INFLUENCES OF PICK-UP/DROP-OFF TRIPS FOR CHILDREN AT SCHOOL ON PARENTS' COMMUTING MODE CHOICE IN HO CHI MINH CITY: A STATED PREFERENCE APPROACH

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Pick-up/drop-off (P&D) trips for children at school are often made on the way to and/or from work, forming a complex tour pattern. The existence of such tour complexity could be a major barrier to the shift from car/motorcycle to public transport, since spatio-temporal constraints of public transport are usually higher than those of the private mode. In such situation, people could shift to public transport only when (1) the school is located close to public transport stations, or (2) the child can go to school alone.

The former may require some land use policies, and the latter may need a safe and secure transport mode for children, such as school bus. On the other hand, little has been known about (1) to what extent the distance from station to school influences parent's commuting mode choice decisions, and (2) to what extent the existence of pick-up/drop-off behavior prevents parents from public transport use and how the introduction of safe and secure transport mode for children affects parents' mode choice decisions. This study empirically investigates these two aspects by using the stated preference survey data collected in Ho Chi Minh City, Vietnam in 2016.

Keywords: *Commuting mode, Stated Preference, Pick-up/Drop-off, Ho Chi Minh City*

1. INTRODUCTION

Commuting is a major component in determining travel demand. Work trips are usually longer in distance than trips for other purposes and occur during congested time periods. Other aspects of commuting are changing in ways that affect other types of travel and transportation systems. One of them is the tendency for many commuters to make their work trips as part of a trip chain or tour: dropping off children, picking up necessities, and conducting household errands are often done on the way to and from work (AASHTO, 2013). This study focuses on the impacts of forming a trip chain or tour on commuting mode choice decisions in Ho Chi Minh City (HCMC). Although some studies emphasize trip chaining is a barrier to the propensity of public transport use (e.g., Hensher and Reyes, 2000), it has been little explored in the context of developing countries.

The most relevant research to the current study is that from Huynh et al. (2017) who explore the impacts of tour patterns (defined by the combination of tour complexity and trip flexibility) on stated commuting mode choice, focusing on estimating the share of the Mass Rapid Transit (MRT) which is currently under construction in HCMC. They propose a simple method to identify the impacts of tour patterns on stated commuting mode choice, where a "currently unavailable" travel mode (i.e., MRT) is included as an alternative. The novel point of their approach is to utilize both revealed preference (RP) and stated preference (SP) data: the tour complexity is represented by the number of trips in the SP survey, while trip flexibility is obtained based on the RP data by asking the possibilities of changing the destination and timing of the trip. This allows for analyzing the impacts of tour patterns on mode choice decisions with less respondent burden. Their empirical results confirm that complex tour patterns would reduce the MRT use. On the other hand, the approach also has drawbacks. One of the major drawbacks is that tour patterns are essentially unobserved in their analysis (i.e., tour patterns are implicitly re-constructed by using both RP and SP information), preventing more detailed analysis, for example, quantifying the impacts of facility relocation and the introduction of feeder transport.

By considering the limitations of the existing studies (also see key issue in Section 2), this study proposes an alternative approach which allows for evaluating the impacts of land use changes on commuting mode choice decisions. Since Huynh et al. (2017) show that the major barrier to the shift from car/motorcycle to public transport is P&D behavior in HCMC[1], this study exclusively focus on P&D trips. More concretely, we focus on (1) to what extent the distance from station to school influences parents' commuting mode choice decisions, and (2) to what extent the existence of pick-up/drop-off behavior prevents parents from public transport use. This study empirically investigates these two aspects by using the stated preference survey data collected in Ho Chi Minh City, Vietnam in 2016. A key challenge in this study is how to give realistic choice situations based on the actual location of respondents' destinations as well as their travel cost and time respectively, we have proposed a method which is simple but effective by using a map with 500-meter grid cells to estimate the real distance from respondents' locations to the nearest MRT station, then multiply with assuming average speed or cost taken per kilometer, each level of time and cost attributes was computed on-site.

The rest of paper is organized as follows. Section 2 briefly explains a key issue and the main focus of this study. Section 3 introduces the survey conducted in Ho Chi Minh city. Section 4 explores the characteristics of P&D trip in HCMC. Estimation results of mode choice model which takes into account the existence of P&D trip and the distance from station to school are shown and discussed in Section 5. Section 6 summarizes the main findings and future challenges.

