Travel Behavior of Condominium Residents near Urban Rail Transit Stations: Case of Metro Manila

Jamiel Louiee L. JAYME [a], Saksith CHALERMPONG [b]

[a,b] *Department of Civil Engineering, Chulalongkorn University, Bangkok, 10330, Thailand*
[a] *E-mail: jemjayme@yahoo.com*
[b] *E-mail: saksith.c@chula.ac.th*

Abstract: Metro Manila's traffic congestion problem had been upsetting the travel patterns of commuters due to the lack of mobility and accessibility difficulty. A shift from automobile to transit use would be beneficial for the progress of a transit-oriented development in Metro Manila. The effects of different socio-economic and land use characteristics among commuters using urban rail transit and automobile, and whose residences are along stations of the rail transit would determine the behavior of their travel. Preliminary results of these travel behavior entails that commuters whose residents are very near the rail transit stations are more likely to utilize them. On the other hand, as the residence to transit station proximity increases, a higher likelihood of choosing automobiles or different public transit as their modes of transport was observed, but due to some beneficial factors and own perception, some commuters with the same land use characteristic, still use rail transit.

Keywords: Travel Behavior, Urban Rail Transit, Condominium Residents, Metro Manila

1. INTRODUCTION

1.1 Background of the Study

Metro Manila's urban rail transit system have been accepted as one of the most active transit mode in the city, with its good accessibility, low-priced fare and traffic congestion-free environment. These transit systems have been utilized by many commuters mainly to avoid a traffic congested travel. According to the Department of Transportation and Communications, DOTC (2010), the annual urban rail transit ridership is about 350 million in 2009, and the estimated growth rate is 5-10% per year. This certainly sets a trend on urban rail transit travel.

The current rail systems in Metro Manila have three operating lines. First, the Light Rail Transit Line 1 (LRT 1) or the Yellow Line is the oldest elevated heavy rail line in the country. Dating back from the 1980's, LRT 1 was the first operated urban rail transit in the Philippines. As of 2011, LRT 1 consists of 20.7 km length network with 20 stations. Second, the Metro Rail Transit (MRT 3) or the Blue Line is also an elevated heavy rail system, which began operating in 1999. It has a total length network of 16.9 km with 13 stations. The MRT Line is located on the busiest road in Metro Manila, EDSA (Epifanio Delos Santos Avenue), which has approximately 350,000 vehicles passing daily (Metro Manila Development Authority, MMDA, 2012). Third, the Light Rail Transit Line 2 (LRT 2) or the Purple Line is the East and West extension of the LRT, which began operating in 2003, and has a total length network of 13.8 km with 11 stations. The location of these rail systems in Metro Manila are shown in Figure 1. These three systems mainly serve commuters in Metro Manila. The number of riderships for the three operating lines is shown in Table 1.

Development of condominiums within the vicinity of rail transit stations in Metro

Manila are most probably beginning to increase due to the numerous amount of residential condominiums being constructed all around the Metro. According to Jones Lang LaSalle Leechiu Research & Consulting (2012), the number of condominium units in Metro Manila alone reached 90,000 in 2011.

Table **Error! No text of specified style in document.**. Ridership of Transit Lines

Rail Transit Lines	Approximate Daily Traffic (in Passengers)	Annual Passenger Traffic (in Millions of Passengers)		
		2010	2011	Mid 2012
LRT 1	550,000	155.91	156.93	83.31
LRT 2	200,000	63.36	63.83	33.16
MRT 3	450,000	153.16	158.81	82.81

Source: Light Rail Transit Authority, 2012; Department of Transportation and Communications, 2012

Figure 1. Metro Manila Rail Transit Systems

1.2 Problem Statement

Mobility dilemmas are highly experienced in Metro Manila. Being a developed city, there is a need for high mobility, but traffic congestion attacks the heart of the Philippines due to an immense density and automobile users. The shift of automobile users to transit oriented travel would have significant effects in an urbanized city and traffic congestion may be lessened. According to Fouracre *et al*. (2003), there may be patent basis for the shift of commuters from private motor vehicles to mass rapid transit in some of Asia's densely populated cities.

The rise of condominiums in Metro Manila, mainly within the surrounding area of rail transit stations, provides better opportunity for residents to use urban rail for their commute. In this manner, promoting transit oriented development can lead to less usage of motorized vehicle such as automobiles, and enhancement of an environment-friendly society.

1.3 Objectives of the Study

The primary objective of the study is to determine the effect of high density residential condominium with Transit-Oriented Development (TOD) near urban rail transit stations in reducing automobile use in the case of Metro Manila, Philippines.
The specific objectives of the study:

1) To determine the effect of residential movement on both transit and automobile use.
2) To understand travel characteristics of people living in condominiums located along rail transit corridors in Metro Manila.
3) To evaluate the effects of the socio-economic and land-use characteristics on travel behavior particularly of those residing in condominiums near the urban rail transit stations.
4) To compare and analyze the relationship between condominium characteristics and residents' socio-economic profile.

1.4 Hypothesis

The travel behavior of urban rail transit users residing in condominiums located in the vicinity of rail transit stations are dependent on their socio-economic profile and characteristics, and their accessibility to the rail transit stations. The travel behavior of commuters towards the use of transit is separated into four clusters. (1) Individuals who currently used rail transit for their commute and whose residence are near rail transit stations. (2) Individuals who use urban rail transit for their commute but whose residence may be far away from rail transit stations may choose to relocate to reside near transit stations in order to have a more convenient way of commute. (3) Individuals who use non-rail transit for their commute and whose residence are far away from rail transit stations, relocate their residence near rail transit stations to shift from non-rail to rail transit. (4) Individuals who use automobiles for their travel and whose residence location have no access to transit, intends to shift from car to transit by relocating their residence near rail transit stations. To promote a Transit Oriented Development (TOD), within the predicted four commuter clusters, having respondents who are in cluster four will definitely have a success result.

