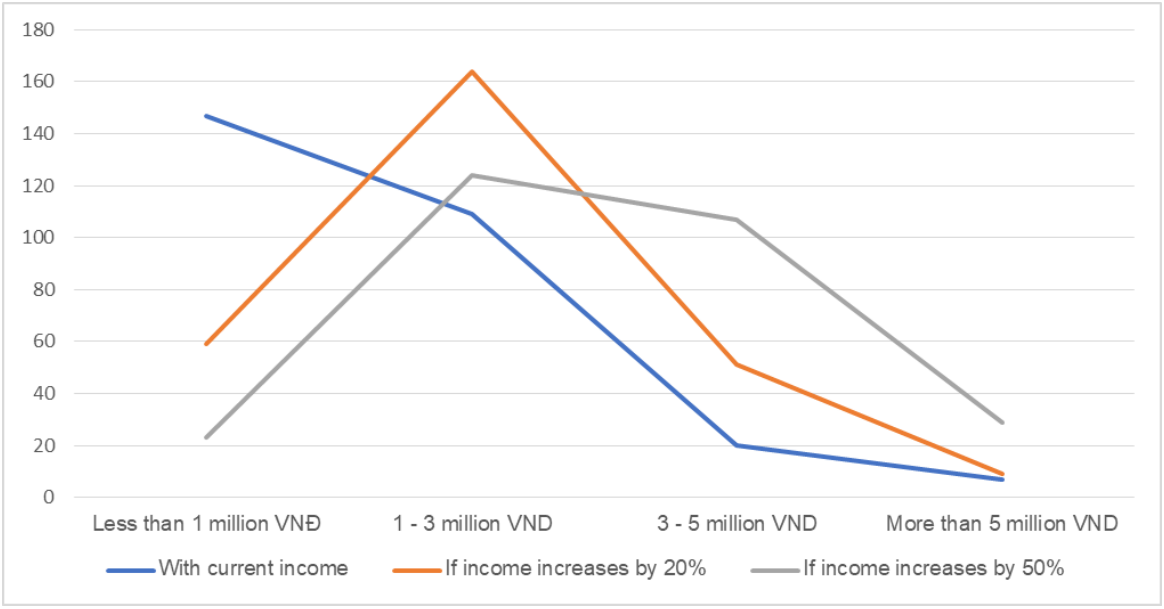
Figure 9. Financial support from family



Source: Survey results

Among the 122 people receiving allowance from their families, 67% students (55%) are provided with less than 3 million VND/month. Respondents with 3 – less than 5 million VND account for 33%. 7% of respondents receive 5 – less than 7 million VND/month, while 4% receive 7 – less than 10 million VND and only 1% receive over 10 million VND/month.

Figure 10. Amount of money willing to save to buy an E-Bikes



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Source: Survey results

With 326 responses, the results show that, as consumers' income increases, the amount of money they are willing to save to buy E-Bikes also increases (considering the overall survey sample). For the survey subjects, the research team, based on the results, calculated the average income to be about 5.64 million VND/month. The amount of money saved by respondents for buying an E-Bike is 1.46 million VND/month. When income increases by 20%, this amount of money goes up to 2.17 million VND/month, and when income increases by 50%, the amount of money saved goes up to 3.04 million VND/month (according to the research team's calculations from survey results).

$$\Delta S/\Delta I = (2.17 – 1.46)/ 0.2*5.64=0.629 \text{ (when income increases by 20\%)}$$

$$\Delta S'/\Delta I' = (3.04 – 1.46)/ 0.5*5.64=0.123 \text{ (when income increases by 50\%)}$$

This shows that when income (including support from family for subjects who have not yet had a likelihood) increases by 20%, for each million VND increased in income, respondents will be willing to save about 629 thousand VND buy an E-Bike. In the range of 50% increase in income, for each million VND increased in income, they will be willing to save 123 thousand VND. This can explain that as income increases, consumers may have more buying choices besides E-Bikes, so their willingness to save to purchase these products decreases.

