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Examining Modal Shift to Public Transport in Developing Asian Cities: A Case Study in Hanoi City, Vietnam

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Abstract: Quite many Asian cities are facing the issues of motorcycle dominance, and to solve it these cities are developing urban mass rapid transit systems (i.e., BRT and MRT) with an intention to attract a large number of motorcycle and car users. However, there might be uncertainties in shifting private transport users to new public transport systems, thereby risking the effectiveness of the investment in public transport. This study aims to examine the possibilities of modal shift to public transport by exploring current patterns of people's travel behavior and anticipating their mode choice changes under policy intervention scenarios. Hanoi City, a typical motorcycle-dominated city in Asia, is selected for a case study. A stated preference survey is conducted and SP/RP mode choice models are estimated for different segments of urban transport market. It is revealed that a significant number of private transport users might still stick to motorcycle and car use despite aggressive improvements of public transport in the future. Trip chaining behavior and presence of school kid(s) in the family may prevent family members from shifting to public transport. A longer travel distance may not necessarily lead to a higher modal shift away from motorcycle. These findings would be helpful to guide policy making towards sustainable development of public transport systems and effective management of private transport in developing cities, especially whose motorcycles are rapidly increasing and being dominant.

Key words: Public transport, BRT, transportation management.

1. Introduction

1.1 The Dominance of Motorcycles in Asian Cities

In developing Asian cities, urban transport situations are getting worse because the large-scale travel demands have been continuously increasing as the consequence of rapid economic growth, rapid urbanization, high densities, and overconcentration in the capital cities [1-3]. These developing cities failed to respond to travel demand growing trends as they have supplied inadequate road infrastructure and substandard public transport services. As a result, motorcycle ownership and use have increased so rapidly that they are now dominating urban transport in many cities. In Hanoi and Jakarta, for examples, motorcycle ownership rates already stood at 600-700 motorcycle/1000 population [4]. The dominance of motorcycles has caused severe road traffic accidents and decreased public transport use. In the meantime, private car ownership and use have been increasing quickly because high income people are seeking for more comfortable and safer transport. These special conditions strongly call for innovative strategies to developing urban transport systems in the long term in order to meet the increasing travel demand and substantially reduce motorcycle and car use.

1.2 Policy Interventions and Modal Splits Changes

The first part of the overall study on "Long-term travel behavior changes and innovative policy response in developing Asian countries" [4] pointed out that modal split shave been changing across Asian cities as

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a result of policy interventions that have been implemented by city governments. In Hanoi, motorcycle share has remained to be higher than 80% of total motorized trips due to poor bus services. In Jakarta, despite the introduction of BRT network, consisting of 10 lines, motorcycle share has suddenly increased from 26% to 63% for a period of 2002-2010. In Bangkok, the share has increased from 18% to 27% during 1990-2010. In Taipei, the figure has remained more than 30% for several decades despite of the fact that public transport services, which consist of MRT lines and dense bus network, have been fairly good. People in these cities have used motorcycle for multi purposes, including commuting, shopping, private business, delivering services and accessing transit stations. In contrast, motorcycle share in Guangzhou started to decline from 31% in 2003 to 7% recently due to a continuous improvement of public transport service and motorcycle ban in urban area. Tokyo and Seoul are extreme cases where motorcycle share has always been minor (only 2-3%) while public transport share has been 70%-80%. Clearly, an early development of urban railways and a continuous improvement of public transport services have made it a very good public transport system. People in these two cities have used motorcycle only for short-distance trips, such as shopping near home, delivering goods/services and accessing railway stations and/or bus terminals and stops. Contrasting pictures between the developing and developed cities in Asia imply that to solve the dominance of motorcycles it will require drastic improvements of public transport services and strong regulations of motorcycle transport. Otherwise, the dominance of motorcycles is likely to continue in the long run, challenging sustainable urban transport development.

1.3 Integrating Motorcycles with Public Transport Systems –a Promising Solution

The concept of integrated transport system has been discussed long time by Givoni and Banister [5], Schipper [6], May and Roberts [7]. Under this system, mass rapid transit lines, such as MRT and BRT, play the role of trunk modes and private passenger cars serve the role of a feeder mode. However, this concept might be not easily realized and implemented as private passenger cars require a huge number of parking spaces and robust and of course expensive infrastructure for intermodal connection. However, such a concept can be realized and could be effective in the context of motorcycle-dominated cities. This is because of two folds. First, these cities have been planning and/or developing mass rapid transit systems to meet increased travel demand due to high urbanization and economic development. For example, Hanoi City has planned to develop an extensive mass rapid transit system, consisting of 8 MRT lines and 5 BRT lines, by 2030 [8]. Second, motorcycles in Asian cities are mostly scooter type (with engine displacement of 50-125cc) and thus are space efficient, especially when parking. Parking space for a standard passenger car (about 25 m2) can store 8-10 motorcycles [4]. Therefore, it would be easy to provide parking infrastructure for motorcycles and bicycles to make them feed the mass rapid transit systems, which are under planning or construction. Further, if motorcycles are only used for short-distance trips and run at low speeds, the danger of motorcycle fatal accidents could be improved significantly [4].

