Analyzing the Effects of Socioeconomic and Land Use Factors on Mode Choice Behaviors of Yangon City

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Abstract: Urban structure is a framework of housing, employment and developments which combined with socioeconomic factors. Urban expansion, population growth, and road network development have resulted in a structural shift toward urban sprawl, increasing commuters' dependence on private modes of transport. This study aims to analyze the influence of socioeconomic and land use factors on mode choice of transport in Yangon City by using multinomial logit (MNL) model. The socioeconomic factors (age, income, gender, car ownership and the house types) and the land use factors (CBD, inner urban ring, outer urban ring, old and new suburban) affect the choice of mode and the destination for their work. Disaggregate level individual, household, and journey to work data are used to determine the effect of socioeconomic and land use factors on mode choice. The results indicate that age, travel time, house types, car ownership and gender affect the commuters for their mode choice.

Keywords: mode choice, socioeconomic, land use, multinomial logit model (MNL), journey to work, Yangon.

1. INTRODUCTION

In many Asian cities, traffic congestion, energy consumption and environmental issues become the main issues which have been deploying the rapid economic growth since the last few decades. Transportation system plays as a major role in the economic development of a city (Wong and Lin, 2011). In the late 1800s and early 1900s, using public transport allowed more dispersed and segregated land use. Although outer suburbs provided a quiet neighborhood for residents, suburbanization had several negative effects such as increase in car use, traffic noise, transport fuel consumption and local and global air emissions (Newton, 1997). As demand for mobility increases with the development and income, the increase in private car purchasing cause the traffic congestion problems more severe.

Planning for transport is closely related to land use planning and urban development. Urban planning can create opportunities to use viable alternatives to the private car. Conversely, it can encourage greater car reliance. Therefore, careful urban planning increases transport advantages and reduces its environmental, social and economic disadvantages; and without land planning integration, achieving transport sustainability is impossible. Accelerated industrialization has led to higher growth rates, increased income and high demand for mobility. The increasing number of vehicles causes congestion and environmental problems that lead to disrupted traffic conditions like delay, accidents which cause huge economic loss every year. Urban expansion, population growth, and road network development have resulted in a structural shift toward urban sprawl, increasing commuters' dependence on private modes of transport.

The choice of transport mode is probably one of the most important classic models in transport planning. Inducing the users of private modes to public transport modes seems to be a solution though it is not easily attainable given the comfort factor for public transport facilities. In order to lighten such deteriorating transportation conditions, the studies to understand the relationship between mode choice and various factors affecting it are needed to be made. The socioeconomic make-up of the traveler, along with the distribution of land use, will significantly affect the mode choice for short and long distance trips.

Taking Yangon in this case, Yangon is not only the former capital city of Myanmar, but also the largest economic center in Myanmar with about 5.7 million people in the area of 1500 km^2 (Inaba and Kato, 2017). Three new satellite towns South Oakkalapa, North Oakkalapa and Thaketa were built as part of a slum clearance program. In 1989, the new township North and south Dagon and Hlaingtharyar townships were constructed. Since then, Yangon City has become a cross pattern, having North and South Dagon and Hlaingtharyar as east-west axis, CBD and Htaukkyant as North-South axis. Various governmental departments of Yangon City have been cooperated in the development of industry zones. Therefore, many people from rural areas migrate to Yangon City for their better life and income.

Besides the rapid population growth, number of car registration are also increased after 2011 due to car import policy changes. The number of cars doubled from 160,000 by the end of FY2011 to 320,000 by April 2015 (Asian Development Bank, 2017). Due to the economic growth and car import policy changes in 2010, Yangon City becomes rapid urbanization and motorization. The process of rapid urbanization in Yangon has resulted into pressure on urban land use as well as urban utilities and services. Due to the poor linkage between transit systems and inadequate service of public transportation, people prefer to use taxi and private car rather than public transportation. Bus services have been steadily losing customers at a rate of 10% a year, so that volumes as of 2015 are only half of those in 2007.

The Yangon City Development Committee (YCDC) estimated that in 2007, even at peak hours, vehicle speed reached 30 kilometers per hour (km/h), which is in the range of LOS (level of service) C (Transportation Research Board, 2010). The vehicle can travel with a stable flow and acceptable delay in this condition. But the vehicle by 2015, the speed may have dropped to 10-15 km/h. In 2013, when the Yangon urban transport master plan was prepared, congestion was only during peak hours at a few intersections. By 2015, congestion had spread beyond traditional peak hours in many arterial streets (Asian Development Bank, 2017). If the current population and vehicle ownership trends continue over the next 2-10 years, the strain on the transport infrastructure will be substantial. Therefore, it is necessary to understand the factors that influence the mode choice of transport in Yangon City.

This study aims to identify the mode choice behaviors of commuters based on the socioeconomic and land use factors. The main focus of this study is to determine how mode choice differs between different zones and between different social groups. Based on this analysis, it is understood which factors influence the mode choice behaviors of Yangon City. Based on these findings, the transportation planners can find the solutions or policy implications such as upgrading bus service, improving the rail transit or reducing private car usage by parking regulations to attract commuters from the private vehicles usage to public transportation.

The structure of this paper is organized as follows: related research works are presented in Section II and the background of the study area is described in section III. The method of analysis is presented in Section IV while the mode choice behaviors of Yangon City is presented in Section V. The results of this study are discussed in Section VI. Finally, conclusion and future work are presented in Section VII.

2. PREVIOUS STUDIES

Mode choice of commuters is influenced by a whole panorama of social, economic, cultural, and environmental factors like travel time, travel cost, number and ease of transfers, comfort, etc. Over the years' mode choice models have been dealing with the general range of tradeoffs individuals are willing to make these factors (Ben-Akiva and Lerman, 1985; Koppleman and Wen, 2000).

