Chapter V

The Development of Mode Choice Model

5.1 Mode Choice Model for Manila

5.1.1 Data Preparation

The data available for model development include 1396 observations of travelers in transit coverage area in Manila. However, due to incomplete data, only 1375 observations can be used. It was found that some observations were not appropriate according to the scope of study. For example, there are some cases where origin or destination is outside the mass transit corridor, and so on. Thus, some data eliminations were carried out as follow.

Since the access to transit station is the main issue in this research, the distance over which variation of access mode is present is used as a basis for data filtering. Figure 5.1 shows the distance to transit station (access distance) and from station (egress distance).

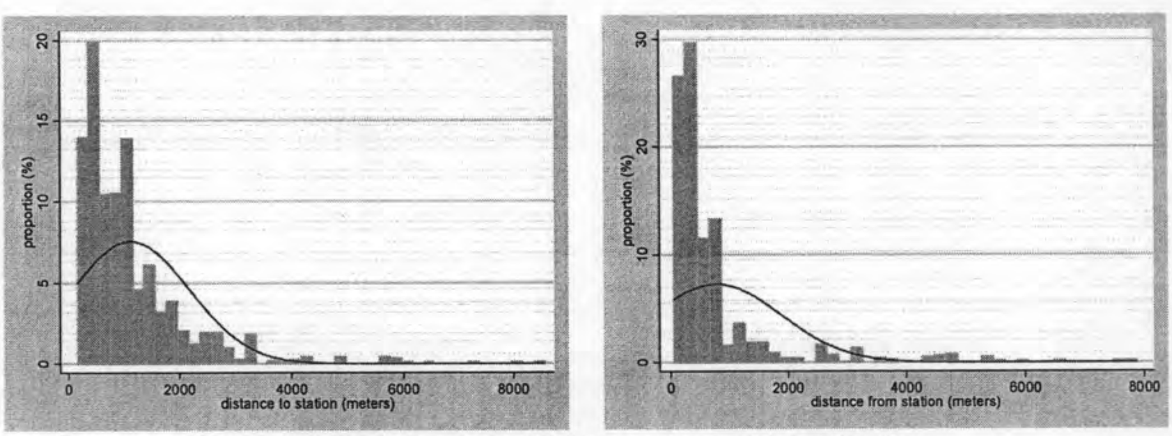


Figure 5.1 Distribution of Distance to and from Station

These distances were calculated based on home and destination address reported by respondents. It can be seen from the figure that access distance is slightly longer than egress distance, with the average access distance and egress distance of 1124 meters and 897 meters, respectively.

The relationship between access distance and access mode share in the study area was discussed in the previous chapter. It was found that no respondents walked for the distance longer than 2000 meters. It was revealed as well that up to the distance of 2000 meters many kinds of access modes exist and become alternative modes to access transit station (see figures in the last section of the previous chapter). So, the distance of 2000 meters was used to screen the data and the resulting number of observations was down to 1071.

5.1.2 Alternative Modes

Besides mass transit and private car, there are many alternative modes can be used to travel from home to destination (i.e. workplace or school) within the mass transit corridor under study. According to the survey results, alternative modes reported by respondents are listed below.

- *Public bus*. Two types of service are provided: air-conditioned and non-air-conditioned. Most of the buses are reconditioned second-hand buses from Japan and they are operated wholly by private companies.
- *Jeepney*. Public transportation in Metro Manila is dominated by jeepney. About 39.1% of commuters used jeepney for daily trip [28]. The jeepney has capacity of about 12 to 14 passengers and it is operated as fixed route transit. All jeepney services are provided by private operators.
- *Fx*. The Asian Utility Vehicle (AUV) or fx. Megataxi is air-conditioned van with capacity of 10 passengers. This passenger-shared mode has fixed route, but sometimes it serves several non-specified routes depending on the demand.
- *Regular taxi*. Most taxis are air-conditioned and metered.

There are many alternative modes reported from station areas surveyed. Some stations have small numbers of observation for some alternatives. Thus, to have balanced proportion, alternative modes were classified into four groups, namely, mass transit (*rail*), private car (*car*), fixed route transit (*fix*), and for-hired transit (*hire*). Summary of mode share for each mass transit line corridor can be seen in Table 5.1 while the detailed ones for each station are presented in the Appendix. Based on their characteristics, in this research, public bus, *jeepney*, and *fx* are classified as fixed-route transit while only taxi was grouped as flexible route transit or for-hired transit. Note that the proportion of walking and non-walking to access mass transit station is 52.9% and 47.1%, respectively.

The alternative of private car is available only for those who own car or live within car owning households or those with car-sharing option available. In other words, in the model development, the alternative of private car was applied to only those who have car availability. Among all observations, only 24.2% of all respondents had car available for use.

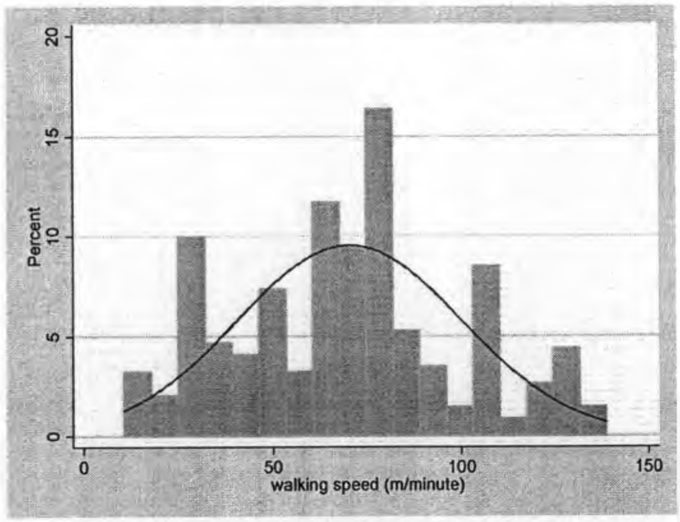
Table 5.1 Summary of Mode Share in Manila

Mass Transit Line	Mass Transit	Private Car		Fixed Route Transit				For-Hired Transit, Taxi	Total
		Drive	Share	Non-AC Bus	AC Bus	*Jeepney*	Fx		
LRT1	213	29	34	5	16	164	15	15	491
LRT2	181	7	7	2	5	110	9	1	322
MRT3	96	19	7	10	19	103	2	2	258
Total	**490**	**55**	**48**	**17**	**40**	**377**	**26**	**18**	**1071**
%	**45.8%**	**9.6%**		**43.0%**				**1.7%**	**100.0%**

5.1.3 Walking Speed in Accessing Mass Transit Station

Generally, there are three sub-trips to travel from home to office or school using mass transit. The first one is going from home to origin station (access trip), the second is traveling by train (line-haul trip), and the last one is reaching office or school from destination station (egress trip). The proportions of access modes share reported by respondents were discussed in the previous chapter. It was revealed that various access modes can be used to reach station, such as walking, bus, *jeepney*, taxi, and, so on.

Walking speed is calculated by dividing the distance between home and station with time reported for walking from home to station. Allan [24] suggested that maximum time that people can maintain the highest speed of walking is 20 minutes. In other words, for walking more than 20 minutes the speed of walking will decrease accordingly. Fruin [25] suggested that walking speed of 140 meters per minutes or more is considered running. The average walking speed to access station in the study area can be summarized as shown in Figure 5.2. The value of walking speed that appeared in the figure is similar to those found in some studies that were previously discussed in the Literature Review, which found that the average walking speed was between 74 to 76 m/min.



