Chapter VII

Frequency of Mass Transit Use

7.1 Modeling Results for Manila

Based on the results from the interview survey, the respondents can be grouped by frequency of transit use into those who never use mass within a week, those who use only once a week, those who use twice and thrice a week, and those who use mass transit everyday. Among the 1071 observations, the proportion of these groups is as follow.

- never use group (not use mass transit within a week): 24.2 %
- occasionally use group (use only once a week): 21.1%
- frequently group (twice and thrice a week): 15.1 %
- regular or everyday use group (more than 3 times): 39.6 %

To obtain similar proportion in the modeling, those four groups were reduced into three outcomes, i.e. *never*, *occasional*, and *regular* and the proportion became 24.2%, 36.2%, and 39.6%, respectively.

As discussed in the previous chapter, the ordered logit model was use to develop the model of frequency of mass transit use. There are many variables that can be included into the model. The simple model is one which incorporates only time and cost. Since the research focuses on mass transit, the difference of total travel time and total travel cost (out of pocket cost) between traveling by using mass transit and traveling by using other transportation mode for the same origin-destination pair were used instead the time and cost for each mode. These differences were calculated based on time and cost that were reported by respondents. In data collection, each respondent was asked to describe his or her trip using mass transit and non-mass transit mode for the same pair origin-destination. However, there were only 672 respondents (63% of all observations) who gave the complete information regarding to his or her trip using mass transit and non-mass transit. Based on these data, the model of frequency of transit use was developed.

Table 7.1 shows the estimation results of the model of frequency of mass transit use with various possible variables. The software package of Stata/SE 8.2 for Windows was used to develop the model. The model of OL-1 is a simple model with incorporated only time and cost. Variables of access distance and number of destinations in station area (destination station) were added into the next model, i.e. OL-2. The role of socioeconomic variables was examined in the OL-3 model, and, lastly, the OL-4 model was selected as the final model.

Table 7.1 Estimation Results of Model of Frequency of Transit Use (Manila)

Parameters	OL-1	OL-2	OL-3	OL-4
Mode Attributes				
Time difference (min.)	-0.0214 (-6.05)**	-0.0215 (-5.9)**	-0.0214 (-6.12)**	-0.0215 (-6.2)**
Cost difference (PHP)	0.0023 (0.85)	0.0021 (0.77)		
Accessibility Parameters				
Access distance (meters)		-0.0002 (-1.02)	-0.0001 (-0.83)	-0.0001 (-0.803)
Number of destinations		-0.0021 (-0.4)		
Socioeconomic Parameters				
Gender (1-women; 0-men)			-0.0143 (-0.1)	
Age (years)			0.0036 (0.41)	
Car availability (1-car available)			-0.6973 (-3.49)**	-0.6752 (-3.53)**
_cut1	-1.1904 (-11.32)**	-1.3942 (-5.24)**	-1.3487 (-5.05)**	-1.4247 (-8.65)**
_cut2	0.7493 (7.73)**	0.5481 (2.1)**	0.6225 (2.37)**	0.5459 (3.53)**
Statistics Parameters				
Log-likelihood at zero	-707.083	-707.083	-707.083	-707.083
Log-likelihood at Convergence	-685.175	-684.6085	-678.633	-678.717
Number of obs	672	672	672	672
LR chi-squared	43.820	44.950	56.900	56.730
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.031	0.0318	0.0402	0.0401
LL-test to Base Model[1]	0.72892	1.86192	13.81358	13.64576
Significance of rejection	0.39323	0.60155	0.00791	0.00022

Note: ** significance at the level of 5%; * significance at the level of 10%
[1]The Base Model is a model with variable of time difference only
Log-likelihood (LL) of Base Model at convergence: -685.539

Access distance or access transit distance is the distance between home to origin station where the transit trip begins. As discussed in the literature review, the access distance plays important role in transit accessibility. Many studies use this distance to define the quality level of accessibility (See Halden et al., 2000 and Zhao et al., 2002 for examples). Therefore, this variable was incorporated in the model development. Moreover, in the interview survey, an open question was given to respondents regarding to the reason of using and not using mass transit. The large number of places that could be reached within ten minutes walking from station was one of main reason for using mass transit. The number of destinations was therefore used to represent this finding, and was incorporated into the model.