Researchers have started assessing sustainable development in terms of urban growth and conversion of cities' growth and function using design tools (e.g. compact urban form (polycentric form) and mixed land use) to reduce the likelihood of private mode use (Mirmoghtadaee, 2012; Badoe and Miller, 2000). Higher densities and mixed land use can resist residents to increase their number of activities in a single trip made on foot (Cervero, 1989). Mixed land use positively affects access to activities and lowers trip distances so that density alone cannot fix the issue of private mode use. A study in Toronto, Canada, identified that the distance to the central distinct business (CBD) was significant in terms of the differences in daily private mode trip lengths, and that was more important than densities.

Gordan and Richardson (2007) argue that land-use factors are less important than socioeconomic conditions, with factors such as income significantly affecting travel patterns. The increased suburbanization of the labor force, combined with the relationship between housing and jobs located in suburban areas, has decreased the distance of trips (Gordon et.al, 1989). Therefore, it is important to acknowledge and assess the relationship between land use and socioeconomic factors to improve traffic problems. The socioeconomic makeup of the traveler, along with the distribution of land use, will significantly affect the mode choice for both short- and long distance trips (Limtanakool et.al, 2006).

Zenina et.al, 2011 investigated the performance of mode choice with socioeconomic and demographic variables, travel characteristics and travel influence conditions by using classification methods such as decision trees, discriminant analysis and multinomial logit model. Another study indicates that the mode choice behavior of commuter is mainly influenced by the urban sprawl as the urbanization increase the travel distance and dependence on private vehicles (Alqhatani et.al, 2013). Cheng et.al, 2014 also applied the knowledge discovery technique of rough sets theory to model travel mode choice incorporating household and individual sociodemographic and travel information and to identify the significance of each attribute. From this research, it was found that the most significant condition attributes identified to determine travel mode choices are gender, distance, household annual income and occupation.

Stead and Marshal, 2001 suggested that the inclusion of socioeconomic factors is vital, because they are more influential than land-use characteristics in mode choice. This was disputed by Chan and McKnight, who suggested that their effect is comparable. Various researchers have shown that income and car ownership variables can function as determinants of transport and mode choice. Kunert and Lipps, 2005 highlighted the place of socioeconomic variables in industrial areas where the majority of households have car ownership. As such, in these situations, demographic factors such as age, gender, household size, as well as composition of a household and life cycle, may be important determinants of mode choice, especially in developed countries.

3. STUDY AREA

Yangon City, with a population of 5.7 million, is not only the former capital city but also the largest economic center in the Republic of the Union of Myanmar. Yangon region comprises

with 45 townships and they can be classified as CBD areas, inner and outer city areas, old suburbs areas, new suburb areas and periphery areas. But the study area is taken at only 33 townships, which are under the control of Yangon City Development Committee (YCDC). Figure 1 illustrates the townships' location which are taken as the area of interest in this study.

The central business district (CBD) of Yangon City is located at the southern part of the city, which is adjacent to the confluence of the Yangon River and Bago River. As the urban population increased, the urban area of Yangon City was extended from CBD to the northern part and consequently, transportation infrastructure such as highways, and rail networks, were developed to connect the CBD with the new parts of the city. The main residential areas are located in the north-east part of the city, from where many commuters travel to their workplaces in the CBD (Inaba and Kato, 2017).

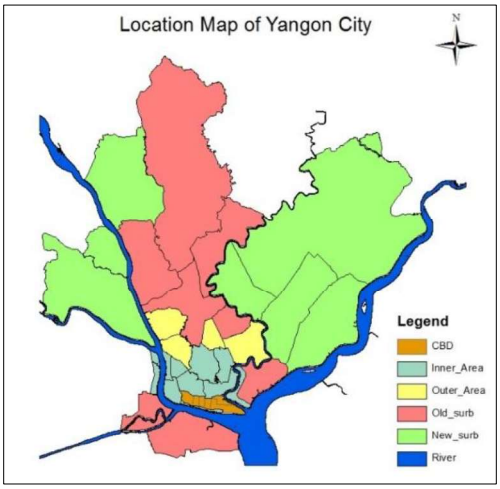

Figure 1. Location of study area

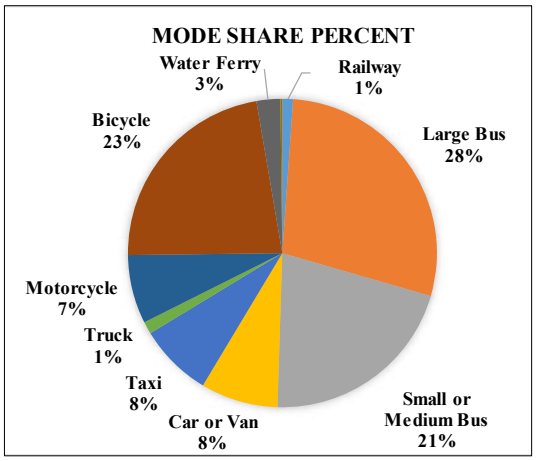

Figure 2. Mode share of Yangon City

Although there are eight modes of transport, the most common modes are private car, rail transit, taxi, bicycle and bus. Figure 2 describes the modes of transportation used in Yangon City and from that figure, it can be seen that the main mode of transportation in Yangon city is bus transit while the second highest mode is bicycle, which is only used for short trip in suburban areas. Motorcycles, bicycles and any slow moving vehicles are prohibited to use in some parts of CBD areas and on some main roads such as Pyay Road,

Kabaraye Pagoda Road, University Avenue Road, U Wisara Road and around Kandawgyi Road (Inaba and Kato, 2017).

The third most common mode of transport is private car and its usage is about 8 percent of the survey data. But there are only a few percent about 1 percent of the daily commuters use the rail transportation system which can transport many passengers with the lowest energy consumption. This is caused due to the poor service and weak linkage with other transportation system. Therefore, daily commuters mainly rely on bus system.