4.2.3. Price of substitute goods

In a particular situation: Suppose, you are planning to buy one of these two following types of vehicles: A 133 Fantasy electric motorbike priced at 9,000,000 VND and a Niija Dibao E-Bike priced at 8,900,000 VND. If the price of the electric motorbike increases, while the price of the E-Bike remains unchanged, the quantity of E-Bikes purchased is given by the following table:

Table 6. Estimation results of the relationship between demand for E-Bikes (Q_{XDD}) and Price of substitute goods (133 Fantasy electric motorbikes) (P_{XMD})

P 133 Fantasy electric motorbike (P_{XMD}) (million VND)	10	11	12	13	14	15
Q E-Bikes (Q_{XDD}) (product units)	62	147	233	252	252	254

Source: Survey results

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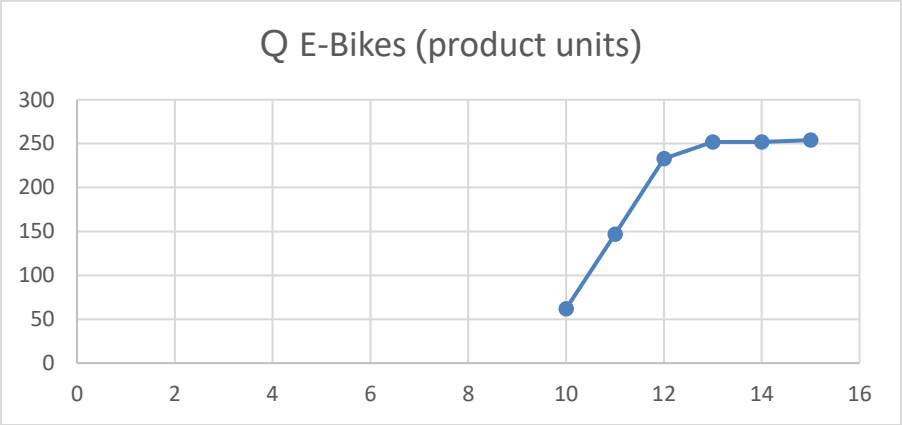
Figure 11. Relationship between demand for E-Bikes (Q_{XDD}) and Price of substitute goods (P_{XMD})



Source: Survey results

Figure 11 shows that there is a positive relationship between the price of electric motorbikes and the demand for E-Bikes. When the price of electric motorbikes increases, consumers are more likely to buy E-Bikes, which is appropriate according to the Theory of Demand. The estimation result of this relationship is shown in Table 7.

Table 7. Estimation results of the relationship between prices for electric motorbikes and demand for E-Bikes

Dependent Variable: QXDD

Method: Least Squares

Date: 09/21/23 Time: 11:25

Sample: 1 6

Included observations: 6

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PXMD	36.97143	10.24380	3.609151	0.0226
C	-262.1429	129.2371	-2.028387	0.1124

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R-squared	0.765065	Mean dependent var	200.0000
Adjusted R-squared	0.706331	S.D. dependent var	79.07718
S.E. of regression	42.85290	Akaike info criterion	10.61463
Sum squared resid	7345.486	Schwarz criterion	10.54521
Log likelihood	-29.84388	Hannan-Quinn criter.	10.33676
F-statistic	13.02597	Durbin-Watson stat	1.037835
Prob(F-statistic)	0.022574		

Source: Model estimation results

From the estimation results, we can build the demand equation as follows:

QXDD=36.97143*PXMD – 262.1429

The equation shows a positive relationship between the price of electric motorbikes and the quantity demanded of E-Bikes (in accordance with the Theory of Demand).

In the considered price range of the 133 Fantasy electric motorbike, which is from 10 million VND to 15 million VND, the demand for E-Bikes increased from 62 to 254 product units.

$$\mathbf{E^D_{X,Y} = [(254-62)/(254+62)] / [(15-10)/(15+10)] = 2.56}$$

It shows that in the price range of the electric motorbike (10-15 million VND), if the price of electric motorbikes increases by 1%, the demand for E-Bikes increases by 2.56%.

Checking model if fits:

+ All coefficients are statistically significant because the coefficient Prob (P)=0.0226 < 0.05;

+ The regression model fits the data, because the Prob coefficient (F-statistic) = 0.022574 < 0.05;

+ The coefficient of determination R-squared and Adjusted R-squared are 0.765065 respectively; 0.706331 > 0.6.

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Table 8. Autocorrelation defect test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.560983	Prob. F(2,2)	0.3905
Obs*R-squared	3.657149	Prob. Chi-Square(2)	0.1606

Source: Model testing results

According to Table 8, the values of Prob. F and Prob. Chi-Square are all > 0.05. The model does not have from autocorrelation defects.

Table 9. Test of heteroskedasticity

Heteroskedasticity Test: White

F-statistic	0.103706	Prob. F(2,3)	0.9046
Obs*R-squared	0.387997	Prob. Chi-Square(2)	0.8237
Scaled explained SS	0.055509	Prob. Chi-Square(2)	0.9726

Source: Testing results

According to Table 9, the values of Prob. F and Prob. Chi-Square are all > 0.05. The is not flawed with heteroskedasticity errors.