Walking Access Speed:
Average: 74.2 m/min.
Standard Dev.: 30.8 m/min
Minimum: 11.5 m/min
Maximum: 138.2 m/min

Figure 5.2 Average Walking Speed to Access Station

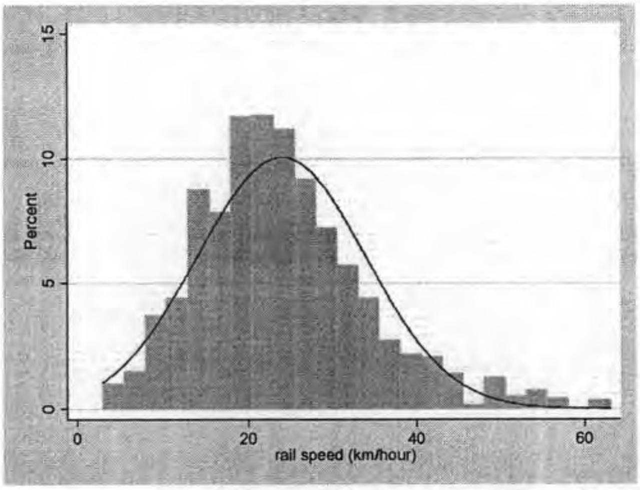
5.1.4 Mass Transit Speed and Its Cost

The distance between stations or station span for Manila Mass Transit System varies among station within a line and among lines. The average station span of LRT1, LRT2, and MRT2 stations is 832 meters, 1150 meters, and 1300 meters, respectively. To illustrate, Figure 4.2 show distance between stations for LRT1 line. These distances were calculated from the city map of Metro Manila. The complete information of the station span distance can be found in the Appendix.

		Monumento	5th Avenue	R Papa	Abad Santos	Blumentritt	Tayuman	Bambang	Doroteo Jose	Carriedo	Central Terminal	United Nations	Pedro Gil	Quirino	Vito Cruz	Gil Puyat	Libertad	EDSA	Baclaran
	Monumento	0																	
	5th Avenue	1,024	0																
	R Papa	1,984	960	0															
	Abad Santos	2,768	1,744	784	0														
	Blumentritt	3,680	2,656	1,696	912	0													
	Tayuman	4,320	3,296	2,336	1,552	640	0												
	Bambang	4,976	3,952	2,992	2,208	1,296	656	0											
Recto	Doroteo Jose	5,632	4,608	3,648	2,864	1,952	1,312	656	0										
	Carriedo	6,352	5,328	4,368	3,584	2,672	2,032	1,376	720	0									
	Central Terminal	7,104	6,080	5,120	4,336	3,424	2,784	2,128	1,472	752	0								
	United Nations	8,336	7,312	6,352	5,568	4,656	4,016	3,360	2,704	1,984	1,232	0							
	Pedro Gil	9,136	8,112	7,152	6,368	5,456	4,816	4,160	3,504	2,784	2,032	800	0						
	Quirino	9,920	8,896	7,936	7,152	6,240	5,600	4,944	4,288	3,568	2,816	1,584	784	0					
	Vito Cruz	10,752	9,728	8,768	7,984	7,072	6,432	5,776	5,120	4,400	3,648	2,416	1,616	832	0				
	Gil Puyat	11,840	10,816	9,856	9,072	8,160	7,520	6,864	6,208	5,488	4,736	3,504	2,704	1,920	1,088	0			
	Libertad	12,496	11,472	10,512	9,728	8,816	8,176	7,520	6,864	6,144	5,392	4,160	3,360	2,576	1,744	656	0		
Taft	EDSA	13,536	12,512	11,552	10,768	9,856	9,216	8,560	7,904	7,184	6,432	5,200	4,400	3,616	2,784	1,696	1,040	0	
	Baclaran	14,144	13,120	12,160	11,376	10,464	9,824	9,168	8,512	7,792	7,040	5,808	5,008	4,224	3,392	2,304	1,648	608	0

Figure 5.3 Station Span for LRT1 Line

Based on station distance and in-train time reported by respondents, rail transit speed can be calculated. Note that most of the respondents included transfer and waiting time in their reported time. Figure 4.3 shows the distribution of rail transit speed from origin station to destination station.



Rail Speed:
Average: 23.28 kph
Standard Dev.: 9.58 kph
Minimum: 3.84 kph
Maximum: 61.82 kph

Figure 5.4 Average Mass Transit Speed

The transit ticket fare between origin and destination stations can be calculated based on the fare structure as shown in Figure 5.5. The fare structure in this figure is an example for LRT1 while those for the other lines can be seen in the Appendix. The fare in the figure is computed on the stored-value ticket basis. On the other hand, in the survey, respondent reported the cost that they actually spent by using mass transit.

				Monumento 301	5th Avenue 302	R Papa 303	Abad Santos 304	Blumentritt 305	Tayuman 306	Bambang 307	Doroteo Jose 308 401	Carriedo 309	Central Terminal 310	United Nations 311	Pedro Gil 312	Quirino 313	Vito Cruz 314	Gil Puyat 315	Libertad 316	EDSA 317 513	Baclaran 318
	301		Monumento																		
	302		5th Avenue	12																	
	303		R Papa	12	12																
	304		Abad Santos	12	12	12															
	305		Blumentritt	12	12	12	12														
	306		Tayuman	13	12	12	12	12													
	307		Bambang	13	13	12	12	12	12												
401	308	Recto	Doroteo Jose	13	13	13	12	12	12	12											
	309		Carriedo	13	13	13	13	12	12	12	12										
	310		Central Terminal	14	13	13	13	13	12	12	12	12									
	311		United Nations	14	14	13	13	13	13	12	12	12	12								
	312		Pedro Gil	14	14	14	13	13	13	13	12	12	12	12							
	313		Quirino	14	14	14	14	13	13	13	13	12	12	12	12						
	314		Vito Cruz	[illegible]	14	14	14	14	13	13	13	13	12	12	12	12					
	315		Gil Puyat	[illegible]	[illegible]	14	14	14	14	13	13	13	13	12	12	12	12				
	316		Libertad	[illegible]	[illegible]	[illegible]	14	14	14	14	13	13	13	13	12	12	12	12			
513	317	Taft	EDSA	[illegible]	[illegible]	[illegible]	[illegible]	14	14	14	14	13	13	13	13	12	12	12	12		
	318		Baclaran	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	14	14	14	13	13	13	13	12	12	12	12	

Figure 5.5 Fare Structure of LRT1 Lines
Source: (http://www.lrta.gov.ph, access date: March 2006)

Table 5.2 shows the results of t-test which were carried out using the Stata/SE 8.2 statistical software. The tests were employed to evaluate the differences between calculated fare (*railfare*) and reported cost (*haulcost*).

The null hypothesis that *haulcost* is same with *railfare* cannot be rejected at significant level of 5%. This implies no significant difference between those values. Therefore, the calculation procedure proposed is used for data generation in the subsequent section.

Table 5.2 Cost Difference Test

```
Two-sample t test with unequal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
haulcost |     901    16.71865    .1907399    5.725375      16.3443    17.09299
railfare |    1029    16.35277    .1792522    5.750059     16.00103    16.70451
---------+--------------------------------------------------------------------
combined |    1930    16.52358    .1306564    5.739966     16.26733    16.77982
---------+--------------------------------------------------------------------
    diff |            .3658763      .26175                -.1474719    .8792245
------------------------------------------------------------------------------

            Ho: mean(haulcost) - mean(railfare) = diff = 0

   Ha: diff < 0                Ha: diff != 0                Ha: diff > 0
     t =   1.3978                t =   1.3978                t =   1.3978
 P < t =   0.9188          P > |t| =   0.1623          P > t =   0.0812
```

5.1.5 Speed of Non-Mass Transit Modes and Their Costs

As discussed earlier, for the same pair of origin and destination (O-D pair), there are many possible alternatives of non-mass transit modes such as car, bus, jeepney and taxi (fx and regular taxi). Based on the measured distance between origin and destination and reported total travel time, average speed for each mode for can be calculated and summarized as shown in Table 5.3.