2. A KEY ISSUE AND THE FOCUS OF THIS STUDY

It is widely known that revealed preference (RP) data cannot be used in a direct way to evaluate demand under conditions which do not yet exist. Therefore, in transportation practice, stated preferences (SP) surveys have been widely used, particularly when evaluating the impacts of introducing a new transport system (Kroes and Sheldon, 1988; Hensher and Reyes, 2000; Louviere et al., 2000; Hensher, 2009). In most SP surveys, respondents are asked to choose one of the alternatives for a particular trip. On the other hand, as we mentioned in Introduction, travelers often form trip chaining or tour. Since it has been repeatedly confirmed that tour complexity affects mode choice decisions (Pendyala and Ye, 2005), the simplified hypothetical scenario which has been widely used in conventional SP surveys can produce biased results.

As pointed out by Huynh et al. (2017), although a tour-based SP survey can be a straightforward option, it would be too complicated, increasing respondents' burdens. This is because a set of activities which will be taken in a given day, the sequence, timing, destinations, and so forth would largely vary across individuals, and thus providing a feasible tour patterns in SP experiment would not be feasible. Although the feasibility can be improved by using Huynh et al.'s (2017) method as mentioned above, the approach still has limitations, since the source of schedule constraints which come from the complexity of tour is not identified. For example, one of the important sources would be a set of activity locations in a tour. If one of activity locations are outside of the catchment areas of public transport networks, a traveler is less likely to choose public transport. In such case, location is the source of constraint. Although there are some empirical studies focusing on the source of constraints by using RP data[2], to the authors' knowledge, there is no study exploring the source in the SP context, where the currently unavailable travel mode is included as an alternative.

One of the major challenges is to expand tour-based analysis to the SP context—which also allow for quantifying the impacts of location on mode choice decisions—is how to simplify the SP choice

[1] the number of P&D trips is the highest among non-work trip purposes, and the P&D trips are the least flexible from the viewpoint of rescheduling their activity patterns

[2] For example, Hensher and Reyes (2000) investigate a hypothesis "[a]s individuals move from a simple trip (say homework-home) to an increasingly more complex multi-chained trip (say homeschool-work-home) the likelihood of using public transport decreases with the increasing number of links in the chain (p. 345)".

context. Fortunately, in the context of HCMC, Vietnam, Huynh et al. (2017) show that the major source of schedule constraints coming from P&D behavior: 43% of trips adding to a simple work-home tour are P&D trips. In addition, Huynh et al. (2017) found that P&D trips are the least flexible in terms of the possibilities of "location change", "shift the trip within the same day", "shift the trip to another day", and "cancel trip". Based on these findings, in this study, we exclusively focus on the P&D trips in the commuting context.

3. SURVEY & DATA COLLECTION

To explore influences of P&D trips on commuting mode choice, we conducted a survey in September 2016 in HCMC, Vietnam. In HCMC, P&D trip is quite popular, occurring in the early morning or late afternoon and often combined in daily commuting trip, together with other non-work trips. Such complex tour potentially reduces MRT use since spatio-temporal constraints of MRT are higher than those of the private mode.

The survey includes both revealed preference (RP) and stated preference (SP) questionnaires. The respondents were commuters having P&D trips on their way to commute and living along the first coming MRT line 1. The line starts from Ben Thanh Market to the North East of Ho Chi Minh City, along Hanoi highway. The population size in its catchment areas counts 170,000 totally. Figure 1 shows the location of survey site.

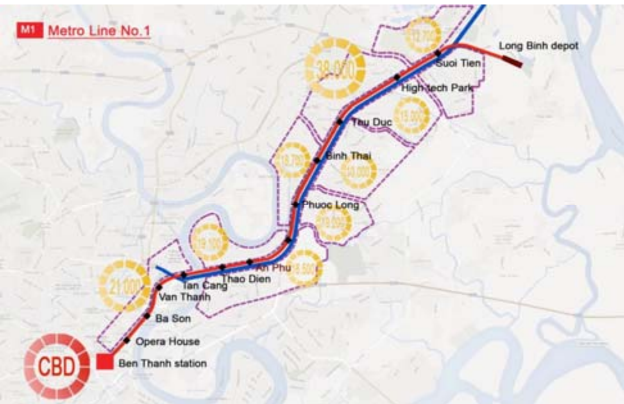


Fig.1 Survey area

There are 320 samples were collected from a face-to-face interview. Each sample comprises of 95 questions divided into 3 main parts: General household and individual information, one-day diary survey (RP survey) and SP survey.

For the general information part, each individual was asked to report age, gender, marital status, job, income (personal and household), level of education, vehicle ownership (personal and household), commuting mode, and so forth. In addition, information of pick-up/drop-off trips such as location, distance from home, frequency, type of vehicle to drop-off/pick-up their children to/from school, bus uses in P&D trip, awareness of going to school alone also included in this part.