The residuals of the model follow a normal distribution, Prob (Jarque-Bera) values in the model > 0.05

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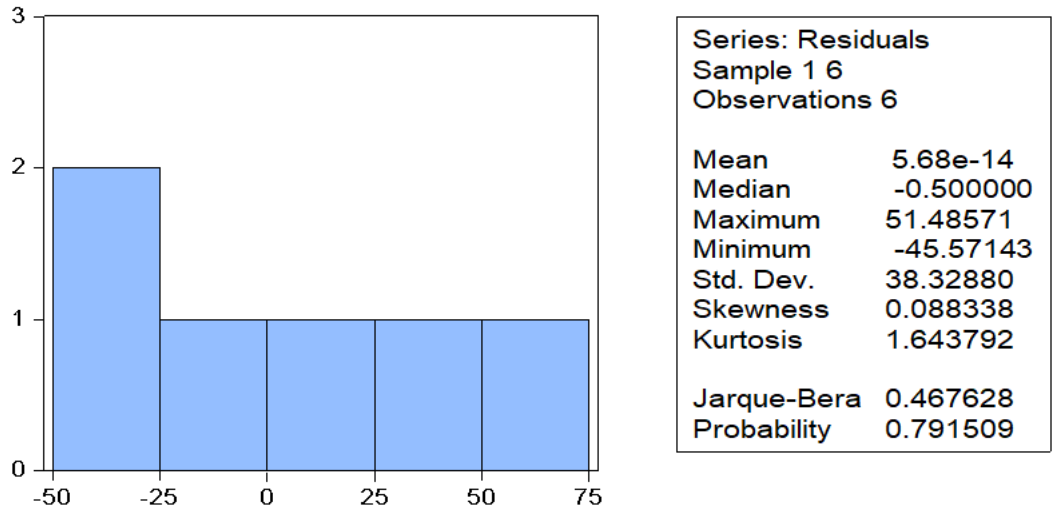
Figure 12. Normal distribution residuals



Source: Testing results

4.2.4. Price of complementary goods

In a particular situation: When buying an E-Bike, consumers tend to pay attention to the important spare parts of the vehicle. These parts are considered complementary goods, the average price ranges from 450,000 - 1,800,000 VND. For example, Yamato accumulator for Niija 2019 E-Bikes (the bike costs about 9,000,000 VND), costs about 1,500,000 VND, and needs replacing every 2 years.

The relationship between the price of complementary goods (the accumulator's price – P_{AQ}) and the quantity demanded of E-Bikes (Q_{XDBS}) is shown in Table 10 and Figure 13.

Table 10. Relationship between the battery/accumulator price and demand for E-Bikes

P battery/accumulator (million VND)	1.6	1.7	1.8	1.9	2	2.1
Q E-Bikes (product units)	259	238	161	100	39	31

Source of survey results

Survey results show that when the price of complementary goods (battery/accumulator) increases, the quantity demanded of E-Bikes decreases at all price levels, showing an inverse relationship between the price of complementary goods and the demand for E-Bikes (This is consistent with the Demand theory). Chart 3 visually shows this inverse relationship.

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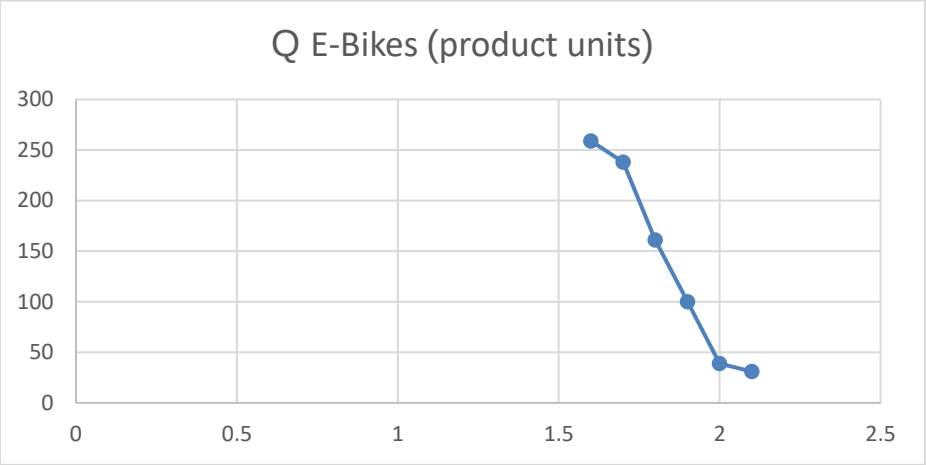
Figure 13. Relationship between the battery/accumulator prices and demand for E-Bikes



