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Influences of Tour Complexity and Trip Flexibility on Stated Commuting Mode: A Case of Mass Rapid Transit in Ho Chi Minh City

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Abstract: The existence of complex tours could be a major barrier to the shift from car/motorcycle to public transport. To properly reflect such a barrier in evaluating the introduction of new public transport, a tour-based approach rather than a trip-based approach is required. However, to the authors' knowledge, there is no study exploring the impacts of tour patterns on commuting mode choice where a "currently unavailable" travel mode is included as an alternative. This study proposes a simple method to identify the impacts of tour patterns on such stated commuting mode choice, where tour patterns are defined by the combination of tour complexity (represented by the number of trips in the stated preference (SP) survey) and trip flexibility (obtained in the revealed preference (RP) survey). For empirical analysis, we collected SP and RP data in Ho Chi Minh City, Vietnam. The results confirm the significant impact of tour patterns on mode choice decisions.

Keywords: Tour Complexity, Trip Flexibility, Mode Choice, SP Survey, Ho Chi Minh City

1. INTRODUCTION

Stated preference (SP) surveys have been widely used to predict the demand for a "currently unavailable" travel mode. In most SP surveys, respondents are asked to choose one of the alternatives given a specific trip context such as commuting (Louviere *et al.*, 2000). The rest of trips, which would actually be made on the same day forming a tour or trip chaining, is not taken into account in the survey design. However, it has been repeatedly confirmed that a trip should not be seen in isolation. For example, it is confirmed that tour complexity influences mode choice decision (Pendyala and Ye, 2005), indicating that the travel demand estimated from the trip-based SP survey could possibly be biased.

From a behavioral viewpoint, a traveler may need to reschedule their whole daily activity pattern to change commuting mode from a car/motorcycle to public transport, largely because spatiotemporal constraints of public transport are higher than those of the private mode. For instance, if the traveler currently sends his child to school on the way to and from the office, the modal shift can only be achieved when (1) the child can go to school alone, (2) other people can send his child to school, or (3) the school is located close to public transport. If such

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schedule constraints and the (im)possibility of rescheduling are ignored, the demand forecasting of public transport can potentially be overestimated (Hensher and Reyes, 2000).

To avoid such potential biases caused by the use of the trip-based SP survey, a tour-based SP survey would be a straightforward solution, where the respondents are asked to choose a travel mode for a certain tour. In fact, such a tour-based mode choice model has been developed with revealed preference (RP) data (Bowman and Ben-Akiva, 2001; Cirillo and Axhausen, 2002). However, implementing the tour-based SP survey is not a simple task due to the huge number of possible tour patterns. For instance, if there are 10 activities which can be potentially added to a simple round trip from home to office, there are $2^{10} = 1,024$ tour patterns even when ignoring the spatial and temporal variations of additional trips. Furthermore, the attributes of the tour may not really be predetermined, but rather these are the results of traveler's decisions which may be made together with the mode choice decision. Thus, to conduct the tour-based SP survey, generating realistic tour patterns for respondents (rather than generating purely hypothetical tour patterns) may be crucial. In this regard, a number of SP survey techniques, which use the RP information to construct more realistic hypothetical situations, have been proposed. These include the pivoted SP and SP-off-RP surveys (Rose *et al.*, 2008; Train and Wilson, 2008). However, these methods may not be directly used to conduct the tour-based SP survey, since, while these methods are designed to nudge respondents to explicitly consider the trade-offs between attributes, what the tour-based SP survey essentially requires is to formulate realistic tour patterns based on the RP information (i.e., pivoting tour contexts around the actual tour the respondent has made) rather than pivoting attribute levels. Presumably due to such difficulties, to the authors' knowledge, there is no study exploring the impacts of the tour on commuting mode choice where a currently unavailable travel mode is included as one of the alternatives.

By considering the above-mentioned difficulties in implementing the tour-based SP, this study introduces a simple method to identify the impacts of tour patterns on stated preference of commuting mode choice. The proposed method utilizes both SP and RP data with special attention to the trade-offs between respondents' burdens and the reality of tour patterns in SP choice experiments. Concretely, this study assumes that tour patterns can be decomposed into two components: tour complexity and trip flexibility. The tour complexity is represented by the number of trips, which are included in SP choice experiments as an attribute. This significantly reduces the complexity of tour descriptions in the SP survey, and thus reduces respondents' burdens. Meanwhile, the trip flexibility is measured in the RP survey by asking questions on the possibilities of canceling the trip, changing the location, and shifting the timing of each trip in the tour. We then develop a mode choice model, where tour complexity and trip flexibility are introduced as explanatory variables. For empirical analysis, we conducted an SP and RP survey in Ho Chi Minh City (HCMC), Vietnam. In HCMC, the Mass Rapid Transit (MRT) system is now under construction and will be operational in the near future. We specifically focus on commuters who live in the suburban areas along MRT Line 1 (Ben Thanh–Suoi Tien) and explore the modal shift from car/motorcycle to the MRT. Our empirical results show that, while tour complexity is a significant barrier to using MRT, the impacts would soften when the temporal flexibility of the trips is high (specifically when the trips can be made on another day).