For the RP part, the respondent was asked to answer one-day travel diary survey on their previous working day (such as origin, destination, distance to each destination, trip purpose, departure time, arrival time, cost and travel mode of each trip). Information about the flexibilities of each trip was also asked: whether or not the respondents could change the location of the activity, shift activity to another day, trip cancelation or willingness to shift to bus service. Possibility of changing of P&D locations (school places) or reasons influencing the school selection for their children were also asked, which may be useful to fully understand the impacts of P&D trips on parents' commuting mode choice.

In the SP part, in order to reduce the complexity of tour pattern, the trips to/from three specific locations—home, school place and workplace—were chosen, forming four simplified trip chain patterns as shown in Table 1. This significantly reduces the complexity of tour descriptions in the SP survey, and thus reduces respondents' burdens.

Table 1 Patterns of 4 simplified trip chain (assumption of patterns in SP survey)

No.	Trip patterns	Configuration
1	None of P&D trips	H-W-H
2	Having drop-off trip on the way to commute	H-D-W-H
3	Having pick-up trip on the way back home	H-W-P-H
4	Having both pick-up and drop-off trip	H-D-W-P-H

In the survey, the respondent was first explained about the plan of MRT line 1 and distributed the map with 500-meter grid cells describing the locations of each station and their living area. Based on their real locations of home, school, workplace located in the distributed map, the distances from these places to the nearest MRT stations was estimated. From this estimated distance, each level of travel time and cost attributes were computed on-site by simple equations as below:

(1) Travel time = Average time taken per km (min/km) x Estimated distance (km)
Where,

- Travel time: value of travel time attribute

(min)
- Average time taken per km: this assuming value was given in each travel mode respectively, calculated from the average speed combining with waiting or delay time.
- Estimated distance: distance from respondents' locations to the nearest MRT stations was estimated from the distributed map

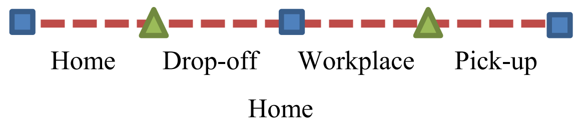
(2) Travel cost = Average cost taken per 1 km (VND/km) x Estimated distance (km)

Where,
- Travel cost: value of cost attribute (VND)
- Average cost taken per km: this assuming value was given in each travel mode, calculated from the level of energy consumption combining with other expenses such as cost of operation, maintenance, insurance, etc.
- Estimated distance: distance from respondents' locations to the nearest MRT stations was estimated from the distributed map

To reduce the burden for the interviewers while calculating many values on-site, an excel file was developed to calculate all the values of time and cost attributes automatically. In addition to the alternative-specific attributes, two contextual attributes are included in the SP survey: (1) patterns of P&D trip (4 levels: None of P&D trip, having drop-off trip, having pick-up trip, having both pick-up and drop-off trips) and (2) the assumption of the distance from the location of P&D trip to the nearest station (we suppose that the location of school was distributed within or beyond an easy walk of a rail transit station with 3 levels: under 100 meters, under 400 meters and under 2000 meters). Each level of P&D pattern significantly affects the value of time and cost attribute due to the change of total trip distance. Under the influences of two given contextual factors, the result of choice process could be biased, therefore these variables were put in front of each choice sets, then we made a great effort to carefully explain the meaning of each in combination with a simply descriptive framework (Figure 2).

Given the above attributes, the respondents were asked to choose their preferred mode from 7 alternatives: 6 alternatives come from MRT with different access and egress modes, and 1 alternative comes from their private mode using for commuting trip (motorcycle or car). Applying fractional factorial design for all attributes of the research, resulting in 64 combinations (respectively car and motorcycle group), then 64 combinations were divided into 8 blocks: each respondent answer 8 SP questions in a randomly certain block. Alternative-specific attributes and their levels are defined as shown in Tables 2 and 3.

-You have **both pick-up and drop-off trip** (Trip framework described as below):



- Distance from Pick-up/Drop-off location to the nearest MRT station: **Under 4.00 m**

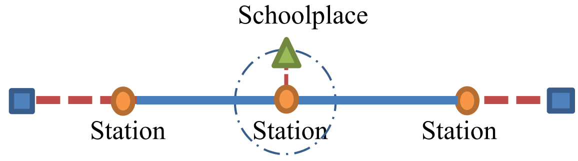


Fig.2 Descriptive framework of two contextual attributes

Finally, among 320 valid samples, 240 samples were motorcycle users and 80 were car users. The results of RP survey show that they made 1,318 trips in total in the survey day, pick-up/drop-off trips account for 34.9% and the average number of observed trips per day is 4.12.