However, an important question is even if the mass rapid transit system is introduced and motorcycle is provided with a parking space at railway station or bus stop, whether it would be possible to attract a large number of motorcycle (and car) users to public transport? This question is new and of course unanswered. There might be uncertainties in changing people's travel behavior that may risk the effectiveness of public transport investments. A better understanding of travel behavior changes may help plan better the BRT or MRT network, which consists of line alignment, station space design, parking and terminals to connect with other modes, and formulate special regulations of motorcycle use, if needed.

1.4 Research Objectives

This research aimed to understand current patterns of people's travel behavior and how they might change their mode choice under scenarios of improved level of service of public transport and increased parking fee. From this understanding, innovative policies were suggested. Hanoi City was selected for a case study.

2. Methodology and Data Collection

2.1 Overall Research Framework

The overall study follows a framework as presented in Figure 1. First, an attempt is made to collect and compile macro time-series data on infrastructures and public transport services, private vehicle ownership, modal splits, and policy responses so far. These data are used to analyze urban transport trends. Second, from the trend analysis results, potentially effective policies are considered and scenarios of policy intervention are set. Third, person trip surveys are conducted in studied cities to collect travel behavior data for analyzing travel behavior changes. Lastly, the considered policies are evaluated and effective policy measures are recommended. Case studies include Hanoi, Jakarta, Bangkok, and Guangzhou for comparison, and Tokyo, Seoul, and Taipei for lesson learning.

This paper presents the results of travel behavior survey in Hanoi City, a typical motorcycle dominated city in Asia and around the world. A person trip survey is conducted to capture the existing travel behavior patterns, examine people's responses to different policy scenarios, and suggest concrete policies for the city and similar cases.

2.2 Stated Preferences Survey

A questionnaire-based survey is conducted in Hanoi City to examine how different groups of travelers might respond to different policy scenarios. The questionnaire includes both revealed preferences (RP) and stated preferences (SP) information items. First, a respondent is asked to reveal what mode he or she actually used to make the trip of concern, identify alternative modes, and give basic travel information on each mode, including access time, waiting time, in-vehicle time, egress time, access cost, fare/fuel cost, parking cost, and toll cost (if any). Revealed mode choice is considered to be a base scenario. Second, the respondent is presented with scenarios or hypothetical changes in travel cost and time of the available modes and hypothetical modes (i.e., BRT and MRT). Actually, four scenarios are set for the survey (see Table 1) with assumptions as follow.

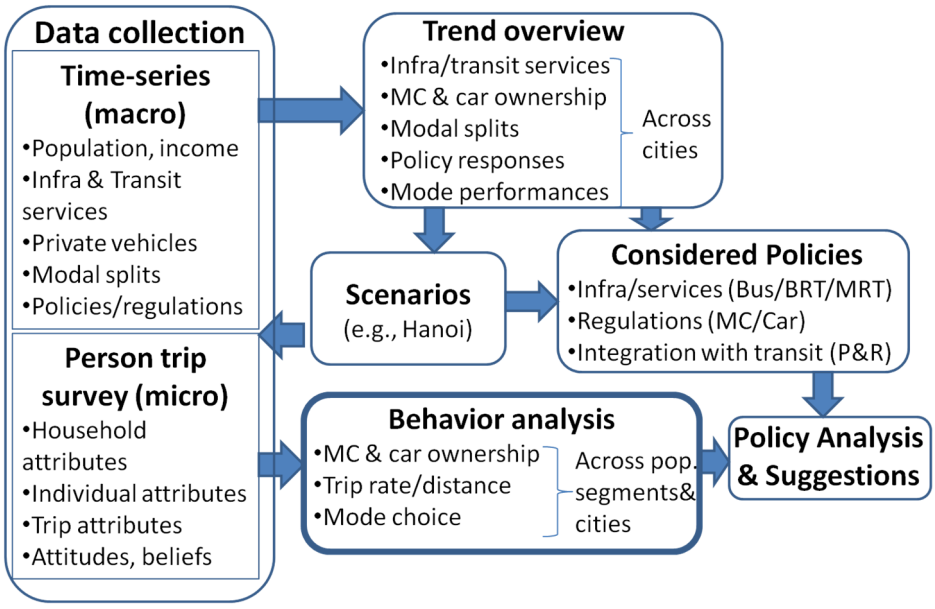


Fig. 1 Overall Study Framework.

Table 1 Scenarios for stated preferences survey.

Mode	Variable	[Scen.1] "BRT only"	[Scen.2] "BRT + Parking"	[Scen.3] "MRT + Parking"	[Scen.4] "MRT + 2Parking"
M-cycle	Parking fee (VND)	0-3,000	8,000	8,000	12,000
Car	Parking fee (VND)	0-30,000	50,000	50,000	75,000
BRT/ imprved Bus	In-veh. time	75% X	75% X	75% X	75% X
	Access & wait time	50% Y	50% Y	50% Y	50% Y
	Fare (VND)	5,000	5,000	5,000	8,000
MRT	In-veh. time			50% X	50% x
	Access & wait time			25% Y	25% y
	Fare (VND)			10,000	15,000

Notes: x = Current bus's in-veh time
Y = Current bus's access & wait time supposed no changes to Bicycle mode
Note: 1 USD = 20,850 VND (average exchange rate in 2012)

Scenario 1 "BRT only": It is assumed that a BRT system will be introduced. BRT is expected to reduce in-vehicle time to 75% of the performance of the current bus service. It is also assumed that the higher frequencies offered by the BRT and the use of bicycle as an access mode instead of walking (as mostly indicated in the base case) would reduce out-of-vehicle time (i.e., access time plus waiting time) to 50% of the existing bus's performance. Parking fees of motorcycle and car are assumed to be the same as the base case.