1.5 Scope and Limitations

The study is focused on the travel behavior of urban rail transit users in Metro Manila and is limited with the following conditions:

1) The survey data to be used are for condominium residents near transit stations
2) Condominiums with an approximate radial distance of 1,000 meters or so from a transit station constructed after the urban rail transit was built will be used to assess the land-use characteristics.
3) Urban rail transit stations within the Central Business District (CBD) areas only will be surveyed.
4) Data will be gathered by the use of online survey questionnaire.

1.6 Significance of the Study

The study will help to promote a Transit-Oriented Development (TOD) in the case of Metro Manila. Transit-Oriented Development is the advancement of an area with more compact dwellings within easy walking to transit stations and accessible to different mix land usage. With this premise, commuters will develop a sense of urge to shift from the use of an automobile to using urban rail transit. Also, individuals may choose to relocate their residential place near a transit station for better transport and easier travel. This will then “create a sense of community and of place” (Reconnecting America, 2012).

2. LITERATURE REVIEW

The interrelation of Land-Use and Transport is shown in Figure 2. There are some variables which are affected by this relationship, accessibility, mobility and proximity. The changes made within the relationship of Land-Use and Transport will influence both and may cause an increase in the demand of transport. In some studies, it is said that the interaction of these two variables is the one of the most dynamic fields in the transportation area. The connection of Land-Use and Transportation is the focal point for formulating policies which are related to travel behavior, automobile usage, and vehicle travel (Senbil *et al.*, 2006).

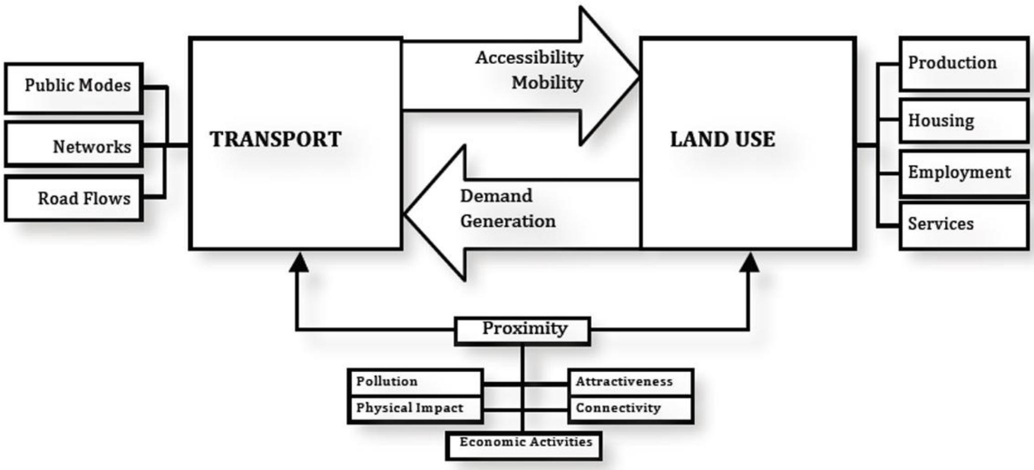

Figure 2. Transport and Land-Use Interaction Diagram (Pacheco-Raguz, 2010)

An illustration of one relationship of transport to land use was given by Stringham (1982), relating the accessibility of the rapid transit stations to the developments within the vicinity of the station. It is evident that the tendency of people’s mode access is quite dependent on the distance from where they will start or end their commute. Figure 3 shows an example of the relation of modes of access to the distance of the transit station. It is seen that walking is a popular mode of access until it reaches the distance where people would not like to walk anymore, which is beyond 1,000 meters. O'Sullivan and Morrall (1996) also confirmed the efficiency of walking to rail transit stations. The case of the light rail transits in San Francisco Bay and Edmonton, Canada, revealed that walking access to LRT stations acquires half of its users and has similar distance limitations as in Figure 3. Other access choice will arise where demand is needed or when the starting point of the commute is not very suitable for walking. In relation with Metro Manila's situation, Wibowo and Chalermpong (2010) established the same concept provided by Stringham. In Figure 4, the mode of access in Metro Manila's urban rail transit stations gave out that generally, walking is suitable for people's travel with a distance not greater than 1,500 meters. On the other hand, other modes for access are commonly used with longer distances relative to the urban rail stations.