The log-likelihood test (LL-test) was performed to select the best model. The null hypothesis of no improvement by adding more variables was tested. The last two rows in the table present the result of the test for each model that was compared to the base model. It can be seen in the table that on the case of the model OL-1 and OL-2 the null hypothesis cannot be rejected while in the case of others, the null can be rejected. Furthermore, OL-3 has some insignificant variables while all variables in OL-4 are significant. Therefore, the model OL-4 is selected for further analysis.

The standard interpretation of the coefficient is that for a unit increase in the variable, the response (ordered logit value) level is expected to change by its respective coefficient. For instance, in the model OL-4, a unit increase in time difference would result in a 0.0213 unit decrease in probability of being in a frequency category, *ceteris paribus*. Note that a unit increase in time difference could be increase of one unit time of mass transit mode or decrease of one unit time of non-mass transit mode. Since the car availability variable is a dummy variable, the ordered probability of those who have car available being regular user is 0.6859 less than those who have no car available, *ceteris paribus*.

The interpretation of the coefficient estimation is not dependent on the ancillary parameters (thresholds or *_cut* value). These parameters are used to differentiate the adjacent levels of the response variable. It can be seen in the table that those parameters are significant at the level of 5% and 10%. The ordered logit model can be interpreted in the term of proportional odd ratios while those ratios can be obtained by taking exponential value of the coefficient estimation, $e^{\text{coeff.}}$, or just specifying the option of **or** in the software package of Stata. In the final model, the odds ratio of variable of time difference is $e^{-0.0213} = 0.9789$. Thus, for one unit of increase in time difference, the odds of the combined regular and frequent transit use versus the never use are 0.9789 times lower, *ceteris paribus*. Similarly for car availability, the odds of the combined categories of regular and frequent user versus never user is $e^{-0.6859} = 0.5036$ times lower for those who have car available compares to those who do not, *ceteris paribus*.

Note that in model estimation, it was often found that the insignificant variables might be caused by the lack of variability among data for the dependent variables [46]. Table 7.2 shows the characteristics of variables that were incorporated into the model development.

Table 7.2 Summary of Variable Involved into the Model

	mean	std.dev.	min	max	n
Time difference (minutes)					
never	-2.73	18.20	-60.5	35	132
occasional	-10.87	22.16	-72	27.6	150
frequent	-16.30	23.47	-70.5	33	126
regular	-18.76	20.48	-86.2	21	264
Cost difference (PHP)					
never	-7.36	31.55	-127	32	132
occasional	-2.93	33.54	-173	53.8	150
frequent	-1.14	26.96	-130	51.4	126
regular	-0.26	14.92	-113	27	264
Access distance (meters)					
never	818.42	492.85	160	2000	132
occasional	749.44	443.50	160	1920	150
frequent	835.30	466.67	240	2000	126
regular	791.52	485.29	160	2000	264
Number of destinations					
never	36.82	13.76	0	71	132
occasional	37.93	14.07	0	71	150
frequent	39.13	14.18	10	71	126
regular	35.36	15.72	0	71	264
Age (years)					
never	24.77	7.80	17	54	132
occasional	26.68	10.59	17	60	150
frequent	24.32	7.42	17	47	126
regular	25.15	7.22	17	50	264

Gender (respondents are women)		**Car availability (a car is available)**	
never	43.9%	never	25.8%
occasional	42.7%	occasional	26.0%
frequent	44.4%	frequent	14.3%
regular	46.2%	regular	10.6%

As can be seen in the table, the time and cost difference were obtained from subtracting the total time of using mass transit by the total time of using other mode (non-mass transit mode) for the same respondent and for the same pair of origin and destination. The negative sign of the value indicates that the total time when using mass transit is less than the total time when using the others.

Unlike the time difference, the cost difference variable seems to have no effect on the frequency of transit use. This might be the cause of the insignificance. Similar reasoning could be applied to access distance variable. It was expected that mass transit would be used more often over shorter distance to reach the station. However, the estimation result was not as expected. Figure 5.1 illustrates the distribution of access distance among the four groups of frequency of mass transit use.