Scenario 2 "BRT+Parking": It is hypothesized that in addition to the BRT introduction, higher parking fees would be imposed on motorcycle and car users. The performance of the hypothetical BRT remains the same.

Scenario 3 "MRT+Parking": It is assumed that MRT system will be introduced in addition to the BRT. MRT system is assumed to be able to reduce in-vehicle time further down to 50% of the current bus's performance as it runs faster and provides higher frequency than BRT. It is also supposed that motorcycle will be used as a feeder mode to MRT station, thus it would help to reduce out-of-vehicle time to 25% of the current bus's performance. Hypothetical BRT's performance and the parking fees remain the same as in Scenario 2.

Scenario 4 "MRT+2Parking": It is assumed that parking fees of motorcycle and car and fares of BRT and MRT would be higher than the levels set in Scenario 3.

Under each scenario, the respondent is asked to indicate his or her most preferred mode among the available ones plus the hypothetical modes for the trip of concern. Of course, the respondent is advised not to choose any private modes that his or her family did not have at moment (i.e., the time of interview). Responses from all the scenarios are pooled together for the purpose of analyzing changes in mode choice behavior.

2.3 Characteristics of the Samples

The survey was conducted in May 2012 with 800 samples successfully collected, including 300 motorcycle users, 200 bus users, 150 car users, and 150 bicycle users. Table 2 presents the characteristics of the samples. The samples are distributed quite evenly in term of gender; however, it is biased towards younger groups, particularly 18-24 years old. Most sampled households have about 3 to 4 persons. The samples also skew towards low income groups (Q1 and Q2).

Table 2 Sample characteristics (800 samples).

Main characteristics		Percentage (%)
Gender	Male	55
	Female	45
Age	Under 18	2
	18-24	44
	24-29	16
	20-39	17
	40-49	10
	50-59	7
	From 60	5
Household size	1 person	4
	2 person	23
	3-4 person	52
	5+ person	21
Household income quintile (Million VND /month)	Q1 (0-7)	33
	Q2 (7-14)	26
	Q3 (14-21)	14
	Q4 (21-35)	14
	Q5 (>35)	13

Note: 1 USD = 20,850 VND (average exchange rate in 2012)

3. Survey Results (Descriptive)

3.1 Pattern of Household Vehicle Ownership

Table 3 presents the average number of vehicles by household size and income. Since people shifted from bicycle to motorcycle over the past two decades (Tuan, 2012), households nowadays own a limited number of bicycles, usually just one as a backup mode or for children to commute to school. The number of motorcycles is higher and increases continuously with both household size and income. This indicates that people are heavily reliant on motorcycles to meet their increased mobility needs. The number of cars is strongly determined by the household income. The highest income group (Q5) is likely to own at least one car. Interestingly, the number of motorcycles continues increasing despite the increased number of cars.

3.2 Revealed Preferences of Mode Choice

Average trip rate is generally indifferent among the income groups. On average, a person makes4 trip/day (including home-work commuting trips), this rate is higher than the one in developed cities, such as Person Trip Survey in Tokyo [9] estimated 2.5 trip/day per person. In other words, people in developing cities may make more trips than their counterparts in developed cities. Mode choice pattern is, however, totally different across the income groups (Figure 2). While the lowest income (Q1) mainly choose bus and bicycle, a wide range of people (Q2 to Q4) select motorcycle, and the highest income (Q5) use car.

Table 3 Average number of household vehicles.

Group		Bicycle	M-cycle	Car
Household size	1 person (N=32)	0.22 *(0.42)*	0.81 *(0.54)*	0.22 *(0.42)*
	2 person (N=184)	0.51 *(0.66)*	1.06 *(0.82)*	0.08 *(0.32)*
	3-4 person (N=419)	0.65 *(0.74)*	1.72 *(0.92)*	0.32 *(0.55)*
	5+ person (N=165)	1.03 *(1.16)*	2.41 *(1.06)*	0.33 *(0.54)*
Household income quintile	Q1(lowest) (N=264)	0.76 *(0.80)*	0.79 *(0.78)*	0.01 *(0.11)*
	Q2 (N=208)	0.72 *(0.85)*	1.78 *(0.80)*	0.08 *(0.35)*
	Q3(middle) (N=112)	0.69 *(0.89)*	2.07 *(0.85)*	0.32 *(0.53)*
	Q4 (N=112)	0.52 *(0.88)*	2.31 *(1.04)*	0.73 *(0.63)*
	Q5(highest) (N=104)	0.40 *(0.72)*	2.52 *(1.00)*	1.19 *(0.54)*

Note: numbers in () parentheses are standard deviations

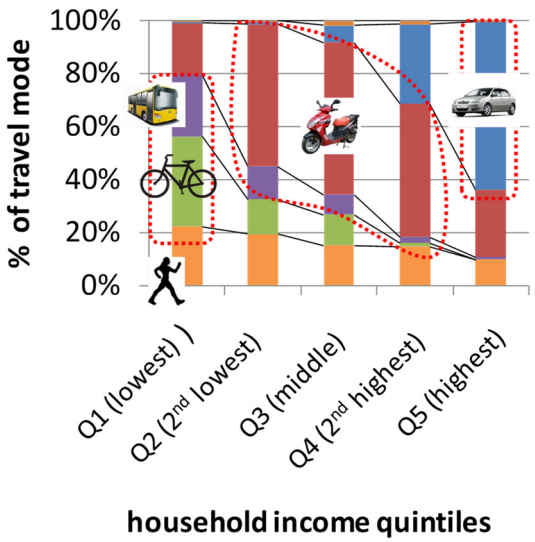


Fig. 2 Individual's daily trip mode by income.