Table 5.3 Average Travel Speed of Non-Mass Transit Modes

Transportation Mode	Observ.	Average Speed (kph)	Std.dev. (kph)	Min. (kph)	Max. (kph)
Car (drive or share)	128	14.82	5.92	5.28	29.18
Bus (AC and non-AC)	76	10.01	3.20	5.30	17.98
Jeepney	238	8.79	3.11	5.00	19.47
Fx (Megataxi)	60	8.69	2.21	5.33	13.12
Regular taxi	40	14.27	4.56	3.88	21.79

Note: the speed was calculated by dividing the distance of O-D with reported total travel time

Note that the values in the table are relatively low compare to those from other studies. The differences might be explained by the fact that the time reported is the total time, which includes other time components, such as transfer time and waiting time. From the trip data, some alternative mode's travel characteristics were also reported by some respondents. It should be noted also that some respondents rounded their reported travel time up to 5 or 10 minutes, thereby lowering the calculated speed.

The fare structure of main public transportation modes in Metro Manila varies as can be seen in Table 5.4. Note that costs of public transportation reported by some respondents differ from those in the table.

Table 5.4 Fare Structure of Main Public Transportation

Public Transportation	Fare System
Jeepney	PHP 5.5 for the first four kilometers and PHP 1.0 for each succeeding kilometer
Air-Conditioned Buses	PHP 9.0 for the first five kilometers and PHP 1.50 for each succeeding kilometer
Non Air-Conditioned Buses	PHP 6.0 for the first five kilometers and PHP 1.25 for each succeeding kilometer
AUV/FX Megataxi	PHP 10.0 minimum and an additional of PHP 5.0 for a certain distance estimated by the driver (pseudo fare)
Regular Taxi	PHP 30.0 for the flag down covering the first 500 meters and PHP 2.50 for every 300 succeeding meters

Source: cited from Fillone, 2005

5.1.6 Mode Attributes for Non-Chosen Modes

The complete itinerary trip data were expected to comprise detailed information of respondents' trip not only by using mass transit, but also by alternative of non-mass transit modes. However, from the survey results, only approximately half of respondents gave complete information for both modes. Since the mode choice model considered three to four available modes, additional information of other alternatives that were not reported by respondents is needed.

The best approach to have information of each alternative is to gather the information directly from the respondents. However, this is not always possible. By assumption that information on the attribute level of all alternatives within the choice set are available at the aggregate level, Hensher et al. (2005) suggested four possible solutions. The simplest one is taking the average of the attribute value for each selected alternative. In this research, one of the proposed solutions was used in order to generate the information of non-chosen alternative. The approach involves synthesizing data by combining other information and average value of alternative's attribute.

Table 5.5 shows data of non-chosen alternative were generated. It can be seen in the table, for instance, that walking is the assumed mode of access and egress. Therefore, the access time can be calculated from access distance to station divided by average walking speed. *Jeepney* was used to represent the fixed route transit because this mode is much more dominant than bus or fx.

Table 5.5 Generation of Time and Cost Variable for Non-Chosen Data

Trip	Assumption Mode	Generating Data For Time	Generating Data For Cost
Access	Walking	acc_dist / walking_speed	0
Egress	Walking	egr_dist / walking_speed	0
Rail	Mass Transit	sta_dist / rail_speed	rail_fare (calculated)
Private car	Car	OD_dist / car_speed	OD_dist*average_cost (per_km)
Fixed route transit	Jeepney	OD_dist / jeepney_speed	Fare structure of jeepney
For-hired transit	Taxi	OD_dist / taxi_speed	Fare structure of taxi

Note:
acc_dist: distance between home to station
egr_dist: distance between station to destination
sta_dist: distance between origin station and destination station
OD_dist: distance between home to destination within mass transit corridor

To check the validity of the generated value, the set of origin and destination pairs were randomly selected from the data set. Since the study area consists of mass transit corridor, the pairs were based on origin and destination stations. Thus, 180 observations from the nine pairs of station origin and station were selected. A student test or t-test was carried out to reject the null hypothesis that average value of actual time and cost was equal to the average from the generated data for the same pair origin and destination. For example, Table 5.6 shows the results of t-test for average travel time of the mode group of fixed-route transit. The variable of *fixtime* refers to the average total travel time of fixed-route transit from actual data and the variable of *tfix* is associated to the average total travel time from generated data.

Table 5.6 The Student's t-test to Evaluate Time of Fixed-Route Transit

```
Two-sample t test with unequal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
 fixtime |      95    52.15789    3.041789    29.64769    46.11835    58.19744
    tfix |     180      57.966    2.308298    30.96907    53.41103    62.52098
---------+--------------------------------------------------------------------
combined |     275    55.95957    1.844658    30.59019    52.32806    59.59107
---------+--------------------------------------------------------------------
    diff |           -5.808109    3.870442               -13.42782    1.811599
------------------------------------------------------------------------------
Degrees of freedom: 273
                  Ho: mean(fixtime) - mean(tfix) = diff = 0
     Ha: diff < 0               Ha: diff != 0              Ha: diff > 0
       t =  -1.5006               t =  -1.5006              t =  -1.5006
   P < t =   0.0673         P > |t| =   0.1346          P > t =   0.9327
```

As can be seen in the table, the null hypothesis that *fixtime* is equal to *tfix* cannot be rejected at the significance level of 5%. Therefore, in this case, the generated value can be accepted statistically to complete the information of the non-chosen alternative. Similar tests were carried out for time and cost of other alternative modes and the results were presented in the Appendix.

5.1.7 Data Format for Modeling

The software package of Stata/SE 8.2 for Windows has limited capability to estimate multinomial model and particularly nested logit models. Estimation procedure in this version of Stata was not consistent in normalized scale parameter in nested logit structure. Thus, the statistical software NLOGIT 3.0 was used to develop the mode choice model. The data setup for this software is somewhat unique with some similarity with the panel data format. Unlike other statistical package that presents each row of data as an independent observation, NLOGIT needs to assign several rows to represent a single observation. In other words, in NLOGIT, each row of data is strictly not independent from each other.

To illustrate, Table 5.7 shows the data format setup in Microsoft EXCEL worksheet that is ready to be imported to NLOGIT data input. The table presents a data set for three individuals with five alternatives. Each alternative has two attributes, i.e. total travel time (*ttime*) and total travel cost (*tcost*). Also are shown two socioeconomic parameters of the individual.

The table is shaded to indicate a number of blocks with each block representing a choice set of an individual. Each row within a block corresponds to an alternative within the choice set. As such, each individual is presented by five rows of data. The *id* variable is the label for an individual, as *id* = 1 indicates first individual, *id* = 2 for the second, and so on. The variable of *altij* is an index that informs NLOGIT which line of data corresponds to which alternative mode. The four alternatives are labeled as number 1 to 4. The *altij* = 1 is for alternative of mass transit, *altij* = 2 for car, and so forth. The variable of *cset* is designed to inform NLOGIT of the number of alternative within a particular choice set. For those who have car availability the number of choice (*cset*) is equal to four while for those who do not have car availability, *cset* is equal to three.

Table 5.7 Data Format for NLOGIT

id	altij	cset	choice	ttime	tcost	gender	age	acdist
1	1	3	1	69.189	14.000	0	32	1280
1	3	3	0	125.413	22.873	0	32	1280
1	4	3	0	77.252	178.942	0	32	1280
2	1	3	0	19.795	12.000	1	52	720
2	3	3	1	25.399	30.000	1	52	720
2	4	3	0	15.645	56.842	1	52	720
5	1	4	0	36.411	24.000	0	20	960
5	2	4	1	40.000	15.000	0	20	960
5	3	4	0	40.000	15.000	0	20	960
5	4	4	0	32.039	89.333	0	20	960
6	1	4	0	23.469	13.000	0	41	560
6	2	4	1	20.000	50.000	0	41	560
6	3	4	0	35.563	9.710	0	41	560
6	4	4	0	21.906	69.250	0	41	560

The *choice* variable indicates which alternative within a choice set was chosen. The number 1 denotes that an alternative was selected while the number 0 denotes that it was not. Thus, the sum of the *choice* variable should be equal 1 for each individual. The variables of *ttime* and *tcost* are specific to each alternative and the value varies among alternatives. The variable of *gender* is a dummy variable to reflect respondent's gender, with value of 0 denoting men and 1 denoting women. The variable *gender* and *age* are specific to each individual, and thus the value is constant for each block.