4. CHARACTERISTICS OF PICK-UP/ DROP-OFF TRIPS

(1) Observed tour patterns

In this study, to capture the impacts of P&D trips on commuting mode choice, we classify tour patterns into 3 types as shown in Table 4.

Table 4 Classification of tour

No.	Tour type	Configuration
1	Drop-off: Respondents have drop-off trip on the way to commute	H-D-W-H
2	Pick-up: Respondents have pick-up trip on the way back home	H-W-P-H
3	Both P&D: They have both pick-up and drop-off trip	H-D-W-P-H

H: Home; W: Workplace; D: Drop-off trip; P: Pick-up trip

Table 5 show the composition of the observed trip purpose for each tour type. It confirms that the three major activities that commuters conducted are: "work", "pick-up/drop-off" and "go back home". Respondents who only have to drop-off their children

Table 2 Alternative-specific attributes and levels in SP design
(distributed to respondents using motorcycle to commute)

	MRT						Motorcycle
	W-MRT-W	M-MRT-W	B-MRT-W	W-MRT-B	M-MRT-B	B-MRT-B	
Access time (mins)	15 mins/km	5 mins/km	8 mins/km	15 mins/km	5 mins/km	8 mins/km	
	19.5 mins/km	7.5 mins/km	9.6 mins/km	19.5mins/km	7.5 mins/km	9.6 mins/km	
Travel time (mins)	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	2.4 mins/km
	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	3.0 mins/km
	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	4.2 mins/km
Egress time (mins)	15 mins/km	15 mins/km	15 mins/km	8.0 mins/km	8.0 mins/km	8.0 mins/km	
	19.5 mins/km	19.5mins/km	19.5mins/km	9.6 mins/km	9.6 mins/km	9.6 mins/km	
Frequency	5 mins	5 mins	5 mins	5 mins	5 mins	5 mins	
	15 mins	15 mins	15 mins	15 mins	15 mins	15 mins	
Delay time							1 per week
							3 per week
Access cost (VND)		2000/km	6000		2000/km	6000	
		2600/km	8000		2600/km	8000	
Travel cost (VND)	3000/km	3000/km	3000/km	3000/km	3000/km	3000/km	2000/km
	3600/km	3600/km	3600/km	3600/km	3600/km	3600/km	2400/km
	4200/km	4200/km	4200/km	4200/km	4200/km	4200/km	3000/km
Egress cost (VND)				6000	6000	6000	
				8000	8000	8000	

6 MRT alternatives with different access and egress modes (W: Walk; M: Motorcycle; B: Bus)

Table 3 Alternative-specific attributes and levels in SP design
(distributed to respondents using car to commute)

	MRT						Car
	W-MRT-W	M-MRT-W	B-MRT-W	W-MRT-B	M-MRT-B	B-MRT-B	
Access time (mins)	15 mins/km	5 mins/km	8 mins/km	15 mins/km	5 mins/km	8 mins/km	
	19.5 mins/km	7.5 mins/km	9.6 mins/km	19.5mins/km	7.5 mins/km	9.6 mins/km	
Travel time (mins)	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	1.6 mins/km	2.0 mins/km
	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.0 mins/km	2.5 mins/km
	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	2.4 mins/km	3.7 mins/km
Egress time (mins)	15 mins/km	15 mins/km	15 mins/km	8.0 mins/km	8.0 mins/km	8.0 mins/km	
	19.5 mins/km	19.5mins/km	19.5mins/km	9.6 mins/km	9.6 mins/km	9.6 mins/km	
Frequency	5 mins	5 mins	5 mins	5 mins	5 mins	5 mins	
	15 mins	15 mins	15 mins	15 mins	15 mins	15 mins	
Delay time							1 per week
							3 per week
Parking fee (VND)							20000
							40000
Access cost (VND)		2000/km	6000		2000/km	6000	
		2600/km	8000		2600/km	8000	
Travel cost (VND)	3000/km	3000/km	3000/km	3000/km	3000/km	3000/km	5000/km
	3600/km	3600/km	3600/km	3600/km	3600/km	3600/km	6500/km
	4200/km	4200/km	4200/km	4200/km	4200/km	4200/km	8000/km
Egress cost (VND)				6000	6000	6000	
				8000	8000	8000	

6 MRT alternatives with different access and egress modes (W: Walk; M: Motorcycle; B: Bus)

at school in the morning tend to do more non-work activities than those having to pick-up children on the way back home. This result may indicate that the trip flexibility of pick-up trip in the evening would be lower than the others do not have pick-up trip due to the schedule constraint.

