Analysis of Motorcycle Ownership: A Case Study in Ho Chi Minh City

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Abstract: This study aims to analyze the determinants of motorcycle ownership by households in Ho Chi Minh City, Vietnam based on the home interview survey. A multinomial logit model was developed to examine these determinants. This paper provides an analysis on how household characteristics, motorcycle attributes, trip attributes and rideshare (sharing motorcycle by household members) can affect motorcycle ownership. The results show that these factors have significant impacts on motorcycle ownership, especially, motorcycle rideshare which has a significant and negative effect on motorcycle ownership. With regards to the policy implication that offers solutions to traffic congestion, the development of rideshare may decrease both the average number of motorcycle per household and the number of motorcycle trips, which results in the limited use of personal transportation mode. In addition, it was found that the dependence of motorcycle ownership on the kilometers traveled by motorcycle, which is representative of its usage, is weak. Hence, restricting motorcycle ownership will not be able to effectively restrict motorcycle usage. This finding notes to policy makers that it is not a guaranteed success to limit household motorcycle ownership when applying a policy to mitigate traffic congestion, as this may not be effective.

Keywords: Motorcycle Ownership; Household Survey; Disaggregate Choice Model.

1. INTRODUCTION

Motorcycles are a primary mode of transportation in Ho Chi Minh City (HCMC), Vietnam. However, many serious problems, such as traffic congestion, accidents, and air pollution, are the inevitable consequences of motorcycle ownership and usage. Based on information from Ho Chi Minh City Department of Transportation in 2015, traffic was brought to a standstill. The average speed of traffic during rush hours on the main roads fell from 21 km/h to 12 km/h and local traffic congestion points increased from 40 points to over 150 points in the entire city. The peak hour is at 7:00 am to 9:00 am and 5:00 pm to 7:00 pm. The impact of transport on the environment has become exceptionally serious and consequential, with all the indicators of air pollution and noise has far exceeded the sustainable limits. In addition, in 2015, there were 3739 traffic accidents, injuring 3,000 people and killing 650 people.

In terms of motorcycle ownership, Figure 1 shows the total motorcycle registration from year 2001 to 2015. Number of motorcycles registered has also increased from 1.9 million motorcycles in year 2001 to 6.8 million motorcycles in year 2015 (Ho Chi Minh City Department of Transportation, 2015). This indicates that the motorcycle ownership is increasing rapidly, at a rate of about 9.4 percent per year. Hence, in order to restrain the considerable growth in this private vehicle ownership, besides an effort to develop the public transportation system, a close examination is required to obtain a deeper understanding of motorcycle ownership.

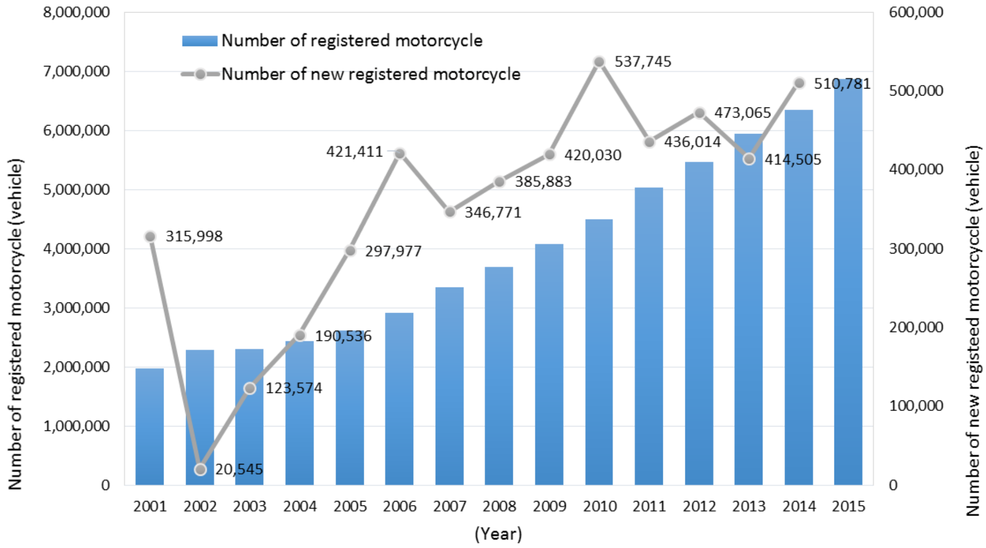


Figure 1. Motorcycle registration in HCMC (HCMC Department of Transportation, 2015)

In the past, many researches of car ownership have been conducted in the developed countries. Nevertheless, due to the quite large differences in the transport system as well as the social and economic development, these researches still have restrictions for application in developing countries. Theoretically, there are still no specific criteria to find out a model of motorcycle ownership. In HCMC, there have not been many intensive studies of this issue. Thus, this study focuses on analyzing factors affecting motorcycle ownership by household in HCMC. The results of the research are expected to provide helpful inputs in the development of the urban transport system for the future.