The rest of the paper is organized as follows. Section 2 briefly introduces the survey we conducted in HCMC. Section 3 explores the current tour patterns and the spatiotemporal flexibilities of the trips in the tour. Estimation results of the mode choice model, which take into account the tour complexity and trip flexibility, are shown and discussed in Section 4. Section 5 summarizes the main findings and future challenges.

2. DATA COLLECTION

To explore the impact of tour patterns on the stated preference of commuting mode, we conducted an SP and RP survey in October 2015. The respondents were commuters who live along the forthcoming MRT route in suburban areas of HCMC and work in the Central Business District (CBD). Figure 1 shows the location of the survey area.

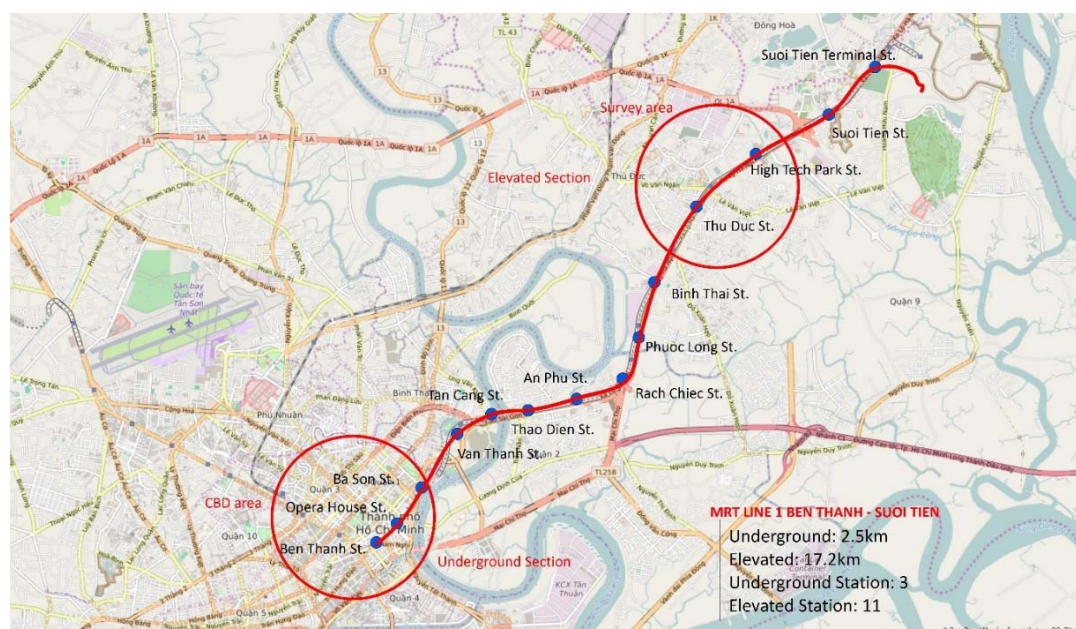


Figure 1. Survey area

The survey was conducted by face-to-face interview as the SP survey we implemented required respondents' clear understanding of our intentions (the details will follow). The collected data include (1) general information for each individual such as age, gender, marital status, presence of children, job information, personal income, level of education, vehicle ownership, (2) one-day travel diary survey on the last working day (RP survey), and (3) SP survey on commuting mode choice after the introduction of MRT Line 1.

For the RP survey, in addition to the conventional one-day travel diary questions (such as origin, destination, trip purpose, departure time, arrival time, and travel mode of each trip), information about the flexibilities of each trip was asked: whether the respondents could change the location of the activity, shift the activity to another time within the same day, shift the activity to another day, and cancel the trip. Note that similar surveys on the spatiotemporal flexibilities of trips have been conducted in the literature with the intention of observing the scheduling process involving combinations of routinized, individually planned and impulsive activities (Lee-Gosselin, 2005; Doherty, 2006), mainly to obtain the data needed for the development of activity-based models (Kitamura, 1988; Axhausen and Gärling, 1992; Axhausen, 1998; Henson *et al.*, 2009; Rasouli and Timmermans, 2014). Information on trip flexibilities is particularly useful in identifying the possibility of rescheduling the whole tour pattern, because decision-making about the temporal and spatial reorganization of activities may largely depend on the flexibilities of trips in the tour (Doherty, 2006). Even when the tour patterns are complex, higher flexibilities of trips indicate the higher possibility of rescheduling and thus presumably the higher possibility of using public transport. To the authors' knowledge, this is the first study exploring trip flexibilities in developing cities.

For the SP survey, first, the plan of MRT Line 1 is explained to the respondents in detail.

The attribute levels of modes were calculated based on the assumption that the distance from home to the workplace is 15 km, which is the average distance between the survey area and CBD. Then, alternative-specific attributes and their levels are defined as shown in Tables 1 and 2.