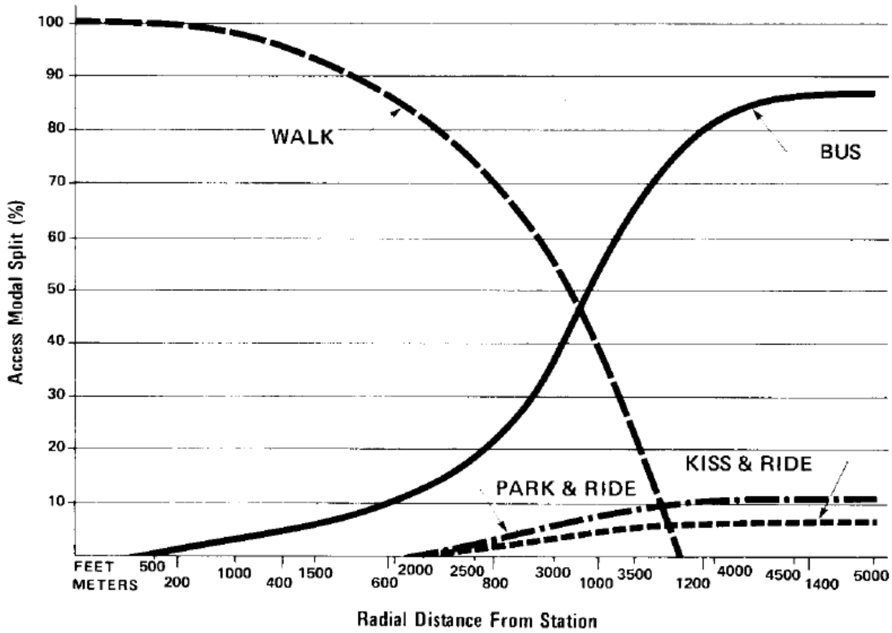

Figure 3. Access to Rapid Transit Station Relative to Distance from Station (Stringham, 1982)

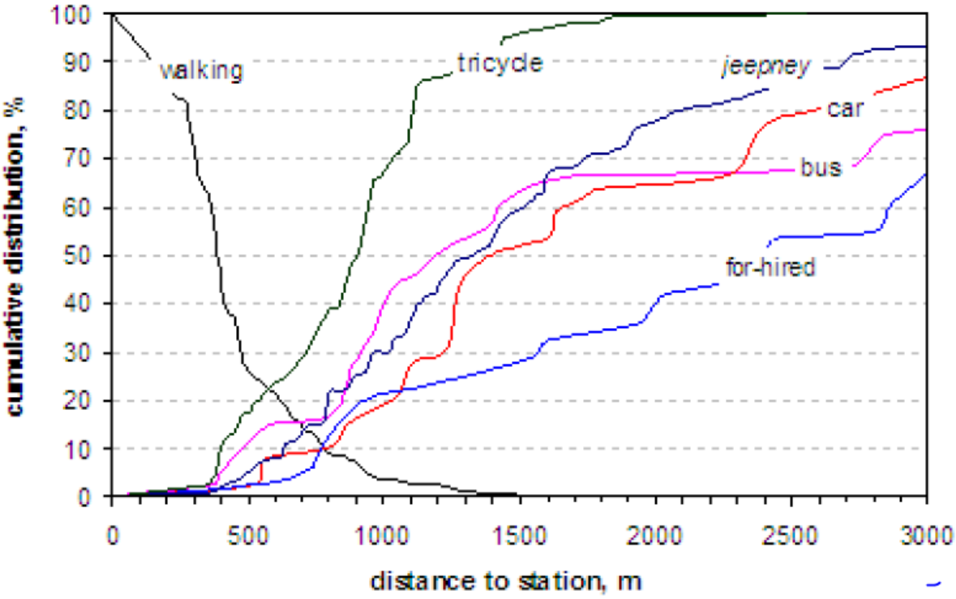

Figure 4. Metro Manila's Access Mode and Distance to Urban Rail Station Relationship (Wibowo *et al.*, 2010)

