Chapter VI

Station Accessibility Score

6.1 The Development of Station Accessibility Score

The various factors affecting the use of mass as discussed in Chapter IV were used to develop the weighting factors of station accessibility score. Table 6.1 shows the summary of the level of importance for the factors in the study area of Manila. The percentage values in the second to the fifth column present the proportion of respondents who indicated the associated level of importance. Thus, out of 901 observations, 95, 259, 396, and 151 respondents valued road crossing as 'not important', 'somewhat important', 'important', and 'very important' factors, respectively, in their decision to use or not to use mass transit.

Table 6.1 Level of Importance Factors to Use Mass Transit (Manila)

Component of	Affected Factors to Use Mass Transit (Variable name)	Level of Importance			
		Not Important	Somewhat Important	Important	Very Important
Access to station	Less road crossing on the way to station (f_rxing)	10.50%	28.70%	43.90%	16.70%
	Presence of escalator or elevator (f_escelv)	10.50%	21.10%	34.60%	33.70%
	Availability of transit modes to access station (f_accmod)	4.40%	18.20%	42.70%	34.60%
	Availability of transit modes from station (f_egmod)	5.00%	11.30%	47.30%	36.30%
	Many offices or schools near the station (f_nodest)	2.10%	10.90%	47.30%	39.60%
	Presence of car park near station (f_park)	31.50%	29.20%	25.20%	14.10%
Station Facility	Security, esp. in the night trip, (f_secure)	2.00%	8.60%	24.80%	64.40%
	Good cleanliness in train and station (f_clean)	2.90%	8.40%	34.40%	54.20%
	Less crowdedness Inside the station (f_crowd)	4.10%	11.50%	32.90%	51.30%
	Good ticketing system (f_ticsys)	4.70%	13.10%	40.00%	42.10%

As discussed in the previous chapter, the number of 1, 2, 3, and 4 were used to express level of 'not important', 'somewhat important', 'important', and 'very important', respectively. These numbers are then multiplied by the associated frequency and taking the summation as the factor's total. The weight was obtained by normalizing the factor's total with the overall total. For instance, for the criterion of *road crossing*, the factor's total is $sum_{road\_crossing}$ = 1*(95) + 2*(259) + 3*(396) + 4*(151) = 2405. Since, the overall total, $\sum sum_i = 27667$, then weight of *road crossing* for the case of Manila is $w_{road\_crossing} = 100 * \frac{2405}{27667} = 8.693$.

Similar process was carried out for Bangkok data and the Figure 6.1 shows the summary of weight value of station accessibility score for the study area of Manila and Bangkok. The line in the figure represents the average value between those study areas. The weight value was derived from respondents' point of view and as it can be seen in the figure, respondents form both of the study areas valued the factors similarly. As can be seen in the figure, the first line refers to the weight of access score and the second one refers to the station facility score. Among the factors related to the access score, the weight of the number of egress mode has the highest value while the number of road crossings along the way to station has the lowest value.