Table 1. SP design (Egress by walk)

	Motorcycle	Car	Bus	Walk-MRT-Walk	MC-MRT-Walk	Bus-MRT-Walk
Access and wait time (minutes)			5	10	5	5
			15	20	15	15
Time on vehicles (minutes)	30	30	40	15	15	15
	45	45	80	45	45	45
Egress time (minutes)			5	10	10	10
			15	20	20	20
Cost (VND)	5000	20000	6000	12500	12500	12500
	10000	35000	12000	20000	20000	20000
Parking (VND)		20000				
		30000				
Access cost (VND)					2000	3000
					4000	6000
Parking for access mode (VND)					1000	
					5000	

Table 2. SP design (Egress by bus)

	Motorcycle	Car	Bus	Walk-MRT-Bus	MC-MRT- Bus	Bus-MRT- Bus
Access and wait time (minutes)			5	10	5	5
			15	20	15	15
Time on vehicles (minutes)	30	30	40	15	15	15
	45	45	80	45	45	45
Egress time (minutes)			5	5	5	5
			15	15	15	15
Cost (VND)	5000	20000	6000	12500	12500	12500
	10000	35000	12000	20000	20000	20000
Parking (VND)		20000				
		30000				
Access cost (VND)					2000	3000
					4000	6000
Parking for access mode (VND)					1000	
					5000	
Egress cost (VND)				3000	3000	3000
				6000	6000	6000

In addition to the alternative-specific attributes, three contextual attributes are included in the SP survey: weather conditions (3 levels: very hot (over 35 degrees Celsius), heavy rain, and normal conditions), number of trips (3 levels: 2 trips, 3 trips, and 5 trips per day), and delay time on the road network in a week (2 levels: no delay, 20-minutes delay once a week). We made an important effort to carefully explain the meaning of the number of trips to the respondents. For example, if the hypothetical number of trips is three, we gave the following

explanation to the respondents: “suppose that you plan to conduct an additional trip, such as shopping, eating out, and pick-up/drop-off, in addition to a simple round trip from home to office. The characteristics of the added trip such as purpose, location, travel mode, timing, duration, with whom, for whom, etc. do not need to be specified, but please imagine a typical activity pattern with three trips in a working day, which are taken regularly in your daily life. Given the imagined activity pattern, which travel mode will you use?” This procedure has at least two advantages. First, since all information on the tour pattern is simply represented by the number of trips, the SP questionnaire can be easily developed. Second, more importantly, the tour pattern in the SP survey becomes more realistic, since the tour pattern is implicitly given by the respondents’ daily experience. The drawback is that all detailed information about the tour is missing. Note that we may not need to observe all detailed information about the tour to identify the impacts of tour patterns on stated commuting mode choice. Rather, the essential information affecting the choice would be the schedule constraints that the respondent imagines. In this study, the imagined schedule constraints are assumed to be represented by the spatiotemporal flexibilities of trips obtained in the RP survey.

Given the above-mentioned attributes, the respondents were asked to choose their preferred mode from four alternatives, including motorcycle, car, bus, and MRT. In the case of MRT, they further chose one of three access modes (motorcycle, bus, walking). Note that the egress mode was not included in the choice set to reduce the number of alternatives, but the impacts were considered by developing two different SP questionnaires: one for egress by bus, and the other for egress by walking. More concretely, we applied fractional factorial design for each egress mode, resulting in 32 combinations for bus egress mode and another 32 combinations for walking egress mode. We divided the 64 combinations (SP cards) into 8 blocks: each respondent answered 8 SP questions in a certain block.

After data cleaning, the valid sample was 320 commuters. The results of the RP survey show that they made 1,428 trips in total on the survey day, forming 449 tours. The average number of observed trips per tour was 3.2, and the average number of observed trips per day was 4.46.