2. LITERATURE REVIEW

Vehicle ownership can use either aggregate or disaggregate models. The disaggregate modeling approach overcomes the weaknesses of aggregate models by capturing individual choice behavior and explanatory variables at an individual level, with the ability to obtain more reliable estimates (Chieh-Hua et al., 2012). Hence, disaggregate models are becoming widely used in vehicle ownership researches. The household's decision to own vehicles can be explored by using either the ordered- or unordered-response choice models (Bhat and Pulugurta, 1998; Chu, 2002; Whelan, 2007; Matas and Raymond, 2008; Potoglou and Kanaroglou, 2008). Contrary to the ordered choice models, the unordered discrete choice models such as multinomial logit model, nested logit model was derived from random utility theory.

There has been substantial researches on car ownership and usage. However, researches on motorcycle ownership are considerably lower. Leong and Sadullah (2007) applied multinomial logit model to consider motorcycle ownership in Penang State, Malaysia; this research has shown that household monthly income, car ownership, total number of household car driving license holder, total number of household motorcycle license holder and number of household member are the parameters that influenced household motorcycle ownership. Hsu et al. (2007) used multinomial logit model to investigate car and motorcycle ownership; this study concluded that the main reason for motorcycle and car ownerships was not cost; the increase in reliability as well as convenience of a car may increase car ownership and reduce motorcycle ownership. Another study of Hsu (2007) applied Poisson regression to investigate car and motorcycle ownerships characteristics in three different cities in Taiwan, namely Taipei, Taichung and Kaohsiung. The results indicated that there was substitution effects between car ownership and motorcycle ownership and high usage of public transportation in the city may cause motorcycle ownership reduce. More recently, Chieh-Hua et al. (2012) proposed a dynamic analysis of motorcycle ownership and usage using panel data. The study suggested that the state dependence effect existed in motorcycle ownership decisions. Tuan and Shimizu (2005) have also made a study of motorcycle ownership in Hanoi city, Vietnam. This study indicated that increasing the number of workers or students, household monthly income, motorcycle cost, and previous transactions affected current transaction decisions. However, very few of these studies have been able to address motorcycle ownership in Ho Chi Minh City.

3. A MOTORCYCLE OWNERSHIP MODEL FOR HO CHI MINH CITY

3.1 Characteristics of survey data

The database used in this research was compiled from a project on motorcycle ownership and usage. An interview survey was conducted in respondents' home from December 2015 to January 2016 from 24 different districts in HCMC. Respondents was distributed proportionally to the district population according to the random sampling method. The survey chose 1620 households to conduct interviews.

The survey questionnaire contains various components, such as household characteristics, vehicle characteristics, and driver/rider demographics. In terms of household attributes, the survey collected information of interviewees, for instance, family size and structure, household monthly income, number of workers and children, number of vehicles, and vehicle characteristics in the household. Individual attributes include gender, age, occupation, income, travel time to work and daily kilometers traveled.

In HCMC, motorcycles are the main mode of transportation in daily activities. The most common capacity is 100 - 125cc, accounted for 90% of total. Auto and manual motorcycle are 41% and 59%, respectively. Ratio of motorcycle registered in HCMC and other provinces are 95% and 5%. The composition of vehicles owned by households consists mainly of cars, motorcycles, bicycles, medium and heavy trucks with about 90.6% of these vehicles being motorcycles. Figure 2 shows the results of motorcycle ownership distribution by number of members per household. A few households owning zero motorcycle ownership are excluded in the statistical process. Households owing 2 motorcycles is the highest, representing 51.2% percentage of the total, with 3-person households representing 16.5% and 4-person households representing 19.8%, 5-person households representing 7.5%. Households owing 3 motorcycles, 1 motorcycles, 4 motorcycles and more than 4 motorcycles account for 25.6%, 13.8%, 7.5% and 2.0% respectively. On average, each household has 4.12 persons and owns 2.33 motorcycles. According to the current working ages (General statistics office of Vietnam, 2016), the percentage of employed workers at 15 years of age and above accounted for 57.6%, i.e. there is 2.37 working age people per a household, a little higher than 2.33 motorcycles ownership. Although the age of driving a motorcycle is over 16 year olds in road transportation law, it can be said that almost every working person in HCMC owns a motorcycle each.