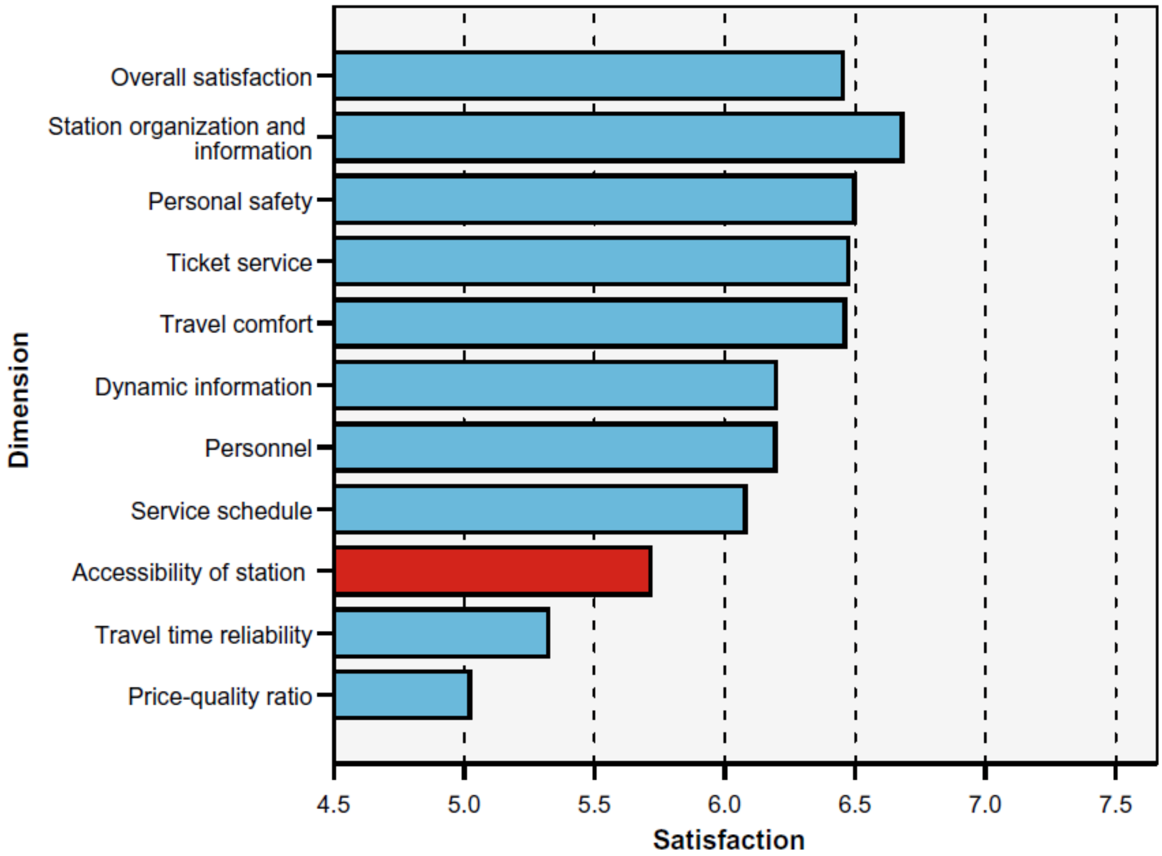

Figure 5. Satisfaction Scores for Rail Journey (Brons *et al.*, 2009)

Likewise, the catchment area of a rail transit station, in relation with walking accessibility, has a great impact on the radial distance needed to capture land use developments where commuters dwell in order for them to use rail transit; this was discussed by Kitamura *et al.* (1996) and with all other factors affecting trip modes. An illustration of Metro Manila's urban rail transit station catchment area is shown in Figure 6. It indicates the average urban rail transit station catchment area with the access of walking. It was compared to a larger radial distance with an access mode for car was observed. It is seen that the there is a vast number of commuters who access the urban rail transit by walking, therefore these people have been dwelling within the vicinity of the rail transit station. As for commuters who use car as their access mode to the rail transit, their dwelling places were a farther to the station. It implements that most of the land use around a transit station were being utilized for the convenience of the urban rail commute (Cao *et al.*, 2008). Land developments around rail transit stations are increasing, mostly are residential and condominium types, due to this substantial theory. As for residents who live farther away from a transit station, they tend to use other modes to access the rail transit but only a few of them actually uses transit. Similarly, O'Sullivan and Morrall (1996) discussed the case of Brentwood station in Calgary, Canada, in relation with the catchment area used. The theoretical catchment area, as shown in Figure 7, of the Brentwood station is very diverse compared to the actual catchment area after the observations. The variation of the catchment area was mainly due to obstructions from the developments around the area, which made the observed area different for the actual pedestrian walking spaces.

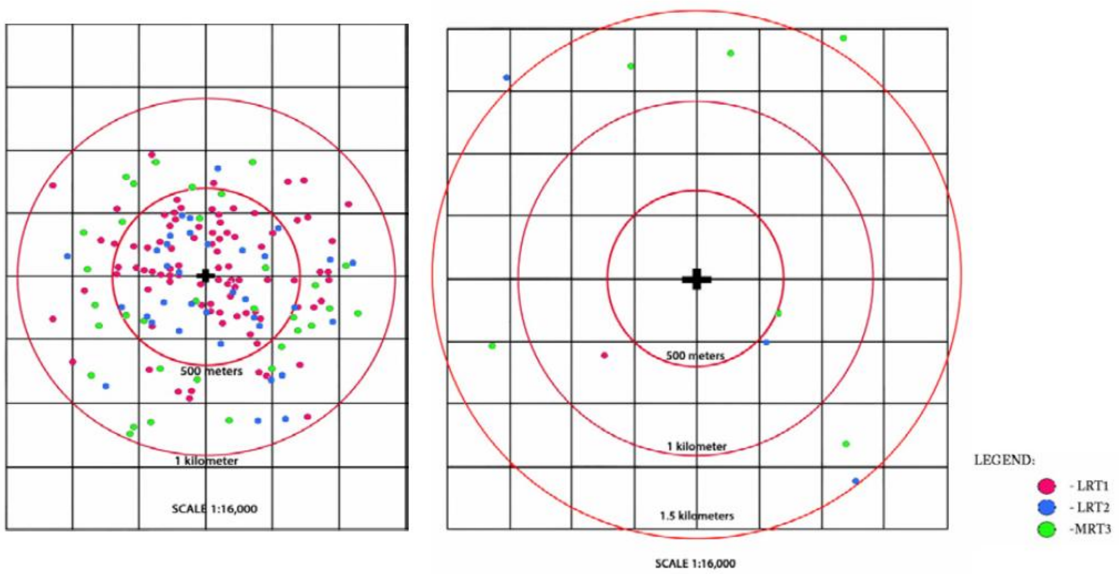

Figure 6. Catchment Areas for Modes of Walking (Left) and Car Use (Right) to Urban Rail Transit in Metro Manila (Fillone *et al.*, 2008)