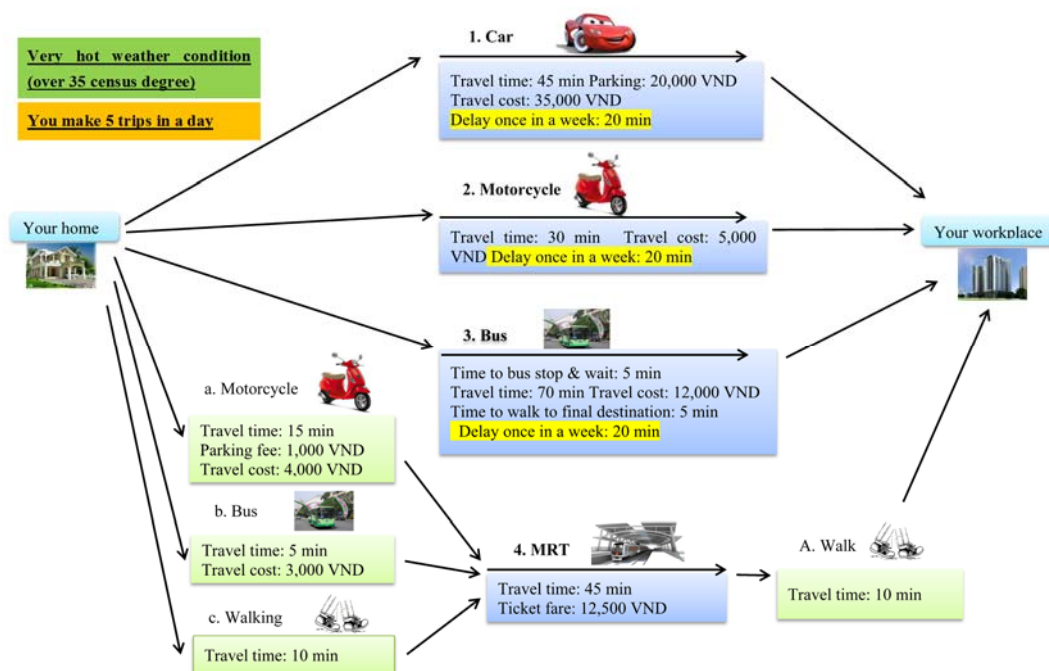


Figure 2. An example of SP survey

3. TOUR PATTERNS AND TRIP FLEXIBILITIES

3.1 Observed Tour Patterns

Studies focusing on trip chaining behavior have long been conducted (Kitamura, 1984; Nishii and Kondo, 1992; Strathman and Dueker, 1995; Hensher and Reyes, 2000; Bowman and Ben-Akiva, 2001; Yang *et al.*, 2007; Primerano *et al.*, 2008), but there is no commonly used trip chain typology. In this study, referring to studies by Strathman and Dueker (1995) and Hensher and Reyes (2000), we classify tour patterns into ten typologies as shown in Table 3.

Table 3. Classification of tour

No.	Tour type	Configuration
1	Simple Work	H – W – H
2	Complex To Work	H – NW – W – H
3	Complex From Work	H – W – NW – H
4	Complex To & From Work	H – NW – W – NW – H
5	Complex At Work	H – W – NW – W – H
6	Complex To & At Work	H – NW – W – NW – W – H
7	Complex At & From Work	H – W – NW – W – NW – H
8	Complex To, At & From Work	H – NW – W – NW – W – NW – H
9	Simple Non-Work	H – NW – H
10	Complex Non-Work	H – NW – NW – H

Table 4 shows the composition of the observed trip purpose for each tour type. It can be confirmed that the three major activities commuters conducted are “Drop-off/pick-up”, “Eat out”, and “Shopping”. These activities seem to be conducted in different places in the chains: “Eat out” tends to be conducted during work time (probably lunch) resulting in tour types 5, 6, and 7. Whereas, “Drop-off/pick-up” tends to be conducted on the way to and/or from work resulting in tour types 2, 3, and 4. Shopping activities tend to be conducted apart from work tours, resulting in tour type 9.

Table 4. Trip purpose by tour type (unit: trip)

	Tour type										Total
	1	2	3	4	5	6	7	8	9	10	
Work	84	42	65	53	88	52	23	12	0	0	419
Study	0	3	5	2	0	0	0	0	1	0	11
Business	0	0	27	15	6	3	1	1	3	0	56
Eat out	0	7	26	26	39	35	11	4	8	2	158
Physical exercise	0	1	1	0	0	0	1	0	15	4	22
Shopping	0	3	15	17	0	0	5	0	37	4	81
Drop-off/pick-up	0	32	14	72	0	13	2	11	9	13	166
Social/recreation	0	0	3	1	0	3	1	1	15	2	26
Home	84	42	65	53	44	26	11	6	105	8	444
Others	0	1	5	5	4	7	2	1	20	0	45
Total	168	131	226	244	181	139	57	36	213	33	1,428

Tour type: 1. Simple Work; 2. Complex To Work; 3. Complex From Work; 4. Complex To & From Work; 5. Complex At Work; 6. Complex To & At Work; 7. Complex At & From Work; 8. Complex To, At & From Work; 9. Simple Non-Work; 10. Complex Non-Work

Table 5 shows the model share by tour type. Interestingly, the motorcycle shows the highest share in tour type 1, and the share of the car is relatively high in complex tours such as tour types 2, 3, 4, 7, and 8. Bus users tend to take tour types 1 and 5, indicating less activities would be made on the way to and from work. These results indicate that the car may provide the most flexible mobility which allows drivers to take complex tour patterns. The share of walking is higher in tour types 5, 6, and 7, mainly because non-working activities associated with workplaces such as lunch may not require motorized modes.

Table 5. Modal share by tour type [%]

[%]	Tour type									
	1	2	3	4	5	6	7	8	9	10
Walk	-	0.8	4.0	4.9	27.6	20.1	31.6	-	14.1	9.1
Bicycle	-	-	0.4	-	-	-	-	-	-	-
Motorcycle - driver	84.5	76.3	75.7	68.4	61.3	75.5	59.6	72.2	66.7	81.8
Motorcycle - passenger	1.2	3.8	4.9	0.8	-	0.7	-	-	8.5	-
Car - driver	4.8	14.5	8.8	21.7	3.3	3.6	8.8	16.7	8.0	9.1
Car - passenger	3.6	-	2.2	2.5	2.2	-	-	11.1	-	-
Taxi	-	-	-	-	-	-	-	-	0.9	-
Bus	4.8	4.6	3.1	1.6	5.5	-	-	-	1.9	-
Company bus	1.2	-	0.9	-	-	-	-	-	-	-
Total	100	100	100	100	100	100	100	100	100	100

Tour type: 1. Simple Work; 2. Complex To Work; 3. Complex From Work; 4. Complex To & From Work; 5. Complex At Work; 6. Complex To & At Work; 7. Complex At & From Work; 8. Complex To, At & From Work; 9. Simple Non-Work; 10. Complex Non-Work

3.2 Trip Flexibility

The observed trip flexibilities by activity type are shown in Table 6. As expected, mandatory activities such as work and study are less flexible than the others. Also, the spatiotemporal flexibilities of drop-off/pick-up are almost the same as work trips. Since 166 drop-off/pick-up trips are made by 320 commuters (see Table 4), drop-off/pick-up can be a big barrier to shifting from private mode to public transport.