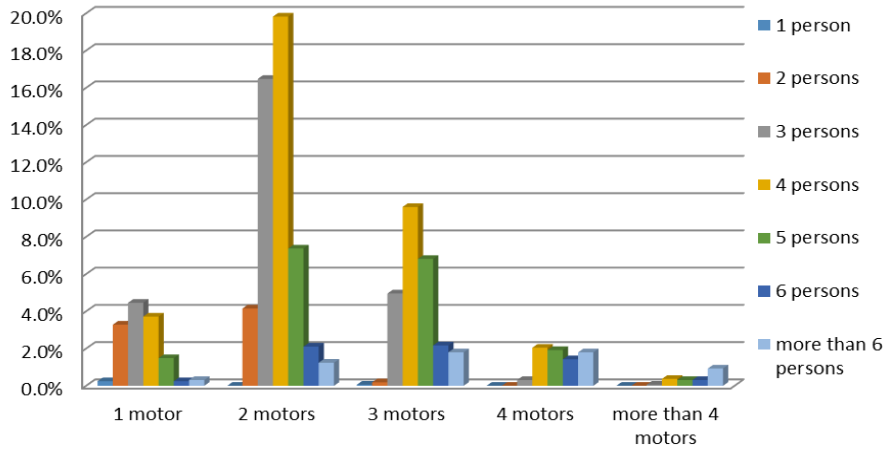


Figure 2. Motorcycle ownership distribution by number of members per household

Figure 3 shows the results of vehicle age distribution by age of owners. Vehicle age of more than 15 years represents the lowest percentage of total, at 5.2%. Vehicle age of 5-10 years represents the highest percentage of total, at 38.5%. Vehicle age with less than 3 years is the second highest percentage at 26.0%. Among these, young age of 25-35 year olds and middle age of 35-50 year olds purchase the most. The high percentage of buying motorcycles of less than 3 years shows that working people continue to purchase new motorcycles and they do not easily give up their motorcycle usage habits.

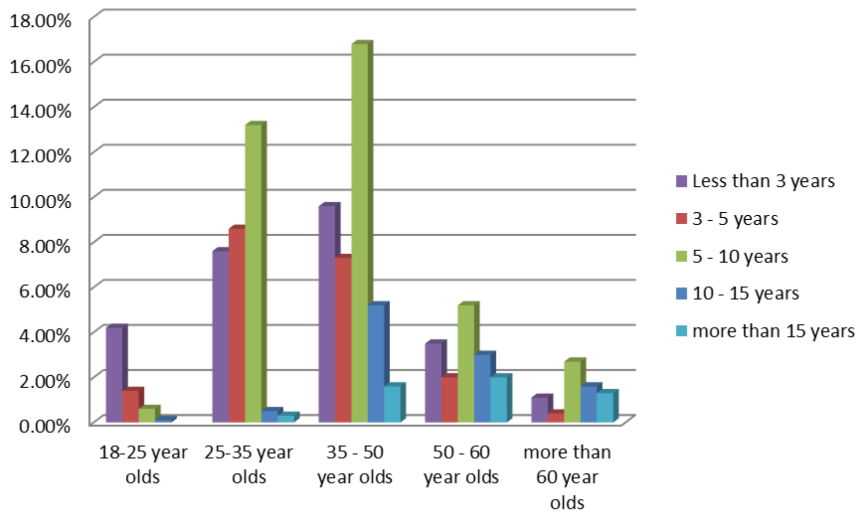
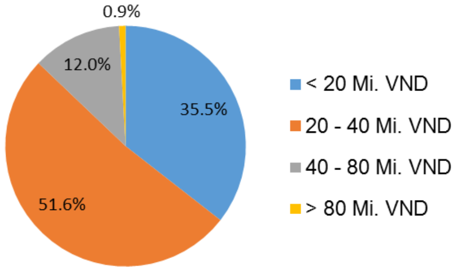
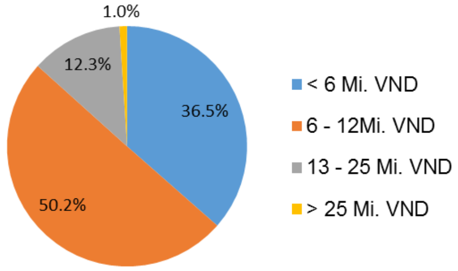


Figure 3. Vehicle age distribution by age of owners

Figure 4 (a) and 4 (b) show the percentage of the motorcycle ownership by purchase price and by month income. Motorcycle purchased at the price of 20 – 40 million VND and the motorcycle owner with income ranging between 6-12 million VND show high percentage of 51.6% and 50.2%, respectively. It is interesting to note that the ratio of motorcycle ownership by purchased price and monthly income are almost the same. If it is assumed that low and high income people will purchase a cheap and expensive motorcycle respectively, then it takes about three months' wages to own a motorcycle.