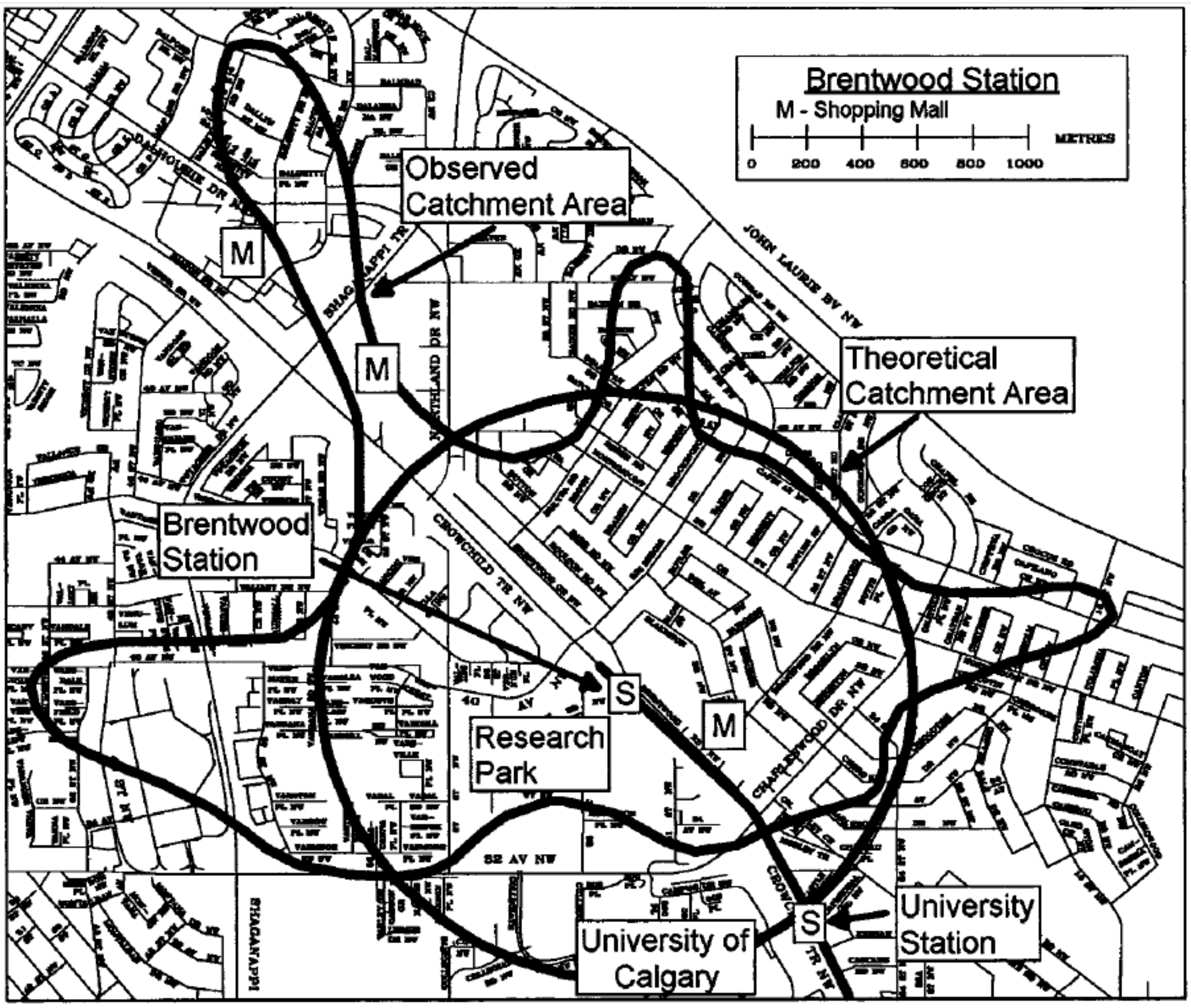

Figure 7. Catchment Area of Brentwood Station, Calgary, Canada (O'Sullivan *et al.*, 1996)

3. METHODOLOGY

In this study, in order to collect travel behavior data of urban rail transit users residing in condominiums near the rail transit stations in Metro Manila, an online questionnaire survey was utilized. Theoretically, condominium residents living within an approximate radial distance of 1000 meters or so, from the rail transit stations are mainly the focused groups. Data inputs would include the following: mode choice, trips characteristics, socio-economic profile of users. After which, a logistic regression model will be used to determine the effects of the travel behavior of each commuter and approximate the car use of commuters with different aspects as functions that affects their travel. Figure 5 shows the research flow diagram.

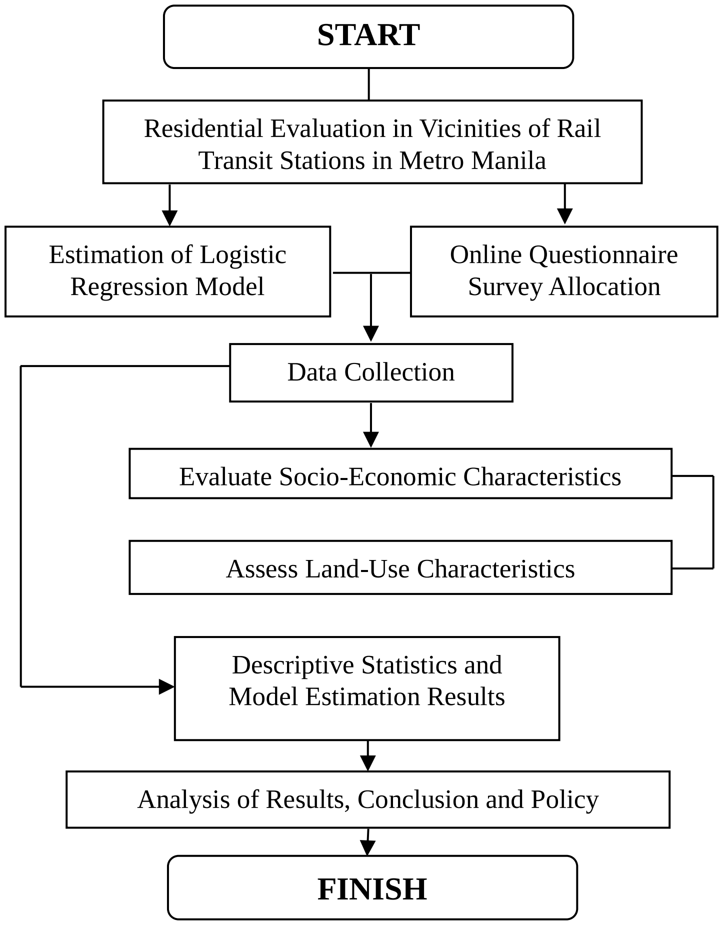

Figure 8. Research Design Flow Diagram

An online questionnaire survey in Google Docs developed by Chalermpong *et al.*, (2012) was used to determine the travel behavior and socio-economic characteristics of commuters using urban rail transit in Metro Manila. The following variables are inputs in the questionnaire survey:

1) Name of Condominium
2) Condominium Street Address
3) Nearest Transit Station to Condominium
4) Distance of Transit Station to Condominium
5) Length of Residency in the Condominium
6) Age

7) Gender
8) Marital Status
9) Occupation
10) Household Number
11) Monthly Income
12) Household Income
13) Motorized Vehicle Ownership (Automobile or Motorcycle)
14) Name of Workplace or School
15) Workplace or School Street Address
16) Nearest Transit Station to Workplace or School
17) Distance of Transit Station to Workplace or School
18) Main Mode of Commute
19) Commute Time by Public Transportation
20) Commute Cost by Public Transportation
21) Access Trip from Condominium to Transit Station
22) Access Time
23) Access Cost
24) Egress Trip from Transit Station to Workplace
25) Egress Time
26) Egress Cost
27) Direction of Trip
28) Automobile Ridership
29) Commute Time by Motorized Vehicle
30) Fuel Cost of Motorized Vehicle
31) Toll Costs
32) Installment Payment
33) Parking Cost
34) Walking Time to Destination
35) Walking Distance to Destination
36) Alternative Mode of Commute
37) Commute Time by Alternative Mode
38) Commute Cost by Alternative Mode
39) Contact and Personal Information

3.1 Logistic Regression Analysis

Logistic regression is used to describe and test the hypothesis in which the relationship of a dependent variable to the independent variables is known. To be able to test the hypothesis of the study, a logistic regression model will be estimated from the travel behavior data using the equation shown (Chalermpong *et al.*, 2012).

$$\ln\left(\frac{p}{1-p}\right) = X\beta + L\gamma + \varepsilon \quad (1)$$

where,

p = probability that the condominium resident commutes by private motorized modes
X = vector of the resident's socioeconomic characteristics variables
L = vector of the condominium location characteristics variables
ε = logistically distributed error

β, γ = vectors of model parameters.

The model consists of dependent and independent variables, model parameters, and residual. The dependent variable is the probability that the respondent uses car as their main mode of commute. Since this variable is dichotomous, the result can either be of the two: 1. a condominium resident uses private vehicles, 2. a condominium resident use transit for their commute.

On the other hand, independent variables are predictors of the estimation of the parameters. There are two independent variables that will be used. First, the socio-economic variables of commuters, which are the following: age, gender, marital status, occupation, number of household members, commuters' monthly income, household income, and motorized vehicle ownership. These variables usually have a significant effect on the way commuters travel and also affect their choice of mode. For instance, commuters who are very young and very old most probably would not choose to take the train regardless of its benefits, and may just choose to ride a car for their travel. Most likely, male commuters would be taking the rail transit than female commuters. There might be an issue of security for different sex groups. Individuals who are not married would be the ones who might take the rail often than married commuters. One factor to consider is that single commuters do not have that much responsibility yet compared to married commuters. The occupation of a commuter may also affect their travel patterns. Most probably, students and employees are the ones who travel most by public transportation, which includes urban rail transit. Business owners or individuals with a high position in a firm would most likely travel by car. Also, some household factors reflect a significant effect on how household members travel. The lesser the number of members of a household, the higher the probability of automobile use will occur, while households with a lot of members tend to use transit due to car ownership factors. The higher the number of car ownership of a household, the more likely members would drive, while transit use would be more significant to low car ownership households. Lastly, the financial state of each commuter or household would be the most remarkable factor which would affect their travel behavior due to some dependency of the other socio-economic variables connected to monetary values. The higher the income of a commuter or household, the most probable automobile use will arise, while low income travellers tend to use public transportation or modes with low pay-out-of pocket cost.

Second, the land use variables also affect the way people travel. The location and proximity of land dwellings to public transit access is particularly the main factor of influence to the mode share of commuters. In this study, two land use variables are considered: housing or residential, and employment or office workplace. In relation with transit use, these land use factors would influence the mobility, accessibility, and proximity. It is more likely for a commuter whose residence and workplace, which is accessible to several public transportation, to actually utilize those modes. Meanwhile, a commuter whose residence or workplace location has an impossible access to transit would likely to choose car to travel. Unlike the socio-economic variables, land use variables cannot be obtained by questionnaire survey alone. With the use of several condominium databases from different agencies, the location, characteristics, and specifications of condominium residences near rail transit stations can be achieved.

The model parameters will be estimated using STATA software. STATA is a statistical software which is capable of managing data, analysis of statistical data, simulations, and programming. Using some statistical tests, built-in through the software, the significance of the data will be analyzed. The use of t-test and z-test are practically the same, they test and compare between two means to suggest whether both samples come from the same population (Gaten, 2000). Also, the use of the likelihood ratio test will be utilized to estimate the unknown parameters of the independent variables. Maximum likelihood test leads to the highest amount of probability that the set of parameters produced. The distribution of the dependent variable will be used to derive the maximum likelihood equation.