Table 6. Trip flexibility [%]

[%]	Location change		Shift activity within the same day		Shift activity into another day		Cancel the activity	
	Yes	No	Yes	No	Yes	No	Yes	No
Work	6.4	93.6	11.7	88.3	2.9	97.1	5.3	94.8
Study	0.0	100	18.2	81.8	0.0	100	0.0	100
Business	39.3	60.7	41.1	58.9	19.6	80.4	23.2	76.8
Eat out	55.7	44.3	35.7	64.3	10.1	89.9	14.6	85.4
Physical exercise	31.8	68.2	40.9	59.1	31.8	68.2	36.4	63.6
Shopping	46.9	53.1	40.7	59.3	27.2	72.8	29.6	70.4
Drop-off/pick-up	7.2	92.8	7.2	92.8	4.8	95.2	4.8	95.2
Social/recreation	53.9	46.2	48.0	52.0	34.6	65.4	38.5	61.5
Home	6.3	93.7	12.2	87.8	4.7	95.3	7.7	92.3
Others	53.3	46.7	61.4	38.6	34.1	65.9	25.0	75.0

Figure 3 compares three major non-work activities' trip flexibilities, i.e., "Eat out", "Shopping", and "Drop-off/pick-up". "Eat out" shows the highest spatial flexibilities, while it is relatively difficult to shift it to another day or cancel. "Shopping" is less flexible in terms of location compared to "Eat out", but temporal flexibilities are higher. Such temporal flexibilities may allow them to conduct "Shopping" in a simple non-work tour, as Table 4 indicates.

3.3 Tour Complexity

As we discussed in Subsection 3.1, there are certain associations between tour complexity and mode choice. Our SP results also support this trend. Figure 4 shows the modal share in SP choice experiments by the different number of trips: when the respondents are assumed to make just a round trip to and from work, around 28% of them chose MRT as a commuting mode. On the other hand, when the additional trips need to be conducted on the way to/from/at work, the MRT share is dramatically reduced, and the respondents tend to choose car and motorcycle.

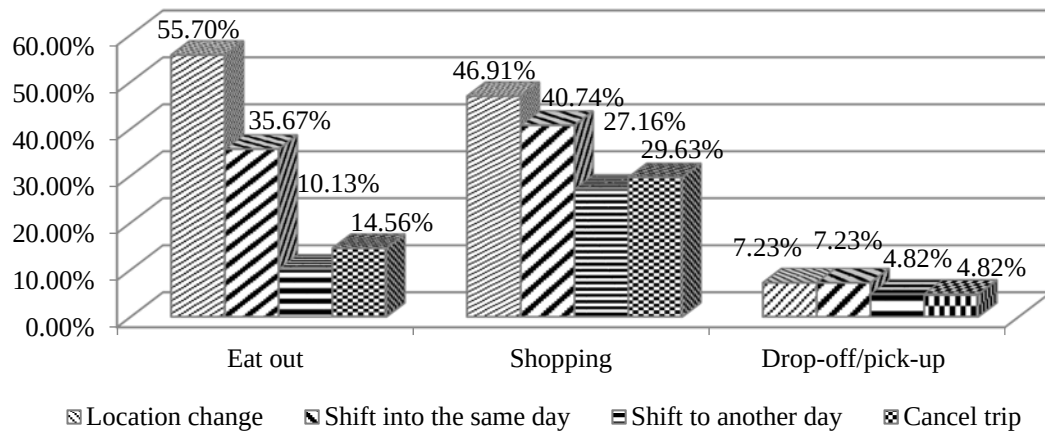


Figure 3. Trip Flexibilities of eat out, shopping, drop-off/pick-up

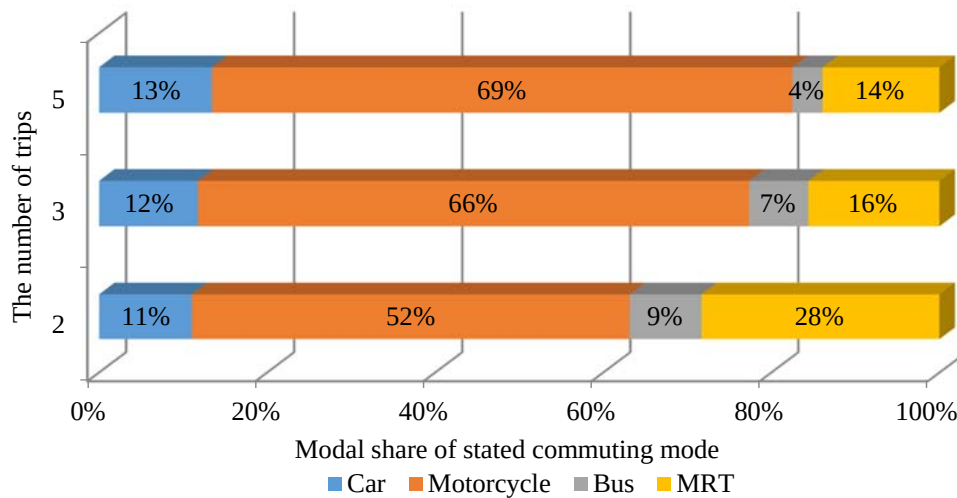


Figure 4. The impacts of the number of trips on stated commuting mode choice

4. MODE CHOICE MODEL

4.1 Model Specification

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

$$U_{ij} = \beta_j x_{ij} + (\alpha_j Z_i) \cdot TC_i + \varepsilon_{ij} \quad (1)$$