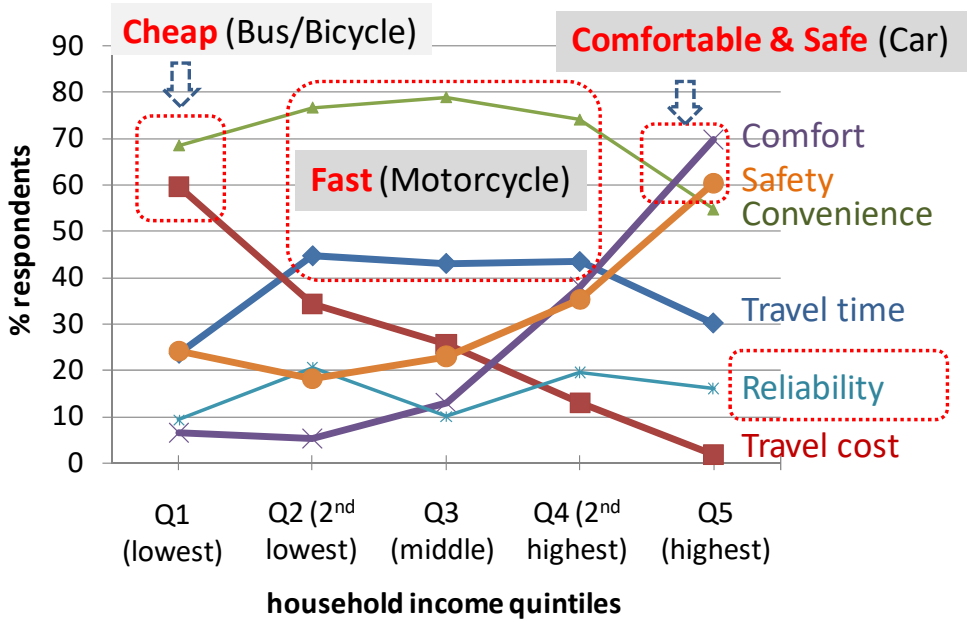


Fig. 3 Revealed mode choice factors.

The mode choice patterns can be explained by the users' revealed preferences, as shown in Figure 3. In principle, a person may choose a specific mode for different reasons, including cost saving, time saving, reliability, convenience, comfort, and safety. Recently, the poorest choose bus and/or bicycle for cost saving; many choose motorcycle for time saving and convenience; and the richest prefer car because of comfort and safety. Interestingly, as household income increases the role of travel cost decreases quickly, while the importance of comfort and safety increases dramatically. Considering door-to-door time (i.e., in-vehicle time plus access, regress, and wait time), bus is the slowest mode while motorcycle is the fastest for any distances. For instances, for a trip of 7.5 km it takes 26 minutes by motorcycle but it takes 46 minutes by bus; similarly for a trip of 15 km, it takes 35 minutes and 64 minutes by motorcycle bus, respectively. In term of

total travel expenses per month, which include costs for bus ticket, fuel, parking, maintenance, and insurance (excluding vehicle purchase cost), motorcycle usage costs about 580 thousands VND while car usage costs 10 times higher (6 million VND). Using bicycle or bus costs 60-80 thousands VND. Taking the travel expenses as percentage of personal income, the lowest to the middle income groups pay 14% of their incomes for daily travel, a double rate of Tokyo's people (about 6-7% as estimated). Surprisingly, the higher and highest incomes pay 30% of their incomes for car use for the sake of comfort, safety, and business-oriented values. In fact, 40% of the respondents used car for their business meetings. When being asked if "driving a car will increase your business opportunities", about two third of the respondents agreed so. That means people strongly perceive the car as a "business investment", so it might be difficult to shift car users to public transport system until their perception is about to change.

The survey revealed the fact that 40% of the respondents linked their daily trips together in order to save time and to seek for convenience. This is so called trip chaining behavior. Among various patterns of trip chaining, shopping on the way to get home and dropping off kids at school on the way to work or picking the kids up on the way to get home are the most dominant patterns (Table 4). Totally, 70% of the respondents did so. This fact carries out important implication for the coordination between transport development and land-use planning and control. Currently, the major public facilities, such as shopping malls, schools and hospitals are distributed in a scatter manner. Therefore, motorcycles fit well for such a land-use pattern because of its high flexibility. In the future, the development of MRT system alone might not be able to support trip chaining, thus it might be difficult to shift motorcycle users to the MRT system. Thus, the future MRT system needs to be supported by drastic changes in land-use pattern. Effective measures may include parking control, realizing the Transit-Oriented-Development (TOD) concept or bringing the major public facilities closer to the planned MRT stations to support the trip chaining practice, thereby further encouraging the modal shift to the MRT system.

In summary, as incomes increase, people would strongly prefer fast, safe and comfortable travel modes. But motorcycle ownership and use are likely to continue increasing at higher income levels despite the growth in car ownership. The trip chaining behavior and the perceived value of the private car as a "business investment" may prevent the people from shifting to public transport.

