

STUDY ON MODE CHOICE AND VEHICLE OWNERSHIP IN A MEDIUM-SIZED ASIAN CITY

Jaruwit Prabnasak¹ and Michael A P Taylor¹

¹Institute for Sustainable Systems and Technologies – Transport Systems, University of South Australia
City-East Campus, North Terrace, Adelaide SA 5000, Australia

ABSTRACT

Massive use of motorcycle is a signature of Eastern-Asia developing countries. This is may be termed a *motorcycle dominant environment*. Although the use of motorcycles is likely to provide many benefits to the riders, it also produces many serious transport issues for the community. To find out the solution, an understanding of traveller behaviour is necessary. *Travel demand modelling* then becomes a useful tool. It is used to capture the behaviours contributing the travel demands, and also to predict expected results of each solution.

This paper reviews previous studies on travel demand modelling in motorcycle dominant environments, and discusses the findings. Results of the discussion have shown that there are still large gaps, arguments and doubts found from those previous studies, especially a lack of knowledge about *medium-sized urban areas*. This can be the inspiration for a new research, as described briefly in the last section of the paper.

KEYWORDS

Motorcycle dominant environment; Travel demand modelling; Medium-sized urban area

1. INTRODUCTION

Massive use of motorcycle is a signature of Eastern-Asia developing countries. This can be called a motorcycle dominant environment. Although the use of motorcycles is likely to provide many benefits to the riders, it also produces many serious transport issues for the community. To find out the solution, the understanding of traveller behaviours is necessary. Travel demand modelling then becomes a useful tool. It is used to capture the behaviours contributing the travel demands, and also to predict expected result of each solution.

This paper starts with the background of massive use of motorcycle in Eastern-Asia developing countries, and follows up by review of the previous studies on travel demand modelling in the motorcycle dominant environments, and ends up to the discussion on those findings. Results of the discussion have shown that there are still large gaps, arguments and doubts found from those previous studies, including a lack of knowledge about medium-sized urban areas and the modelling techniques used. This can be an inspiration for the new research as described briefly in the last part of the paper.

2. MOTORCYCLE AND EASTERN-ASIA DEVELOPING COUNTRIES

Recently, most people recognize that the massive use of motorcycle has become a part of Eastern-Asia lifestyle. In the last few years, more studies have attempted to discover the reasons behind the massive use. Many evidences have showed that the massive use is a consequence of mistaken development directions of those countries over the past few decades, such as: deficiency of land-use and urban planning; private vehicle oriented developments that result to a lack of public transit improvement; and narrow social and economic development which leads a large gap of income among population.

Hayashi (1996) stated that the deficiency of proper land-use and urban planning leads a free-form giant growth of urban communities, called urban sprawl pattern. For such communities, the improvement of transport infrastructure mostly cannot follow the pace of the growth. This results to a lack of public transit in the community. Since the activities increase, travel distance is longer, public transit service is poor, and marketing of private vehicle is extensive, the consequence of this combination is that more and more people do have to own a private vehicle to facilitate their travel needs. This situation generates many subsequent issues; for example, traffic congestion, accidents, high energy consumption, noise pollution and emission to the community. (Phiu-nual 1996)

Why does the motorcycle become a part of lifestyle? Several studies such as Tuan & Shimizu (2005), Liu (2006), Hsu, Tsai & Lin (2007), Leong & MohdSadullaha (2007), Lai & Lu (2007) and Senbil, Zhang & Fujiwara (2007), collectively suggested that the income has a strong influence on the number and type of the vehicles in the household. Since most people have to travel by private vehicle as a consequence of urban sprawl pattern and private vehicle oriented developments, but most population in Eastern-Asia developing countries have lower income, compared to the developed world. Owning a private car is probably not the right way. Most travellers with lower income therefore have to find the other alternatives which are affordable for them.

Motorcycle seems to be the best candidate for those Asian people due to its characteristics. Tuan & Shimizu (2005), Liu (2006), Hsu, Tsai & Lin (2007), and Leong & MohdSadullaha (2007) stated similarly that the cost is the greatest advantage of using a motorcycle, particularly for the lower income group. That is because the cost of holding and using a motorcycle (e.g. purchase price, tax and registration fee, fuel consumption, maintenance cost, parking fee) is much lower than holding and using a private car.