Two unique transportation policies have been introduced in Yangon City. The first one is the regulation of importing foreign second hand motorized vehicles and the other is the motorcycle ban in most of the city areas. Due to the car import policy changed in 2011 and the higher levels of economic development, the number of automobiles has increased rapidly.

As a result of the increased private car fleet and mismatch between residential and work places, most of the roads are congested with traffic especially on peak hours and traffic congestion that Yangon citizens have never experienced before arose in Yangon City. Therefore, the deteriorating urban transportation situation has become a serious concern in Yangon socially and environmentally.

4. METHOD OF ANALYSIS

Mode choice is that aspect of the demand analysis process that determines the number (or percentage) of trips between zones that are made by automobile and by transit. The selection of one mode or another is a complex process that depends on factors such as the traveler's income, the availability of transit service or auto ownership, and the relative advantages of each mode in terms of travel time, cost, comfort, convenience and safety. Mode choice models attempt to replicate the relevant characteristics of the traveler, the transportation system, and the trip itself, such that a realistic estimate of the number of trips by each mode for each zonal pair is obtained (Garber and Hoel, 2009).

Since public transportation is a vital transportation component in urban areas, mode choice calculations typically involve distinguishing trip interchanges as either auto or transit. Modeling of mode choice is done by means of discrete choice model and these modelling techniques are used in this research in order to identify individual mode choice. Discrete choice model is based on selecting the alternative that provides highest utility to the choice maker. Predicting the correct alternative for an individual is not always possible as many unobserved and situational variables come into play for decision making, thus the concept of random utility appeared. The probability of choosing one of the alternative options can be compared to the variance between its estimated utility and the estimated utility of other alternatives.

As a result, utility is understood to be a linear function that includes parameters that reflect aspects of the modes including travel time, cost and frequency as well as decision maker factors such as income, car ownership, age and occupation. Utilizing maximum likelihood methods allows for the creation of estimated utility function coefficients. Study on mode choice analysis benefits engineers, transportation planner and policy makers to study the existing transportation system and forecast the future needs of the proposed transportation system as an insight to preferences and requirements of commuters is obtained.

The multinomial logit model (MNL) is used in this study to investigate the factors which affect the mode choice behavior. These models are used to model relationships between a polytomous response variable and a set of regressor variables. MNL model is a simple form that suggests that random error terms are both identically and independently distributed, which is important when examining IID errors. It also allows the supposition of

equal preference among alternatives, such as the use of MNL and the introduction of service improvements to an existing mode, which then leads to a reduction in the probability of other existing modes that correspond to probabilities before changing. The IID can be used in both flexible and complex method forms as a way of minimizing this issue.

4.1 Modelling Framework

As Multinomial Logit model is the simplest and most popular practical discrete choice model (Orthuzar, 2011), the mode choice behavior for Yangon City was developed by using MNL model. The purpose of MNL is to estimate the function that determines the probabilities of the outcome. The model allows for the exploitation of the depth of individual information that is available at a disaggregate level. MNL is developed based on the random utility theory. The decision of the individual to mode choice is associated with the value of utility choice among alternatives that have maximum utility.

In the mode choice model, U_{nj} is the utility of individual n choosing alternative j, (in 1,2, 3,4), where j=1 for private car, 2 for public transportation, 3 for ferry and 4 for two wheel for an individual. The form of utility function is:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1}$$

Where U_{nj} is the utility of individual j for alternative n, V_{nj} is the deterministic part of the utility of the alternative n for individual j, $\mathcal{E}_{nj}$ is the random component of the utility of the alternative n for individual j.

$$V_{nj} = \alpha_j + \beta_{nj} x_n \tag{2}$$

Where, x_n is the vector of explanatory variables of individual n. α_j and β_{nj} are the parameter vectors to be estimated.

In this study, the explanatory variables are the age of traveler, income level, house types, occupation level, private vehicle ownership, and the gender type. Besides these variables, the location of the household is also taken as the explanatory variable in order to analyze its influence on mode choice behavior. MNL assumes that the random variable $\mathcal{E}_{nj}$ are independently and identically distributed and follows a Gumbel Distribution such that:

$$P_{ni} = \frac{\exp(V_{ni})}{\sum_j \exp(V_{nj})} \tag{3}$$

Where P_{ni} is the probability that household n chooses alternative i.

The discrete choice model is estimated by the maximum likelihood approach, and the software SPSS is used for estimation purposes. In order to investigate the relationship between traveler's characteristics and mode choice (private car, public transportation, ferry and two wheel) in the MNL model, private car usage is taken as the reference category, typically the first, last, or the value with the lowest or the highest frequency. The probability of each category is compared to the probability of the reference category.

4.2 Data Description

In order to model the mode choice of Yangon City, three components of JICA survey data are used. The first one is socioeconomic characteristics in which gender, age, occupation, income,

house type and vehicle ownership of travelers include. Then, the second is the land use characteristics which describe the location of their home whether they are situated in CBD or suburb areas. Lastly, trip characteristics which include travel distance, cost and travel time are taken as the third data component. These data components are provided from the survey compiled in the project for Comprehensive Urban Transport Plan of Greater Yangon (YUTRA) project organized for JICA in 2013. The YUTRA project team implemented eleven surveys aimed to capture the travel patterns of local people and the level of transportation, and it is the first dataset available to the city for transportation-related analysis, including transportation modeling and planning purposes.