3.3 Stated Preferences of Mode Choice

Figure 4 presents the result of the stated mode choices by scenario. As expected, when the level of intervention by scenario increase, motorcycle and car users are more likely to shift to public transport. Comparing the "BRT+Parking" and "MRT+Parking" scenarios, it shows that if BRT system is introduced only, there would remain 63-75% of motorcycle and car users. However, if MRT system is added, it is likely to reduce the shares of motorcycle and car users to 46-49%. Further, while motorcycle users would prefer both BRT and MRT, car users would prefer MRT only. Such different responses imply the important role of MRT system in achieving the substantial modal shift. However, given the most aggressive intervention in the scenario "MRT+2Parking", there would remain 36-43% of motorcycle and car users who will still stick to their private vehicles, not shifting to MRT or BRT system.

Examining the ratio of shifting away from motorcycle, it shows interesting findings. We usually expected that as trip distance increases, motorcycle user was more

Table 4 Patterns of trip chaining (328 samples).

Chaining pattern	Percentage (%)
Shopping → Home/Other	35
Kid drop-off/pickup → Work/ Home	32
Eating out → Work	10
Main work → Part-time work	8
At work/social/study, etc. → Other	15

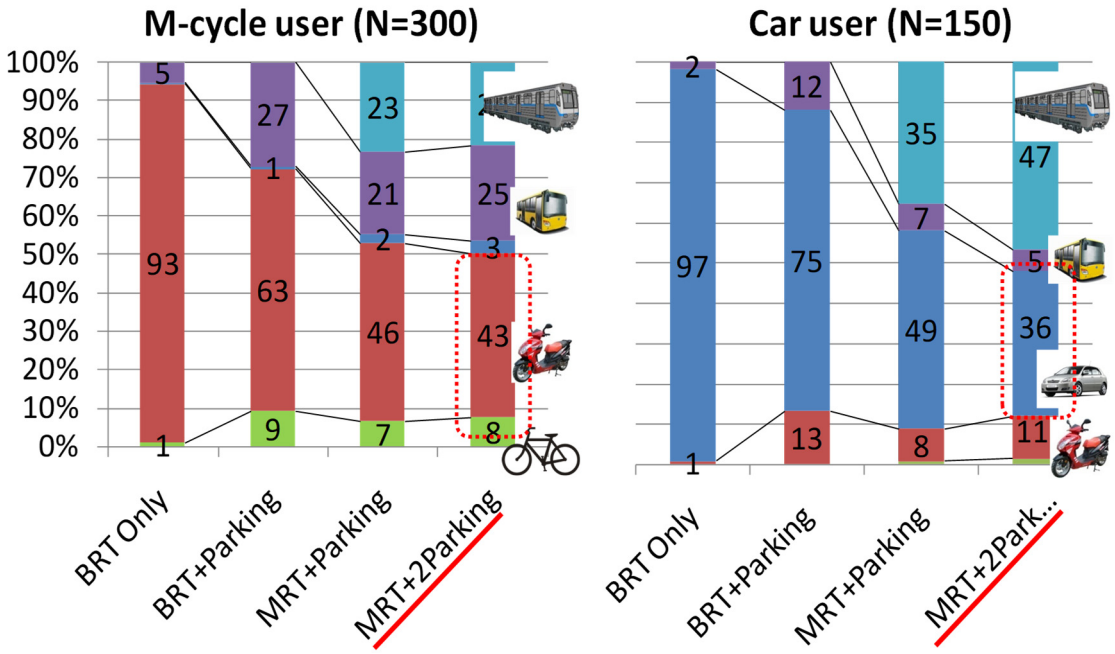
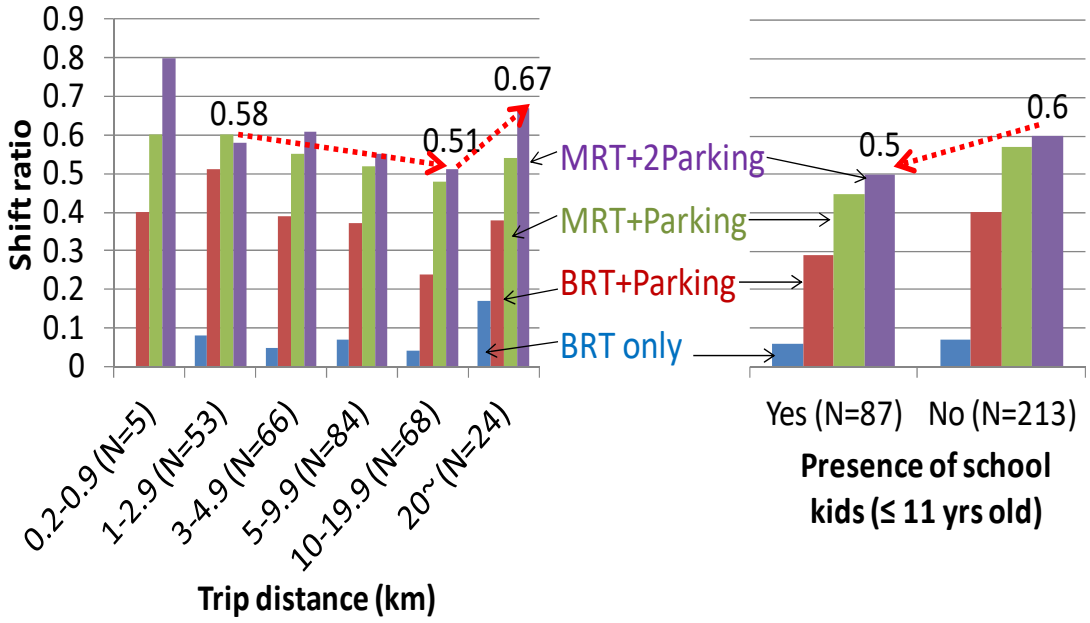


Fig. 4 Stated mode choices by scenario.