Source: Survey results

Table 11. Estimation results for the relationship between price for complementary goods and demand for E-Bikes

Dependent Variable: QXDBS

Method: Least Squares

Date: 09/21/23 Time: 11:30

Sample: 1 6

Included observations: 6

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAQ	-513.7143	49.00562	-10.48276	0.0005
C	1088.371	91.04589	11.95410	0.0003

R-squared	0.964878	Mean dependent var	138.0000
Adjusted R-squared	0.956097	S.D. dependent var	97.84069
S.E. of regression	20.50052	Akaike info criterion	9.139979

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Sum squared resid	1681.086	Schwarz criterion	9.070566
Log likelihood	-25.41994	Hannan-Quinn criter.	8.862111
F-statistic	109.8883	Durbin-Watson stat	2.168686
Prob(F-statistic)	0.000468		

Source: Estimated results

From the estimation results, we can build the following equation:

$$\mathbf{Q_{XDBS} = - 513.7143*PAQ+1088.371}$$

The equation shows an inverse relationship between the price of accumulators and the quantity demanded of E-Bikes (in accordance with the Theory of Demand).

In the considered battery/accumulator price range from 1.6 to 2.1 million VND, the demand for E-Bikes decreased from 259 to 31 product units.

$$\mathbf{E^D_{X,Y} = [(31-259)/(31+259)] / [(2.1-1.6)/(2.1+1.6)] = -5.8}$$

That shows that, in the battery/accumulator price range (1.6-2.1 million VND), when the battery/accumulator price increases by 1%, the demand for E-Bikes decreases by 5.8%.

Checking model if fits:

+ All coefficients are statistically significant because the coefficient Prob (P)=0.0005 < 0.05; Prob (C)=0.0003 < 0.05;

+ The regression model fits the data, because the Prob coefficient (F-statistic) = 0.000468 < 0.05;

+ The coefficient of determination R-squared and Adjusted R-squared are 0.964878 respectively; 0.956097 > 0.6.

Testing for autocorrelation defects, the results are given in Table 12.

Table 12. Autocorrelation defect test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.428823	Prob. F(2,2)	0.6999

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Obs*R-squared	1.800739	Prob. Chi-Square(2)	0.4064

Source: Testing results

According to Table 12, the values of Prob. F and Prob. Chi-Square are all > 0.05. The model does not have autocorrelation defects.

Testing for heteroskedasticity, the results are given in Table 13.

Table 13. Test of heteroskedasticity

Heteroskedasticity Test: White

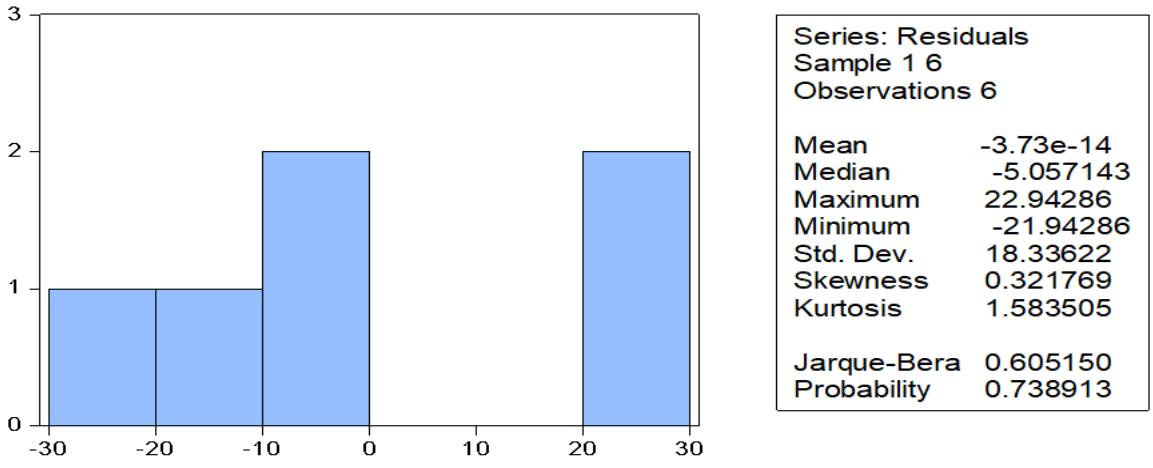
F-statistic	0.504008	Prob. F(2,3)	0.6476
Obs*R-squared	1.508999	Prob. Chi-Square(2)	0.4702
Scaled explained SS	0.195669	Prob. Chi-Square(2)	0.9068

Source: Testing results

According to Table 13, the values of Prob. F and Prob. Chi-Square are all greater than 0.05. The model is not flawed by heteroskedasticity errors.