Table 1. Number of Trips with respect to Trip Purposes

Trip Purpose	No. of Trips	Percentage	Explanation
Home	42393	46.1%	Go back Home
Work	11443	12.5%	Go to Working in Office/Shop
School	11130	12.1%	Go to School
Business	4913	5.3%	Business (Sales, Meetings, Visit other office, Carrying cargo)
Shopping	9472	10.3%	Shopping (not including seller, seller's car)
Social	3620	3.9%	Social activities
Leisure	2396	2.6%	Sightseeing, Recreation, Leisure
Driver	1896	2.1%	Driver for passengers
Others	4601	5.0%	Others
Total	91864		

Person trip survey was conducted by interviewing 44,988 individuals who made 91864 trips in 39 townships from February to August 2013. Table 1 describes the number of trips generated from 44,988 individuals with respect to the trip purposes. According to the person trip survey data, the highest percentage of the trip purpose can be found for home trip and the second highest purpose is work trip which possess about 13% of all trips. Although there are nine trip purposes in the survey, only the mode choice behavior of work trip in Yangon City is analyzed in this study.

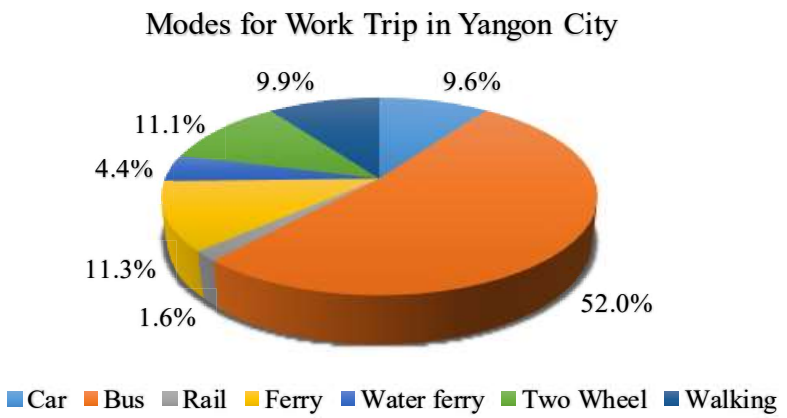

Figure 3. Modes for Work Trip in Yangon City

Among 91864 trips of various purposes, there are about 11450 work trips in 39

townships. But as the study area is considered for only 33 townships which are under the control of YCDC, only 7964 trips for work are taken to analyze the mode choice behavior of travelers. In this section, the alternative modes of transport for work trips are discussed with particular reference to the nature of Yangon City. In the study area, the main mode of transportation system is the bus transit and currently seven alternative modes are used which are passenger car, bus, rail, ferry, water ferry, two wheel and walking. A summary of the mode choices is presented in Figure 3.

From Figure 3, it is found that over 50% of people use bus transit for their journey to work. Unlike the other countries, the rail transit, which is the mass transit system in Yangon, has the lowest percentage of usage. About 9.6% of people use passenger car while about 10% of people go to work by walking. In Yangon City, many governmental offices and company offices provide ferry service to their staffs and about 11% of people use ferry service. People living in the suburban areas own bicycle and motorcycles and therefore in that areas using two wheel modes is found. Over 11% of people use two wheel modes as their mode of transport.

In order to investigate the mode choice behavior of Yangon City, the modes of transport used for work trips in Yangon City are categorized into four groups, namely, private car, public transportation, two-wheel and ferry service. Buses, rail and water ferry are considered as the public transportation while walking is excluded from the mode of transportation. According to the availability of data, the variables used in the MNL models are illustrated in Table 2. Eight socioeconomic components, one land use component and three trip components are collected to investigate the relationship with mode choice of people in Yangon City. Since the number of trips and selection of mode are related to the occupation, income level, vehicle ownership, travel time, travel cost and distance between origin and destination, these factors need to be considered.

Table 2. Explanation of the Variables

Type of Variables	Variable Name	Notation	Definition
Dependent Variable	Mode Choice	Mode	
	Car	1	Car Mode
	Public Transportation	2	Buses, Rail and Water Ferry Mode
	Ferry	3	Ferry Service provided from Offices/ companies
	Two Wheel	4	Motorcycle and Bicycle Mode
Independent Variables	Age Group	Age_Group	
	Below 18	1	1 if Commuter's age is below 18 years old
	19-60	2	2 if Commuter's age is between 19 and 60 years old
	above 60	3	3 if Commuter's age is above 60 years old
	House Type	House_Type	
	Apartment	1	1 if commuter's house is apartment and condominium.
	Detached	2	2 if commuter's house is detached.
	Timber	3	3 if commuter's house is timber building.
	Attached & Barracks	4	4 if commuter's house is attached and barracks.

Table 2. Explanation of the Variables (Contd)

Type of Variables	Variable Name	Notation	Definition
Independent Variables	Occupation	Occupation_Level	
	White Collar	1	1 if commuter is white collar staff.
	Blue Collar	2	2 if commuter is blue collar staff.
	Business	3	3 if commuter is business person.
	Income	Income_Level	
	Low Income	1	1 if commuter's income is below 150000
	Medium income	2	2 if commuter's income is 150000-500000
	High Income	3	3 if commuter's income is above 500000
	Region	Region_Code	
	CBD	1	1 if commuter's house is located in CBD areas.
	Inner	2	2 if commuter's house is located in inner ring areas.
	Outer	3	3 if commuter's house is located in outer ring areas.
	Old Suburb	4	4 if commuter's house is located in old suburb areas.
	New Suburb	5	5 if commuter's house is located in new suburb areas.
	Gender	Gender	
	Male	1	1 if commuter is male.
	Female	2	2 if commuter is female.
	Travel Cost	Travel_Cost	
	No Cost	1	1 if commuter cost no out of pocket cost for one trip.
	Below 200 Kyats	2	2 if commuter cost below 200 kyats for one trip.
	200-500 Kyats	3	3 if commuter cost 200 to 500 kyats for one trip.
	Above 500 Kyats	4	4 if commuter cost above 500 kyats for one trip.
	Travel Time	Travel_Time	
	Below 15 min	1	1 if commuter's travel time is below 15 minutes.
	16-30 mins	2	2 if commuter's travel time is between 16 to 30 minutes.
	31-45 mins	3	3 if commuter's travel time is between 31 to 45 minutes.
	46-60 mins	4	4 if commuter's travel time is between 46 to 60 minutes.
	above 60 mins	5	5 if commuter's travel time is above 60 minutes.
	Travel Distance	Network_Dist(km)	Commuter's travel distance in kilometers.
	Motorcycle Ownership	Ownedmotorcycle	Number of motorcycles that commuter has.
	Car Ownership	OwnedCar	Number of cars that commuter has.
	Other Vehicles Ownership	OwnedVehicle	Number of cars that commuter has.
	Household Size	Household_size	Number of people in commuter's family.