(a) by trip distance (b) by school kid presence

Fig. 5 Ratio of shifting away from motorcycle.

likely to shift to public transport for more comfort and increased safety. However, the stated responses show the opposite trend (Figure 5a): Within a distance of 20 km, the shift ratio actually decreased. Perhaps, the habit of trip chaining prevents a portion of motorcycle users from shifting to the improved public transport even for long distances. Figure 5b further shows that the motorcycle users with school kids or children in their households might be less likely to shift than the ones without school kid. That means people with school kids would still prefer to use motorcycles for the convenience of kid drop-off and pick-up.

In sum, the descriptive analysis found that at higher incomes household motorcycle ownership is likely to continue increasing despite the growth in household car ownership. As incomes increase, people would strongly prefer fast, safe and comfortable modes. It may be difficult to shift motorcycle and car users to new or improved public transport systems because of the trip chaining behavior often made by motorcycle users and the perceived value of private car as a "business investment".

4. Modelling of Mode Choice Behavior

This part presents the results of modeling mode choice behavior by traveler groups which are classified by personal income quintile and presence of school kids in the household. A multinomial logit model framework [10, 11] was applied for the analysis. The utility function was assumed to be a linear function of explanatory variables. Various models were specified and estimated based on the combination of RP and SP data. Estimated models that best fit the data are presented below.

4.1 Estimated Mode Choice by Income

Table 5 presents the estimated models of mode choice by income. The respondents are classified by three income levels, low income (Q1 and Q2), middle income (Q3), and high income (Q4 and Q5). Key findings can be summarized as follow. First, regarding the ratio "Travel cost by Income", the middle-income group seems to be most sensitive to this factor. This group also seems to be most sensitive to the factor of "Travel time", however, it is interesting that it may be insignificant for the high income because they may do care more about safety and comfort as explained previously. Third, "personal income" factor has positive effect on car choice, negative effect on BRT and bicycle choice, but has insignificantly negative on MRT choice, especially for low- and high-income groups. Interestingly, "Car ownership per household adult member" would increase car choice, but only significant to the middle income as this group is strongly seeking the social status from this mode. They may want to mimic the high-income class by trying to own and use private passenger car. More importantly, the number of motorcycles per household adult member has the most negative impact on BRT, MRT and bicycle. In fact, these people are the main users of the existing bus service as they do not have regular access to motorcycle. However, as their incomes increase, they will buy motorcycle and shifting away from current bus or would not use new public transport systems like BRT and MRT. It is also interesting that within the middle- and high-income groups the higher the number of bicycles per adult member the higher the choice of MRT and BRT. This could be explained by the fact that these people like to use bicycle, an environmentally friendly mode, so they wish to use BRT and MRT if these modes are introduced. So, it is important to encourage the people to use bicycles daily. This mode was so popular in the 1980s and 1990s, but people drastically shifted to motorcycles. Nowadays, a limited number of peoples are using bicycle. Therefore, policy measures to revitalize bicycle transport culture in Vietnam are very important to support the development of new public transport systems in the future. Lastly, it is found that destination of the trip may influence the mode choice, but only significant to BRT. The low and middle income are likely to choose BRT if they go outward of the city center, however, it is opposite to the high income. As the high income usually live in newly developed areas or out of the city center and they do have car, so they use car to make such trips, not willing to shift to BRT system.

4.2 Estimated Mode Choice by Presence of School Kid(s)

It is important to understand how different that travelers with and without school kids would change their mode choice in response to changes in travel time, travel cost, and vehicle ownership. Table 6

shows that the ones with school kid(s) are less negatively sensitive to increase in travel cost relatively to income than the ones without. However, they are more negatively sensitive to increase in total travel time. The number of cars per adult member may lead to increase in the likelihood of choosing car; however, the effect is not statistically significant. As the number of motorcycles per adult member increases, the respondents without school kid would be less willing to choose BRT and MRT. Interestingly, the ones with school kid(s) may be more likely to choose BRT and bicycle as the number of bicycles per member increase. These findings may imply that people who got married and having school kids are more concerned about traffic safety and time saving than travel cost.

Table 5 Estimated SP/RP mode choice models by income.