Table 5 Trip purpose by tour type (unit: trip)

	Tour type			Total
	Drop off	Pick up	Both P&D	
To work	119	53	141	313
To study	2	2	-	4
At work / Business	33	12	10	55
P&D trips	126	54	280	460
To eat out (include drinking)	28	7	18	53
To go market/ shopping	12	9	11	32
Social/ recreation/ religious	10	3	4	17
To go home	149	65	157	371
Other	2	7	4	13
Total	481	212	625	1,318

Table 6 shows the modal share by tour type. It's interesting that people having to do both P&D trip prefer their private mode (car or motorcycle) to others, 10% higher than those having only Pick-up or drop-off trip in total car and motorcycle share. In contrast the total share of motorcycle-passenger, car-passenger and motorcycle-taxi in group having only drop-off trip is higher than the 2 remaining groups.

Table 6 Modal share by tour type [%]

[%]	Tour type		
	Drop-off	Pick-up	Both P&D
Walk	1.7	5.7	1.8
Motorcycle	65.1	60.4	67.7
Motorcycle-passenger	9.1	6.1	4.2
Motorcycle-taxi	0.4	-	-
Car	14.1	17.4	19.6
Car- passenger	6.7	7.6	5.4
Bus	0.2	1.9	0.6
Company bus	2.7	0.9	0.5
Other	-	-	0.2
Total	100	100	100

(2) Trip flexibility

The observed trip flexibilities by activity type are shown in Table 7. As expected, mandatory activities such as work, study and pick-up/drop-off are less flexible than the others. This indicates the spatio-temporal flexibilities of the 3 mandatory activities are almost same. Therefore Drop-off/pick-up can be a big barrier to shift from private mode to public transport (Huynh et al., 2017).

Table 7 Trip flexibility [%]

[%]	Location change		Shift activity to another day		Cancellation of the activity	
	Yes	No	Yes	No	Yes	No
Work	15.34	84.66	11.18	88.82	10.86	89.14
Study	25.00	75.00	50.00	50.00	75.00	25.00
Business	63.64	36.36	52.73	47.27	52.73	47.27
Pick-up/ Drop-off	18.04	81.96	13.48	86.52	14.13	85.87
Eat out	50.94	49.06	33.96	66.04	32.08	67.92
Shopping	68.75	31.25	59.38	40.63	53.13	46.88
Social/ recreation	52.94	47.06	35.29	64.71	41.18	58.82
Home	19.95	80.05	16.17	83.83	18.87	81.13
Others	30.77	69.23	46.15	53.85	30.77	69.23

Figure 3 compares the flexibilities among major non-work and work activities. Non-work activities such as "Shopping" and "Social/recreation" are more flexible than the 3 mandatory activities in this study ("Home", ""Pick-up/Drop-off", "Work"). Spatial flexibility is always higher than temporal flexibility in all the 5 groups.

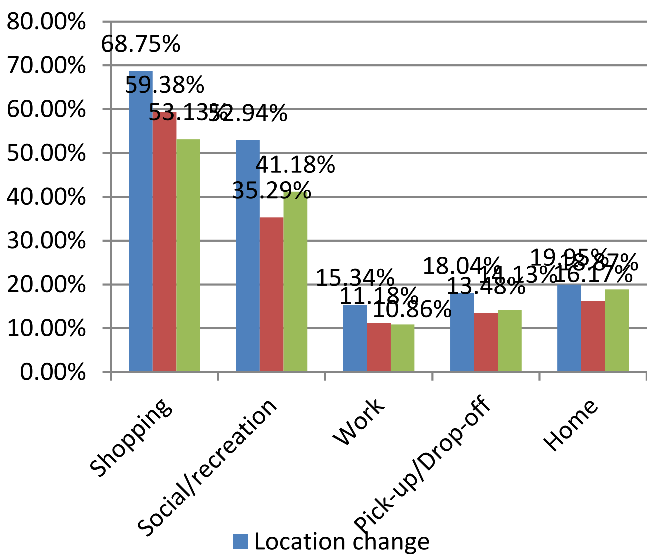


Fig.3 Trip flexibilities of shopping, social/recreation, work, home, and pick-up/drop-off trip

5. MODE CHOICE MODEL

(1) Model Specification

This study uses a multinomial logit model with the following utility function:

$$U_{ij} = \beta_j x_{ij} + \varepsilon_{ij}$$

Where,

U_{ij}: Alternative j's utility that individual I would obtain

β_j : Vectors of unknown parameters to be estimated

x_{ij}: A vector of explanatory variables (including alternative-specific attributes, individual-specific attributes, and a constant variable)

ε_{ij} : Error term which is assumed to be Gumbel distributed

The first term on the right hand of the equation is a conventional systematic utility function which includes alternative-specific attributes such as travel time and cost, individual and contextual attributes.