a) By purchased price



b) By month income

Figure 4. Motorcycle ownership by purchase price and monthly income

Figure 5 shows the distribution of number of kilometers traveled per day by numbers of motorcycle per household. 8 households with zero motorcycle ownership are excluded. Pearson correlation coefficient evaluating the linear relationship between motorcycle ownership and number of kilometers based on the sample is 0.16. A t-test was conducted with the null hypothesis of the population correlation coefficient being equal to 0. Hence, t-test statistic = 6.47 and p-value = 1.35e-10 were obtained, meaning we can reject the null hypothesis. It is conclusive that there is still no obvious relationship between motorcycle usage and ownership. A household owning many motorcycles does not indicate that the household will travel frequently. This finding notes to policy makers that it is not a guaranteed success to limit household motorcycle ownership when applying a policy to mitigate traffic congestion, as this may not be effective.

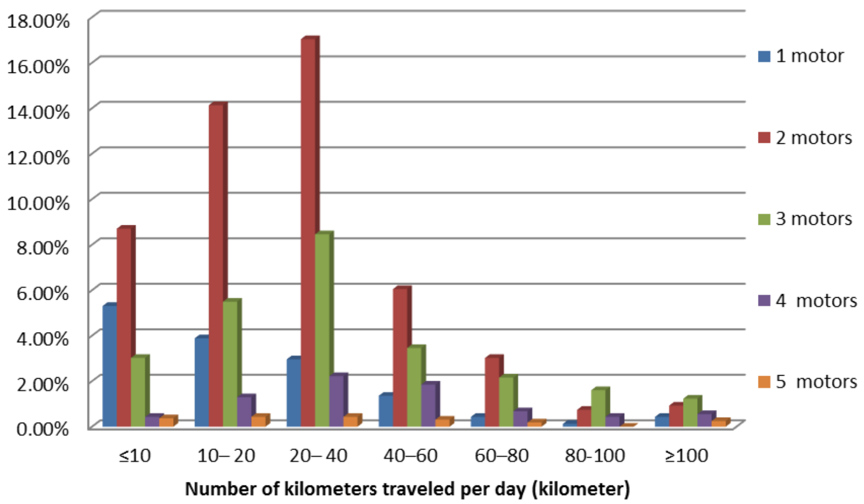
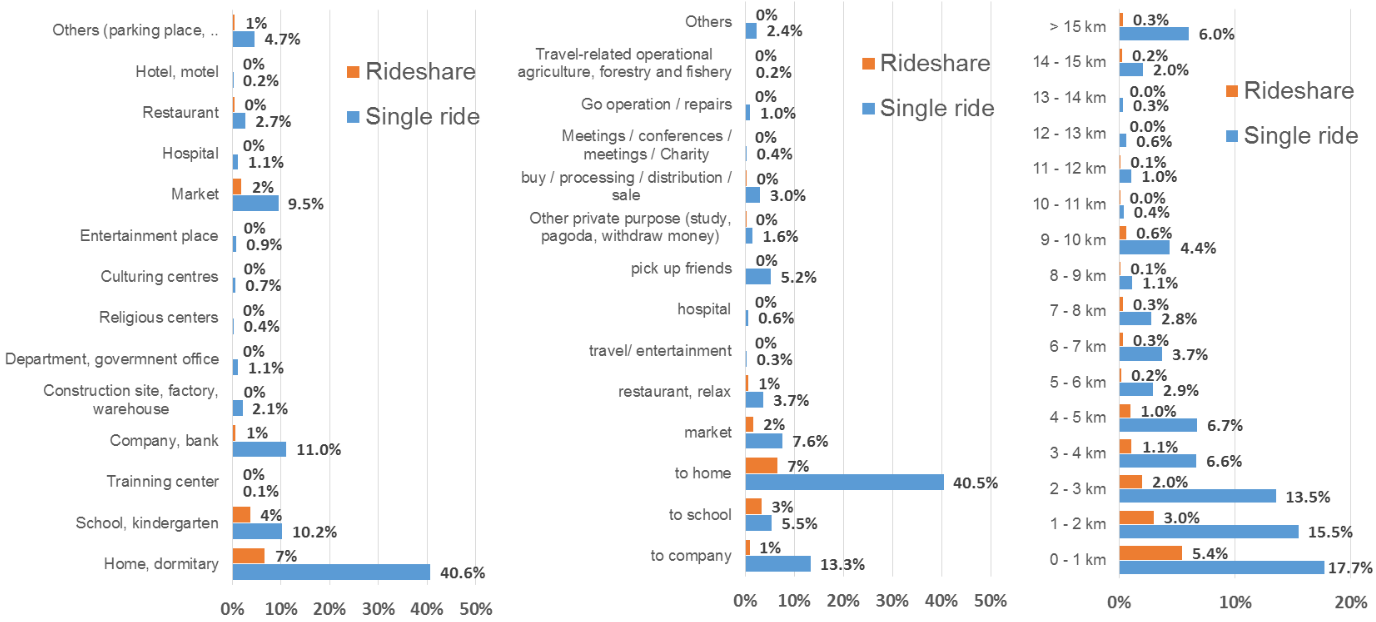