5.1.8 Model Development with MNL Model

The *multinomial logit* (MNL) model was developed with four alternative modes in the choice set, with some respondents having partial choice set. The alternative of private car was only for those with car availability. The models were estimated using data with choice-specific attributes in addition to individual-specific characteristics to explain the mode choice. Note that this type of model is also known as *conditional logit model* [36] or *categorical logit model* (in Stata/SE 8.2).

Table 5.8 shows the mode choice model with generic variables of alternatives modes. The alternative specific constant of for-hired transit (*hire*) is the base alternative, whose coefficient is therefore not estimated. As can be seen in the table, the MNL-1 model is an initial model that was developed with only variable of time and cost. MNL-2 and MNL-3 improved upon the base model by adding accessibility and socioeconomic variables. MNL-4 incorporated all statistically significant variables in the utility function specification.

Table 5.8 Mode Choice Model for Parameter Selection (Manila)

Parameters	MNL-1	MNL-2	MNL-3	MNL-4
Total time (minutes)	-0.066 (-14.93)**	-0.0719 (-15.13)**	-0.0669 (-13.22)**	-0.0732 (-15.38)**
Total cost (PHP)	-0.0223 (-6.92)**	-0.0238 (-7.23)**	-0.0261 (-6.4)**	-0.0248 (-7.44)**
Accessibility Parameter				
Access distance (meters)		-0.0012 (-7.1)**		-0.0012 (-6.92)**
Number of destinations		-0.0046 (-0.87)		
Socioeconomic Parameters, specific to mass transit				
Age (years)			-0.0247 (-2.08)**	-0.0307 (-3.09)**
Income (PHP)			-0.0005 (-0.13)	
Education (1-bachelor & above)			-0.0034 (-0.04)	
Constant				
Mass transit	2.8287 (8.87)**	2.8793 (7.28)**	2.5847 (4.39)**	2.8556 (8.45)**
Private car	3.7068 (13.22)**	3.7023 (13.13)**	3.3099 (8.94)**	3.6561 (12.94)**
Fixed route transit	1.8325 (5.95)**	1.8281 (5.65)**	2.04 (4.98)**	1.8716 (8.58)**
Parameters of Statistics				
Log-likelihood at zero	-1484.7213	-1484.7213	-1197.7583	-1484.7213
Log-likelihood at constants	-921.6390	-921.6390	-743.5070	-921.6390
Log-likelihood at convergence	-717.4256	-689.5897	-551.4538	-684.9485
Rho squared w.r.t. zero	0.5168	0.5355	0.5396	0.5387
Rho squared w.r.t. constants	0.2216	0.2518	0.2583	0.2568
Number of observation	1071	1071	864	1071
%-correct prediction	59.85%	61.72%	61.00%	62.00%
LL-test to the base model	-	55.6717	331.9435	64.9541
Significance of rejection	-	0.0000	0.0000	0.0000

note: ** significance at the level of 5%; * significance at the level of 10%

There are many variables that can be incorporated into the models. Variable selection was carried out based on initial finding in the survey and justified by results from previous transit studies discussed in the literature review. For instance, the number of destinations, such as offices, schools, retail shops and so on, reflects the variety of purposes that can be achieved in the area of destination station. Past transit accessibility studies show that the number of destinations within 10 minutes of walking from the station may influence station's attractiveness as an activities location [2], [44]. Moreover, Abdel-Aty [16] showed that travelers' age, income, and level of education influenced the tendency of transit use.

It can be seen in the table that both of estimated coefficients for time and cost have negative sign. These results indicate that the probability of an alternative mode to be chosen decreases as the total travel time or total travel cost increasing. Since private car is a possible alternative only for those with car availability, comparing with the base alternative, car is preferred, *ceteris paribus*. On the other hand, the transit users with no car prefer to use mass transit rather than fixed-route transit.

Examining the constant term, it is revealed that after controlling for all other factors, the probability of private car to be chosen has the highest level while the probability of for-hired transit (i.e. taxi) has the lowest. The results imply that the order of preference of modes in the study area are car, mass transit, fixed-route transit (bus, jeepney and fx), and taxi (for-hired transit). This finding concurs with the result study by Fillone [28] that found car was the most preferable mode to travel within Metro Manila while taxi is the least level. According to the author, the lowest level of choosing taxi to travel was caused by its cost that was relatively high among other public transport modes.

In this study, the alternative of private car consists of travel mode by those who have ability to use car, drive alone or share car. This group of respondents valued alternative of car as the highest among other modes and is less likely to use mass transit. This finding agrees with the result of survey that the main reason of not using mass transit is because having a car that is available for the trip (See the previous chapter for more detail).

To evaluate how the variables of time, cost, distance, and so on play their roles in choosing mass transit in more detail, the model of MNL-4 was estimated again with respect to mass transit with the result presented in Table 5.9. As can be seen in the table, the model of MNL-5 exhibits clearly the role of access distance in mass transit use.

The negative sign of the access distance variable indicates that the probability of mass transit being chosen decreases as the distance increases. In other words, the probability of non-mass transit mode increases as the distance increases.

The last two rows in the table indicate that in the term of statistical fit, the model MNL-5 is better than MNL-4. The null hypothesis, that MNL-5 is not better than MNL-4, can be rejected at the significant level of 5%. Therefore, MNL-5 is used for further analysis.

Table 5.9 Mode Choice Model with respect to Mass Transit (Manila)

Parameters	MNL-5
Total time (minutes)	
Mass transit mode	-0.0579 (-7.1)**
Non-mass transit mode	-0.0702 (-14.5)**
Total cost (PHP)	
Mass transit mode	-0.0113 (-3.28)**
Non-mass transit mode	-0.0243 (-7.04)**
Variables w.r.t. Mass Transit	
Access distance (meters)	-0.0014 (-7.39)**
Age (years)	-0.0304 (-3.01)**
Constant	
Mass transit	2.8252 (6.25)**
Private car	3.666 (12.97)**
Fixed route transit	1.7608 (5.36)**
Parameters of Statistics	
Log-likelihood at zero	-1484.7213
Log-likelihood at constants	-921.6390
Log-likelihood at convergence	-680.6324
Rho squared w.r.t. zero	0.5416
Rho squared w.r.t. constants	0.2615
Number of observation	1071
%-correct prediction	62.18%
Chi-squared vs. MNL-4	8.6322
Rejection significance	0.0134

note: ** significance at the level of 5%;
* significance at the level of 10%

5.1.9 Nested Logit Model

The Hausman's specification test was conducted to test the assumption of *independence from irrelevant alternatives*, IIA. It posits that if a subset of the choice set truly is irrelevant, omitting it from the model altogether will not change parameter estimates systematically. If the independence from irrelevant alternatives test fails, it was suggested that the alternatives are grouped into subgroups that allow the variance to differ across the groups with the IIA assumption held within the groups. This specification is defined as the *nested logit model* [36].