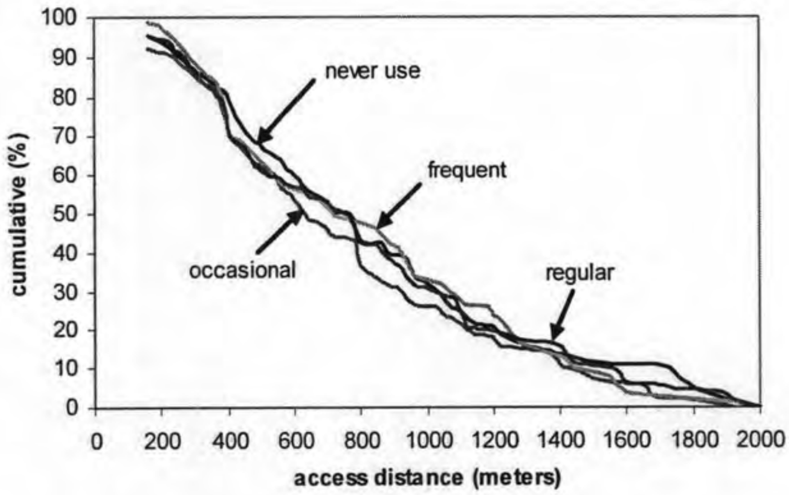

Figure 7.1 Access Distance and Frequency of Transit Use

It can be seen in the figure that there is no difference in the access distance among those groups. It could be said that each respondent within the group of transit use frequency faced similar attributes of access distance. The insignificant variables might also indicate that there was no statistical evidence to consider their roles in frequency of mass transit use.

Table 7.3 shows the model prediction as compared with the observations. The model OL-4 was selected and the percentage of correct prediction is 44.9%. It means that is about 44.9% observations are predicted correctly by the model.

7.2 Modeling Results for Bangkok

Regarding the frequency of mass transit use, the 255 surveyed respondents can be grouped as follow.

- those who never use (not use mass transit) within a week: 28.2 %
- those who occasionally use (only use once a week): 13.9%
- those who frequently use (use twice and thrice a week): 21.0 %
- those who regularly use or everyday use (more than 3 times): 36.9 %

Table 7.3 Model Prediction (Manila)

		Predicted			Total
		0	1	2	
Observed	0	6	104	22	132
	1	10	168	98	276
	2	2	134	128	264
Total		18	406	248	672

Note:
0: never use mass transit within a week
1: use once to thrice a week
2: use mass transit everyday

The frequency of transit use model was developed in the same way with the previous work for Manila data. The ordered logit model was estimated, starting with the simple mode parameters, i.e. time and cost only. Accessibility parameters and socioeconomic variables were then added to improve the model.

In the case of Bangkok data, there were only 181 respondents (71%of total observations) who gave the complete information regarding to his or her trip data, including both mass transit and non-mass transit trips for the same pair of origin and destination. Thus, according those numbers of observations, the model of frequency of transit use for Bangkok data was developed, and Table 7.4 shows the results of model estimation. The OL-1B model is the simplest model with only time and cost incorporated. Access distance and number of destinations in station area were then added into the OL-2B model. The role of socioeconomic variables was evaluated in the OL-3B model and, lastly, the OL-4B model was selected as the final model.

The last two rows in the table present the result of the LL-test for each model that was compared to the base model. It can be seen in the table that the null hypothesis cannot be rejected for OL-1B but can be rejected for others. Although OL-2B and OL-3B are better than the base model, they have some insignificant variables. Based on these results, OL-4 model is selected for further analysis.

As can be seen in the table, the final model for Bangkok is slightly different from the one for Manila. As expected, the coefficient estimation of access distance is significant and has negative sign. Hence, for Bangkok, it could be said that there is statistical evidence that access distance plays a role in infrequency the frequency of mass transit use.

Table 7.4 Estimation Results of Model of Frequency of Transit Use (Bangkok)

Parameters	OL-1B	OL-2B	OL-3B	OL-4B
Mode Attributes				
Time difference (min.)	-0.0321 (-4.96)**	-0.0312 (-4.27)**	-0.0243 (-3.61)**	-0.0228 (-3.5)**
Cost difference (THB)	0.0052 (0.88)	0.0072 (1.13)		
Accessibility Parameters				
Access distance (meters)		-0.001 (-2.39)**	-0.0015 (-3.55)**	-0.0015 (-3.6)**
Number of destinations		-0.0041 (-1.03)		
Socioeconomic Parameters				
Gender (1-women; 0-men)			0.4505 (1.42)	
Age (years)			0.0054 (0.5)	
Car availability (1-car available)			-1.0094 (-3.03)**	-1.1162 (-3.59)**
_cut1	-1.5769 (-7.72)**	-1.1248 (-2.22)**	-1.4553 (-2.38)**	-1.0814 (-2.58)**
_cut2	0.2113 (1.72)*	0.7277 (1.81)*	0.5302 (1.77)*	0.8855 (1.97)**
Statistics Parameters				
Log-likelihood at zero	-193.525	-193.525	-193.525	-193.525
Log-likelihood at convergence	-178.849	-173.604	-166.167	-167.273
Number of obs	181	181	181	181
LR chi-squared	29.350	39.840	54.720	52.500
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0758	0.1029	0.1414	0.1356
LL-test to Base Model[1]	0.77084	11.25928	26.1351	23.92204
Significance of rejection	0.37996	0.01040	0.00003	0.00001