The residuals of the model follow a normal distribution, Prob (Jarque-Bera) values in the model are greater than 0.05.

Figure 14. Normal distribution residuals



Source: Testing results

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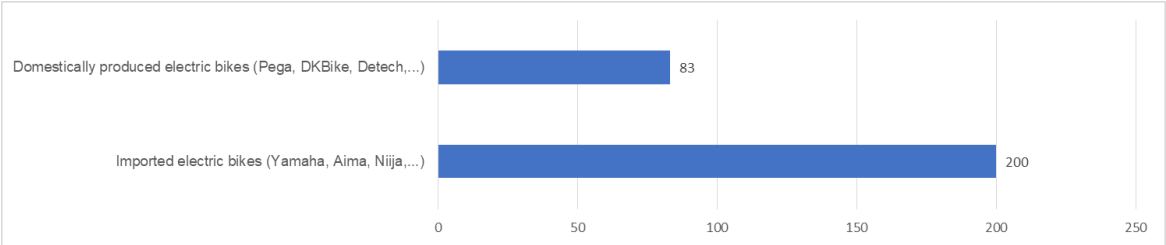
4.2.5. Trends

According to survey on the choices of imported domestic E-Bikes, 200 respondents indicated that they prefered imported E-Bikes (Yamaha, Aima, Niija...), while only 83 people chose domestically produced E-Bikes (Pega, DKBike, Detech...).

Figure 15. Preference for imported and domestic E-Bikes



Source: Survey results

According to survey results on the features of E-Bikes, respondents were most likely to choose an E-Bike with fast charging time (235 choices). They were interested in brands which have modern, luxurious, and customized designs (216 choices), and E-Bikes that had low costs incurred during use (214 choices).

Nearly 200 respondents were willing to purchase an E-Bike with a high price but had larger travel range (199 choices). Famous brand manufacturers such as Yamaha, Honda, Niija, Pega, etc… were trusted by 180 respondents. The feature “Compact design, easy to use, to carry” were chosen by 80 respondents. Only 68 people were willing to purchase E-Bikes with a low price and ready to accept limited range of movement (25 - 40km).

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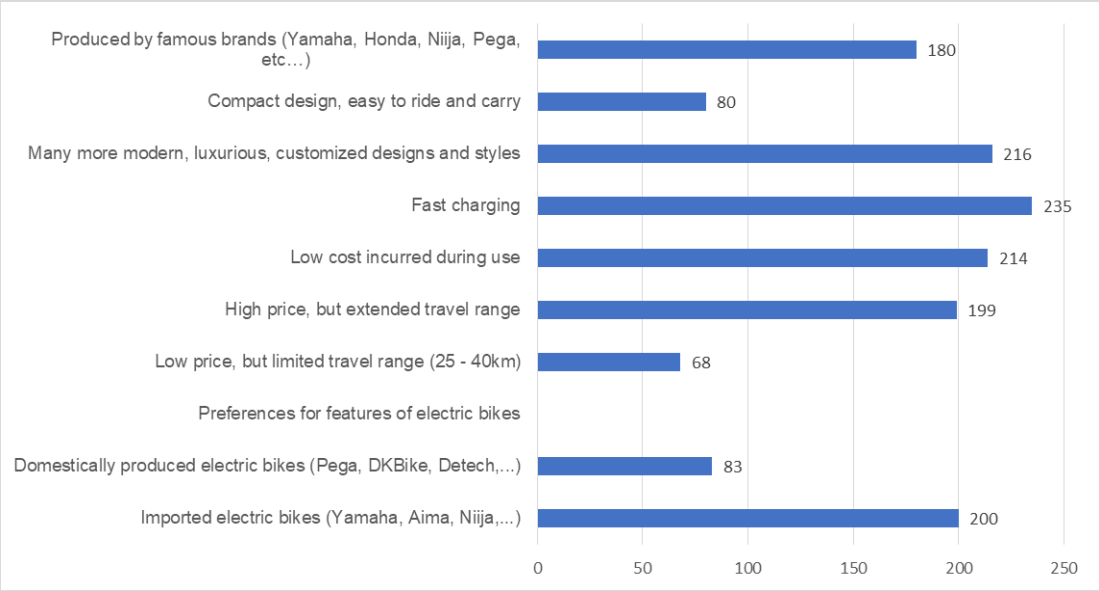
Figure 16. Preferences in choosing E-Bikes



