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Application of Discrete Choice Modeling to Access Modes of the LRT Systems

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ABSTRACT:

The Light Rail Transit System makes traveling across Metro Manila, faster and more convenient. Improving the conditions of access modes to the LRT System can help improve ridership of this transport mode. The access modes that are widely used by people could be determined with the application of discrete choice modeling. The improvement of these access modes could generally make an impact to the urban traveler. Finding the factors that affect the access modes of each light rail transit station is a major objective of this study. Developing a model through multinomial logit could help in determining the choices of access modes that an urban traveler would make. This research shows demographic analysis of the existing access modes of the LRT System. The effects of policy implications such as improvement on the total travel time and increase in fare cost of the access modes can also be determined.

Rail-based transit systems have gained popularity in recent years in the Asean Region because of its high capacity and efficiency. However, in some instances, the estimated passenger demand is not usually met to compensate for its high initial cost and annual operating and maintenance costs.

The study looked at competing access modes of rail-based transit systems in Metro Manila and how the role of access modes, station amenities and the general environment around the transit station could be improved to increase the potential captive passengers. Captive passengers are

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those who are within the one kilometer radius of the transit station. Access modes within the one-kilometer radius of the rail station include walking, tricycle (a three-wheeled vehicle run by a motorcycle), pedicab (human powered three-wheeled vehicle), jeepney, fx taxi (a 10-seater airconditioned vehicle), regular taxi and the private car.

Multinomial and nested logit models were developed to capture the access mode choice behavior of rail users. In the nested logit model, the walk, private and public modes were the upper branch where the private car and taxi were under the private mode and the tricycle, pedicab, jeepney and fx taxi were under the public mode. The important deterministic variable include, access time, access cost, as well as some qualitative variables related to the general environment around the station, such as convenience and comfort.

Some policy tests were conducted in relation to the improvement of access of rail stations and the impact of these policies on rail demand were then estimated.

1. INTRODUCTION

The Light Rail Transit System has been a common mode of transportation in Metro Manila for the last 20 years. Today, it has three lines of mass rapid transit system known as LRT1, LRT2 and MRT3. It began with the Light Rail Transit 1 or LRT1 when it started to operate back in May 1985, which is considered as the first mass rapid transit system in South-East Asia. It was then followed by the MRT3 or Metrostar Express which was fully operational around December 1999. The latest addition of mass rapid transit system in Metro Manila is the LRT2 or Megatrenn which is a driverless system that started to operate in April 2003 and was fully operational by the end of 2004.

There are numerous choices for a commuter to access a light rail transit station. A study about the "Transport Mode Choice Set Generation for Work Trips in Metro Manila" was conducted by Fillone et. al. (2006) [1] found out that the light rail transit system is the most used transport mode of an urban traveler in Metro Manila. The second choice of urban transport mode in Metro Manila is the jeepney which is often used to access the light rail transit system. Another study of Fillone and Muhi (2005) about the "Access Modes of Rail-Based Transit Systems in Metro Manila" [2] shows that the highest percentage of their respondents walks to the station. It is then followed by jeepney, and then by tricycle.

In Metro Manila, especially in the city of Manila, Makati, Quezon, and other cities nearby, mass rapid transit are a critical component of the transport system because it provides the fastest and great convenience to the riding public compared with the other means of transportation available. However, there are people, even though their homes are near a light rail transit station, do not use this system. In order to encourage more ridership, especially for people whose place of residence and work are near a light rail transit system, there is a need to come up with a clear picture of the existing access modes to these light rail transit stations which may need improvements. An application of the discrete choice modeling to access modes of the LRT Systems can be a helpful tool to determine which improvements on the access facility are needed and what will be the impact of these improvements. These will help determine the access modes that are generally used by an urban traveler from home to work/school.

2. OBJECTIVES OF THE STUDY

This study aims to determine what are the improvements needed on the access modes of the LRT systems. It intends to see and evaluate the access modes of each station of the three urban rail systems in Metro Manila. The research aims to determine the factors that affect the access modes of each station

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which includes the mode of public transport availability, and the cost and time of travel from origin to a light rail transit station.