Note: ** significance at the level of 5%; * significance at the level of 10%
[1]The Base Model is a model with variable of time difference only
Log-likelihood (LL) of Base Model at convergence: -179.234

Table 7.5 shows the characteristics of variables that were incorporated into the model. It can be seen in the table that all the significant variables, i.e. time difference, access distance, and car availability, have influence on the frequency of mass transit use. Unlike in the case of Manila, respondents who are grouped into regular user have the shortest walking distance to reach station while those in the group of never use have the longest distance. The access distance of other groups decrease gradually according to the frequency of mass transit use.

Table 7.6 shows the model performance as compared with the actual data using the final model of OL-4B. The percentage of correct prediction is 54.7%, slightly higher than the Manila's model.

Table 7.5 Summary of Variable Involved into the Model

	mean	std.dev.	min	max	N
Time difference (minutes)					
never	-5.58	22.40	-92	54	41
occasional	-12.86	23.56	-65	47	25
frequent	-11.12	20.22	-45	49	40
regular	-18.04	30.76	-126	31	75
Cost difference (THB)					
never	2.38	15.50	-55	28	41
occasional	-3.29	24.73	-73	28	25
frequent	9.56	25.73	-62	105	40
regular	3.76	25.33	-45	53	75
Access distance (meters)					
never	961.69	410.27	74	1875	75
occasional	826.53	388.37	149	1835	40
frequent	792.44	421.42	149	1668	25
regular	621.20	253.78	149	1189	41
Number of destinations					
never	79.08	38.04	31	193	41
occasional	90.95	42.77	31	193	25
frequent	85.03	42.14	31	193	40
regular	74.98	34.47	31	193	75
Age (years)					
never	36.49	14.04	12	68	41
occasional	42.56	15.58	17	73	25
frequent	37.75	13.84	15	70	40
regular	38.48	13.95	14	73	75

Gender (respondents are women)		Car availability (a car is available)	
never	56.1%	never	61.3%
occasional	60.0%	occasional	32.5%
frequent	57.5%	frequent	56.0%
regular	56.0%	regular	24.4%

Table 7.6 Model Prediction (Bangkok)

		Predicted			Total
		0	1	2	
Observed	0	14	18	9	65
	1	8	34	23	65
	2	1	23	51	75
Total		23	75	83	181

Note:

0: never use mass transit within a week

1: use once to thrice a week

2: use mass transit everyday

7.3 Notes on Frequency of Transit Use Model

The objective of the development of frequency of transit use model is to understand how to persuade those who are infrequent or irregular users to use mass transit more often. From both of the study areas, the users could be grouped as those who never use mass transit within a week, use occasionally, and use everyday. The ordered models were developed with those groups as the model outcome. To compare the results, Table 7.7 shows the summary of the final models for the study areas.

Table 7.7 Summary of Frequency of Transit Use Model

Parameters	Manila	Bangkok
Mode Attributes		
Time difference (min.)	-0.0215 (-6.2)**	-0.0228 (-3.5)**
Accessibility Parameters		
Access distance (meters)	-0.0001 (-0.803)	-0.0015 (-3.6)**
Socioeconomic Parameters		
Car availability (1-car available)	-0.6752 (-3.53)**	-1.1162 (-3.59)**
_cut1	-1.4247 (-8.65)**	-1.0814 (-2.58)**
_cut2	0.5459 (3.53)**	0.8855 (1.97)**
Statistics Parameters		
Log-likelihood at zero	-707.083	-193.525
Log-likelihood at convergence	-678.717	-173.604
Number of obs	672	181
LR chi-squared	56.730	39.840
Prob > chi2	0.0000	0.0000
Pseudo R2	0.0401	0.1029
%-correct prediction	44.9%	54.7%

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

Many transit studies revealed that as the travel time by transit increases, commuters would be less likely to use transit (See Abdel-Aty [16] for example). Accordingly, as the travel time of mass transit decreases, commuters might be more likely to use mass transit with higher frequency. However, a question may arise: what mode would the commuters be likely to use if the travel time of their alternative non-mass transit mode decreases as well? Would the commuters be likely use mass transit more often still?