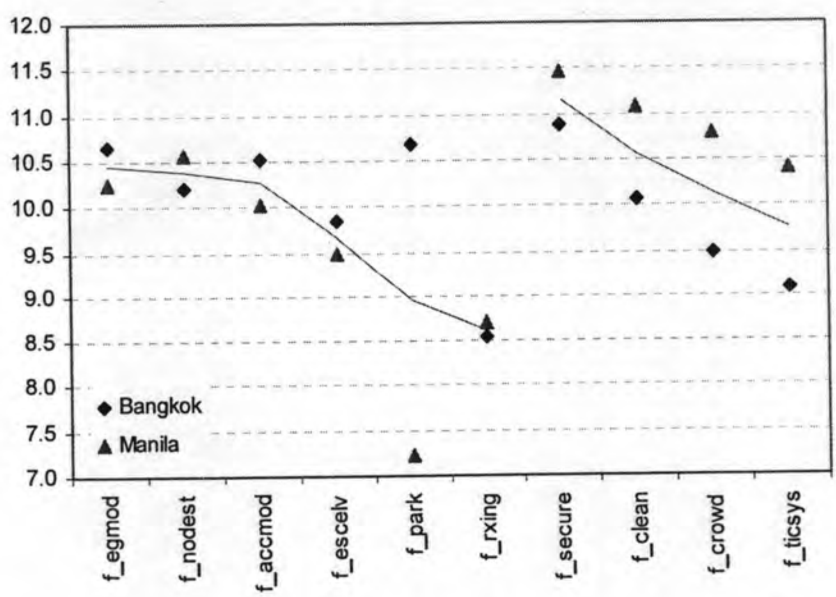

Figure 6.1 Weight Value of Station Accessibility Score

The results are quite different between the two study areas for the factor related car park space in station area. Respondents from Bangkok valued it very highly comparing to their counterparts from Manila. It might be caused by the difference in the rate of car ownership between those areas. From the survey result, it was found that the proportion of car ownership in Bangkok was almost three times that of Manila.

For the station facility score, as can be seen in the figure, the weight of security is the highest while that of ticketing system is the lowest. It is shown as well that respondents in Manila placed more importance on factors related to station facility than did their counterparts in Bangkok. This possibly indicates that on average the station facilities in Bangkok are better than in Manila.

By employing equation (3.9) and (3.10) from Chapter III, access score and facility score for each station can be calculated. Score of station accessibility can be obtained by taking the average value of those scores. However, it might be more interesting to examine access score and facility score separately. Figure 6.2 presents the station accessibility scores for selected stations in Bangkok. Note that the first nine stations are BTS station (from Mo Chit to Saphan Taksin) and the rest are MRT stations (from Hua Lamphong to Bang Sue). It is shown by the figure that facility score for selected BTS and MRT station are generally similar. This is understandable because typical facilities are similarly provided in all station, such as the number of station guards, ticketing system, and the availability of seating for waiting.

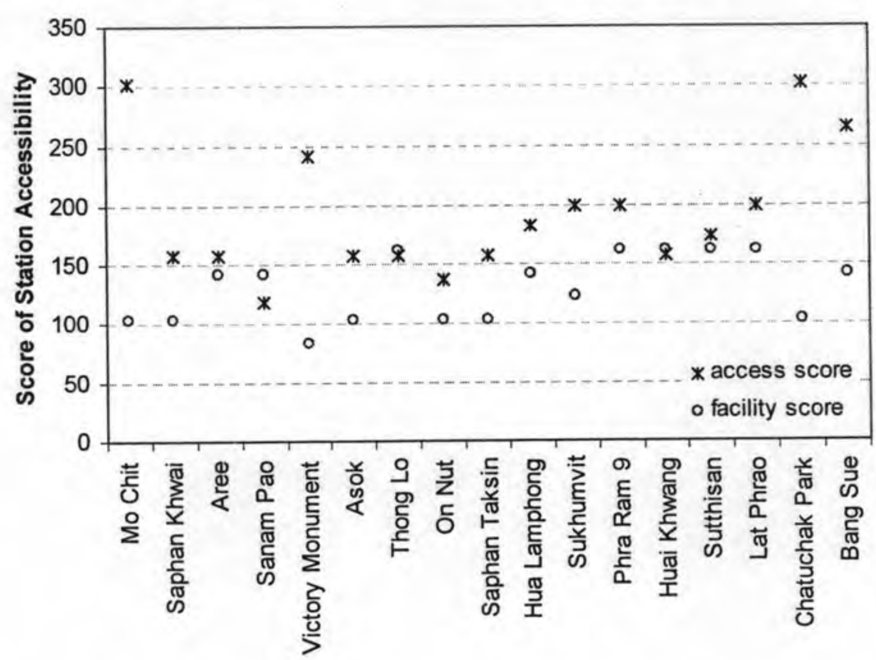

Figure 6.2 Score of Station Accessibility (Bangkok)

Victory Monument and Mo Chit are both main public transportation hubs but their access scores are quite different. This difference is caused by the presence of a huge car park facility in Mo Chit. MRT's Chatuchak Park and BTS's Mo Chit are interchange stations and share the same car park facility with the total capacity of 1600 cars. Asok and Sukhumvit are also interchange stations, and also share a car park facility with the small capacity of 100 cars. Another station with a nine-storey parking building is MRT's Lat Phrao station with the capacity of 2,400 cars.

Although the access scores of MRT and BTS show similar pattern, the MRT subway is newer than the BTS and provides better station accessibility in general. Elevators with ramp and escalators are installed on all MRT stations while these are available only at a limited number of BTS stations.