where,

- U_{ij} : alternative j 's utility that individual i would obtain
- β_j, α_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)
- Z_i : a vector of trip flexibility variables, represented by the possibilities (or probabilities) of “location change”, “shift the trip within the same day”, “shift the trip to another day”, and “cancel trip”. A constant variable is also included, representing the main effect of TC_i on mode choice.
- TC_i : tour complexity, represented by the number of trips given in the SP survey
- 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, and some contextual and individual specific attributes. The second term is introduced to capture the impacts of tour patterns. The impacts of tour patterns are modeled as interaction factors of tour complexity and trip flexibility: even when the tour is complex, the impacts on the mode choice would be small when the flexibilities of trips are high enough since people can reschedule non-work activities and vice versa. Note that the possibilities of “location change”, “shift the trip within the same day”, “shift the trip to another day”, and “cancel trip” were only observed for the activities the respondents actually made on the survey day, while it can be easily expected that tour patterns and their flexibilities vary from day to day. The direct observation of such day-to-day variability is ideal, but implementing a multiple-day travel diary survey with trip flexibility questions would be heavy burdens for respondents. Thus, in this study, we represent trip flexibilities in a probabilistic way, rather than directly use the observed flexibilities in a deterministic way. Concretely speaking, we develop a trip flexibility model for each flexibility indicator by applying the binary probit model (1: yes, the trip can be changed, 0: no, the trip cannot be changed), and then the estimated probabilities are used as flexibility indicators Z_i in the mode choice model. When the multiple non-working activities were made by an individual, flexibility indicators Z_i are calculated by taking the average probabilities of all non-working trips. Note that some of the respondents (34 respondents out of 320) did not make any non-working trips. In this case study, these samples are excluded from the analysis. The estimation results of the trip flexibility model are briefly introduced in the next subsection, followed by the mode choice estimation results.

4.2 Estimation Results of Trip Flexibility Model

The estimation results of the trip flexibility model with non-work trip data are shown in Table 7. The number of activities shows the positive and significant effects on all flexibility indicators, indicating that the added trips are usually more flexible in nature. “Drop-off/pick-up” trips are found to have a negative effect on all aspects, indicating that schedule constraints generated by drop-off/pick-up could be quite large. This is consistent with the aggregation shown in Table 6. “Eat out” has a positive effect on the location change indicator, but a negative impact on the rest of the indicators. High-income variables are found to have significant negative impacts on “shift the trip to another day” and “cancel trip” indicators, implying that high-income people may have larger constraints in terms of their daily activity schedule. Finally, it is confirmed that the age variable has a negative effect on the “shift within the same day”, indicating that older people are unlikely to shift the activity to another time in the day.

4.3 Estimation Results of Mode Choice Model

The estimation results of the mode choice model are shown in Table 8. Since the impacts of access and egress time and cost on mode choice decision are not significant, the total travel time and cost are used for the final mode choice model. Explanatory variables were selected based on whether the corresponding parameters are significant or not. Note that we found that the correlation between “shift the trip to another day” and “cancel trip” is considerably high (0.71), presumably because these two variables would capture similar schedule constraints. Thus, we decided not to put both variables into the utility function for a specific alternative. Rather, we selected one of them which gives a better goodness-of-fit.

The signs of parameters on travel time and cost are negative and significant as expected. Regarding weather conditions, respondents tend to avoid motorcycle use when it is hot or there is heavy rain. Males tends to use cars, and not use buses and the MRT. High-income people prefer to use cars, while low-income people prefer to use motorcycles. It is interesting that buses and the MRT lie between motorcycles and cars in terms of the impacts of income. The estimation results of the age variable indicate that older people are more likely to choose the car and MRT than younger people. Married people tend not to use the MRT while preferring to use a car, presumably because of joint household activities. Highly educated people tend to use the MRT. This is possibly because their environmental awareness can be higher than the other groups. Distance from home to the workplace is found to have a significant positive effect on MRT use.

As expected, the number of trips has a negative impact, particularly on MRT and bus use. This indicates that, when the tour is complex, people tend not to use public transport. This finding supports the previous literature which found that complex tours were less likely to be public transport based (Wallace *et al.*, 2000; Cirillo and Axhausen, 2002; Ho and Mulley, 2013). We also found that some of the interaction terms significantly influence mode choice decision: With an increase in the possibilities of changing location, the car tends to be chosen; With an increase in the possibilities of shifting non-work trips within the same day, the MRT and motorcycle tend to be chosen; With an increase in the possibilities of shifting non-work trips to another day, the MRT tends to be used; With an increase in the possibilities of canceling trips, bus and car tend to be chosen. Furthermore, since the interaction terms of trip flexibility (represented by the number of trips) and trip flexibility are introduced, we can easily confirm the interaction effects. Figure 5 shows an example of the interaction effects between the number of trips and the probability of “shift to another day”. We can confirm that the number of trips has a relatively large negative effect when the probability of “shift to another day” is low, while the effect would be smaller with the increase in the probability. This implies that, even when the tour is complex, higher temporal flexibilities of trips could help to encourage people to use the MRT.