5. MODE CHOICE BEHAVIORS OF YANGON CITY

Based on three datasets, the mode choice behavior of Yangon City is studied. The choices of modes according to age group, household income level, house type, occupation and regions are discussed. After that the average travel distance, the travel time and cost for the trip based on different modes are presented.

5.1 Influence of Socioeconomic Characteristics on Mode Choice Behavior

Table 3 describes the behavior of mode choice based on socioeconomics and land use characteristics.

Table 3. Socioeconomic and Land Use Characteristics on Mode Choice Behavior

Characteristics	Level	Car	Bus	Rail	Ferry	Water ferry	Two Wheel	Walking
Age	Below18	1.0%	42.2%	2.3%	18.5%	15.3%	11.0%	9.7%
	19-60	9.5%	52.9%	1.6%	11.2%	4.0%	11.1%	9.7%
	above60	25.6%	37.6%	2.6%	5.1%	3.4%	11.5%	14.1%
Occupation	White Collar	13.6%	58.6%	1.0%	12.7%	1.6%	4.2%	8.3%
	Blue Collar	6.1%	51.3%	1.6%	13.5%	4.8%	14.3%	8.4%
	Business	16.4%	45.1%	2.8%	1.4%	7.3%	9.8%	17.2%
Income level	Refused to answer	16.7%	55.3%	1.5%	7.3%	0.2%	5.3%	13.6%
	Low	3.8%	50.2%	2.3%	10.5%	7.9%	14.3%	11.0%
	Medium	8.5%	53.6%	1.6%	12.0%	3.8%	11.2%	9.3%
	High	28.2%	45.1%	.4%	11.1%	1.9%	5.3%	8.1%
House Types	Condominium	38.5%	35.9%	5.1%	7.7%	0.0%	5.1%	7.7%
	Apartment	19.1%	52.8%	1.6%	8.1%	.4%	3.3%	14.7%
	Detached	17.5%	54.1%	.9%	12.4%	.7%	8.5%	5.8%
	TImber	4.2%	52.0%	1.8%	11.9%	6.9%	14.0%	9.1%
	Attached and Barrack	9.4%	43.1%	3.1%	9.7%	3.4%	11.4%	19.9%
Origin Region	CBD	22.4%	44.6%	.5%	6.4%	.9%	2.8%	22.4%
	Inner	16.6%	49.2%	1.4%	7.5%	7.9%	3.3%	14.2%
	Outer	15.7%	49.8%	3.1%	9.8%	0.0%	8.6%	13.0%
	Old Suburb	6.4%	53.6%	1.9%	12.1%	7.4%	11.9%	6.8%
	New Suburb	3.1%	55.0%	.9%	14.8%	.2%	19.2%	6.7%

The age of people in Yangon City is categorized into three groups; the first group is below 18 years old group, the second group is between 19 years old and 60 years old group and the last group is the age above 60 years old. In the first group, the highest mode usage is bus transit followed by the ferry usages which are provided from offices and industries. The least usage is the passenger car and there are only a few users of rail transit.

In the middle age group, the highest mode choice is the bus transit like the first group. But in that group, the usage of passenger car increases and there is no significant difference between ferry, two wheel and walking. In this group, the usage of water ferry is lower than the first group while there is also a little usage of rail transit. In that age group, about 60% of people are blue collar staff and the others are white collar staff and own business people.

In the third group, about 57% of people are white collar staff and the others are blue

collar staff. Like the former two groups, the highest mode in this group is the bus transit but the second highest mode is the passenger car usage. Most of the elders prefer to use passenger car and bus as they can give a better safety measures. In Myanmar, most of the people who are over 60 years old are the retired people from their jobs and therefore, in that group, the usage of ferry which is provided from the offices are low. Most of the people who work above 60 years old are the own business persons and white collar staffs. The walking mode in above 60 age group has the highest percentage in compared with other modes.

Three types of occupation which are white collar staff, blue collar staff and own business categories are considered in this study due to the availability of data. Legislator, senior officials, managers, professionals, technical and associate professionals are classified as white-collar staffs. Clerical workers, service workers, shop and market workers, farmers, forestry workers, fishermen, craft and related trade workers, machine operators, laborers, unskilled workers and armed forced occupation are classified as blue collar staff. The proprietors, shop keepers, street vender and day worker are taken as the own business category. The choice of transport mode according to the occupation level is clearly seen in Table 3.

The highest usage of passenger car is found in the own business category while the highest usage of bus is in the white collar staff category. The usage of motorcycle and bike is the highest in the blue collar staff category. The usage of ferry is nearly the same in both white and blue collar staff categories but it is the lowest percentage in own business category. There are only a few percentages of rail users in all occupation categories. There are 4.8% and 7.4% of water ferry users in blue collar staff and own business group although there is 1.7% of water ferry users in white collar staff.

The mode choice of a person depends on his income and therefore, the mode choice behavior according to the income level is discussed in this section. Although high household income level group has the lowest bus transport usage in compared with other group, it has the highest passenger car usage. It is obvious that the high income people prefer to use passenger car rather than public transportation. Among the groups, the group who refused to mention their income has the highest percentage of bus transit and walking mode.