Source: Survey results

4.2.6. Consumer expectation with E-Bikes

Among the 326 survey participants, when asked about their expectations for the E-Bikes market, they believed in the future, E-Bikes would be more popular to consumers (251 choices); The operating range of E-Bikes is increased thanks to battery/motor optimization (244 choices); Public charging station system with widespread coverage in the future (235 choices); E-Bikes would have more designs and models (232 choices); The price of E-Bikes would be lower (89 choices). Some other expectations include but were not limited to "Higher safety when charging", "More sturdy bikes", "Batteries/Accumulators do not cause dangers" and "Designing smart E-Bikes for blind people", etc...

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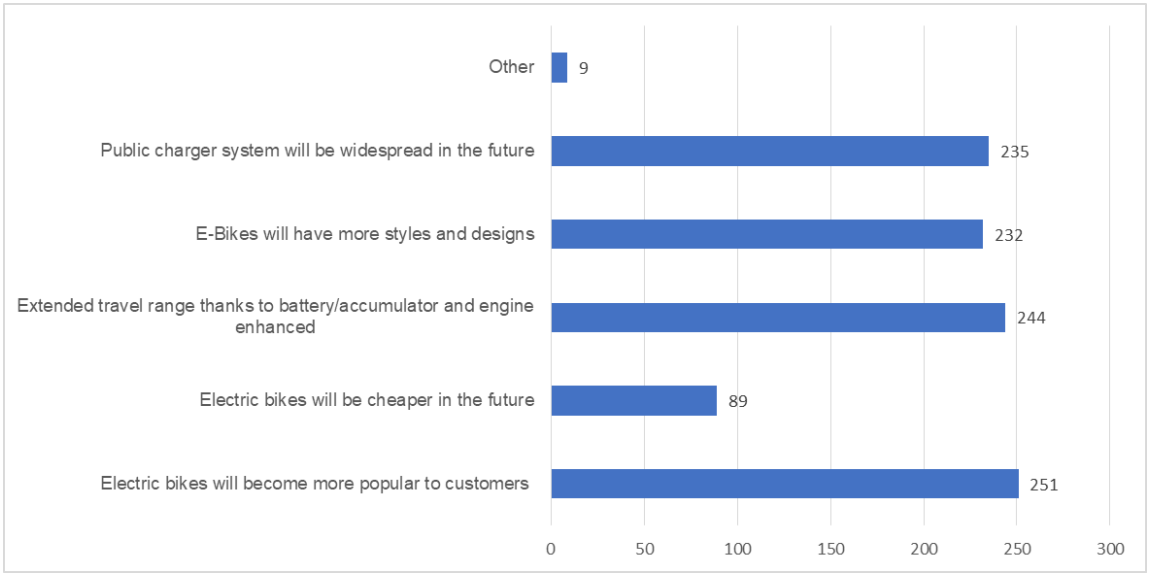
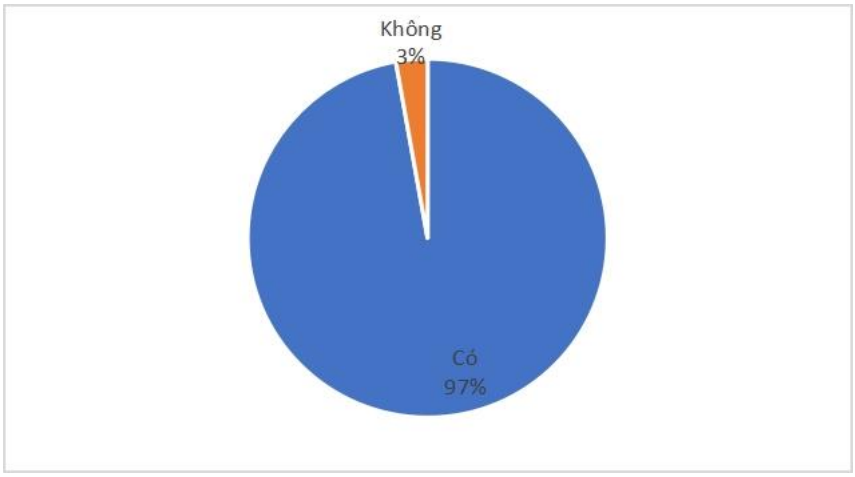
Figure 17. Expectations of consumers for E-Bikes



Source: Survey results

Regarding consumer confidence/support for E-Bikes in the future, the majority of respondents showed support and confidence in this mode of transport (97%).