Figure 5. Distribution of motorcycle usage behaviors under various numbers of motorcycles owned by household.

Figure 6(a) shows the percentage number of trips made by rideshare and single ride classified by destination, trip purpose and travel distance per day of household members. Single ride and rideshare show percentage of 84.7% and 15.3%, respectively. Trip destinations of going home, school, company and market count for 40.6%, 10.2%, 11.0% and 9.5%, respectively by single ride and 7%, 4.9%, 1% and 2% by rideshare. Accept for going to company, other destinations shows high percentage of rideshare. Trip purpose shown in Figure 6(b) and trip destination show the same trend of rideshare by the family members because the correlation between them is high. Figure 6(c) indicates that rideshare is easily conducted in a vey short distance of from 0 to 2 kilometers.



a) By destination b) By trip purpose c) By distance per day

Figure 6. Number of trips by rideshare and single ride

3.2 Model specification

Motorcycle ownership model considers effects of explanatory variables on the number of motorcycles owned by households. The discrete choice models are increasingly being used by motorcycle ownership researchers on a basis of random utility theory. Under the framework of the theory, the household's decision to own vehicles is based on utility maximization. The utility of each motorcycle ownership alternative can be represented by the sum of observable and unobservable components. The total utility of an alternative i for household n is specified as

$$U_{ni} = V_{ni} + \varepsilon_{ni} = \alpha_i + \beta X_{ni} + \varepsilon_{ni} \tag{1}$$

where,

U_{ni}: total utility of an alternative i for household n.
V_{ni}: the observed component of utility.
ε_{ni}: the random error term.
X_{ni}: vectors of alternative specific variables.
α_i, β: the unknown parameters to be estimated.

Due to unordered nature of discrete data, this research applies the multinomial logit model (MNL) and nested logit model (NL) - disaggregate choice models. For multinomial logit model, the probability that an alternative *i* will be chosen by household can be written as:

$$P_{in} = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}}} \tag{2}$$

The MNL model assumes that the error term has independently and identically distributed for an alternative *i* (Train, 2003; Louviere et al., 2000). It means that the error term of alternatives is uncorrelated and has equal variance. As a result, a criterion required to apply the model is the independence of irrelevant alternatives (IIA).

The NL model is allowed to consider correlation between the utilities of alternatives in a common nest - a set of motorcycle ownership alternatives. This helps relax the IIA property. For nested logit model, the probability that an alternative *i* will be chosen by household can be written as:

$$P_{in} = \frac{e^{V(in/\mu_m)} \times \left[\sum_{j \in N_m} e^{V_{jn}/\mu_m}\right]^{\mu_m - 1}}{\sum_m \left[\sum_{j \in N_m} e^{V_{jn}/\mu_m}\right]^{\mu_m}} \quad (3)$$

where,

N_m: a set of alternatives in the nest m

μ_m: Inclusive value (log-sum parameter) for the nest m, the degree of correlation between alternatives' utilities in the nest

The value of log-sum parameter must lie within the range of 0–1 for consistency with utility maximization. If the value is out of the range, NL models are not significantly different from MNL model.

3.3 Explanatory variables

In this study, alternatives are number of motorcycles owned by the household, which are nominal in nature. After excluding samples of a few households owning more than four motorcycles or less than one motorcycle, the motorcycle ownership model considers four alternatives (from 1 to 4 motorcycles). The alternative of household with 1 motorcycle ownership was selected as the reference, meaning the constant component in utility function of the alternative is set to be zero (Chieh-Hua, 2012). All the explanatory variables obtained from our survey which affect motorcycle ownership are presented in Table 1.