The model MNL-5 was used to perform the Hausman's specification test. To do so, firstly, one alternative was dropped from the data set and the model is estimated again. The chi-squared statistic of the *restricted model* (the model with some alternatives removed) and the *unrestricted model* (the original model) was then calculated. The model is considered in violation of the IIA assumption if the chi-squared value is greater than critical value. The example calculation in the case where the *rail* is removed is as follows.

$$\chi^2 = \left(\hat{\boldsymbol{\beta}}_{rail} - \hat{\boldsymbol{\beta}}_{all}\right)'\left[\hat{\mathbf{V}}_{rail} - \hat{\mathbf{V}}_{all}\right]^{-1}\left(\hat{\boldsymbol{\beta}}_{rail} - \hat{\boldsymbol{\beta}}_{all}\right) = 362.7928 < \chi^2_{3,0.05} = 7.8147$$

Hypotheses that alternative of *rail* is independent from other modes cannot be rejected at the significance level of 5% while the *p-value* for this scenario is 0.5694. Hence, the structure of *nested logit model* should be considered.

There are various *nested logit* tree structures that can be examined to evaluate mode choice models within mass transit corridor in the study area. Referring to [28], the various tree structures for traveling within mass transit corridors in this study are illustrated in Figure 5.6. Descriptions and discussion of these tree structures are as follow.

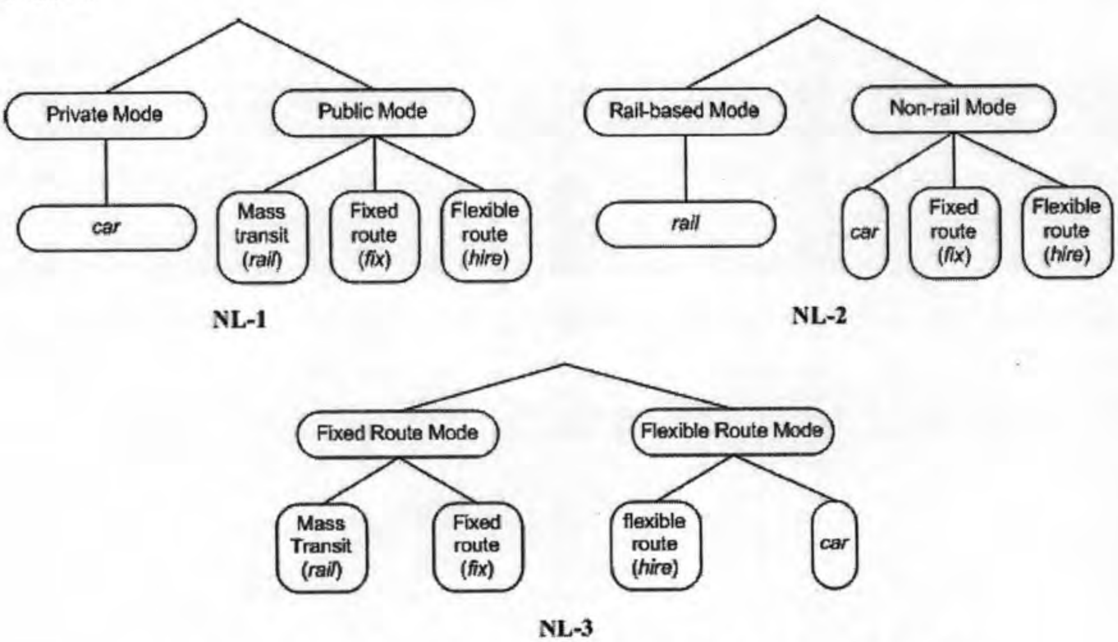


Figure 5.6 Various Tree Structures of Nested Logit Model

NL-1: The alternative modes are arranged into two branches, i.e. private mode and public mode. Mass transit, fixed-route transit, and for-hire or flexible-route transit are grouped as public mode.

NL-2: The alternative modes are arranged based on infrastructure characteristics, i.e. rail-based mode and road-based mode, regardless of whether they are public transportation or private mode.

NL-3: The alternative modes are arranged based on their characteristics of route, i.e. fixed route and flexible route.

Note that in the data for analysis, the proportions of observations by alternative mode were not balance. Mass transit and fixed-route transit has the higher proportion while private car and, particularly, for-hired transit has very low proportion. Thus, the 3-level of nested logit cannot be performed.

Indeed, there is no standard procedure to select the best tree structure of nested logit model [36], [37]. However, many studies carried out tree selection by examining the goodness of fit, percentage of correct prediction, and number of statistical significance of explanatory variables [38], [45].

Note that in the nested logit models, there is a unique Inclusive Value (IV) parameter for each specific level of the tree structure. The IV parameters are within the 0-1 bound as necessary for consistency with the utility maximization [37]. To estimate the IV parameter, normalization of the scale parameter was carried out. By default, the statistical software program NLOGIT 3.0 will normalize the scale parameter of the lowest level or RU1 [45].

Table 5.10 shows the model estimation of the nested logit model in order to select the best tree. The model MNL-5 was used as the base model on which the nested logit models were developed. Under the RU1 condition, for NL-1 model, the inclusive values (IVs) are within the 0-1 bound. The RU1 condition cannot be applied for NL-2 and NL-3 because the IVs were more than one that implies the assumption for utility maximization was no longer valid. In the NL-2 model, alternative of rail is the degenerative alternative while under RU2 the IV of the alternative was fixed to be one. In the NL-3 model, the IV of the flexible route mode branch is also greater than 1.0 and it is significant. As a result, the utility maximization assumption for the NL-3 model does not hold either.

As can be seen in the table, the MNL model is added for comparison with the nested models. The last two rows in the table is to indicate whether within the same set of explanatory variables, the nested models would show significant improvement over the MNL model at the level of 5%. Accordingly, NL-1 and NL-3 model improve significantly over the MNL model while the NL-2 is not significant at any level. The goodness of fit, percentage of correct prediction, and number of statistical significance of explanatory variables are not much different among the three models. Thus, based on IV parameters and comparison with the MNL model, the model of NL-1 is selected for further consideration.

Table 5.10 Estimation of Nested Logit Model (Tree Selection)

Parameters	NL-1	NL-2	NL-3
Total time (minutes)			
Mass transit mode	-0.0626 (-6.64)**	-0.0579 (-6.97)**	-0.045 (-4.4)**
Non-mass transit mode	-0.072 (-13.57)**	-0.0702 (-13.21)**	-0.049 (-4.37)**
Total cost (PHP)			
Mass transit mode	-0.0257 (-2.55)**	-0.0113 (-3.38)**	-0.0131 (-2.03)**
Non-mass transit mode	-0.0439 (-5.68)**	-0.0243 (-6.24)**	-0.0269 (-6.95)**
Variables w.r.t. Mass Transit			
Access distance (meters)	-0.0014 (-7.35)**	-0.0014 (-7.9)**	-0.001 (-4.15)**
Age (years)	-0.0313 (-3.04)**	-0.0304 (-3.04)**	-0.0198 (-2.53)**
Constant			
Mass transit	2.0671 (3.46)**	2.8328 (3.33)**	2.6374 (4.79)**
Private car	2.964 (4.65)**	3.6754 (4.7)**	3.8064 (8.13)**
Fixed route transit	1.3652 (2.8)**	1.7679 (2.33)**	1.6155 (3.05)**
Inclusive Value (IV) parameters			
NL-1: private mode	0.5810 (4.92)**	-	-
public mode	0.8409 (4.55)**	-	-
NL-2: rail-based mode	-	1.000 (fixed)	-
non rail-based mode	-	0.9967 (4.9)**	-
NL-3: fixed route mode	-	-	1.5396 (4.31)**
flexible route mode	-	-	0.3885 (6.65)**
Parameters of Statistics			
Log-likelihood at zero	-1805.8173	-1380.6544	-1484.7213
Log-likelihood at constants	-921.6390	-921.6390	-921.6390
Log-likelihood at convergence	-675.0813	-680.6322	-656.2761
Rho squared w.r.t. zero	0.6262	0.5070	0.5580
Rho squared w.r.t. constants	0.2675	0.2615	0.2879
%-correct prediction	62.46%	62.18%	63.21%
Chi-squared vs. MNL model	19.7344	8.6326	57.3448
Rejection significance	0.0062	0.1953	0.0000

note: ** significance at the level of 5%; * significance at the level of 10%

As can be seen in the table, in the NL-1 model, the sign and magnitude of the mode specific constants with the for-hired transit as the base alternative, mass transit is less preferable than car but more so than fixed route transit, *ceteris paribus*. The results of NL-1 also show that access distance have a significant role on mode choice.