The summary of station accessibility score for Manila can be seen in Table 6.3. LRT1 is the oldest mass transit line in South East Asia and so it probably has the worst facility. From field investigation result, it was recorded that only manual ticketing system was used at almost all LRT1 stations. Long lines at the ticket booths and disorderly crowd during the peak hour are common place because of limited ticket booths and the lack of station guards. LRT2 and MRT3 are the newer systems that generally provide better station facilities.

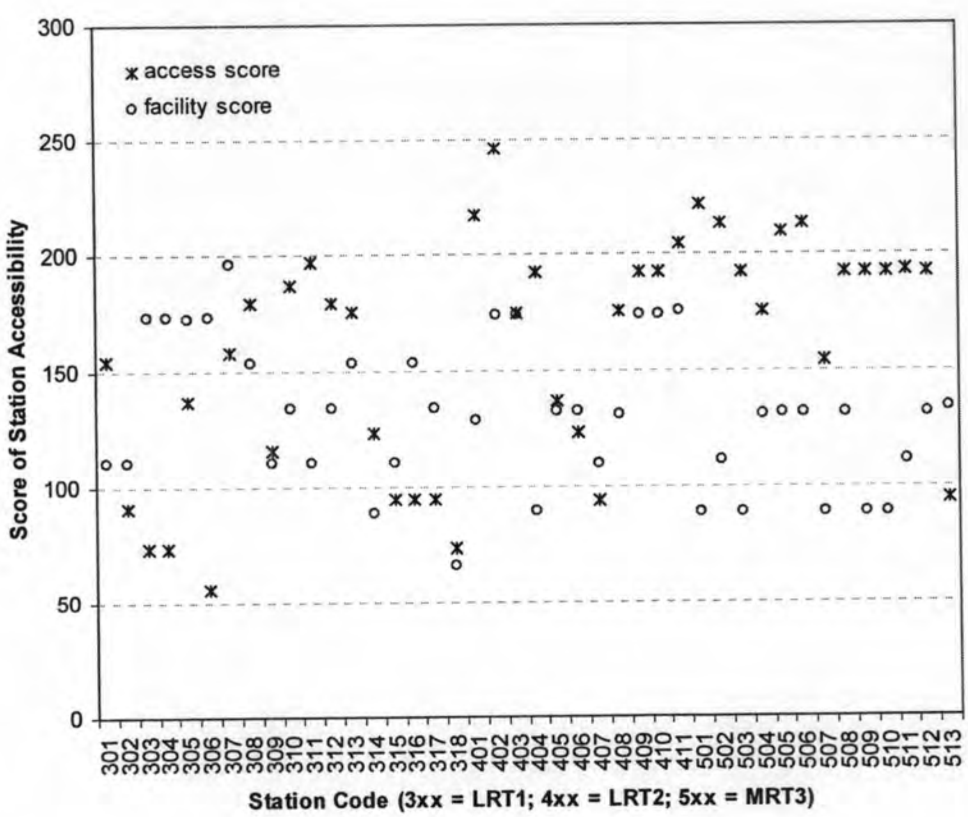

Figure 6.3 Score of Station Accessibility (Manila)

Considering the provision of escalator and elevator, the LRT1 line was built with the lack of accessibility concept in mind. No escalator or elevator was built for all its elevated stations. Some stations have direct connection with commercial buildings that provided escalator and elevator but the use of those equipments to access the station is limited. Therefore, LRT1 users need to exercise more effort to reach the station than those using other lines. It was found in the previous analysis that LRT1 has the highest number of infrequent mass transit users comparing to other lines. The lack of accessibility at most of its station might reduce the station attractiveness that can magnetize more passengers even within station coverage areas.

6.2 Notes on Station Accessibility Score

The main purpose of the development of station accessibility score is to quantify accessibility and facility characteristics of station into a score that represents the relative quality among stations within the transit line or within the service area. By employing the score, the role of accessibility and station facility characteristics on mass transit use can be examined. Using the score, for instance, the effectiveness of strategy of installing escalator and promoting a fare discount can be evaluated and compared directly.

Note that the score was developed from respondents' perception on mass transit use. The score might be different among study areas and should not be compared directly from one area to other areas. The score is more appropriate for evaluation of accessibility and facility changes within the same transit system.