The effectiveness of the estimation of the model would be evaluated overall. Logistic models provide the best fit for the data if the model exhibits developments more than the null model or the intercept. Statistical t-test and z-test would measure the significance of each parameter for each predictor.

4. DATA AND RESULTS

In order to test the research methodology, a pilot test was made to ensure the capability of the design flow. The pilot test was held by several Civil Engineering students from De La Salle University-Manila Philippines (DLSU). The objective of this pilot test was to allocate the information about the online questionnaire survey of the study with the help of the students from DLSU. At the end of the pilot test, a total of 266 respondents were obtained and used for the preliminary data analysis.

4.1 Data Statistics

The descriptive statistics of the preliminary survey data were obtained to evaluate each of the socio-economic characteristics of each household and their condition with respect to their proximity to rail transit stations, shown in Table 2. The average household income of the respondents was approximately PHP 360,000 annually, around 8,854 USD, (1 USD = PHP 40.66), which is quite high compared to the national average household income of PHP 206,000 annually, about 5,066 USD, stated by the National Statistical Coordination Board, NSCB (2011). The respondents' age average is at 23.31 years and the range is from 12 to 70 years.

Dummy variables were used to represent the different variables which will be treated in the regression analysis. The mean values of these variables are the percentage of respondents that fits the cluster. The dummy variables used for the socio-economic and household characteristics in this sample are the gender, marital status, occupation, and type of condominium unit (rent or owned), that will have a value of 1 if a respondent is a male, single, student, and rents a condominium unit respectively, and 0 otherwise. The percentages of the respondents regarding these variables are as follows: 51.88% are males, 85.34% are single, 51.50% are students, and 91.35% of the respondents are renting a unit.

Also, location of the residence and workplace of each respondent were considered as dummy variables. Respondents whose residences are within 500 meters to the rail transit station are 51.13% of the sample, while only 20.30% have their residence within 500 to 1000 meters to a rail station.

Lastly, condominium residence and workplace near rail transit stations located within the Central Business District (CBD) were considered as well to be dummy variables. In Metro Manila, there are four CBD areas, but only 3 CBD areas have a close access to the urban rail transit stations, which are the following: Makati CBD, Manila CBD, and Ortigas CBD. In the sample, 40.60% lives near a CBD station while 45.11% works or studies near a CBD station.

Table 2. Respondent's Socio-economic, Household and Location Characteristics

Variable	Mean	S.D.	Min.	Max.
Household income (PHP per month)	30000	18708.29	5000	55000

Age (Year)	23.31	3.44	12	70
Male	0.5188	0.5208	0	1
Single	0.8534	0.8566	0	1
Student	0.5150	0.5170	0	1
Rent unit	0.9135	0.9170	0	1
No. of years of residency	2.5	1.8708	1	5
No. of household members	2.5	1.2910	1	4
No. of cars owned by household	0.5752	0.5774	0	3
No. of motorcycles owned by household	0.0414	0.0415	0	2
Location Characteristics				
Condo located within 500m	0.5113	0.5132	0	1
Condo located within 500-1000m	0.2030	0.2038	0	1
Condo located near CBD station	0.4060	0.4075	0	1
Office located near CBD station	0.4511	0.4528	0	1

4.2 Mode Share

The mode share of the respondents was summarized and can be seen in Table 3. Also, the trip characteristics of individuals, which include travel time and cost were statistically measured by modes. It can be seen that the greatest mode used in the sample is rail followed by car and jeepney. Even though rail has the second longest time of travel, many commuters still use it as their main mode of transportation. Car users pay out the most between the modes followed by taxi users, and it can be seen that there is a significant difference between the cost of using car and taxi compared to all other modes. The use of cars is still being utilized being the second highest percentage with the fact that it gains the highest amount of cost. Meanwhile, jeepney users experience the lowest travel cost among the modes. With the jeepney’s low cost commuters managed to use this as their main mode of transportation, this is reflected by being third highest in the mode share percentage. Walking was very not likely considered to become commuters’ main mode of travel due to the fact that it will endure the longest travel time even if no cost will be utilized.

Table 3. Overall Sample Mode Share with Trip Characteristics

Mode	Frequency	Percentage	Travel Time (Min.)		Travel Cost (Php)	
			Average	S.D.	Average	S.D.
Bus	19	7.15	39.68	12.27	22.37	10.05
Jeepney	45	16.92	28.47	12.91	17.44	7.68
Rail	102	38.35	38.09	8.38	28.32	13.18
Taxi	12	4.52	36.08	15.18	100.83	49.88
FX	18	6.77	34	19.41	25.29	17.44
Walk	10	3.76	8	4.47	-	-
Car Total	60	22.57	34.38	13.63	101.04	56.26
Total	266	100				