The negative sign of the coefficient estimated for mass transit indicated that the probability of choosing that alternative decreases as the distance increases. As can be expected, the signs of alternative attributes, i.e. total time and total cost are negative, implying that the increasing in time or cost will decrease the utility value of alternative modes and their probability of being chosen.

5.1.10 Value of Travel Time Saving

Further analysis of the mode choice model is to determine the amount of money that an individual is willing to sacrifice in order to obtain some benefit from using one of alternative modes or it was known as Willingness to Pay (WTP). Since the estimated mode choice model is a linear in utility, WTP can be calculated as the ratio of two parameter estimates with at least one attribute measured in monetary unit and all else held constant. One important WTP measure in transportation studies is the value of time or value of travel time saving, VTTS that is defined as the amount of money an individual is willing to pay in order to save a unit of time spent traveling [37]. To calculate VTTS measure for each alternative, mode choice model results of MNL model with time and cost parameters as alternative specific is used.

Table 5.11 represents the estimation results of models with mode-attributes specific. The models MNL-6 and MNL-7 were developed in order to examine the role of each variable on each alternative mode. The model MNL-6 was developed from MNL-5 while the model of MNL-7 was the modification of MNL-6 with the age dropped. As can be seen in the table, in general, the results of MNL-6 and MNL-7 are similar with the previous models. However, in term of statistical performance, these models are not better than the final model, i.e. MNL-5. The last two rows in the table indicate the null hypothesis that MNL-6 and MNL-7 are not better than similar with MNL-5 cannot be rejected. It implies that there is no significant improvement by modifying MNL-5 to be MNL-6 and MNL-7.

It is important that coefficients of attributes of time and cost should be significant in order to calculate VTTS, otherwise the result of calculation would be meaningless. Although the MNL-7 model did not improve statistically on the model MNL-5, the model can be employed to calculate VTTS since all variable of time and cost for each alternative is significant. Referring to the result in Table 5.9, VTTS of mass transit can be calculated as the ratio $\beta_{time}/\beta_{cost}$ = (-0.0618) / (-0.0295) = PHP 2.094 per minute or 2.094 × 60 = PHP 125.65 per hour. Table 5.10 shows the summary of VTTS for each alternative mode as computed from the results of MNL-7.

As can be seen in the table, the VTTS of car alternative is slightly higher than the VTTS of mass transit mode with lower values for other modes. According to the results, an individual who travel by car is willing to spend more money to save travel time than those using transit.

Table 5.11 MNL Models with Attributes Specific (Manila)

Parameters	MNL-6	MNL-7
Mass transit		
Total travel time (minutes)	-0.0619 (-7.21)**	-0.0618 (-7.22)**
Total travel cost (PHP)	-0.031 (-3.06)**	-0.0295 (-2.97)**
Private car		
Total travel time (minutes)	-0.0626 (-4.18)**	-0.062 (-4.02)**
Total travel cost (PHP)	-0.0276 (-5.1)**	-0.0265 (-4.8)**
Fixed route transit		
Total travel time (minutes)	-0.0753 (-14.23)**	-0.0743 (-14.15)**
Total travel cost (PHP)	-0.0464 (-3.74)**	-0.0431 (-3.53)**
For-hired transit		
Total travel time (minutes)	-0.0702 (-5.51)**	-0.0675 (-5.46)**
Total travel cost (PHP)	-0.0449 (-6.97)**	-0.045 (-7.04)**
Access distance (meters)		
Mass transit	-0.0086 (-3.28)**	-0.0017 (-3.74)**
Private car	0.0019 (1.75)*	0.0018 (1.73)*
Fixed route transit	0.0014 (1.85)*	0.0013 (1.71)*
Age (years)		
Mass transit	-0.0169 (-0.69)	
Private car	0.0266 (1.02)	
Fixed route transit	0.0169 (0.7)	
Constant		
Mass transit	1.7446 (2.43)**	1.5762 (2.92)**
Private car	2.1431 (2.15)**	2.4415 (3.89)**
Fixed route transit	1.2407 (1.69)*	1.303 (1.65)*
Parameters of Statistics		
Log-likelihood at zero	-1484.7213	-1484.7213
Log-likelihood at constants	-921.6390	-921.6390
Log-likelihood at convergence	-677.7082	-679.1669
Rho squared w.r.t. zero	0.543545	0.542563
Rho squared w.r.t. constants	0.2647	0.2631
%-correct prediction	61.53%	61.81%
Chi-squared vs. MNL-4	14.4806	11.5633
Rejection significance	0.1522	0.1159

note: ** significance at the level of 5%; * significance at the level of 10%

Table 5.12 Summary of Value of Travel Time Saving (VTTS)

Alternative Modes	VTTS (PHP per minute)	VTTS (PHP per hour)
Mass transit	2.094	125.65
Private car	2.342	140.54
Fixed route transit	1.726	103.55
For-hired transit	1.499	89.93

5.1.11 Demand Elasticity Implied by The Model

Figure 5.7 shows the effect of changes in time and cost values on mode probability or elasticity of demand for each mode. Note that model of MNL-4 was used to examine the demand elasticity. As can be seen in the figure, the mode probability decreases as time or cost increases. The alternative of for-hired transit is very sensitive in the change in cost comparing to other modes. The increasing of 1% of total travel time and travel cost can change the probability of using the mode by nearly 2%.

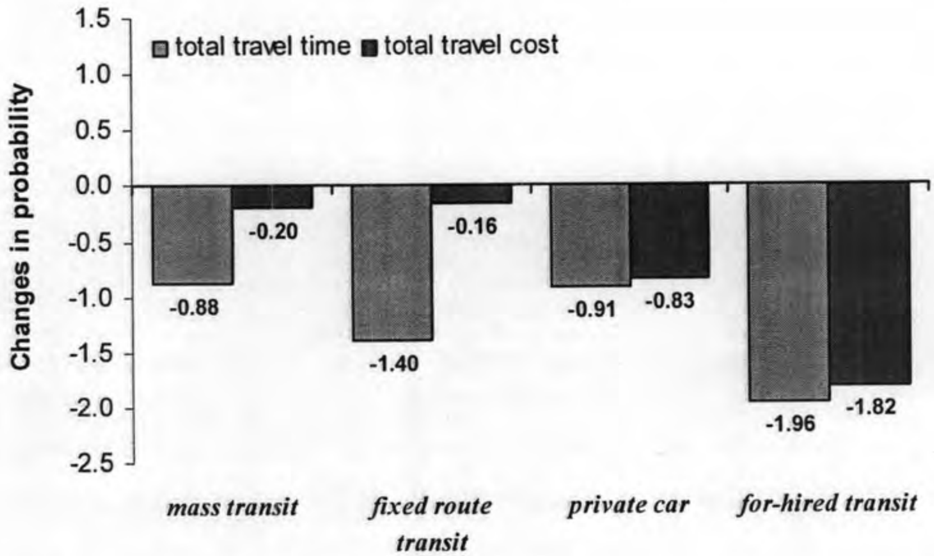


Figure 5.7 Total Effect on Probability by Changing in Time and Cost (Manila)

The probability of using mass transit mode will decrease about 0.9% and 0.2% as the increase of 1% time and cost, respectively. This implies that mass transit demand is inelastic with respect to total travel time, and particularly more inelastic to total travel cost. Therefore, this finding indicates that policy initiatives to reduce fare are less likely be successful in increasing ridership than those that address to total travel time reduction. In other words, reducing time will gives greater effect on mass transit ridership than reducing cost.