Additionally, Department for Transport (2004), Leong & MohdSadullaha (2007), Chang & Wu (2008) and Minh (2007) supported that the usage performance is the other major advantage of the motorcycle. In several situations, a motorcycle can provide greater comfort and convenience to the travellers than a private car and public transit. Comparatively, motorcycle generally provides more manoeuvrability as well as easier to find a parking space than a private car. Motorcycle, on the other hand, provides door-to-door service which does not allow for public transit. Some people also said that riding a motorcycle is more enjoyable.

Motorcycles seem to provide many benefits to the riders. However, those motorcycles also produce many problems to the community, such as road safety issue, noise pollution, emission, and discourage the use of other sustainable transport modes such as walking, cycling and public transit, which seem to be more obvious year by year. Eventually, these are the contributions in increase of research and studies on the massive use of motorcycle in Eastern-Asia developing countries in the last few years.

3. PREVIOUS STUDIES

3.1. Previous Travel Demand Studies

The number of studies on the massive use of motorcycle in Eastern-Asia countries has been increasing rapidly over the last decade. Among them, one popular topic is the travel demand modelling in motorcycle dominant environments. The main objective of those studies is to develop a comprehensive understanding of the traveller behaviours in choosing alternative modes to travel, as well as to develop a tool to forecast in-exist travel demand which plays important role in transport policy and planning design.

Among previous travel demand studies in motorcycle dominant environments, two aspects of interest to recent researchers are household vehicle ownership and mode choice behaviour. The vehicle ownership is paid attention by recent researchers because those believed that the vehicle ownership has a strong influence on mode choice behaviour and travel demands. Hsu, Tsai & Lin (2007) and Lai & Lu (2007) showed that the number of vehicles in the household can be used to indicate the household travel demand, and also the potential mode choice.

Mode choice behaviour is the other important aspect in travel demand study, because it is directly related to the travel demand of alternative modes in the market. Well understanding of the mode choice behaviours can help researchers to develop a more accurate travel demand model, which allows more possibility of design better policies, planning and infrastructure developments, eventually.

Several studies, including Tuan & Shimizu (2005), , Lai & Lu (2007), , Leong & MohdSadullaha (2007), Hsu, Tsai & Lin (2007), Senbil, Zhang & Fujiwara (2007), and

Chang & Wu (2008), all agreed that the income is one of the greatest factors influencing both vehicle ownership and mode choice behaviour. Other factors, such as demographic characteristics of travellers, land-use characteristics, traffic condition and mode attributes, also affect the behaviour, but in various levels depended on the area.

This paper attempts to gather recent travel demand studies in motorcycle dominant environments. As best we can determine presently, there are perhaps 12 academic studies directly discussing on the topic. (It is important to note that all studies presented in this review came from free academic databases. There should be some more studies pressed in restricted academic databases. Additionally, some other studies were found, but not directly related on the massive use of motorcycle, and not referred to in this paper.) The locations of the previous studies are presented in Figure 1.