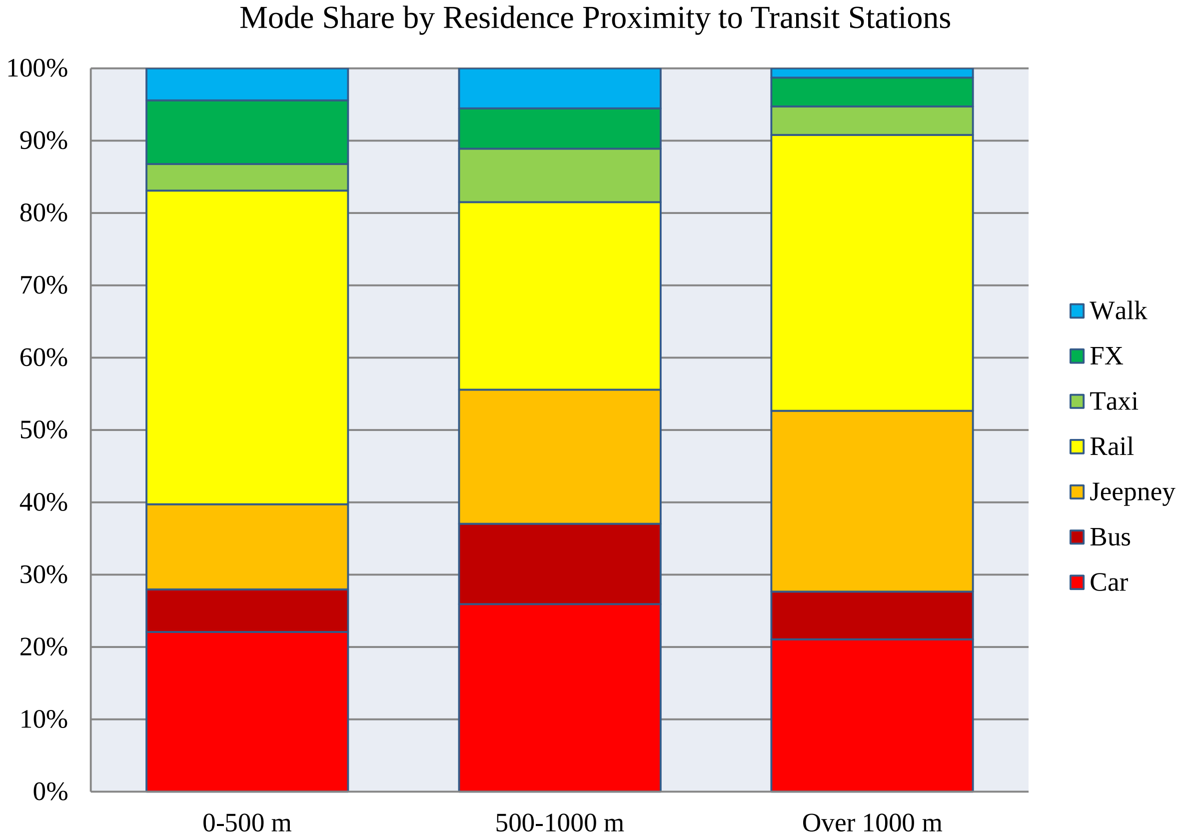

Figure 9. Mode Share of Individuals by Residence Proximity to Transit Stations

The mode share of the respondents was divided into their proximity to the rail transit stations, being 0 to 500 meters, 500 to 1000 meters, and over 1000 meters. The trend is to have lower share of rail users with a higher proximity of residence to the transit station. In the sample, rail users are dominant having their residence not more than 500 meters away from a transit station, as expected the commuters using rail decreased when the distance increased until 1000 meters. Having the trend in place, surprisingly there were a lot of commuters using rail residing more than 1000 meters. This may be due to the incapability of the other public modes to efficiently transport commuters to their destination. Other public modes of transport in Metro Manila for instance, jeepneys, buses, and FX's, have fixed routes to serve and may not access directly from respondents' residence location. Whether the lines of public bus and jeepneys do not coincide with their workplace, an expensive taxi ride is too much for their commute, or the mere traffic congestion problem exists as factors to their mode choice.

Meanwhile, other public modes have a relatively steady increase and decrease in the mode share. Bus and taxi users increase between residences from 500 to 1000 meters away from a rail transit station, but decreases as the proximity gets higher. On the other hand, jeepney and FX users have an inverse proportion relationship. Jeepney users increase as the rail transit stations are farther away from commuters' residence, while FX users decrease. The overall use of public transportation in all areas is interestingly similar.

The car users are quite the same for all the distances from residence to transit station, although car share are higher within a distance of 500 to 1000 meters. The car share determines that prominent car users are unlikely to use public transportation as their main mode of transport but more likely as an alternative.

5. CONCLUSION AND FUTURE WORK

The preliminary findings in this paper show the low response of commuters to the survey. The number of respondents can incorporate some certain rail transit station only due to response abundance. There was a high amount of commuters using urban rail transit in Metro Manila. This indicates the significance of having the urban rail transit as the main mode of transport, for most respondents of the survey. These rail transit users are mostly residing near the rail transit stations and most of them are students renting condominiums to accommodate them to their schools or universities. The premise of people having residences near rail transit stations, who will utilize the transit more, was found out to be true. However, student respondents may not have strong relative reasoning regarding TOD, because of their school or university location influence on their residential preference. Moreover, some automobile users also have condominium residences near rail transit stations. It implies that even a car user may choose to take the transit due to economic reasons.

Having a residence near a rail transit station is convenient for commute purposes. This implies to commuters without car ownership. The premise is that they are more likely to reside near transit stations because they utilize it, but the results found out that more share of car users are in the range of condominium residences that are 1000 meters radially away from the transit station. This is a result of some land use factors affecting the travel behavior of commuters. A denser land use has a higher property value so it only means that there is a high rate of rent for condominium residences.

The broadening of this study includes the final data collection with a new set of online questionnaire survey which was constructed based on the restrictions evident on the preliminary online questionnaire survey. The estimation of the logistic regression parameters will also be measured to fully understand how travel behavior of people residing in condominium residences near rail transit station is affected by their socio-economic characteristics. Also, the effects of the land use characteristics will be further analyzed.

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