Model	All cases		Low Income		Mid Income		High Income	
Variable	para.	*t-test*	para.	*t-test*	para.	*t-test*	para.	*t-test*
Travel Cost by Income (VND per mil. VND)	-2.53E-04	*-9.84*	-2.84E-04	*-8.51*	-3.31E-04	*-4.53*	-2.20E-04	*-3.15*
Total travel time (min.)	-0.0521	*-10.74*	-0.0562	*-9.42*	-0.0666	*-5.59*	-0.0193	*-1.23*
Personal income (mil. VND)								
Car alternative	0.0899	*3.34*	0.0885	*0.46*	0.0104	*0.17*	0.114	*3.26*
BRT alternative.	-0.193	*-5.80*	-0.207	*-3.54*	-0.149	*-2.93*	-0.109	*-1.88*
MRT alternative	-0.022	*-0.76*	-0.126	*-1.45*	-0.0913	*-1.91*	-0.0136	*-0.33*
Bicycle alternative	-0.478	*-6.95*	-0.558	*-5.89*	-0.445	*-3.59*	-1.03	*-1.98*
Car ownership (per adult)								
Car alternative	0.152	*0.26*	3.82	*1.42*	3.14	*2.85*	-0.922	*-1.37*
M-cycle ownership (per adult)								
Car alternative	0.118	*0.26*	-0.482	*-0.34*	0.38	*0.49*	0.0824	*0.13*
BRT alternative	-2.36	*-9.72*	-2.3	*-7.51*	-2.81	*-5.43*	-1.06	*-1.39*
MRT alternative	-1.51	*-5.81*	-2.09	*-5.06*	-0.454	*-1.54*	-1.37	*-1.90*
Bicycle alternative	-1.01	*-3.63*	-1.33	*-3.89*	1.01	*1.32*	3.33	*0.83*
Bicycle ownership (per adult)								
BRT alternative	0.154	*0.65*	-0.41	*-1.46*	2.08	*3.45*	1.91	*1.80*
MRT alternative	0.515	*1.46*	-0.168	*-0.36*	1.89	*2.67*	5.72	*3.24*
Bicycle alternative	1.45	*4.27*	1.47	*3.70*	1.17	*1.27*	0.513	*0.17*
Trip Destination zone								
BRT alternative	0.478	*5.66*	0.531	*4.81*	0.719	*4.09*	-0.999	*-2.50*
MRT alternative	-0.0823	*-0.74*	0.235	*1.36*	-0.211	*-1.20*	-0.189	*-0.61*
Scale parameter	0.535	*11.22*	0.492	*10.44*	0.753	*2.07*	0.589	*3.39*
Value of time (VND/hour)	79077		36095		82576		94061	
Initial log-likelihood	-3873.47		-2474.41		-727.22		-671.84	
Final log-likelihood	-3025.58		-2040.84		-570.25		-337.56	
Rho-square	0.23		0.184		0.331		0.412	
Adjusted rho-square	0.226		0.178		0.311		0.383	
Sample size	3,922		2438		770		714	

Notes: Motorcycle is treated as a reference mode

1 USD = 20,850 VND (average exchange rate in 2012)

Table 6 Estimated SP/RP mode choice models by presence of school kid(s).

Model	All cases		Without Kid ≤ 11		With Kid ≤ 11	
Variable	para.	*t-test*	para.	*t-test*	para.	*t-test*
Travel Cost by Income (VND per mil. VND)	-2.53E-04	*-9.84*	-2.98E-04	*-9.04*	-1.88E-04	*-4.32*
Total travel time (min.)	-0.0521	*-10.74*	-0.0518	*-8.85*	-0.0535	*-6.25*
Personal income (mil. VND)						
Car alternative	0.0899	*3.34*	0.138	*2.77*	0.0693	*2.67*
BRT alternative	-0.193	*-5.80*	-0.278	*-5.54*	-0.0743	*-2.25*
MRT alternative	-0.022	*-0.76*	-0.186	*-3.35*	0.0706	*2.82*
Bicycle alternative	-0.478	*-6.95*	-0.459	*-5.26*	-0.465	*-4.50*
Car ownership (per adult)						
Car alternative	0.152	*0.26*	-1.69	*-1.62*	0.86	*1.47*
M-cycle ownership (per adult)						
Car alternative	0.118	*0.26*	0.755	*1.07*	-0.271	*-0.60*
BRT alternative	-2.36	*-9.72*	-2.67	*-8.48*	-1.59	*-4.77*
MRT alternative	-1.51	*-5.81*	-1.33	*-3.94*	-1.25	*-3.67*
Bicycle alternative	-1.01	*-3.63*	-1.67	*-4.45*	-0.376	*-0.88*
Bicycle ownership (per adult)						
BRT alternative	0.154	*0.65*	-0.0139	*-0.05*	0.73	*1.77*
MRT alternative	0.515	*1.46*	0.654	*1.49*	0.136	*0.23*
Bicycle alternative	1.45	*4.27*	1.39	*3.38*	2.14	*2.96*
Destination zone						
BRT alternative	0.478	*5.66*	0.665	*6.14*	0.101	*0.85*
MRT alternative	-0.0823	*-0.74*	0.204	*1.38*	-0.397	*-2.48*
Scale parameter	0.535	*11.22*	0.488	*11.57*	0.75	*2.38*
Value of time (VND/hour)	79077		50062		189527	
Initial log-likelihood	-3873.47		-2785.83		-1087.64	
Final log-likelihood	-3025.58		-2263.66		-729.375	
Rho-square	0.23		0.216		0.3	
Adjusted rho-square	0.226		0.21		0.284	
Sample size	3,922		2891		1031	

Notes: Motorcycle is treated as a reference mode
1 USD = 20,850 VND (average exchange rate in 2012)

4.3 Estimated Value of Travel Time

Based on the estimated models, the value of travel time is derived by dividing coefficient of "Total travel time" by coefficient of "Travel cost by Income" and timing by average personal income. Then, the value of travel time is compared with average pay rate per group of travelers. Table 7 presents the comparison result. The low- and middle-income people may be willing to pay double of their pay rate for saving an hour of travel time (ratio = 1.90-1.97), while the high income would pay less than their pay rate (ratio = 0.84). It implies that the low and middle income or the majority of the population in Hanoi City are willing to pay high cost for travel time saving. Further, travelers with school kids in their families are willing to pay an extremely higher rate (ratio = 2.73) than the ones without school kid. This fact shows the strong influence of school kids in the family on mode choice behavior of the adult members not only now but also in the future. These important points should be kept in mind by the local urban transport planners, managers, and international consultants and experts when they plan investments in public transport improvement and development.