The second most usage of mode in low income group is the two wheel which are motorcycle and bike. In this group, the usage of passenger car for work trip has the lowest percentage. The water ferry usage in this group is higher than any other group while the usage of ferry and walking do not have significant difference with other group. In the medium income group, the highest mode usage is the public transportation which is followed by the ferry mode. The passenger car usage in this group is higher than the low income group but lower than the remaining two groups. There are over 10% of people in this group use two wheel and walking mode for their job trips.

In the high income level group, the usage of passenger car is about twice than the usage in other groups. The third highest usage in this group is the use of ferry provided from the respective offices or companies. The lowest mode usage in this group is the rail transit which is followed by the water ferry. From this study, it is clearly seen that the mode choice of a person is strongly correlated with the income level of a household.

Most of the apartments and houses in CBD and inner areas do not have parking lots and the house types become an important factor to own a private motor car. The effect of house types upon the mode choice is analyzed in this section and the house types versus mode choice is shown in Table 3. The house type which has the highest percentage of passenger car usage is the condominium. In condominiums, they have adequate parking lots for the residents.

Among the five house types, most of the people living in the apartment and detached

house use bus transit. About 20% of people living in these two house types use passenger car for their job trips while below 1% of people use water ferry. The usage of rail transit in these house types are below 2%. In apartment house type, the usage of ferry is lower than the walking while the detached house type shows the opposite results.

The main mode used by the people living in timber house type is the bus transit and the second most used mode is two wheels. Over 10% of people use ferry as the mode for job trip while about 10% of people walk to their jobs. Only a few percentages of people which are under 5% use rail and passenger car usage. The walking mode in the attached and barrack house type has the highest percentage among house types. Based on this analysis, it can be concluded that the people living in the house type with available parking space tend to own car and use passenger car as their main mode of transportation.

Another factor which can influence the mode choice behavior of Yangon City is the region of the home locate. As mentioned before, Yangon City is composed of five regions which are CBD, Inner Urban Ring, Outer Urban Ring, Old suburb and New Suburb areas. In CBD areas, many commercial places, governmental offices, famous markets and shopping centers and recreational places are located. But in new suburban areas, the main land use is the residential and industrial areas.

The highest percentage of bus transit is found in the new suburb region while the lowest percent is seen in others region which is beyond Yangon City areas. The percentage of passenger car usage decreases when the distance between CBD and the region increases. Among the five regions, new suburb region has the highest usage of two wheeled vehicles and ferry mode. On the other hand, CBD areas have the highest passenger car usage and the walking mode.

About 10% of people living in inner urban ring and old suburb areas use water ferry. Some townships in these regions are close to the port or jetty and the main mode to travel from Data and Seikkyiganaungto to Yangon City is the usage of water ferry system. About 2% of people in inner and old suburb areas use rail transit while there is just only below 1% of people in CBD and New suburb areas use rail transit. But about 4% of people in outer urban ring areas use rail transit.

According to this analysis, it was found that the main mode for the people living in the suburban regions is the bus transit which is affordable by the low income household people. Unlike suburban areas, the people living in CBD and inner areas use different modes of transportation due to the availability and easy accessibility of various modes.

5.2 Mode Choice by Travel Characteristics

In this section, the average distance, travel cost and travel time with respective to the modes are discussed. Figure 4 shows the average travel distance for each mode. The longest travel distance is seen in rail transit user. Yangon Circular Rail is the local commuter rail network that operates the Yangon urban areas. It is the loop system which has 39 stations that span 45.9 kilometers and connects suburban areas to the city areas. Therefore, most of the people who live in outer ring areas and old suburban areas use rail transit for their long trips. As the roads are congested with the vehicles, usage of rail transit for a long trip can save time and cost. But the rail transit only has a loop network and there is no linkage between rail and bus transit. Therefore, the rail transit can be served the people living in the vicinity of the stations.

The travel distances for bus and ferry are 9.5 km and 9.3 km respectively. The main mode of transport for people in Yangon City is the bus transit. In Yangon City, the people from the Old and New Suburban areas come to CBD and Inner Urban Ring Areas by using buses while some people are travelled by using the ferry provided from their respective

companies or offices. The passenger car or taxi users travelled about 7.5 km for their jobs while the people who use water ferry have the travel distance of about 4.5 km. The average travel distance for walking is about 2.5 km and for two-wheel mode is about 5.4 km. Based on the study, it can be understood that, the rail transit has the longest travel distance which is about 12 km and the walking has the lowest travel distance.