By examining time difference, this question can be answered. In both of the study areas, the time difference variable is significant and has negative sign. This implies that the probability of using mass transit more often is likely to be higher as the total travel time by mass transit is less than the total travel time by non-mass transit for the same pair of origin and destination.

As can be seen in the table, there is a similar effect that appeared in both of the study areas. It is apparent from the coefficient estimation of the time difference variable in the table, for Manila and Bangkok, they are -0.0215 and -0.0228, respectively.

Walking to transit stop or transit station generally caused inconvenience to the transit users. As discussed in Chapter II, many transit studies agreed that longer walking distance would reduce the probability of using transit [2]. Note that the frequency of transit use model was developed within station coverage areas where walking is possible. In the model development, it was expected that mass transit would be used more often for the shorter distance of access to reach the station. From the models of the both study areas, the coefficient estimation of access distance has negative sign. It implies that the models revealed expected result although the variable for Manila was not significant. In other words, those who lived farther from station would be likely to use mass transit less frequently.

It can be seen in the table as well that the models from both of the study areas demonstrate the relationship between the frequency to use mass transit and commuter who currently have a car that is available for their daily trip. It is revealed that those who have car availability (drive alone or car sharing) would likely to use mass transit less frequently. It is also shown that the magnitude of the coefficient estimation of car availability is the highest among others variable in both of the study areas and has negative sign. It indicates the dominant role of car availability in causing mass transit to be used less often.

The estimation results show that the coefficient of car availability for Manila and Bangkok is -0.6752 and -1.1162, respectively. These imply that the effect of car availability in Bangkok is greater than in Manila. More effort is needed in Bangkok than in Manila to persuade those who with car availability to use mass transit more often. This difference might be caused by the higher proportion of car ownership in Bangkok.

Fouracre [1] indicated that most private vehicle users in developing cities are unlikely to be attracted to use of public transportation. These travelers come mainly from high-income groups who value comfort and convenience of personal transport very highly. Table 7.8 shows the proportion of car ownership and car availability for the study areas based on the data that were used in the modeling. It can be seen in the table that the proportion of car availability is similar in both study areas, but the proportion of car ownership in Bangkok is almost three times to that of Manila.

Table 7.8 Car Ownership and Car Availability in Study Areas

Study Area	Have a car	Have a Car and It is Available
Manila (n = 672)	22.6%	73.0%
Bangkok (n = 181)	57.1%	80.0%

It should be noted that there is a positive correlation between higher income group and car ownership in both Bangkok and Manila. This agreed with many transit studies (See [42] and [1] for examples). Unfortunately, incorporating the variable of income into the model did not work due to the correlation between income and car ownership. Moreover, some respondents did not report their individual income and this reduced number of observations (the software of Stata converted the unfilled data as missing value and the observation with missing value would be excluded in model estimation).

The findings from the model of frequency of mass transit use can be applied with various strategies to attract more passengers. For instance, since the car availability is the dominant factor, providing car park for park & ride scheme could probably be considered. Typically in developing countries, such as Philippines and Thailand, there is a positive correlation between high income group and the car ownership, and these groups value highly on comfort and convenience. Thus, policy to provide exclusive shuttle buses that connect between high-income residential areas and mass transit station may encourage private car users to use mass transit more often. This policy would be more effective if applied in the station areas with high proportion of car dependencies.

In the case of Manila, the previous chapter has shown that the LRT1 line is the oldest and in worst condition in term of access to reach and enter the station. On the other hand, the proportion of infrequent mass transit for this line is the highest compared to other lines, i.e. LRT2 and MRT3. There appears to be a correlation between the lack of accessibility and the high proportion of the infrequent transit users. Note that in data collection, it was found that the time to reach mass transit station represent a significant proportion to the total travel time (more than a quarter). Thus, the improvement of access environment for all LRT1 station could be the best strategy to attract more passengers along the LRT1 corridor.

An important lesson that can be drawn from the modeling results is that in the future development of new rail transit stations, the system's planning should be done in conjunction with proper zoning policies that would encourage transit use. High-density residential development that would attract families with school-aged children and with no car should probably be given priority within the transit coverage area. Investments should be made on improving walkway networks and walking amenities to make walk trips within the coverage area as attractive as possible.