Table 1. Explanatory Variables

Group	No	Variable Name	Description
Household characteristics	1	FamilyNo	Number of household members
	2	ChildrenNo	Number of children in the household
	3	WorkNo	Number of workers in the household
	4	OldNo	Number of members over the age of 60 in the household
	5	Car	Number of cars owned by the household
	6	Income	Total household income per month
	7	MotorLicenseNo	Number of members with motorcycle license in the household
	8	CarLicenseNo	Number of household members with car license
Motorcycle attributes	9	Time	Number of years of motorcycle usage per household
	10	PurchasePr	Total purchase price of motorcycles per household
Trip attributes	11	OD	Total number of trips per day by household

			members
	12	Distance	Total number of kilometers traveled per day by household members
Rideshare	13	Share	Total number of trips per day of household members made by sharing rides in motorcycle.

3.4 Parameter estimation process

The process follows these steps below:
Step 1: Decreasing number of explanatory variables

The Akaike information criterion (AIC) is used to select a better model by dealing with the trade-off between the goodness of fit of the model and the decreasing number of explanatory variables (Akaike, 1974). Given a set of candidate models with different number of variables, the preferred model is the one with the minimum AIC value. For logit model, AIC is calculated as below:

$$AIC = Residual\ Deviance + 2k$$

,where k represents the number of explanatory variables.

A MNL model with 13 variables is calibrated in this study. The result of Hausman test indicates that the IIA assumption of the MNL model holds. Using AIC criterion, 2 variables (CarLicenseNo, OldNo) were deleted to obtain the goodness-of-fit model as shown in this Table 2.

Table 2. Explanatory variables using AIC criterion

Explanatory variables	AIC criterion
13 variables (a full model)	1670
12 variables (deleting CarLicenseNo variable)	1667
11 variables (deleting two variables: CarLicenseNo and OldNo)	1665

Step 2: Estimating parameters of MNL
A MNL model with 11 variables obtained from Step 1 is calibrated in this study. The parameter results are presented in the next Section. Therefore, the MNL specification is chosen as the appropriate motorcycle ownership model.

Step 3: Estimating parameters of NL models
Any alternative can be grouped into a nest theoretically. However, the nature of the number of motorcycles in households is ordered, so the adjacent alternatives should be grouped into a nest. For example, alternative of households owning 1 motorcycle (Alt.1) and alternative of households owning 2 motorcycles (Alt.2) can be grouped into a *Nest 1*, and alternatives of households owning 3 motorcycles (Alt.3) and 4 motorcycles (Alt.4) are single alternative nests. This research estimates 5 NL models, presented in Table 3.

Table 3. Nested Logit models

Model Name	Structure of NL model	Log-sum parameters μ_m
NL1	*Nest 1* + Alt.3+ Alt.4	-1.0348^{***}
NL2	Alt.1 + *Nest 2* + Alt.4	0.1750
NL3	Alt.1 + Alt.2 + *Nest 3*	-2.2789^{***}
NL4	*Nest 4* + Alt.4	0.2427
NL5	Alt.1 + *Nest 5*	-0.2155^{***}

* Significance of t-statistics at 10%.
** Significance of t-statistics at 5%.
*** Significance of t-statistics at 1%

The nested structure of NL1 model is inappropriate because the log-sum parameter (μm) of nest 1 fell outside the reasonable range (0 – 1). The NL2 and NL4 models have the log-sum parameter values that lie within the 0–1 range, but they were not statistically significant. Therefore, NL5 model is compared to MNL model to consider the most appropriate model.

Step 4: Testing the goodness-of-fit between MNL and NL model.
Using the likelihood ratio test, the NL5 model does not outperform the MNL model using likelihood ratio test as shown in Table 4. Hence, in this research, multinomial logit model is used to analyze factors affecting on household motorcycle ownership.

Table 4. Results of the likelihood ratio test for MNL model and NL model

Model	**Log-likelihood value**	**likelihood ratio (ρ^2)**
NL5	-795.95	0.5672
MNL	-796.44	0.5669

4. RESULT AND DISCUSSION

4.1 Result of motorcycle ownership model

After filtering data for parameter estimation, the number of valid samples is reduced from 1620 to 1578 households. Table 5 reports the parameter results of MNL model variables.