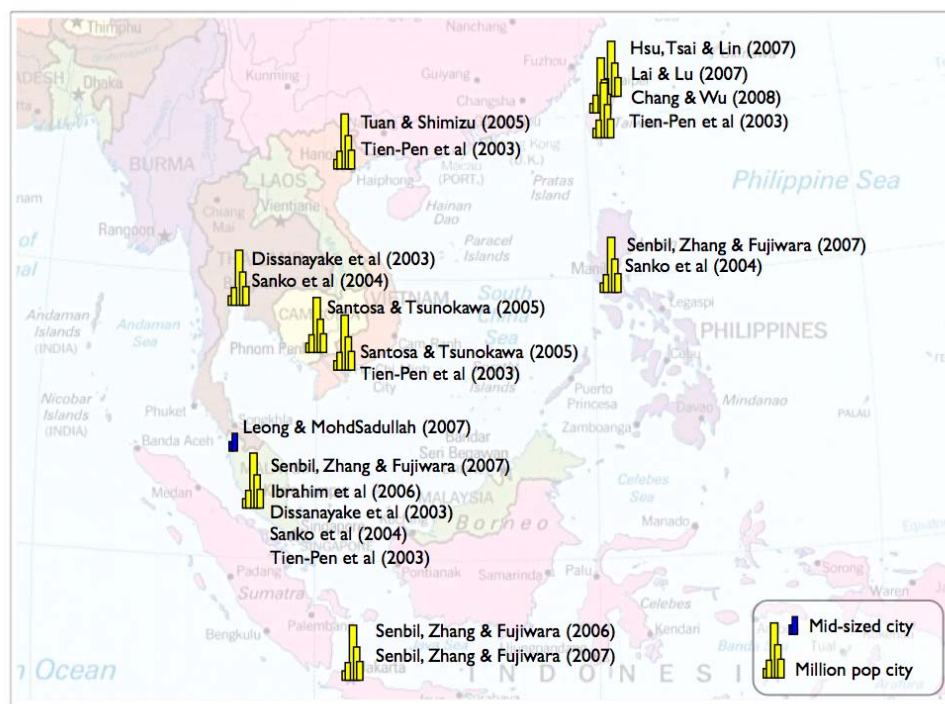


Figure 1 Locations of the previous studies on travel demand in motorcycle dominant environments

In Figure 1, most of the previous studies were undertaken in such multimillion population cities as Taipei, Kuala Lumpur, Hanoi, Ho Chi Minh, Bangkok etc. Only Leong & MohdSadullah (2007) report a study from a medium-sized city, which was Georgetown, Malaysia.

In those contents, all the previous studies provided a general discussion on the massive use of motorcycles, such as number of motorcycles, traffic composition, public transit services and several social demographic statistics, regarding to the study areas. Several studies also investigated further to the modelling of vehicle ownership and/or mode choice behaviour. Various modelling techniques were established to capture the actual behaviours as well as to predict the future demands. A summary of the contents of the previous studies on travel demand modelling is illustrated in Table 1.

Table 1 Contents of the previous travel demand studies in motorcycle dominant environments

	Large city	General Discussion	Travel Demand Modelling			Modelling Technique
			Ownership Model	Mode Choice Model	Mixed Model	
Tien-Pen et al (2003)	✓	✓				-
Dissanayake et al (2003)	✓	✓	✓	✓	✓	NL
Sanko et al (2004)	✓	✓	✓			Probit
Tuan & Shimizu (2005)	✓	✓	✓	✓		MNL
Santosa & Tsunokawa (2005)	✓	✓		✓		MNL
Ibrahim et al (2006)	✓	✓		✓		BL
Senbil, Zhang & Fujiwara (2006)	✓	✓	✓	✓		Pobit
Lai & Lu (2007)	✓	✓	✓	✓	✓	NL
Hsu, Tsai & Lin (2007)	✓	✓	✓	✓		Poisson
Leong & MohdSadullah (2007)		✓	✓			MNL+SP
Senbil, Zhang & Fujiwara (2007)	✓	✓	✓			Pobit
Chang & Wu (2008)	✓	✓		✓		Rasch

Denote: MNL = Multinomial Logit Discrete Choice Model Rasch = Rasch Model SP = Stated Preference
 BL = Binomial Logit Discrete Choice Model Pobit = Bivariate-Ordered Pobit Model
 NL = Nested Logit Discrete Choice Model Poisson = Poisson Regression Model

3.2. Critique of the Previous Studies

The previous studies, shown in Table 1, have demonstrated their achievement in progressing the state of knowledge of travel demand modelling in motorcycle dominant environments. However, the number is still small compared to those in private car dominant environments. Additionally, several arguments have been still unsolved yet. Three major arguments established in this paper are: the deficiency of study in a medium-sized urban area; the model combined vehicle ownership and mode choice behaviour; and the argument on modelling techniques.