Table 7 Comparison of estimated value of travel time and average pay rate.

Traveler Group	Estimated value of travel time (VND/hour)	Average pay rate (VND/hour)	Ratio between VOT and average pay rate
Average (all cases)	79,077	40,000	1.97
Low income	36,095	19,000	1.90
Middle income	82,576	42,750	1.93
High income	94,061	111,688	0.84
Without school kid	50,062	30,000	1.67
With school kid(s)	189,527	69,375	2.73

Note: 1 USD = 20,850 VND (average exchange rate in 2012)

In summary, the analysis suggests that just improving bus services or introducing BRT system may be not effective enough to attract a large number of motorcycle and car users until MRT system will be introduced. There might be a significant number of motorcycle and car users who would be still choosing their vehicles despite the MRT introduction and much higher parking charges. This behavioral change resistance may be explained by the facts that motorcycle users usually make daily trip chaining behavior and higher income people strongly perceive owning and using a car as a business investment. Household motorcycle ownership is likely reducing modal shifts to MRT/BRT system in the future. The value of travel time may vary significantly across population groups, especially by income level and the presence of school kids in the household. Low and middle income and the ones with school kid in their homes are willing to pay high cost for travel time saving. Middle- and high-income people are more concerned about traffic safety and comfort.

5. Discussions and Conclusions

The findings suggest that Asian cities should invest in MRT system development to meet increased travel demand and help solve the issues of motorcycle dominance in the long run as the high level of service of the MRT system will be effective to attract a large number of motorcycle and car users. However, there might be a significant number of motorcycle and car users who may not shift to public transport systems, including MRT system. Therefore, other supplementary policies will be strongly needed to support the intended modal shift. The supplementary policies may include the following. First, a good coordination between MRT development and land-use development around MRT stations should bring the major public facilities or land-use functions closer to the planned MRT stations. This strategy will help accommodate the trip chaining behavior, thereby encouraging drastic modal shift.

Second, strong regulations will be inevitably needed to restrict motorcycle ownership and use. Motorcycles should be converted from currently a main mode to a feeder mode by a series of regulations as follow. The survey has shown that many travelers are likely to commute for a distance longer than 20 km by motorcycle. To discourage long-distance motorcycle trips and improve motorcycle safety, developed countries in Asia like Taipei, South Korea, Japan, and Hong Kong already prohibited motorcycle ride on urban expressways and trunk roads. Thailand and the Philippines also restricted motorcycles on expressways and trunk roads. However, Malaysia still allows motorcycles run on expressways by providing exclusive motorcycle lanes. As a result, the country has been suffering from the highest fatal accident and death rates among developing Asian countries [12]. It is highly suggested that Vietnam and other developing countries like Indonesia shall prohibit motorcycle use on expressways, including urban expressways.

At the same time, it is important to provide park-and-ride facilities for motorcycle users at the planned MRT stations and BRT terminals as experienced by Taipei and Bangkok. In Taipei, although the bus and rail

networks have been quite extensive, still 20% to 30% of the residential and office areas are located beyond 2km from transit stations. To increase the coverage of transit systems, the city decided to provide more motorcycle parking spaces at transit stations. They revised Planning Manual for Rapid Transit Systems in 2005 to accommodate this. As a result, motorcycle parking spaces increased from 7,000 to 9,000, sharing 40% the total parking spaces. In Bangkok, motorcycle taxi service is very popular. Motorcycle taxis are operating along narrow and deep streets (Sois) branching off the main streets where bus routes and railways operate. It has contributed to 30% of the total access trips, followed by Songtaeow 23%. Realizing the importance of this service, the Thai government accepted this mode as a formal public transport in 2005 and has regulated since then. The city controls fare and regulates license plates, driver's uniform, safety service and driving behavior. This policy also helps improve safety for passengers and increase incomes for the drivers. The city is also proposing terminals connected with stations for motorcycle taxi operation. More aggressive could be a staged restriction of motorcycle use in urban area as experienced by Guangzhou and other Chinese cities.

Third, measures to control car ownership and use at early stage are urgently needed. Parking restriction is an obvious solution. Alternative measures could be to provide convenient and high-quality places for business meeting at MRT stations (e.g., Starbuck or Macdonald) to upgrade the image of public transport and thus attract more high-income people or car users to use it.

Finally, other cities would need to implement a similar survey and study on travel behavior changes in response to improvements in urban transport infrastructure and services. This will aid the planning of mass rapid transit systems and other policy makings. As a future work, the study will incorporate factors other than travel cost and time, such as comfort, safety, reliability, and flexibly into the mode choice models.

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