The following are the scope and limitations of the study:

1. The results of the study will be based on the surveys that were carried out in areas within 1500 meters of the LRT/MRT stations.
2. The destination of the respondents would only be at the light rail station that they access.
3. A lot of survey questionnaire are needed to be answered and only a few of the survey samples may be deemed acceptable and used for analysis.
4. Public transport commuters who are making a side trip (or doing trip chaining) were not considered; only mode and route choices of commuters having a single origin and single destination were considered.
5. The questionnaires include the respondents' description of their trip from home to their destination in detail.
6. The relevant variables that were used in formulating this model are limited from the output of the programs used. This means that for a variable to be used, it should pass certain standards set by the analyst.

3. CONCEPTUAL FRAMEWORK

The accessibility of the LRT system could be determined through application of discrete choice modeling. The discrete choice model has to make certain assumptions in order to obtain operational models. These assumptions must be specific in order to develop models capturing how individuals are making choices. The type of model that is used in this study is a multinomial logit model.

Certain factors may contribute to the accessibility of the LRT systems. These are the general trip characteristics, characteristics of the access modes, etc. The general trip characteristics include the travel itinerary using the LRT/MRT and the travel itinerary without using LRT/MRT. Users of the LRT/MRT may be divided into regular and non-regular. Lastly, the characteristics of the commuters are also a considerable factor in the accessibility of transit. In here are the gender, age, educational background, civil status and economic status of a commuter.

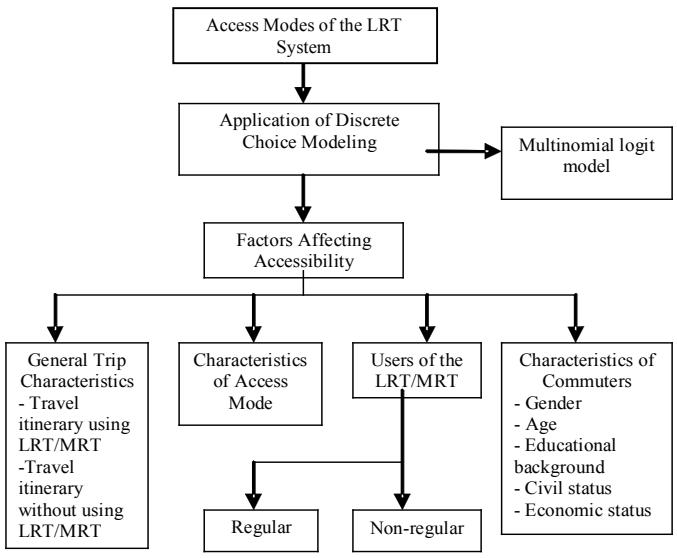

Fig. 1: Conceptual Framework

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4. METHODOLOGY

Data collection was done through home interview surveys that were carried out in areas within 1.5 kilometers of the LRT/MRT stations. The survey asks the respondents to describe how they travel from their homes to their school or workplace. These questions includes whether they use the lrt/mrt regularly or not, what are their access modes to reach the station, what are the characteristics of their access modes, and what are the characteristics of the respondents. The address of the respondent is also asked in the questionnaire to determine the location of each respondent.

The road network that was constructed was based on the GPS referenced 2006 Metro Manila CITIATLAS. The road network is within 1.5 kilometers of a light rail transit station. The road network is used to conduct a detailed analysis of individual transit trips. It computes the optimal strategy to reach the destination coordinates of a trip from its origin coordinates, using the sets of access and egress nodes entered along with the coordinates. Assign the individual trips for each sample to acquire the total travel time. For the taxi and private car users, only the shortest path method can be applied to determine the in-vehicle time of the correspondent.

The results were derived from the data using EMME/2, which can be turned to an equation or model using the NLOGIT. These equations can then determine the possibilities of a commuter on choosing what type of access mode he/she would be using on going to a light rail station. The model divides the persons between the various modes depending on each mode's relative desirability for reaching to a specific light rail station. The model made would be called the utility of the mode, in which it will have a mode constant and mode specific variables. The mode constant is a constant in the equation for a given mode.