3.2.1. Deficiency of Study in a Medium-Sized Urban Area

In the past, it was quite sensible for those previous studies to be undertaken in such multimillion population cities. That is because transport issues can be reflected more obviously in a large city in general. Those cities are moreover quite significant to the country's economy and political views. But from the other angle, the majority of urban populations in Eastern-Asia countries are in fact living in medium-sized cities (World Bank 1998; Brinkhoff 2008). In a projected view, while several medium-sized cities are likely to become a large and important city in the future, the transport issues in those cities seem to be growing following the size of the population. Thus, the development with pointing to the large cities but ignore medium-sized cities may not be appropriate idea for the present time.

In recent years, the national governments of several countries have started paying more attention to the medium-sized cities which have the potential for future significant growth. In Thailand, several sustainable transport development projects have recently been setup in medium-sized cities, including three public transit improvement projects (Komna 2006; OTP 2007; SIRDC 2008); however those are still in the embryonic stage. This implies the increase in significance of medium-sized cities in political views of the governments, as well as the needs for a travel demand study in medium-sized cities of Eastern-Asia developing countries.

3.2.2. Model Combined Vehicle Ownership and Mode Choice Behaviour

Evidence found by Dissanayake (2003) Tuan & Shimizu (2005) Senbil, Zhang & Fujiwara (2006) Hsu, Tsai & Lin (2007) and Lai & Lu (2007) correspondingly supported the hypothesis that there is a strong relationship between vehicle ownership and mode choice behaviour. This implies the possibility that joint modelling of both aspects may produce a more accurate result than modelling each of them separately.

From Table 1, only Dissanayake (2003) and Lai & Lu (2007) who attempted to relate the mode choice model to the ownership model. Both studies used a similar modelling technique, which was *discrete choice model* with *nested logit* structure. However, the model developed by Dissanayake (2003) did not purport to deeply investigate the correlation among traveller characteristics, mode choice behaviour and vehicle ownership, while Lai & Lu (2007) did.

Although Lai & Lu (2007) investigated the correlation among those aspects comprehensively, some points on their work still can be argued. Firstly, the model developed by Lai & Lu (2007) focused on the travellers in Taipei, which is a multimillion population city. Another factor is that while Taipei and other urban communities in Taiwan have motorcycle dominant environments, they are substantially from other urban communities in Eastern-Asia developing countries because of the higher income levels of people in Taiwan. That means the behaviour of people and the weight of influential factors may be different. For example, personal income may not be as important a factor behind the massive use of motorcycles in Taiwan as in other countries.

Secondly, the model developed by Lai & Lu (2007) took only the main worker in household into account, in order to simplify the complexity of the model. In fact, that main worker may not totally represent all members in the household. The simplest example is the difference between two households with similar amount of income: the first household has one worker and one student; on the other hand, the second household has more than one worker but no student. These two households are likely to make different numbers of daily trips generated, mode choice and also number of vehicles and types required.

Thirdly, the *Rho-Square* (ρ^2) value, which is commonly used to indicate to what extent the model fits to the data, in the model developed by Lai & Lu (2007) were quite low (between 0.17 and 0.30). Besides, predictability of the model relies more on the mathematics than actual behaviour of travellers. These factors suggest that the model is likely to contain a large amount of errors which may result in low accuracy of prediction. This issue is discussed further in the following section.

Due to the limitations in the previous studies, several arguments have remained and need to be resolved. Examining the correlation among vehicle ownership, mode choice behaviour and several influential factors using travel demand model thus seems to be a fascinating topic for the further research on travel demand in motorcycle dominant environments.

3.2.3. Argument on Modelling Techniques

In travel demand studies, one of the most difficult tasks is model development. Travel demand modelling techniques are under continual improvement in order to increase their predictive capability. Each technique has its own advantages and disadvantages, and is likely to be more appropriate in certain conditions. Nevertheless, success in developing a model is not only dependent on the technique chosen; it also depends on the expertise and experiences of the modellers and on many other factors of influence.

Several modelling techniques have been used in the previous travel demand studies in motorcycle dominant environments. Those include discrete choice, bivariate-ordered probit model, Poisson regression and the Rasch model (see Table 1). Among these, the discrete choice model seems to be one of the most popular techniques. The major advantages of this model are its simple form for the choice probabilities and its flexibility (Haaijer 1999). It also provides a set of regression models that represents the relationship among parameters involved in the model and its utility function. The coefficients of each parameter can also help analysts to interpret the relationship straightforwardly.