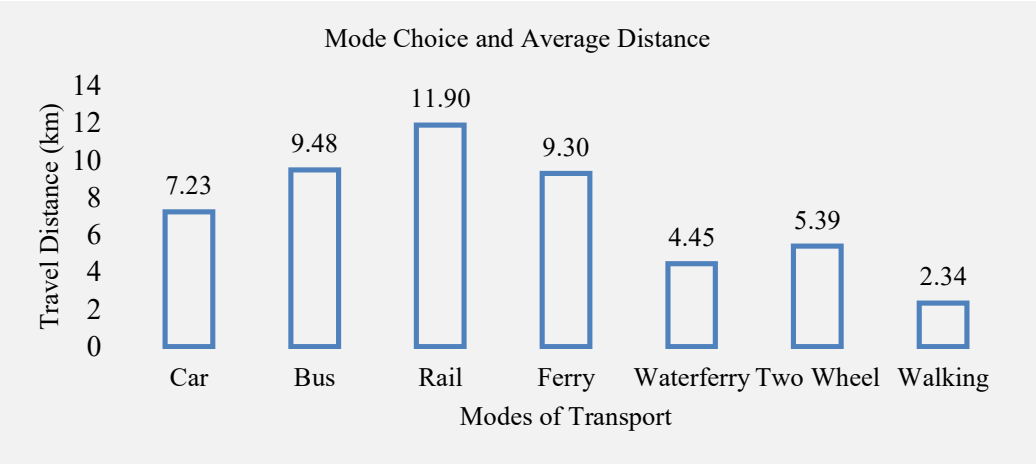

Figure 4. Average Travel Distance of Commuters by Each Mode

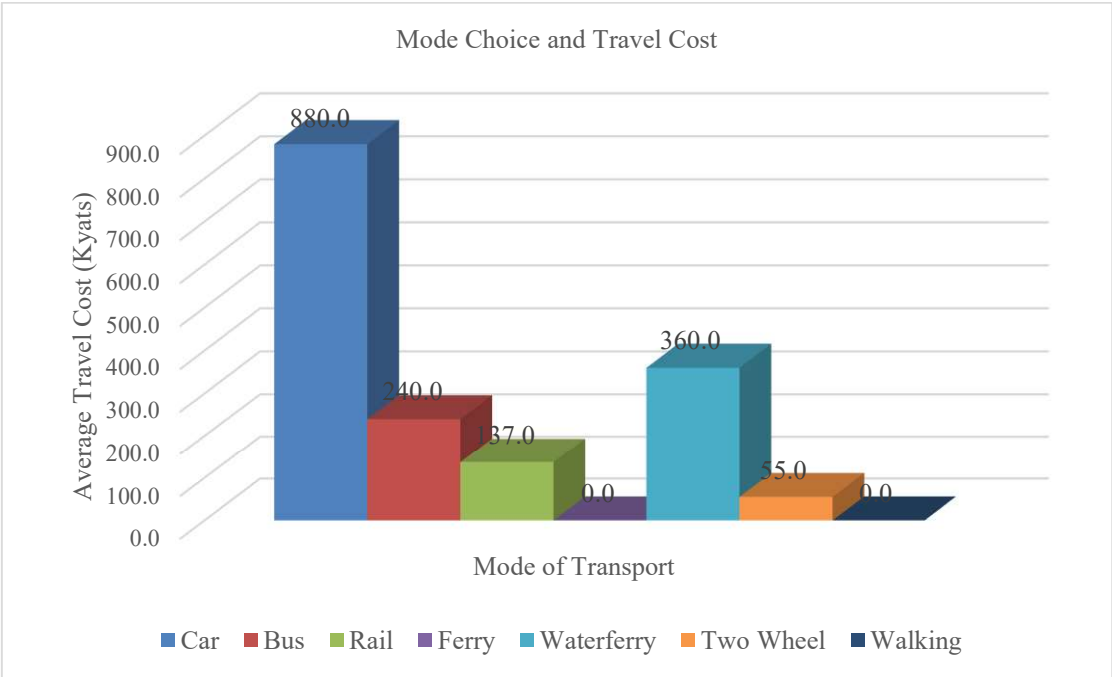

Figure 5. Average Travel Cost for Each Mode

Figure 5 describes the travel cost with respect to the different modes. The average cost for a work trip by using passenger car is about 900 kyats while the cost for bus is about 250 kyats. But there is no out of pocket cost for walking and ferry as ferry service is provided by the respective companies or offices for their staffs. The cost for motorcycle and bicycle is about 55 kyats and it can cost about 360 kyats if a person uses water ferry. The average travel cost for rail transit is about 140 kyats. According to this analysis, it is obvious that the average

travel cost for passenger car is the highest while the walking and ferries have no cost.

The average travel times by modes are mentioned in this section and the comparison of average travel time according to each mode are described in Figure 6. The longest average travel time among modes is found in rail transit which is followed by the bus transit. Walking has the shortest travel time which is about 18 minutes. The average travel time for work by passenger car takes about 40 minutes and travel time by ferry is about 50 minutes. As the motorcycle and bicycle usages are not allowed in city areas, they are only used for the intrazonal or short trip. Therefore, the travel time for them is about 24 minutes.

Based on this data analysis, it is found that the travel time for public transportation is about one hour while the others are just below 40 minutes. The average travel speed for public transportation system is only about 9 km per hour while the speed for passenger car and taxi is about 11 km per hour.

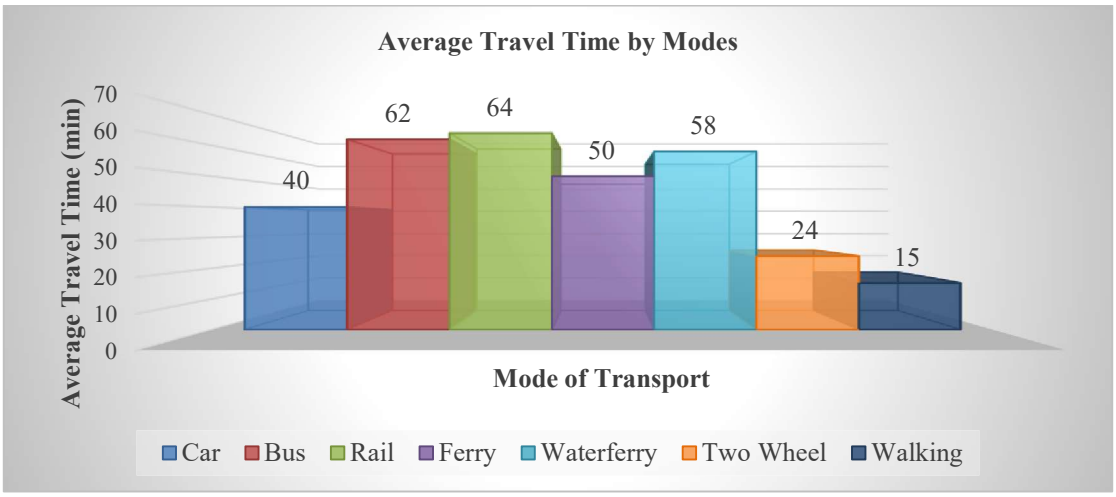

Figure 6. Average Travel Time Based on Mode Choice

The slow speed in both public and private transportation system occurs due to the traffic congestion problems in urban areas. Reduction in passenger car usage and encouraging the use of rail transit can be a solution to mitigate the traffic problem in Yangon City.