Table 5. Model estimation results

Variables	**Household motor categories**	**Parameter (β)**	
Alternative specific constants	2 motorcycles	-10.610	***
	3 motorcycles	-23.838	***
	4 motorcycles	-32.892	***
Distance	2 motorcycles	-0.001	
	3 motorcycles	0.004	
	4 motorcycles	0.009	*
OD	2 motorcycles	0.124	*
	3 motorcycles	0.144	*
	4 motorcycles	0.157	
Car	2 motorcycles	-0.523	
	3 motorcycles	-1.091	

	4 motorcycles	-3.893	***
FamilyNo	2 motorcycles	0.453	***
	3 motorcycles	0.817	***
	4 motorcycles	1.102	***
Income	2 motorcycles	0.217	**
	3 motorcycles	0.325	***
	4 motorcycles	0.294	**
ChildrenNo	2 motorcycles	-0.063	
	3 motorcycles	-0.548	*
	4 motorcycles	-0.353	
WorkNo	2 motorcycles	0.113	
	3 motorcycles	0.649	**
	4 motorcycles	1.166	***
MotorLicenseNo	2 motorcycles	0.678	***
	3 motorcycles	1.935	***
	4 motorcycles	1.914	***
PurchasePr	2 motorcycles	0.127	***
	3 motorcycles	0.186	***
	4 motorcycles	0.217	***
Time	2 motorcycles	0.313	***
	3 motorcycles	0.487	***
	4 motorcycles	0.579	***
Share	2 motorcycles	-0.020	
	3 motorcycles	-0.187	*
	4 motorcycles	-0.226	*
Log-likelihood value		-796.44	
Likelihood ratio ρ^2		0.567	
Adjusted likelihood ratio $\bar{\rho}^2$		0.557	
Sample size		1578	

* Significance of t-statistics at 10%.
** Significance of t-statistics at 5%.
*** Significance of t-statistics at 1%.

Based on Table 6, the prediction of “2 motorcycles” response category is the highest with 89.60% correct prediction, followed by the “1 motorcycle category” with 82.70% correct prediction, “3 motorcycles category” with 77.40% correct prediction and lastly the “4 motorcycles” category with only 49.60% correct prediction. In conclusion, the accuracy of the model is good enough with 82.40% of correct prediction.

Table 6. Model prediction summary

Observed	Predicted				
	1 motorcycle	2 motorcycles	3 motorcycles	4 motorcycles	Percent Correct
1 motorcycle	186	39	0	0	82.7%
2 motorcycles	29	735	53	3	89.6%
3 motorcycles	4	68	319	21	77.4%
4 motorcycles	0	10	51	60	49.6%
Overall Percentage	13.90%	54.00%	26.80%	5.30%	82.4%

4.2 Analysis results

Based on the estimation results of MNL model in Table 6, parameter coefficients of explanatory variables are significantly different from zero at the 10% level, indicating that household characteristics, motorcycle attributes, trip attributes, and rideshare have significantly affected on household motorcycle ownership. The explanatory variables in the model are alternative specific to the number of motorcycles. Positive parameter coefficients suggesting that increasing the value of each variable will increase motorcycle ownership (i.e., households need more motorcycle for travel). On the contrary, negative parameter coefficients indicating that increasing the value of each variable will reduce motorcycle ownership.

An important variable used in this research is motorcycle rideshare. The result shows that the rideshare variable has two negative coefficients related to two alternatives (three, and four motorcycles in the household), showing that as household members share more trips, the households are inclined not to own too many motorcycles, particularly household with three and four motorcycles. Based on our survey, there is on average 2.37 working age people and 2.33 motorcycles in a household, indicating that most households can afford to purchase motorcycles for workers. Hence, purchase cost of motorcycles is not a reason. The lack of parking space at home may be a reason for this situation. The result is unlikely to be consistent for household with two motorcycles. This can be explained by the fact that a household with two main workers such as the father and mother need at least two motorcycles to travel and it is difficult to share a ride because their daily trips are often different.

Among variables of trip attribute, number of kilometers traveled per day of household members represents motorcycle usage. The parameter coefficients related to alternatives of household owning two and three motorcycles are not significantly different from zero. In the case of four motorcycles, parameter coefficient is significantly different from zero at the 10% level. This suggests that distance is not strongly associated with household ownership. This may be due to motorcycle dependent transportation system of Ho Chi Minh City. The survey data also reveals that 2.37 people in working age in a household own 2.33 motorcycles. This finding is similar to the result reported in Section 3.1 indicating that there is still no obvious relationship between motorcycle usage and ownership. Another variable of trip attribute is number of trips per day of household members. Coefficients related to two alternatives (two and three motorcycles in the household are positive and significant, suggesting that the more trips per day there are by family members, the more motorcycles need to satisfy their travel demands. However, coefficient for household owning 4 motorcycles is not statistically significant. This may be due to rideshare of family members.