Considering the databases used for developing models in those previous studies, except Leong & MohdSadullah (2007), all other models were developed from two sets of information. The first set includes demographic and socioeconomic information of travellers, the attributes of alternative modes, and/or trip characteristics. Let us call the information in this set *general attributes*. The other set is usually called *revealed preference (RP)* information. This kind of information includes the individuals' actual historic choices and experiences, such as usual travel mode or number of vehicles purchased by the household. A major advantage of a model built on general attributes and revealed preference information is the capability of the model to reflect actual choice-making behaviour of people. However, the predictability of those models is limited to the products, services or situations presently available in the market.

Figure 2 allows us to see more clearly on this problem. The shade area represents the existing condition. That means both general attributes and revealed preference information can be only in the area so. Since the model is built on the existing condition, called *revealed model*, the predictability is therefore limited to the boundary of the shaded area too. This boundary is generally called *technological frontier*. Nevertheless, a major purpose of those models is to predict the potential travel demand in the future. To allow a revealed model to cross the boundary of the shade area, some techniques are introduced; one popular technique is called *elasticity analysis*. Although the elasticity allows the revealed model to go beyond the boundary of existing condition, the result of prediction relies purely on mathematics, not the actual traveller behaviours. This can perhaps cause the predicted result of the model to be impractical in reality, which is the major disadvantage of models built on general attributes and revealed preference information. (Louviere, Hensher & Swait 2000; Hensher, Rose & Greene 2005)

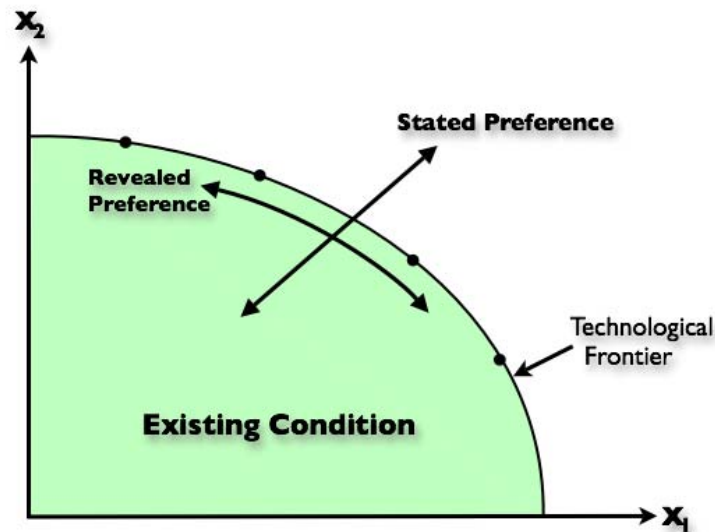


Figure 2 The technological frontier and the roles of RP and SP
(Hensher, Rose & Greene 2005)

Modern discrete choice model allows us to reduce the error of prediction by integrating new technique called *stated preference (SP)* technique into the traditional model. The main objective of the technique is to investigate the choice-maker behaviours regarding to the future situations by using choice experimental setting where the choices are made in hypothetical situations. Individuals are repeatedly required to make a choice among a group of products, services or situations, while choice attributes, such as cost, time, service quality, etc, varies. This allows possibility of the model to capture the choice-maker behaviours beyond the technological frontier directly, which results to more capability in reflecting the future demands than using pure mathematical techniques, such as elasticity analysis. (Louviere, Hensher & Swait 2000; Hensher, Rose & Greene 2005)

Since the SP technique aims to investigate how individuals respond to a set of hypothetical situations, a unique questionnaire instrument design, called 'choice experiment design', is required. The research questions in this level must be made specifically on some interested situations, such as variation of fuel price, travel distance, traffic condition, parking fee application and public transit improvement. The difficulty of choice experiment design is the beauty of using SP technique. A more complex choice experiment means higher number of parameters involved. This can potentially reflect the correlation among larger set of parameters. In contrast, simple choice experiment can demonstrate the correlation of only few parameters, but easier for respondent to understand. Design of the attribute values contained in choice experiments is also important. The values should not be very different from the possible future to avoid extrapolation when using the model to make a prediction. However, the value should not be too realistic as well. Otherwise, the orthogonality of the SP design may be compromised. (Khan, Ferreir & Bunker 2006)