5.2 Mode Choice Model for Bangkok

5.2.1 Alternative Modes

There were 344 observations obtained from interview survey at 14 mass transit station areas in Bangkok. Due to incomplete data, only 322 observations were ready to be used for model development. Similarly to the procedures used with Manila data, the data should be cleaned up first and the access distance of 2000 meters was used to screen the data. Thus, it was 255 of 322 observation was used.

Regarding to the number of observations used, there are many alternative modes, including mass transit and private car, for traveling from home to desired destination within the mass transit corridors in the case of Bangkok. In general these modes are listed as follow.

- *Public bus*. There are two types of buses provided: ordinary and air-conditioned buses. Some articulated buses are provided by the Bangkok Mass Transit Authority (BMTA), the main operator of public transportation in the Metropolitan Bangkok.
- *Van*. This is the air-conditioned van that serves point-to-point. The capacity has 12 to 14 passengers, no fixed route and mostly connected suburban area with the main CBD areas.
- *Regular taxi*. Most taxis are air-conditioned and metered.
- *Tuk-tuk*. This is the tricycle-motor taxi with capacity of 2 or 3 passengers.
- *Songtaew*. This is a modified pickup truck with capacity of 10 to 12 passengers. It has fixed routes and operates like paratransit (can stop everywhere to discharge and to collect passenegers).
- *Boat*. This is a bus-water that operates in waterway network in Bangkok area. The capacity varies depend on its size and the route. Within the station surveyed, there is only one intersection between mass transit station and pier (water-bus stop point), i.e. Saphan Taksin BTS station.

Summary of mode share from station areas surveyed can be seen in Table 5.13. It can be seen from the table that the mode proportion is far from balanced. Due to limited data, only alternative modes of rail, car, and bus were used in model development.

Table 5.13 Summary of Mode Share (Bangkok)

Mass Transit Line	Mass Transit		Private Car		Fixed Route (Bus)	For-Hired Transit		Other*	Total
	Walking Access	Motorized Access	Drive	Share		Van	Taxi		
BTS	61	5	14	12	40	0	2	6	140
MRT	33	11	11	9	42	1	2	6	115
Total	**94**	**16**	**25**	**21**	**82**	**1**	**4**	**12**	**255**

* boat and motorcycle

5.2.2 Attributes of Alternative Modes

Table 5.14 shows the average speed of various modes within station areas surveyed. All speeds were obtained by dividing the distance between with the time as reported by respondents. The speed in the table appears similar to those found in Manila with average travel speed of rail, car, and bus being 23.3 kph, 14.8 kph, and 10.0 kph, respectively.

Table 5.14 Average Speed of Various Modes within Station Areas Surveyed

Mode	Average speed (kph)	Std.Dev.	Minimum	Maximum	Observations
Rail	23.0	6.69	4.1	73.0	146
Car	17.4	7.74	4.3	36.3	55
Bus	10.3	3.69	2.7	17.2	94

The walking speed was calculated by dividing the distance between home and station with the access time as reported by respondents. It was found that average walking speed is 74.89 m/min. This speed is similar to the one found for Manila data, i.e. 74.25 m/min.

Similar to Manila, data synthesis was carried out to generate data of non-chosen alternatives. The mode speed in the table was used to generate travel data for respondents who did not report the non-chosen mode characteristics. Table 5.15 shows the summary of how to generate data of non-chosen alternative.

Table 5.15 Generating of Time and Cost Data for Non-Chosen Data (Bangkok)

Trip	Assumption Mode	Generating Data For Time	Generating Data For Cost
Access	Walking	acc_dist / walking_speed	0
Egress	Walking	egr_dist / walking_speed	0
Rail	Mass Transit	sta_dist / rail_speed	rail_fare (calculated)
Private car	Car	OD_dist / car_speed	OD_dist*average_cost (per_km)
Bus	Bus	OD_dist / jeepney_speed	OD_dist*average_cost (per_km)

Note: *acc_dist*: distance between home to station; *egr_dist*: distance between station to destination *sta_dist*: distance between origin station and destination station; *OD_dist*: distance between home to destination within mass transit corridor

Note that the fare structure of air-conditioned and non-AC bus were different and unfortunately they were not captured in the survey form. No such information was obtained regardless of whether a respondent used AC or non-AC bus. Therefore, the average cost per kilometers was used instead the actual fare structure.

5.2.3 Model Development

Initially, the MNL model with three alternative modes was used to develop the mode choice model with some respondents having only partial choice set. The alternative of private car was only for those who have car availability. The mode choice models with time and cost as the generic variables are presented in Table 5.16. The alternative of bus is the base alternative, whose coefficient is therefore not estimated.

Table 5.16 Mode Choice Model for Parameters Selection (Bangkok)

Parameters	MNL-1B	MNL-2B	MNL-3B	MNL-4B
Total time (minutes)	-0.1059 (-7.26)**	-0.0994 (-6.01)**	-0.1056 (-6.95)**	-0.0997 (-6.85)**
Total cost (THB)	-0.0284 (-2.38)**	-0.0342 (-2.36)**	-0.0262 (-2.11)**	-0.0285 (-2.35)**
Accessibility Parameter				
Access distance (meters)		-0.0013 (-2.6)**		-0.0012 (-2.65)**
Number of destinations		-0.0009 (-0.18)		
Socioeconomic Parameter, specific to mass transit				
Age (years)			-0.0145 (-0.98)	
Income (THB)			-0.0008 (-0.7)	
Education (1-bachelor & above)			-0.5252 (-1.17)	
Constant				
Mass transit	0.9348 (3.42)**	2.3552 (3.22)**	1.9065 (2.55)**	1.9214 (4.04)**
Private car	1.2038 (2.73)**	1.2002 (2.32)**	1.041 (2.28)**	1.1446 (2.54)**
Parameters of Statistics				
Log-likelihood at zero	-261.4697	-213.1308	-250.4836	-261.4697
Log-likelihood at constants	-169.7189	-135.0776	-155.0749	-169.7189
Log-likelihood at convergence	-124.0330	-95.5220	-117.1442	-120.4586
Rho squared w.r.t. zero	0.5256	0.5518	0.5323	0.5393
Rho squared w.r.t. constants	0.2692	0.2928	0.2446	0.2902
Number of observation	238	194	228	238
%-correct prediction	71.01%	73.20%	71.49%	71.85%
LL-test to the base model	-	57.0220	13.7775	7.1487
Significance of rejection	-	0.0000	0.0032	0.0075

note: ** significance at the level of 5%;* significance at the level of 10%

MNL-1B is the initial model that incorporates time and cost only while in MNL-2B and MNL-3B variables of accessibility and socioeconomic were added respectively. The model MNL-4B includes significant variables only and may be the one with the best statistical fit.

From the constant term by the best model, it is shown that mass transit is the preferable mode and followed by car and bus. The findings are slightly different from those in the Manila case. Note that data collection was carried out for selected station areas and captured commute trips that have origin and the destination within mass transit corridor area. Since the mass transit line was built over the dense road networks, using mass transit to travel in peak period might have some advantages over road-based modes. It can be seen in the table that the best model is similar to those developed based on Manila data. Accordingly, the best model was updated by doing re-estimation with mass transit as base and the result is presented in Table 5.17. As can be seen in the table that the updated model has some variables that are not significant at the level of 5% or 10% although, considered as whole, based on log-likelihood ratio test result, the MNL-5B model is better than the MNL-4B.