The above results lead to a couple of important policy implications. In Vietnam, it is quite common to drop-off/pick-up children to/from school. This additional *mandatory* activity could be a major barrier in shifting from private modes to public transport. Relocation of schools to a place close to a station and/or provision of a school bus would be practical options in reducing the barrier. Or, more generally, our results reconfirm that the importance of designing public transport services from the users’ viewpoint: “faster and cheaper” may not be attractive enough to encourage people to use it. The service should fit their current daily activity-travel patterns, or be attractive enough to change their daily activity-travel patterns. From the former viewpoint, it would be important to develop an area-wide public transport network with a special attention to the last one-mile problem, so that people can use public transport without changing their current activity patterns. From the latter viewpoint, it would be crucial to develop public

transport with the development of a station as a town center, so that people could change their activity locations. The importance of these policies is well known, but the empirical evidence from the viewpoint of tour patterns may be valuable for designing stations and the last one-mile public transport services.

Table 7. Estimation results of trip flexibility model

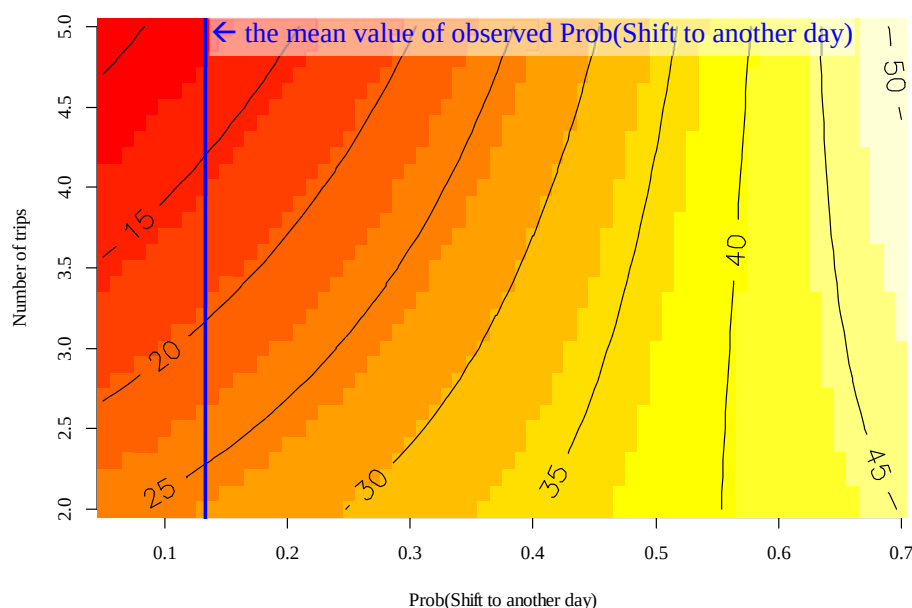
Variables	Change location	Shift the trip within the same day	Shift the trip to another day	Cancel trip
Constant	-1.111**	-0.340	-1.605**	-1.122**
Number of activities	0.176**	0.127**	0.199**	0.117**
Drop-off/pick-up trip dummy	-1.385**	-1.326**	-1.111**	-1.090**
Eat out trip dummy	0.320*	-0.219	-0.637**	-0.434**
High income [above 20 mil. VND]	-	-	-0.362*	-0.348*
Age	-	-0.015*	-	-
Log-likelihood at Zero	-391.628	-389.549	-390.935	-390.935
Log-likelihood at Convergence	-306.806	-302.317	-208.823	-231.235
Rho	0.217	0.224	0.466	0.409
Rho.adj	0.206	0.211	0.453	0.396
Number of samples (trips)	565	565	565	565

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

Table 8. Estimation results of mode choice model

	Motorcycle (base)		Car		Bus		MRT	
	param	t-stat	param	t-stat	param	t-stat	param	t-stat
Travel cost [1,000 VND]	-0.016	-2.16	-0.016	-2.16	-0.016	-2.16	-0.016	-2.16
Travel time [minute]	-0.010	-3.73	-0.010	-3.73	-0.010	-3.73	-0.010	-3.73
Constant	-		-8.508	-11.68	-2.259	-5.33	-1.573	-4.11
Very hot or heavy rain	-		0.430	2.23	0.299	1.52	0.338	2.65
Male	-		1.190	5.65	-0.321	-1.87	-0.367	-3.30
High income [above 20 mil. VND]	-		0.071	9.04	0.040	4.73	0.014	2.24
Age	-		0.044	2.62	-		0.036	3.81
Married	-		2.032	5.31	-		-0.416	-3.07
Presence of children	-		-0.480	-2.50	-0.339	-1.75	-	
High education [above bachelor degree]	-		-		-		0.320	2.57
Distance from home to workplace [km]	-		0.110	6.07	0.067	3.65	0.026	2.02
Number of trips (tour complexity)	-		-0.340	-3.46	-0.469	-3.96	-0.481	-8.01
Prob(Change location)*Number of trips	-		0.799	2.13	-		-	
Prob(Shift same day)*Number of trips	-		-1.317	-1.68	-2.305	-4.56	-	
Prob(Shift to another day)*Number of trips	-		-		-		0.750	3.55
Prob(Cancel trip)*Number of trips	-		2.640	3.48	4.515	6.23	-	
Log-likelihood at Zero								
Log-likelihood without tour patterns ^(a)								
Log-likelihood at Convergence								
Rho								
AIC								
Number of samples								

^(a) the second term on the right hand of equation (1) is removed from the model (Estimation results are shown in Table A in Appendix).