Recent years, researchers have experimented with integrating the SP technique into travel demand models. Various levels of complexity of choice experiment were examined, but most of these studies have come from developed countries. In fact, there seem to be large differences between choice experiment designs for developed and developing countries, such as the education level, income and public transit accessibility which can vary widely in

developing countries. One difficulty in choice experiment design in developing countries, for example, is that low educated respondents may not be able to understand and make a choice in a sensitive choice experiment (i.e. one that contains many parameters and variations of attribute values). The measurement unit can possibly be a problem as well. Some respondents may not be able to imagine how far 'two kilometres' is, for example. Large gaps of incomes and high proportions of captive travellers in developing countries also lead to difficulties in setting a range of values and number of levels for each attribute in a choice experiment.

From above discussion, a discrete choice model with stated preference technique seems to provide a great benefit in term of improving predictability of the model outside the technological frontier. There are however many possible problems still found in using of this technique especially in developing countries. Therefore, this can be the other fascinating quest for the further work on travel demand: the evaluation of SP choice experimental design in Eastern-Asia developing countries.

4. NEW RESEARCH

From the above discussion on previous, the direction of a new research project can be defined. The aim of this research is to develop a comprehensive understanding for the current household vehicle ownership and mode choice behaviour of residents in a medium-sized urban area with the motorcycle dominant environment, and also to develop a model to predict the vehicle ownership and usage behaviour of various travel modes in the future.

To achieve the aim of the research, discrete choice modelling is selected due to its advantages. Stated preference (SP) technique is integrated to improve the predictability of discrete choice model beyond the technological frontier. The difficulty and challenge of addressing SP technique into Eastern-Asia developing countries is in the choice experiment design process. The degree of complexity of the choice experiment is therefore another fascinating point to be investigated.

The variation in sample sizes is also of interest and will be tested in the research. The purpose of this experiment is to observe the stability of the model when the sample size used for calibration is varied. Findings from the first experiment will influence the sample size required for the other proposed experiment, which is the experiment on model transferability. The purpose of the study on transferability is to investigate whether or not the model developed in one study area can offer similar predictability if it is transferred to another urban area. Thus, another survey with a smaller sample size is required to be undertaken in the other medium-sized urban area. The sample size of this survey will be defined after the variation in sample sizes has been studied.

In all, the research is expected to provide answers to several questions related to travel demand modelling in a medium-sized urban area with motorcycle dominant environment, such as: what is the vehicle ownership and mode choice behaviour of residents in the study area; what is the difference between medium-sized and large cities; what is the accuracy of discrete choice models; can the SP technique improve the accuracy of traditional models; what is the proper sample size for a study area; is it possible to transfer the model to other medium-sized cities; and so on?

5. CONCLUSION

Even though the motorcycle is seen to provide many benefits to the users, especially in Eastern-Asia developing countries, it also produces many serious transport issues for those countries. In recent years, many research works and studies have been undertaken on these issues. Travel demand study in motorcycle dominant environment is one fascinating topic among those previous studies. It seeks to explore the traveller behaviours and demands, as well as to predict expected changes of demand under different policy and planning strategies in the future.

As discussed earlier in this paper, recent studies have demonstrated a large progression in knowledge on travel demand modelling in Eastern-Asia developing countries. However, there are still large gaps of knowledge, arguments and doubts found from those previous studies, including lack of knowledge about medium-sized urban areas and modelling techniques used.

To fill those gaps and eliminate the arguments, a new research project is therefore introduced. Discrete choice modelling with a combination of revealed and stated preference data will be used for this purpose. The evaluation of SP choice experiment design, the experiments on model stability in various sample sizes and model transferability will also be undertaken.

After all, the research is expected to provide answers to several questions related to travel demand modelling in a medium-sized urban area with motorcycle dominant environment, and this would be the next step of the travel demand study in Eastern-Asia countries.

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