(2) Estimation results of Mode choice model

In this study, we separated respondents into 2 group based on their main travel mode for daily commuting trip: motorcycle and car users group. Each of the private modes will be compared with other six MRT alternatives respectively. In addition to examining the influence of P&D trip to/from school on parents' commuting mode choice. We also observe notable differences between these 2 groups which are currently dominant commuting mode in Ho Chi Minh city.

a) Mode choice model of motorcycle users

The estimation results of mode choice model of motorcycle users group are shown in Table 8. The sign of parameters of in-vehicle travel cost and time are negative as expected, however only in-vehicle travel cost significantly influence on mode choice decision. Access cost and time are negative and significant, while results of egress attribute are unclear, negative but not significant (egress cost) or vice versa (egress time), this indicates that access mode plays an important role more than egress mode on mode choice.

Males tend to use motorcycle while high income people prefer to use MRT than their private mode. The estimation results of school location indicate that if school place is distributed in an easy walking distance around the MRT transit station (under 400 meters) they are more likely to choose MRT. P&D trip is also found to have significantly positive effect on motorcycle uses, indicating that when the tour is complex, people tend not to use public transport, this finding supports the previous literature which found that complex tour were less likely to be public transport based (Wallace et al., 2000; Ho and Mulley, 2013).

Parameter of awareness of safety is positive and significant, it shows that the probability of choosing MRT is higher in group of people aware that MRT is a safe and secure mode. This finding would bring a couple of important policy implication in Ho Chi Minh city that MRT would play an important role in P&D trips, and introduction of MRT as a safe and secure mode would promote MRT use for P&D trip as well as going to school alone of children.

b) Mode choice model of car users

The estimation results of mode choice model of car users group are shown in Table 9. It has been lightly different in mode choice as compared with motorcycle group. Parameters of in-vehicle travel cost and time are not negative as expected, in-vehicle cost is even found to have a positive effect, however this tendency could be explained from the parameters of distance from home to the nearest station and egress time which are found negative and significant, this indicates that in car users group, the closer distance from home or other destinations to MRT stations are, the higher probability of using MRT becomes, in contrast if those locations are far from the MRT stations, people tend to use their private car even the travel cost and time are much higher.

High income people and female prefer their private car to MRT, this trend is quite opposite with motorcycle users. Existence of P&D trip and school location still has a positive effect on MRT use, they are more likely to choose MRT in P&D trip in case of school place is distributed in an easy walking distance. The estimation result of awareness of safety does not affect to mode choice in contrast with motorcycle users group.

(3) Sensitive analysis

Figure 4 and 5 show the effects between the distance from the school to the nearest MRT station and the probability of using motorcycle and car. We can confirm that the location of school has a positive effect on probability of private mode choice. The increase of distance from school to nearest station will make the probability of using private mode higher, or in contrast this will decrease the probability of MRT use. This implies that location of school could be a barrier for MRT use and each

Table 8 Estimation results of mode choice model (Motorcycle users)

	MRT						
Access mode	Walk	Motorcycle	Bus	Walk	Motorcycle	Bus	Motorcycle
Egress mode	Walk	Walk	Walk	Bus	Bus	Bus	
In-vehicle travel cost	-0.0213***	-0.0213***	-0.0213***	-0.0213***	-0.02136***	-0.0213***	-0.0213***
Access cost	-	-0.0708**	-0.0708**	-	-0.0708**	-0.0708**	-
Egress cost	-	-	-	-0.0236	-0.0236	-0.0236	-
In-vehicle travel time	-0.0030	-0.0030	-0.0030	-0.0030	-0.0030	-0.0030	-0.0030
Access time	-0.0196***	-0.0196***	-0.0196***	-0.0196***	-0.0196***	-0.0196***	-
Egress time	0.0075**	0.0075**	0.0075**	0.0075**	0.0075**	0.0075**	-
Constant	0.7059**	0.0559	0.6984**	0.8756*	0.9915*	0.2886	-
Male	-	-	-	-	-	-	0.8808***
High income	-	-	-	-	-	-	-0.8030**
Having P&D trips	-	-	-	-	-	-	1.1143***
Location of school place in the easy walking distance	-	-	-	-	-	-	1.0281***
Awareness of safety	0.2869	0.7631***	0.4236*	0.5668**	0.4773**	1.4872***	-
High frequency	0.1266	0.1266	0.1266	0.1266	0.1266	0.1266	-
LL0	-3736.14						
LL1	-2808.01						
Rho	0.2484						
Rho.adj	0.3129						
Number of samples	1,920						