The purpose of the development of station accessibility score is to quantify the quality of station accessibility and then express it in 'access score' and 'facility score'. The access score is related to the effort to reach station while convenience could be the most critical component. On the other hand, facility score related to how a station can accommodate the process of entering the station area and boarding the train where comfort might be the key. Therefore, the score of station accessibility can be used to express level of convenience and comfort quality of the station.

Weighting factors in score of station accessibility were derived from transit users' point of view. Since characteristics of mass transit users in Bangkok and Manila are different, the weighting factors for those areas might not be same. However, the typical quality of station accessibility for developing countries can be reflected by through those areas. Note that the score is more meaningful in comparison analysis of accessibility level between two stations or among stations within a line system or between lines in mass transit system.

It has been discussed previously how to use the score of station accessibility in mode choice model for Manila data. Good accessibility can encourage more ridership, especially shifting from non-mass transit users. Note that station accessibility is in the transit operator's domain where the operators have substantial control over many improvements in order to increase transit attractiveness. Employing station accessibility score will help the transit operators to develop better improvement strategies. For instance, as simulated by some scenario improvements, installation of escalator or adding more access modes could have a substantial effect on increasing ridership. This finding agrees with some other studies that increasing accessibility aspect of mass transit is important in attracting ridership [12], [11].

6.3 Station Accessibility Score in Mode Choice Model

6.3.1 Model for Manila

The development of mode choice model that was discussed in the previous chapter revealed the role of accessibility characteristics on mode choice, especially the choice of mass transit. To develop better insights into the role of accessibility on mass transit use, further analysis was carried out by incorporating station accessibility score into the mode choice model. The MNL and NL models were used to conduct the analysis. Table 6.2 shows the estimation results of mode choice model with the station accessibility score. The model of MNL-8 and NL-4 were expanded from model MNL-5 and NL-1, respectively, by adding accessibility score.

It can be seen in the table that the estimated coefficient of station accessibility score, i.e. access score and facility score have positive sign with respect to mass transit. This implies that increasing the quality of access and facility as reflected by access and facility score can increase the probability of mass transit being chosen. However, in both of the models, the variable of facility score is not significant at level of 5% or 10% thereby providing no hard statistical evidence on the role of station facility improvement over increasing ridership.

Table 6.2 Mode Choice Model with Station Accessibility Score (Manila)

Parameters	MNL-8	NL-4
Total time (minutes)		
Mass transit mode	-0.0586 (-7.08)**	-0.066 (-6.66)**
Non-mass transit mode	-0.0701 (-14.45)**	-0.0734 (-13.32)**
Total cost (PHP)		
Mass transit mode	-0.0113 (-3.1)**	-0.0218 (-2.09)**
Non-mass transit mode	-0.0241 (-7.0)**	-0.0549 (-5.13)**
Variables w.r.t. Mass Transit		
Access distance (meters)	-0.0014 (-7.47)**	-0.0015 (-7.43)**
Age (years)	-0.0307 (-3.04)**	-0.032 (-3.02)**
Access Score	0.0055 (1.84)*	0.0065 (1.95)*
Facility Score	0.0022 (0.47)	0.0035 (0.72)
Constant		
Mass transit	2.617 (4.38)**	2.0344 (4.7)**
Private car	3.6644 (12.96)**	2.8619 (4.39)**
Fixed route transit	1.7713 (5.4)**	1.3238 (3.06)**
Inclusive Value (IV) parameters		
private mode	1.000 (fixed)	0.5479 (4.63)**
public mode	1.000 (fixed)	0.8239 (4.36)**
Parameters of Statistics		
Log-likelihood at zero	-1484.7213	-1773.5657
Log-likelihood at convergence	-677.8288	-672.9293
Rho squared w.r.t. zero	0.5435	0.6206
%-correct prediction	62.37%	62.56%
Chi-squared vs. control model	5.6072	4.3040
Rejection significance	0.0606	0.1163

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

The log-likelihood ratio between mode choice model with and without station accessibility score is presented at the last two rows. It can be seen in the table, for the MNL-8 and NL-4 model the *p-value* for rejection is 0.0606 and 0.1163, respectively. This means that, for the MNL-8 model, the null hypothesis of no improvement by adding station accessibility score can be rejected. Therefore, the MNL model is improved by adding accessibility score. On the other hand, the NL model failed to reject the null hypothesis, and this implies no improvement by adding the scores into the model.