5. SURVEY RESULTS

There were a total of 1,147 survey results that were gathered. Of these 1,147 samples, 820 of them are regular users of the light rail stations, while 327 are non-regular users. Since the destination that is in the scope of the study is only at the light rail stations, only the regular users' survey would be used. From the 820 regular users of the light rail stations, there were only 344 samples that were acceptable to be used in formulating the discrete choice model.

In Fig. 2, 50% of the correspondents walk from their origin to the light rail station. Basically, this kind of access mode is very popular to those who live near a light rail transit station and because this mode does not cost anything. While 18% of them takes the jeepney and 22% takes the tricycle to reach a light rail station. Other modes such as buses and taxis are at a very low percentage because the correspondents that were surveyed live near a light rail station, and usually this types of access modes are used for long travel and may be expensive than the other types of modes available.

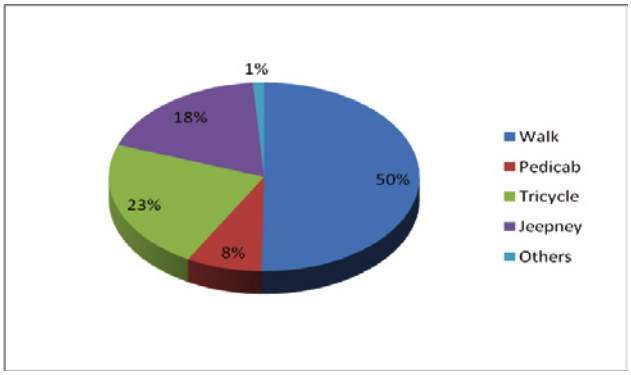

Fig. 2: Access modes going to station

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The average straight line distance of each access mode may differ from each other. In Fig. 3, the graphical presentation of two access modes, walk and private car mode have a major difference from each other. The colored dots resemble the location of the correspondents from their point of origin and at the center of the circle is the light rail transit station that they access. Comparing the walk and private car mode, it can be seen that a large number of people who walk to the station have their point of origin within a 500-meter radius of the light rail transit station. While for the private car mode, most of the origins are farther from the center. The mean of the straight line distance for walk mode is 0.4728 km, and for the private car mode is 1.1342 km.

The reason for having a high number of people walking to a station is because most of the sample surveyed are living near these stations, and only a few who live near are using private cars.

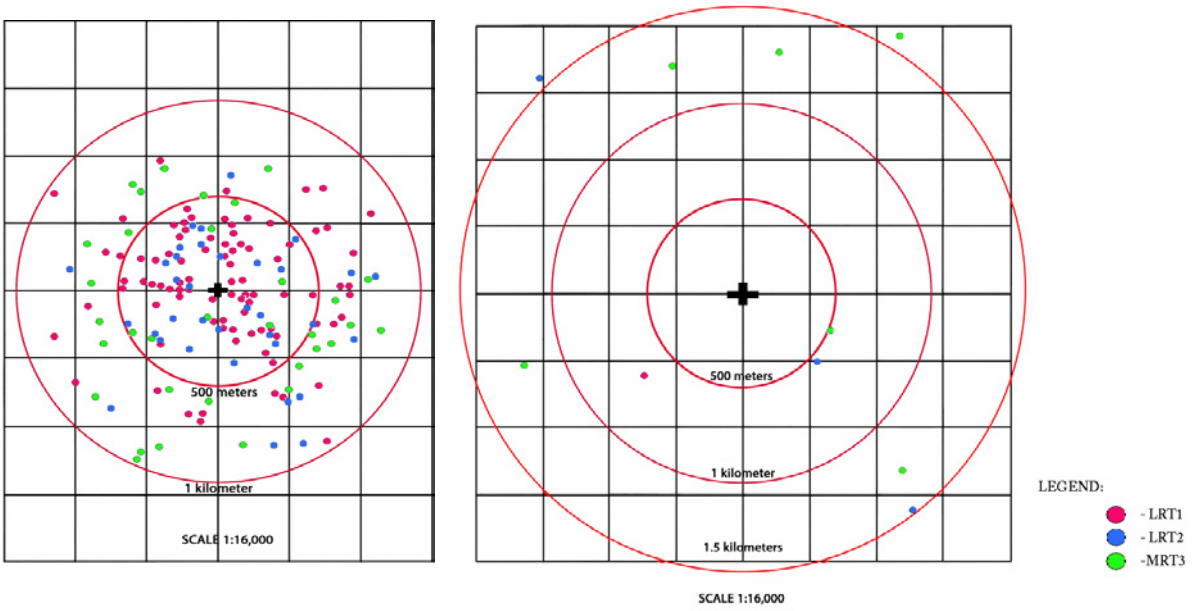

Fig. 3: Graphical presentation of walk mode (*left*) and private car mode (*right*)