Figure 18. People's confident/support for E-Bikes



Source: Survey results

5. Discussions and Policy Implications

The most obvious advantages of E-Bikes "Friendly to the environment and good for health" and "Saving power" were agreed by many survey participants. However, the rate of E-Bikes ownership/use is still relatively low (42%), so it is necessary to raise awareness about the environmentally friendly features of these vehicles, focusing on groups of people who do not own/use vehicles. use E-Bikes. Businesses and governments need to associate forms of propaganda and promotion about the ability of E-Bikes to contribute to sustainable development with the goal of reducing emissions in Vietnam's commitments at the Summit. on Climate Change (COP26). From there, encourage more individuals to participate in the transition to using green energy, limiting the increasing amount of emissions that pollute the environment.

Besides, the most significant barriers to using E-Bikes are limited range and long charging times. In theory, the difference between E-Bikes and many other types of electric two-wheeled vehicles (E2V) is the integration of power pedals. In fact, if the vehicle runs out of power or breaks down, it will greatly affect the driver's experience and they often have to calculate to adjust the driving mode throughout the journey to consume less energy and less effort on the bike as possible (Yannick, 2023). Therefore, manufacturers need to innovate battery level control features based on real data to support drivers in certain situations. A software that predicts the required power level based on a map displaying real-time traffic conditions needs to be integrated into the vehicle's display unit. At the same time, some businesses can improve vehicle quality, improve battery capacity and charging speed to extend the vehicle's travel time. Survey results show that many people accept the higher price of E-Bikes but longer travel range, showing that they are willing to buy an electric bike with technology to predict electricity consumption based on data. Actually or simply the battery/battery has been improved but costs more than a conventional car.

With electric motorbikes in the same segment capable of replacing E-Bikes, when the price of replacement vehicles increases, the results show a change in consumer behavior to switch to using E-Bikes. Therefore, electric bike companies need to develop a pricing strategy to ensure competitiveness with alternative electric motorbikes.

Recorded from the survey results, if income increases, the amount of money consumers save to buy E-Bikes also increases. The most popular type of electric bike is one completely imported from abroad such as Yamaha, Honda, Aiima or Niija. In addition, the E-Bikes that most young people are aiming for have a modern, luxurious, stylish design, low costs during use, and are manufactured by a famous brand. This poses a big challenge for domestic manufacturers to design and continuously innovate their products to meet market needs and regain domestic market share.

The government has an important role in promoting the process of replacing inefficient petroleum-powered vehicles. Administrative tools such as bans, standards, restrictions or economic tools such as

taxes and fees have a greater impact on people's consumption patterns than educational and communication tools to raise awareness (Vu & Hien, 2017).Therefore, the government needs to synchronously deploy people's awareness raising, policies and legal tools, along with promoting monitoring and evaluation to ensure policies are effectively implemented. In Vietnam, gasoline vehicles cannot be completely replaced in the short term, but specific measures are needed to minimize people's demand for these vehicles. Vietnam can learn experience in controlling vehicle emissions from Taiwan, where gasoline cars are taxed with an environmental tax, and motorbikes must be inspected at emission testing stations of the Conservation Agency. Taiwan Environment and automatic emission monitoring systems are also used on many roads (Duong, 2021). Vehicles that exceed emission standards must be maintained to be returned to traffic. From there, people will have greater awareness of emission issues, reduce the frequency of using gasoline cars and gradually move towards cleaner vehicles.

According to the survey results, the majority of survey participants expect E-Bikes will become more popular and many people think that electric bike prices should be lower in the future. As a developing country with limited resources, Vietnam needs to build a roadmap suitable to specific goals for the widespread adoption of electric two-wheeled vehicles (E2W). A foundational resolution is to apply tax reduction and loan subsidies for businesses to focus on developing two-wheeled electric vehicles in general. Along with that is a policy to support small and medium-sized enterprises to establish alliance with each other, which allows them to share technology, finance, resources and business risks to thereby increase supply and reduce product costs. In addition, it is necessary to plan stimulus packages for E-Bikes with benefits aimed at people. Vietnam has so far not had a clear policy to stimulate the demand for E-Bikes in particular or electric two-wheeled vehicles in general, even though the government has made commitments to reduce carbon emissions at the Summit. climate change (COP26). The state needs to develop subsidy programs for converting from gasoline cars to E-Bikes. According to a report from Dat Bike (electric bike business), Vietnam has about 3 million motorbikes sold each year and the market space has more than 60 million gasoline cars to convert. In localities, it is necessary to reduce electricity bills and maintenance costs for electric bike owners. When the majority of electric bike users are students (Survey results), the support mechanism to reduce costs and repair and maintenance costs will contribute to increasing the demand for this vehicle in the future. hybrid.