Further analysis of mode choice model with station accessibility score was carried out by evaluating four improvement scenarios that are discussed in the next section. The case of stations along LRT1 line and MNL-5 model are used in this analysis.

6.3.2 Evaluation of Policy Initiatives to Increase Ridership

A. Installation of Escalator at Each Station

As discussed earlier, during data collection period, there are no escalators or elevators in place at all LRT1 stations. Suppose, the mass transit authority plans to install one escalator to each station within the LRT1 line. The mode choice model with accessibility score can be employed to evaluate how much ridership could be gained by this improvement. Table 6.3 shows the summary of change in probability of mass transit being chosen after implementation of the improvement for all trips originated from LRT1 stations areas. Note that the important assumption of *ceteris paribus* in the evaluation scenario must hold.

Table 6.3 Changes in Probability as a Result of Installation of Escalator

Code of Origin Station	No. of Gates	Changes in Probability of Mass Transit
301	4	1.6%
302	4	2.2%
303	2	2.2%
304	2	3.0%
305	2	3.4%
306	3	3.0%
307	2	2.7%
308	3	2.9%
309	4	4.2%
310	2	3.7%
311	4	5.4%
312	2	3.6%
313	3	3.9%
314	5	2.5%
315	5	4.1%
316	4	4.3%
317	5	3.2%
318	4	4.9%
LRT1	**60**	**3.4%**

It can be seen in the table that the probabilities of mass transit use increases by installing an escalator to all stations in LRT1 line. The minimum and maximum changes in mass transit probability are 1.6% and 5.4%, respectively, while the average increase is 3.4%. This finding indicates that this type of accessibility improvement could be pursued to increase ridership. Further economic evaluation, however, needs to be conducted to determine the cost efficiency of such policy initiative.

B. Increasing the Number of Access Modes

It was shown in the previous chapter that one important factor that can encourage people to use mass transit more often is the number of access modes in the station area. Adding more transit service to feed mass transit should make access to station easier and increase the attractiveness of mass transit. Suppose that the transportation authority of Metro Manila wishes to rearrange transit service in the metro area, especially to add more feeder service to mass transit station in order to increase mass transit ridership.

Currently, some stations within LRT1 line are already served by a large number of feeder routes in their station area in the form of bus and *jeepney*. Thus, this policy can be applied in some station areas only. The improvement scenario is such that each station's gate can be served by at least two or three bus or *jeepney* routes. Table 6.4 shows the change in probability as result of adding more feeder transit service in selected station areas. The more feeder services provided could make access to transit station become easier. It can be seen in the table that percentage of change in probability of mass transit being chosen is 10.6% at the most while the average is about 7.2%.

Table 6.4 Changes in Probability as Results of Adding More Feeder Service

Code of Origin Sta	No. of Gates	Existing Transit Route	New Transit Route	Changes in Probability of Mass Transit
302	4	3	9	4.6%
303	2	4	5	4.7%
304	2	4	5	6.5%
306	3	5	7	6.4%
309	4	7	9	9.0%
314	5	4	11	5.2%
315	5	7	11	8.8%
316	4	3	9	9.2%
317	5	6	11	6.8%
318	4	6	9	10.6%
LRT1	**38**	**49**	**86**	**7.2%**

C. Fare Discount

The low fare of mass transit ticket is one of important factors that affect transit demand, as already discussed previously. As with most goods and services, an increase in transit fare will reduce demand, *vice versa*. In this section further analysis was carried to evaluate the effect of changes in mass transit fare on mass transit use. As before, the *ceteris paribus* assumption must hold. This means that are no changes in other factors, such as national wage, inflation, new regulation regarding public service and financing, and so on. Suppose the mass transit authority plans to reduce the transit fare for any trip using mass transit originated from LRT1 stations in order to gain more ridership. Currently, the average mass transit fare is about PHP 16.1. The scenarios of fare discount of 10%, 25%, and 50% was introduced and the mode choice model was used to evaluate potential ridership can be gained by applying such discount program. Table 6.5 shows the changes in probability of mass transit as results of fare discount.