6. DISCRETE CHOICE MODEL

The study has made several trial and errors on developing this model, using different sets of variables to predict the utility and probability of an access mode. According to Fillone (2005) [3], there are usually two things in a particular parameter that one has to look into, to know whether it is acceptable or not. These are (1) the sign of the parameter and (2) if whether it passed the asymptotic t-test.

The first multinomial logit model (MNL-1) has the following deterministic variables: EGRESS, TTIME and COST. For the second multinomial logit model (MNL-2), the variable TTIME was not included in the analysis. The third multinomial logit (MNL-3) has only one deterministic variable, which is EGRESS. As shown in Table I, the signs of the coefficients of the deterministic variables were all negative because egress consumes the time of a commuter, the same goes with the total time of travel and cost is the money spent by the commuter for transport fare. While the mode constants, also known as alternative-specific constants have positive signs. These values were computed using a level of significance of ninety-five percent (95%) in which alpha is equal to five percent (5%). The jeepney mode has no value since it is used as the base mode.

The test statistics are the quantity that was calculated from the sample data. According to Ben-Akiva and Lerman (1985) [4], the asymptotic t test is used primarily to test whether a particular parameter in the model differs from some known constant, often zero. The critical values for the test statistic are percentiles of a standardized normal distribution, which for two-tailed tests at the frequently used




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significance levels of 0.10 and 0.05 are ±1.65 and ±1.96, respectively. The level of significance of this two-tailed test is 0.05 and the critical value for the test statistic is ±1.96. Only the t-value of TTIME was below the critical value of ±1.96.

TABLE I: Summary of the Statistical Reports

Variables	MNL-1		MNL-2		MNL-3	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
EGRESS	-0.25	-5.73	-0.27	-6.76	-0.26	-6.59
TTIME	-0.1	-1.67	-	-	-	-
COST	-0.08	-2.88	-0.07	-2.67	-	-
A_WALK	2.351	4.46	2.797	6.079	3.141	7.2
A_PEDICA	1.706	4.154	1.597	3.95	1.048	2.968
A_TRICYC	2.136	5.385	2.507	7.551	2.045	7.328

TABLE II: Prediction Accuracy of the Logit Models

Logit Models	**MNL-1**	**MNL-2**	**MNL-3**
	Prediction Accuracy (%)		
Walk	66	66	66
Pedicab	29	29	25
Tricycle	57	57	56
Jeepney	40	40	40

So as for Table II, it shows the prediction accuracy of the developed logit models. The accuracy is consistent for MNL-1 and MNL-2, with only a slight difference on the accuracy of MNL-3 with the other two models. The values were obtained by dividing the number of prediction with the number of samples. The probability for the other access modes such as fx, bus, private car and taxi were not obtained because there were insufficient data, the NLOGIT could not predict for the utility of the said access modes.

Table III shows the calibrated utility function for walk, pedicab, tricycle and jeepney based on MNL-1:

TABLE III: Calibrated Utility Functions of Access Modes based from MNL-1

Modes	MNL-1
Walk	U w = -.25 X – .08 Y – .10 Z + 2.35
Pedicab	Up = -.25 X – .08 Y – .10 Z + 1.71
Tricycle	Ut= -.25 X – .08 Y – .10 Z + 2.14
Jeepney	Uj= -.25 X – .08 Y – .10 Z

Where: X = Egress time (from origin to LRT/MRT station)
Y = Cost (fare cost of access mode)
Z = Total Travel Time

The probability of a commuter to choose an access mode when going to a light rail transit station may be computed. The utility of each mode may be obtained based from the model that was developed. In Fig. 4, the average probability of each access modes to be used were shown. It shows that the mode “tricycle” has the highest probability with 34%, followed by “walk” with 33%. The probability for the “jeepney” is 18% and the “pedicab” has 15%.