Note: (***) Significant at 0.1% level; (**) Significant at 1% level; (*) Significant at 5% level

Table 9 Estimation results of mode choice model (Car users)

	MRT						Car
Access mode	Walk	Motorcycle	Bus	Walk	Motorcycle	Bus	
Egress mode	Walk	Walk	Walk	Bus	Bus	Bus	
In-vehicle travel cost	0.0220***	0.0220***	0.0220***	0.0220***	0.0220***	0.0220***	0.0220***
Access cost	-	-0.0485	-0.0485	-	-0.0485	-0.0485	-
Egress cost	-	-	-	-0.0379	-0.0379	-0.0379	-
In-vehicle travel time	0.0162	0.0162	0.0162	0.0162	0.0162	0.0162	0.0162
Access time	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	-
Egress time	-0.0151**	-0.0151**	-0.0151**	-0.0151**	-0.0151**	-0.0151**	-
Constant	1.3489*	2.9094**	3.4453***	3.6258***	3.1543***	1.4224	-
Male	-	-	-	-	-	-	-0.5256*
High income	-	-	-	-	-	-	2.68941***
Having P&D trips	-	-	-	-	-	-	0.6795**
Location of school place in the easy walking distance	-	-	-	-	-	-	0.4683***
Distance from Home to the nearest station	-0.8251*	-0.8251*	-0.8251*	-0.8251*	-0.8251*	-0.8251*	-
Awareness of safety	0.1116	0.1116	0.1116	0.1116	0.1116	0.1116	-
High frequency	0.2589	0.2589	0.2589	0.2589	0.2589	0.2589	-
LL0	-1245.38						
LL1	-831.71						
Rho	0.3322						
Rho.adj	0.3129						
Number of samples	640						

Note: (***) Significant at 0.1% level; (**) Significant at 1% level; (*) Significant at 5% level kilometer far from the station will decrease the probability of MRT use approximately 10% in motorcycle group, twice more than car group.

These findings above support the previous literature which found that drop-off/pick-up could be a barrier to shift from private modes to public transport (especially in the motorcycle users group). Relocation of school to the place close to a station would be practical options to reduce the barrier (Huynh et al., 2017). Well designed, concentrated, mixed-use development around transit nodes can boost transit use around five to six times higher than comparable development away from transit" (Cervero et al., 2004). Having offices, shops, restaurants, and other amenities around a major transit station in high density areas encourages less driving and more non-motorized travel (Arrington and Cervero, 2008).

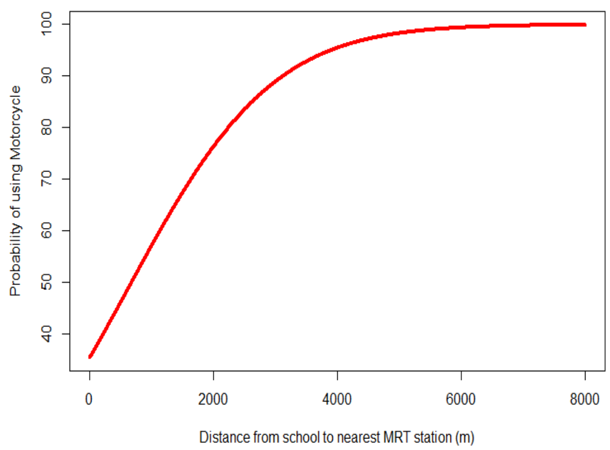


Fig.4 Sensitive analysis: the impact of distance from school to nearest station on the choice probability of motorcycle in P&D trip