Table 6.5 Changes in Probability as Results of Fare Discount

Code of Origin Sta.	Fare Discount of 10%		Fare Discount of 25%		Fare Discount of 50%	
	Ave. Fare Reduction (PHP)	Change in Prob. of Mass Transit	Ave. Fare Reduction (PHP)	Change in Prob. of Mass Transit	Ave. Fare Reduction (PHP)	Change in Prob. of Mass Transit
301	1.5	0.3%	3.9	0.7%	7.7	1.3%
302	1.5	0.4%	3.7	0.9%	7.3	1.7%
303	1.7	0.4%	4.2	1.0%	8.5	2.1%
304	1.5	0.5%	3.7	1.2%	7.3	2.4%
305	1.5	0.6%	3.8	1.4%	7.7	2.8%
306	1.5	0.5%	3.7	1.2%	7.5	2.5%
307	1.9	0.6%	4.9	1.4%	9.7	2.8%
308	1.5	0.5%	3.7	1.2%	7.5	2.4%
309	1.4	0.6%	3.6	1.7%	7.2	3.3%
310	1.3	0.5%	3.3	1.4%	6.5	2.7%
311	1.6	0.9%	3.9	2.3%	7.8	4.6%
312	1.7	0.7%	4.2	1.7%	8.3	3.3%
313	1.6	0.7%	3.9	1.7%	7.8	3.4%
314	2.0	0.5%	5.0	1.3%	10.0	2.7%
315	1.6	0.7%	4.0	1.8%	8.0	3.5%
316	1.5	0.7%	3.7	1.8%	7.4	3.5%
317	1.4	0.5%	3.4	1.2%	6.8	2.4%
318	1.3	0.7%	3.3	1.8%	6.7	3.6%
LRT1	**1.6**	**0.6%**	**3.9**	**1.4%**	**7.8**	**2.8%**

It can be seen in the table that the probability of mass transit being chosen increases as the fare decreases. At the scenario of fare discount of 10%, the reduction of fare is about PHP 1.6 on average and the demand of mass transit use increases by 0.9% at the most and 0.6% on average. The fare reduction of 25% results in additional mass transit demand of 2.3% at the most and 1.4% on average. The fare reduction of

50% escalates the probability of mass transit being up to 10% at the most and 7.8% on average. It can be seen that more reduction yield more ridership.

D. Improving Train Speed

During the period of data collection, two different types of rolling stock were used for LRT1 and LRT2. The LRT1 or the Yellow Line utilized light rail vehicles with various types of trains, i.e. two-car trains, three-car trains, and four-car trains. The two-car trains were eventually expended into three-car trains, although some two-car trains remain in service. The four-car trains are the newest trains and more advanced vehicles among other trains. On the other hand, unlike LRT1, the LRT2 or the Purple Line utilized eighteen four-car trains, which have higher capacity than LRT1. The trains also feature air-conditioning, driverless, automatic train operations. The LRT2 trains are also more disabled-friendly than their counterparts on the Yellow Line (LRT1). Table 6.6 shows the probability changes as a result of this initiative.

Table 6.6 Changes in Probability as a Result of Increased Train Speed

Code of Originated Station	Average Time Reduction (min)	Changes in Probability of Mass Transit
301	3.2	2.8%
302	2.6	3.2%
303	3.2	4.0%
304	2.6	4.5%
305	2.9	5.5%
306	3.5	6.0%
307	2.3	3.5%
308	2.7	4.5%
309	2.9	7.0%
310	1.5	3.2%
311	2.5	7.7%
312	3.3	6.8%
313	3.0	6.7%
314	3.4	4.7%
315	2.1	4.8%
316	1.9	4.7%
317	2.6	4.7%
318	2.9	8.1%
LRT1	**3.0**	**5.1%**

From the survey results, it was found that the average train speed of LRT1 is the lowest among all transit lines. It was recorded that the average speeds of LRT1, LRT2, and MRT3 are 21.6, 24.9, and 24.8 kph, respectively. Suppose in this case, the mass transit authority plans to use the type of advanced train as used on LRT2 on LRT1 line. The objective of this plan is to increase the average speed and reduce the in-train time. The authority wishes to estimate an increase in ridership by introducing such new trains for LRT1 line. Under this scenario, the average speed of LRT1 increases by 3.3 kph resulting in the reduction of in-train time by about three minutes on average.