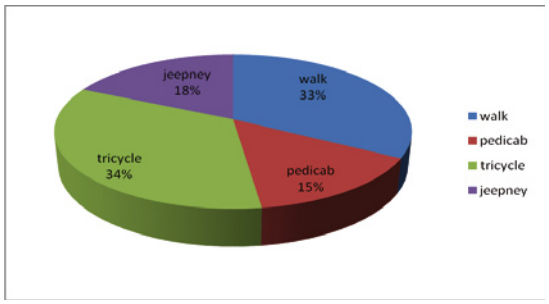

Fig. 4: Average Probability of Access Modes

TABLE IV: Percentage of Actual Choices of Modes

Choice	Actual	Percentage (%)
Walk	174	50.6
Pedicab	28	8.1
Tricycle	79	23
Jeepney	63	18.3

In Table IV, the percentage of actual choices of modes by the commuter is based from the number of observations. Walk has the highest percentage with 50.6%. It is followed by tricycle with 23% and jeepney with 18%. Pedicab has the least number of commuters accessing it with 8.1%.

7. POLICY VARIABLES

There are many important uses of discrete choice models. One of them is predicting the effects of policy implications. Such predictions can be made only if the model includes explanatory variables, called policy variables. These variables represent the policy implications being considered.

The model can predict the change in jeepney ridership if there is an increase of 20% on the fare cost of jeepneys. It means that if the current fare for jeepneys is Php 7.00, the increase would make it to Php 9.00. On Table V, the effect on the probabilities of commuters using jeepney as their access mode with an increase in the fare cost is shown. There is a significant decrease in the probability of the jeepney being used by commuters with .75%. As for the remaining access modes, there is an increase in walk with .44%, .065% with pedicab and .25% with tricycle. This table was taken from NLOGIT.

TABLE V: Effect on Probabilities with a 20% Increase in Jeepney Fare Cost

Derivative (times 100) Averaged over observations.				
Attribute is COST in choice JEEPNEY				
Effects on probabilities of all choices in the model:				
*indicates direct Derivative effect of the attribute.				
Decomposition of Effect				
	Trunk	Limb	Choice	Total Effect
Trunk=Trunk{1}				
Limb=Lmb[1:1]				
Choice=WALK	0	0	0.443	0.443
Choice=PEDICAB	0	0	0.065	0.065
Choice=TRICYCLE	0	0	0.247	0.247
*Choice=JEEPNEY	0	0	-0.755	-0.76




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8. CONCLUSION

The factors that affect the access modes of each station include a lot of deterministic variables such as in-vehicle time, wait time, access, and egress. The main variables that were used in this model were egress and cost. Other factors are socio-economic which include cost of travel, gender, age, civil status, income, etc. The most popular choice of access mode to the light rail transit stations is walk, since it is cost-free and majority of the correspondents live near the stations. The least used access modes to the LRT systems are the bus, private cars and taxis. These access modes are generally used for very long distances and are more expensive compared to the other access modes. This study achieved in making a model that can be useful in predicting the utility of an access mode regarding the policy measures. This policy measures may vary from time to time, but the model can still predict the utility and probability of an access mode. Having an increase in the fare cost of jeepneys resulted in a decrease in its ridership.

9. RECOMMENDATIONS

The following is a list of all the improvements and recommendations that can be done in doing this study.

1. In this study, it is greatly recommended to get more samples. Adding more samples will greatly increase the accuracy of the data and making it more realistic.
2. Locate the specific locations of the addresses of all the respondents. Having their specific locations would actually improve the validity of all the samples.
3. Have adequate number of samples for certain access modes so that the data can be as accurate as possible.
4. Have specific data on some factors of the access modes, like actual fare cost of a certain access mode. Some fare costs may vary with an access mode depending on its location.
5. Familiarize with all of the transit stations to determine all the possible pathways leading to the station in a certain location.

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