Table 5.17 Mode Choice Model with respect to Mass Transit (Bangkok)

Parameters	MNL-5B
Total time (minutes)	
Mass transit mode	-0.1381 (-5.62)**
Non-mass transit mode	-0.1095 (-6.75)**
Total cost (THB)	
Mass transit mode	-0.0245 (-1.59)
Non-mass transit mode	0.0403 (1.25)
Variables w.r.t. Mass Transit	
Access distance (meters)	-0.0052 (-9.39)**
Constant	
Mass transit	1.2831 (2.22)**
Private car	1.0361 (2.74)**
Parameters of Statistics	
Log-likelihood at zero	-261.4697
Log-likelihood at constants	-169.7189
Log-likelihood at convergence	-115.4810
Rho squared w.r.t. zero	0.5583
Rho squared w.r.t. constants	0.3196
Number of observation	238
%-correct prediction	73.53%
Chi-squared vs. control model (MNL-4B)	9.9552
Rejection significance	0.0069

note: ** significance at the level of 5%;* significance at the level of 10%

Similar to what has been done with Manila data, the model development was continued by estimation with time and cost as the mode specific attributes. Table 5.18 shows the estimation result of the MNL model with specific attributes. The MNL-6B model was developed from MNL-4B and it can be seen in the table that the model is not better than the previous one. Only few variables are significant and the result of log-likelihood ratio test indicates that there is no significant improvement by transforming the MNL-4B model becomes specific attributes model. Therefore, for further analysis, MNL-4B model was used. Note that due to limited number of observations for each mode alternative, the Hausman test could not be performed. Thus, for Bangkok data set, the final model is MNL-4B.

Table 5.18 MNL Model with Attributes Specific (Bangkok)

Parameters	MNL-6B
Mass transit	
Total travel time (minutes)	-0.1237 (-1.72)*
Total travel cost (THB)	-0.0801 (-1.29)
Private car	
Total travel time (minutes)	-0.1163 (-1.15)
Total travel cost (THB)	-0.3099 (-1.81)*
Fixed route transit	
Total travel time (minutes)	-0.1116 (-0.21)
Total travel cost (THB)	-0.0473 (-1.75)*
Access distance (meters)	
Mass transit	-0.0048 (-1.82)*
Private car	0.0012 (1.36)
Constant	
Mass transit	1.1712 (1.74)*
Private car	0.7401 (1.6)
Parameters of Statistics	
Log-likelihood at zero	-261.4697
Log-likelihood at constants	-169.7189
Log-likelihood at convergence	-117.3223
Rho squared w.r.t. zero	0.5513
Rho squared w.r.t. constants	0.3087
%-correct prediction	73.53%
Chi-squared vs. MNL-4	6.2727
Rejection significance	0.2806

note: ** significance at the level of 5%; * significance at the level of 10%

5.2.4 Demand Elasticity Implied by the Model

Figure 5.8 shows the effect of changes in time and cost on mode probability or elasticity of demand for alternative of mass transit, bus (fixed-route transit), and private car. The model of MNL-4B was used to compute the elasticities shown in the figure. As can be seen in the figure, probability of any mode being chosen decreases as time or cost increases. The users of fixed-route transit are the most sensitive than others to the change of time while private car users are the most sensitive the change of cost.

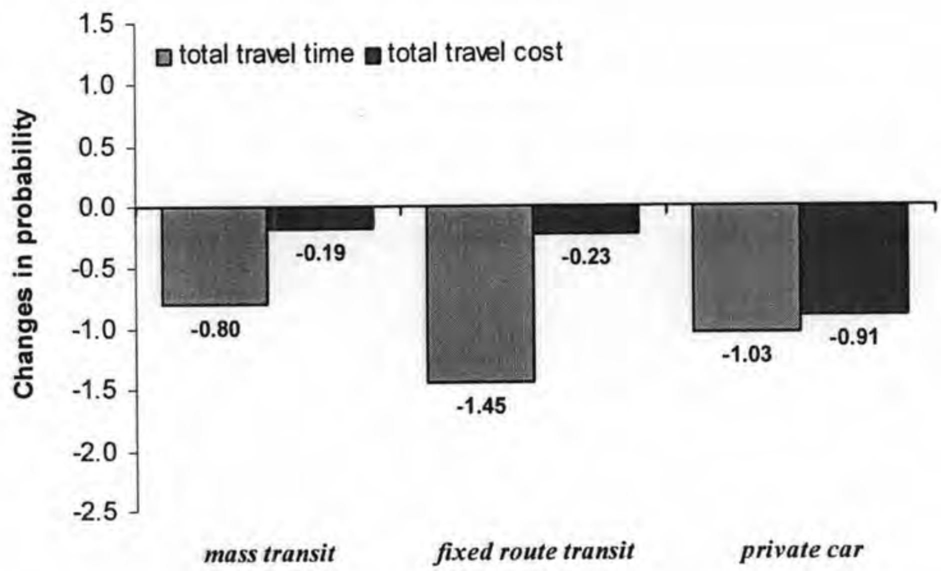


Figure 5.8 Total Effect on Probability by Changing in Time and Cost (Bangkok)

5.3 Notes on Model Choice Model

The purpose of the development of mode choice model is to understand how to persuade more travelers to change their travel mode to mass transit. Due to the data characteristics, the final models for Manila and Bangkok are slightly different. In the case of Bangkok, the mode alternatives include mass transit, car, and bus while in the Manila case the alternatives include mass transit, car, fixed-route transit (bus, *jeepney*, and *fx*), and for-hired transit (i.e. taxi). In both of the study areas, the alternative of car is available only to those with car availability. Based on Bangkok data, the final model is the multinomial model with generic variables of attributes (MNL-4B) while, based on Manila data, the final one is the multinomial model with mass transit as the base mode (MNL-5). The nested logit model can be estimated as well with the Manila data (NL-1). Despite the model form, both models reveals similar results related to factors affecting mode choice behavior and mode preferences.

From the model of both of the study areas, it is revealed that time, cost, and distance to station have roles to attract people shift travel mode to mass transit. The time is associated with the total travel time while the cost is referred to the total of out-of-pocket cost. These findings agree with other transit studies as discussed in the literature review.

The role of age, found in the Manila model, indicates that younger people are more likely to use mass transit. This is similar to the result found in literature review, such as from Abdel-Aty [16]. However, almost all variables related to socioeconomics data were not significant in the final model of the study areas. Lack of variability of the individual characteristics data among the alternative modes might be the reason of the insignificant results. In spite of this, it might also imply that those characteristics have less influence on the mode shifting.

The interpretations of the constant terms in the model imply that those who have car available are most likely to use their car as compare to mass transit. However, as found in the case of Bangkok, the mass transit mode is slightly preferred to car even when a car is available. It is probably due to mass transit's advantage in the term of time saving for the pair of origin-destination within mass transit corridors. Note that mass transit network in Bangkok covers only 20% of the total population while those in Manila cover more than 70%.

The demand elasticity of mass transit in both of the study areas appeared similar. In Manila, the values are -0.88 and -0.20 for total travel time and total travel cost, while in Bangkok, they -0.80 and -0.19, respectively. While demand is inelastic with respect to both time and cost, it appears to be more elastic with respect to time. This finding indicates that improvements related to reduction in travel time will give greater effect over the improvements related to with regards to increasing ridership. Similar findings were reported by Kohn [12] who concluded that the demand for urban transit service is price-inelastic.

In both of the study areas, the distance between home and transit station has negative effect on the probability of choosing mass transit. Since the data used for model estimation were defined within the distance of 2000 meters where many access modes, foremost walking, are available this result highlights the impact of walking access on transit ridership. Most of other variables reflecting transit accessibility revealed insignificant effect on choice probabilities. It was conjectured that the insignificant results of the effect accessibility variables may be due to the lack of variability in the observed value of variables. The development of station accessibility scores in the next chapter addresses this issue by providing more refined sets of accessibility variables.