To summarize, Table 6.7 shows the changes of probability of mass transit being chosen as results of improvement scenarios. The second column of the table shows the changes in probability of mass transit. The third column shows the list of model variables that are affected by such improvement scenarios. The next column is the percentage changes of variable before and after the improvements.

Table 6.7 Summary of Changes in Probability of Mass Transit

Scenarios of Improvement	Changes in Probability of Mass Transit	Parameters Affected by the Scenarios	Percentage Change of the Parameter	Ratio of Change*
Installation of Escalator	3.4%	No of Escalators	100% [1]	0.034
Increasing Access Modes	10.6%	Access Mode	75% [2]	0.096
Fare Discount of 10%	0.6%	Fare	10%	0.060
Fare Discount of 25%	1.4%	Fare	25%	0.056
Fare Discount of 50%	2.8%	Fare	50%	0.056
Improving Train Speed	5.1%	In-train time	8.3%	0.614

* ratio = change in probability / percentage change of variable value
[1]changing from none to be installed per station. Change in the term of score is 33.1%
[2]changing from limited numbers to be 2-3 transit routes per gate. Change in the term of score is 34.2%

The last column in the table shows the ratio of changes in probability of mass transit per percentage change of the variable value. This ratio could reflect how effective a scenario in gaining more ridership. Since the assumption of *ceteris paribus* must hold, an increase in mass transit probability implies a decrease of non-mass transit probability. In other words, values in the second column represent the possible new ridership that can be gained from mode shifting to mass transit.

According to Table 6.7, installing escalators and adding more feeder modes increases the score of station accessibility and gain about 3.4% and 7.2% of mode shift from non mass transit, *ceteris paribus*. The ratio of change or elasticity of those scenarios is 0.034 and 0.096, respectively. The ratio of change of the three fare reduction scenarios has similar value, i.e. 0.06. It implies that number of ridership might not increase significantly by providing more discounts. The scenario of improving train speed increases ridership by 5.1% while the ratio of change is 0.614.

Note that the ratio of change, presented in the last column, illustrates the effectiveness of a scenario as compared to the others. Therefore, based on that, the scenario of improving train speed might be the most effective improvement strategy that should be applied.

6.3.3 Notes on Model for Bangkok and Discussion

Similar to Manila, model that incorporated Station Accessibility Score was developed for the Bangkok data. Table 6.8 presents the station accessibility scores for selected stations in Bangkok.

Table 6.8 Mode Choice Model with Station Accessibility Model (Bangkok)

Parameters	MNL-8B
Total time (minutes)	-0.1016 (-5.96)**
Total cost (THB)	-0.0344 (-2.31)**
Variables w.r.t. Mass Transit	
Access distance (meters)	-0.0013 (-2.63)**
Access Score	0.0024 (0.55)
Facility Score	0.003 (0.38)
Constant	
Mass transit	1.442 (9.67)**
Private car	1.2492 (2.31)**
Parameters of Statistics	
Log-likelihood at zero	-213.1308
Log-likelihood at convergence	-115.3547
Rho squared w.r.t. zero	0.4588
%-correct prediction	73.20%
Chi-squared vs. control model	10.2078
Rejection significance	0.0696

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

As can be seen in the table, the mode choice model is slightly improved by adding station accessibility score. The log-likelihood ratio test indicates that model improves at the significant level of 10%. In spite of this, both variables of accessibility scores are not significant. As it had been discussed earlier, the station accessibility score was developed in station basis while number of observations for each station in Bangkok data is very small. However, the coefficient estimation of those variables has positive sign with respect to mass transit. It implies that improvement on the quality of access to station and the station facilities as well could have positive influence on mass transit ridership.

Access and Facility Scores were expected having positive correlation to mass transit use. From the both of study areas, the coefficient estimation of the scores has positive sign. It agrees to that was expected. However, the magnitudes of the coefficient estimation of the scores are relatively smaller than other variable, especially variable of time and cost. It implies improving on total time and cost still give greater effect than improving the access and facility.

The variable of facility score from the both of study areas are not significant but have positive sign. It might indicate that station facility does not have direct influence to increase ridership. However, it can increase the utility value of mass transit mode and somewhat increase the mass transit attractiveness in order to gain more ridership.