Note: Values in the contour indicates the share of MRT (%).

Figure 5. Sensitivity analysis: the impacts of number of trips and Prob(Shift to another day) on the choice probability of MRT

5. CONCLUSIONS

This study introduced a simple method to identify the impacts of tour patterns on stated preference of commuting mode choice. From a viewpoint of survey methodology, a key challenge in the tour-based SP survey is how to give realistic choice situations, where the survey should nudge respondents to pay attention to the costs of rescheduling their activity patterns when they change travel mode. We have proposed a method which is simple but effective in the sense of reducing the complexity of tour patterns in SP choice experiments while capturing the impacts of tour patterns on mode choice decisions. The key idea is to utilize the RP information: given the number of trips, respondents were asked to imagine a typical activity pattern in a working day which has been taken regularly in their daily life. The flexibilities of this “unobserved” activity pattern are imputed using the RP information, and then estimates the impacts of tour patterns, which are represented by the tour complexity and trip flexibility, on stated commuting mode choice.

We conducted an empirical analysis by using the data collected in HCMC, Vietnam, where the MRT system is currently under construction. Our results indicate that tour complexity would reduce MRT use, while the impact would be eased with the possibility that the added trips are flexible in terms of shifting them to another day. This finding would bring a couple of important policy implications. For a successful MRT development, allowing respondents to reorganize their activity schedules would be crucial. In the case of the study area, drop-off/pick-up would be one of the biggest barriers for a successful rescheduling. In this regard, relocation of a school to a place close to a station and/or provision of alternative travel modes which allow children to go to school by themselves could be effective policy options, though different barriers would come in when implementing these policies. For the former option, acquisition of land would be a major barrier, and, for the latter option, the cost allocation (i.e., who should pay for running the school bus) needs to be clarified.

There are a number of limitations. One of the most important challenges is that, while our proposed method allows for reducing the respondents’ burdens while capturing the impact of

tour patterns on stated mode choice, the contents of tour patterns are unobserved, preventing more detailed analysis on the impact of facility relocation and the introduction of feeder transport. To evaluate such policy impacts, we may have to directly model the rescheduling process, which would increase respondents' burden. The trade-offs between respondents' burden and the usefulness of the detailed activity-travel information need to be revisited. For example, Doherty (2006) questioned the usefulness of traditional activity types in the understanding and modeling of travel behavior, and proposed an alternative way to classify them to better explain complex travel behavior. Accumulating such fundamental analysis would be a necessary step towards evaluating the impacts of introducing a "currently unavailable" travel mode comprehensively. Another interesting extension of our analysis is to include the punctuality aspect of MRT. The punctuality would be important when executing *a single scheduled activity*, while the temporal flexibility of the trip would be important when executing *a set of activities (or tours)*. By investigating both factors together, we could have a better understanding of how users' scheduling preferences influence their public transport use.

APPENDIX

Table A shows the estimation results of the model without tour complexity and trip flexibility variables. The AIC (in comparison with the AIC of the proposed model shown in Table 8) indicates that tour complexity and trip flexibility variables improve the goodness-of-fit considerably.

Table A. Model estimation results (without tour complexity and trip flexibility variables)

	Motorcycle (base)		Car		Bus		MRT	
	param	t-stat	param	t-stat	param	t-stat	param	t-stat
Travel cost [1,000 VND]	-0.016	-2.17	-0.016	-2.17	-0.016	-2.17	-0.016	-2.17
Travel time [minute]	-0.009	-3.61	-0.009	-3.61	-0.009	-3.61	-0.009	-3.61
Constant	-	-	-8.464	-14.63	-3.062	-8.48	-2.314	-6.66
Very hot or heavy rain	-	-	0.420	2.22	0.293	1.51	0.371	2.95
Male	-	-	1.082	5.25	-0.426	-2.55	-0.392	-3.60
High income [above 20 mil. VND]	-	-	0.053	8.56	0.015	1.91	0.007	1.26
Age	-	-	0.060	5.25	-	-	0.029	3.19
Married	-	-	1.808	4.79	-	-	-0.415	-3.12
Presence of children	-	-	-0.625	-3.47	-0.151	-0.88	-	-
High education [above bachelor degree]	-	-	-	-	-	-	0.318	2.60
Distance from home to workplace [km]	-	-	0.104	5.66	0.063	3.38	0.021	1.68
Log-likelihood at Zero								
Log-likelihood at Convergence								
Rho								
AIC								
Number of samples								

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