Household characteristics and motorcycle attributes are the two remaining groups of factors affecting the motorcycle ownership. For motorcycle attributes, number of years of motorcycle usages and total purchase price of motorcycles owned by the household all have positive effects on motorcycle ownership. For household characteristics, motorcycle driver's license number, the household monthly income, the number of cars, the number of family members, the number of children, and the number of workers affected motorcycle ownership significantly. Number of cars has a negative coefficient related to household with four motorcycles, indicating high substitution relationship between car and motorcycle. Coefficients of household members are positive and significant, showing that as the number of family members increases, the more motorcycles the entire family tends to own. These results are also reported in Chieh-Hua et al. (2012). Number of workers affects positively two alternatives with 3 and 4-motorcycle households, demonstrating that the need to own motorcycle of working members in the family is very high. Coefficients of number of motorcycle license holders are significantly positive for all the alternatives, indicating that the more household members there are with motorcycle license, the higher the number of motorcycles per household. Monthly income of households, as expected, positively influences all motorcycle ownership alternatives. If the economic status of the family grows, households can afford to buy motorcycles to satisfy their travel requirements. These results are similar to those found in the study of Leong and Sadullah (2007).

4.3 Discussions

According to the analysis, there is no clear distribution that can be identified for the relationship between motorcycle usage and ownership as explained in Figure 5. Therefore, restricting motorcycle ownership will not be able to effectively restrict motorcycle usage. In reality, the bus system in HCMC is short of effective at present, so residents will find easier to accept motorcycle usage behaviors adjustment more than motorcycle ownership restraint immediately. Among traffic congestion mitigation measures in a short-term period, the measure that uses motorcycle effectively to decrease daily trips is easier to implement than the one which directly restricts motorcycle ownership because the former may face less opposition than the latter. Even so, gradually reducing the usage of such private vehicle in the future will need careful consideration, especially when public transportation systems such as Mass Rapid Transit (MRT) or Bus Rapid Transit (BRT) come into operation.

One of the elements affecting motorcycle ownership is number of trips per day by family members. The more trips per day the family members have, the higher the motorcycle ownership. According to the study of Hsu et al. (2007), when the city has better public transportation service, the more usage of public transportation in the city will reduce motorcycle ownership. The issue here is that compared to private vehicles, the bus system in HCMC still have many constraints on network connection and information provision system of for example, a trip schedule, origin – destination and so on. Besides upgrading the level of service, bus line connection and extension between residential areas and commercial zones will also be required. Furthermore, improving the quality and credibility of passenger collection vehicles such as car taxis, motorcycle taxis, or vehicles from Grab or Uber services will have to be taken into account as well.

Motorcycle rideshare is a new factor used in this research. This is the factor which negatively affects on motorcycle ownership. It is related to how use motorcycle effectively to decrease daily trips. As family members can drive together to their destinations such as company or school, it will help to decrease number of private vehicles, number of trips; thereby reducing traffic jam and environmental pollution. There have been many studies of rideshare in the world. Recently, rideshare service relying on mobile phone technologies known as Real-time ridesharing has gained in popularity (Amey et al., 2011). Nevertheless, this is still comparatively new in Vietnam.

Another factor is number of car in household. Numbers of cars in the household show significant and negative effects on an alternative of four motorcycle households. It means that households prefer cars than owning 4 motorcycles. However, due to infrastructure constraints, shifting from motorcycle to car is not necessarily better, and might possibly cause an even more severe traffic congestion.

5. CONCLUSIONS

This study investigates factors influencing household motorcycle ownership in HCMC by using disaggregate choice models. In order to create an appropriate motorcycle ownership model, the study considers the use of MNL and NL models to accommodate the possible existence of independence among alternatives. The result shows that almost all factors of household characteristics, motorcycle attributes, trip attributes, and motorcycle rideshare have significant impacts on motorcycle ownership.

Motorcycle rideshare and number of cars owned by the household have negative and significant effects on motorcycle ownership. Besides the development of public transportation systems in the future in HCMC, several solutions in this research are also proposed to decrease motorcycle ownership such as development of motorcycle rideshare or concentration on management strategies in reducing motorcycle ownership. Developing a motorcycle ownership model in this research will enable better understanding of the motorcycles ownership trend in HCMC; for this reason, planning and development of traffic system will be easier for the future.

This study has several limitations that need to be examined for future research. Data in this research had only been collected within one year, and new surveys should be continuously conducted to enrich the data sets and move on from static to dynamic modeling, accounting for state dependence and heterogeneity (Kitamura and Bunch, 1990; Hanly and Dargay, 2000; Giuliano and Dargay, 2006; Dargay and Hanly, 2007). Moreover, in order to create appropriate development and management strategies, some factors should be taken into account for motorcycle ownership model such as annual license tax, fuel cost, maintenance and insurance costs, environmental attitude as well as the impacts of public transportation. Collecting more detailed information about motorcycle usage, such as annual kilometers traveled, is necessary to have a comprehensive analysis by using discrete or continuous modeling structures.

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