Because this is a new market and domestic businesses have not yet developed, the government needs technological support. Vietnam has many potential businesses, but lacks connectivity with foreign businesses, so it is difficult to participate deeply in the supply chain. Therefore, it is necessary to sponsor innovative research projects so that domestic electric bike businesses are self-sufficient in technology, improve vehicle quality, and have price advantages to increase market share in the domestic market. . In addition, most of the world's leading technology corporations such as Apple, Samsung and Intel own factories in Vietnam, so they need to take advantage of the supply chain of components for E-Bikes.Infrastructure is a fundamental challenge for the domestic e-bike market.

About half of the survey participants do not own E-Bikes due to limited availability of public charging stations, and 235/326 people surveyed think that the public charging station system needs to have wider coverage. Currently, the number of public charging stations is still very limited, which is an obstacle to using E-Bikes for transportation. Vehicle users are usually pupils, students and working people. So charging stations need to be built on a large scale, concentrated in densely populated areas such as schools, companies or factories. It is necessary to cooperate with a number of large electric vehicle enterprises to improve charging station efficiency, take advantage of charging station technology, swap batteries and optimize power supply speed. For example, Gogoro, a company that is shifting its focus to the Southeast Asian market, has the strength of a battery swap station with a very small area (equivalent to a vending machine) to operate (Shanshan, 2023) - especially suitable for the land fund situation and dense traffic density in many urban areas in Vietnam.

Data from the survey shows that reducing the price of additional goods such as batteries will motivate people to use E-Bikes more. Therefore, it is necessary to improve power transmission capacity, expand the scale and improve the operational efficiency of the power network. Besides, in developing countries like Vietnam, vehicles use electricity with the main source being thermal power, causing indirect emissions effects (Sarmad & Johan, 2020). Therefore, it is necessary to prioritize investment in renewable energy development projects as well as focus on integrating the renewable power network into the national power network. Thereby reducing electricity costs and contributing to Vietnam achieving the net zero emissions target by 2050.

The results recorded that 97% of surveyors have positive belief in the future development of E-Bikes. Expectations include the popularity of E-Bikes, expanded travel range, widespread charging station system, E-Bikes will have many designs and models suitable for more audiences, and In addition, some people believe that batteries need to be safe when charging and using. This is a development opportunity for the electric bike market in the future and is also a challenge for manufacturers to meet market demand and is also a problem for the government in the transition process transition to the green fuel era.

6. Limitations and Future study

The research results have met the proposed research objectives. However, the work still has some limitations.

The survey was only conducted in Hanoi and Ho Chi Minh City, two most populated cities of Vietnam. However, the cities do not accurately reflect the entire country. The sample size (326 people) is small compared to the country's population size and compared to each survey subject group.

In addition, as the survey was conducted online with convenience sampling, the survey was difficult to reach retired people, which accounts for a large proportion of E-Bikes users. Therefore, the

representativeness of the sample is not ensured and some of these subjects' opinions about the E-Bike market are also ignored.

In future research, efforts should be made to expand the sample size, increase representativeness, and avoid uneven distribution among target groups. In addition, demographic and psychological factors also need to be specifically considered when evaluating factors affecting the demand for E-Bikes in Vietnam.

7. CONCLUSION

The research utilizes survey data of 326 people from many different target groups in Hanoi and Ho Chi Minh City, with the goal of reviewing and analyzing factors affecting the demand for E-Bikes in Vietnam. Thereby, the biggest barriers to this market come from the characteristics of E-Bikes (limited range of travel and long charging time) and undeveloped infrastructure for E-bikes (battery charging station system is not yet available across cities). Some consumer expectations about E-Bike styles, designs and low cost during use also need to be paid attention by businesses to make appropriate manufacture decisions, build investment strategies, enhance product quality, thereby meeting consumer preferences. The government also plays a big role in supporting small and medium-sized enterprises in this sector. Along with that, it should encourage the replacement of petroleum 2-wheeled vehicles and offer financial stimulus for E-Bikes to facilitate the green energy transtition. Moreover, national investment in renewable energy should be increased to ensure electric vehicles to completely use clean energy instead of thermoelectricity, contributing to achieving emissions goals. Consumer confidence in E-Bike products is a positive sign that Vietnam is motivated by people's consensus in the energy transition during the green energy era.

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