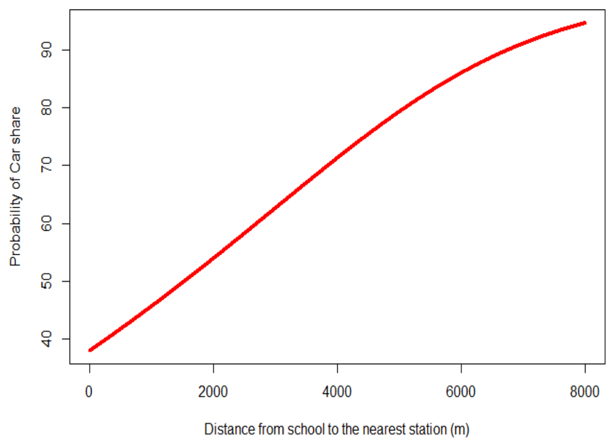


Fig.5 Sensitive analysis: the impact of distance from school to nearest station on the choice probability of car in P&D trip

6. CONCLUSIONS

This study analyzed the impacts of land use changes (i.e., location of school) on parents' commuting mode choice decisions under the condition that a currently unavailable travel mode is included as an alternative. A core hypothesis is that picking-up/dropping-off children at school is a major barrier to the shift from car/motorcycle to public transport, but the barrier could be alleviated when the school is located near station. In the empirical study, we focused on commuters who lived in suburban areas of Ho Chi Minh City and who regularly pick-up/ dropp-off their children at school. In particular, we explore the impacts of land use changes on the share of Mass Rapid Transit which is currently under construction. The empirical results support the hypothesis mentioned above: the elasticity of MRT use with respect to the distance from station to school.

While comparing the choice process among the tour patterns and assuming location of school, our results indicate that location of school would be one of the biggest barriers for MRT use to those people who have to pick-up or drop-off their children on the way to commute. Relocation of school around MRT stations (distributed in an easy walking distance) would allow respondents to re-organize their activities. Combining P&D trip on daily commuting trip will reduces the complexity of tour patterns, and thus increase possibility of using MRT. This finding would bring a couple of important policy implication in Ho Chi Minh city that MRT would play an important role in P&D trips, and introduction of MRT as a safe and secure mode would promote MRT use for P&D trip as well as going to school alone of children. For a further successful MRT development, provision of transit network (bus/school bus) to the final destination could be effective policy options in case of workplaces far from the station or relocation of school cannot be achieved.

There are number of limitations. One of the most important challenge is some of high flexible activities were reduced to form simple tour patterns while capturing the impacts of P&D trip on stated mode choice, the influences of the whole daily tour patterns are unobserved, preventing more detailed analysis on the impacts of relocation of other facilities such as shopping malls, market, recreational or commercial places, etc. Another interesting extension of our study is to analyze the impacts of MRT mode on the awareness of going to school alone in case relocation of school around stations achieved. By investigating those factors, we could have a better understanding on how deep the MRT system could change the P&D behaviors in Ho Chi Minh city.

REFERENCES

1) Kroes E.P, Sheldon R.J (1988). Stated preference methods. 11-24.
2) Hensher, D.A., Reyes, A.J., 2000. Trip chaining as a barrier to the propensity to use public transport. Transportation 27, 341-361.
3) Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. State Choice Methods: Analysis and Application. Cambridge University Press, Cambridge.
4) Wallace B., Barnes J., Rutherford G.S. (2000). Evaluating the effects of traveler and trip characteristics on trip chaining, with implications for transportation demand management strategies. Transportation Research Board, 2038, 139-147.
5) Cervero R., G. Arrington, J. Smith-Heimer, R. Dunphy, and others (2004). Transit Oriented Development in America: Experiences, Challenges, and Prospects. Washington, D.C.: Transit Cooperative Research Programs, Report 102.
6) Pendyala, R.M., Ye, X., 2005. Contributions to understanding joint relationships among activity and travel variables, in: Timmermans, H. (Ed.), Progress in Activity-Based Analysis. Elsevier, The Netherlands.
7) Arrington, G.B., Cervero, R., 2008. TCRP Report 128: Effects of TOD on Housing, Parking, and Travel. Transportation Research Board of the National Academies, Washington, DC p. 3.
8) Hensher, D.A., 2009. Research in Transportation Economics Empirical approaches to combining revealed and stated preference data : Some recent developments with reference to urban mode choice. Research in Transportation Economics 23, 23-29.
9) Ho C.Q., Mulley C. (2013). Multiple purposes at single destination: a key to a better understanding of the relationship between tour complexity and mode choice. Transportation Research Part A: Policy and Practice, 49, 206-219.
10) AASHTO (2013). Commuting in America 2013: The national Report on commuting Patterns and Trends. 3-21.
11) Huynh N.A., Chikaraishi M., Fujiwara A., Seya H., Zhang J. (2017). Influences of tour complexity and trip flexibility on stated commuting mode: A case of mass rapid transit in Ho Chi Minh city. Asian Transport Studies, 1-12.