6. MODEL ESTIMATION RESULTS

In selecting the variables for this model, the backward elimination process of multinomial logit model was followed using SPSS version 23. All of reduced variables were selected using Likelihood Ratio (LR) Chi-Square test. The limitations of MNL approach are that there is an assumed equivalence between the different alternatives. The data applied in this model were based on the personal and land use criteria of each user, per household, with ultimate results from the MNL model. The parameters were identified at confident level greater than 95 percent.

The goodness of fit test is done in order to assess how well the model fits the data and in this test, two types of measure are provided. Table 4 describes the goodness of fit test for this multinomial logit model. If the Pearson Chi-square value is too high, it indicates a poor fit of the model. The first row, labelled Pearson, presents the Pearson Chi-square statistic. In this model, the Chi-square value is not too high. A statistically significant result (i.e., $p<0.05$) indicates that the model does not fit the data well. From Table 4, it can be seen that the

p-value from the Sig. column is 0.129 and therefore, it is not statistically significant. Based on this measure, the model fits the data well.

Table 4. Goodness-of-Fit

	Chi-square	df	Sig.
Pearson	589.792	552	0.129
Deviance	514.075	552	0.875

Table 5. Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	4546.779			
Final	1246.227	3300.552	33	.000

From Table 5, it can be seen that *p*-value under "Sig." column is statistically significant, and this means that the full model predicts the dependent variable better than the intercept only model. The likelihood ratio test is based on deviance [-2 Log Likelihood (LL)] and the significance of the difference between the (-2LL) for the selected model minus likelihood ratio for a reduced model (intercept only) are shown in Table 4. A common use of the likelihood ratio test is to test this difference (it called chi-square model) dropping an interaction effect. If the chi-square model is significant, the interaction effect is contributing significantly to the full model and should be retained. The presence of a relationship between the response variable and combination of explanatory variables is based on the statistical significance of the final model chi-square. In this model, the p-value of the model chi-square (3300.552) was 0.000, less than the level of significance 0.05. Then it is rejected the null hypothesis which states that there was no difference between the model without explanatory variables and the model with explanatory variables. The existence of a relationship between the explanatory variables and the response variable was supported.

Table 6. Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	1246.227[a]	.000	0	.
Owned Car	1743.994	497.767	3	.000
Gender	1646.670	400.443	3	.000
House type Groups	1492.962	246.735	9	.000
Age Group	1282.114	35.887	6	.000
Travel Time group	3060.660	1814.433	12	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

The likelihood ratio of the mode choice can be seen in Table 6. This table describes

which independent variables are statistically significant and the independent variables which are car ownership, house type, age and travel time are statistically significant in the mode choice model as they have p values which are less than 0.05. This table is mostly useful for nominal independent variables because it is the only table that considers the overall effect of a nominal variable.

The estimated parameters for mode choice model are shown in Table 7. In multinomial logit model, one dependent category is taken as the reference category and the probability of each category is compared to the probability of reference category. The multinomial logit model is an appropriate technique when the dependent variable is categorical and the explanatory variables are continuous or categorical. In this model, car mode is considered as the reference category. There are four categories which are car, public transportation, ferry and two-wheel mode. According to this model, it can be clearly understood that which factors affect the mode choice behaviors of commuters and the utility equations for each mode is shown in equations 3 to 5.

A total of 7964 person trip information is obtained from JICA survey (2014). After excluding some outliers and walking trips, about 6600 person trip data are used to analyze among 7964 person trips data. The estimated coefficients were interpreted as follow: a positive significant coefficient indicated that the tendency to use the public transportation is more than that of passenger car. Negative coefficient indicated that the tendency to use passenger car is more than that of public transportation.

Table 7. Estimated Parameters of Mode Choice in MNL Model

Variables	Mode								
	Public Transportation			Ferry			Two Wheel		
	Constant	Sig.	Odd Ratio	Constant	Sig.	Odd Ratio	Constant	Sig.	Odd Ratio
Intercept	3.083	0.000		1.004	0.028		-2.876	0.000	
OwnedCar	-1.847	0.000	0.158	-1.496	0.000	0.224	-2.052	0.000	0.128
Male	-0.814	0.000	0.443	-1.677	0.000	0.187	0.529	0.000	1.698
Apartment	-	-	-	-0.728	0.009	0.483	-1.192	0.000	0.304
Timber	0.73	0.001	2.075	0.786	0.002	2.194	1.408	0.000	4.088
Below 18	2.532	0.000	12.582	3.028	0.000	20.666	2.019	0.003	7.533
19-60	0.64	0.005	1.897	0.782	0.027	2.186	0.559	0.059	1.748
Travel Time <15 mins	-2.688	0.000	0.068	-1.743	0.000	0.175	2.951	0.000	19.116
Travel Time 15-30 mins	-1.903	0.000	0.149	-0.755	0.000	0.47	2.132	0.000	8.428
Travel Time 30-45 mins	-1.086	0.000	0.338	-	-	-	0.909	0.005	2.481
Travel Time 45-60 mins	-0.812	0.000	0.444	-	-	-	0.754	0.024	2.125

$$y_{\_PT} = 3.083 - 1.847\ \text{Owned Car} - 0.814\ \text{Male} + 0.73\ \text{Timber House} + 2.532\ (\text{Below } 18) + 0.64\ (19-60) - 2.688\ (< 15\ \text{min}) - 1.903\ (15-30\text{min}) - 1.086(30-45\text{min}) - 0.812(45-60\ \text{min}) \quad (3)$$

$$y_{\_Ferry} = 1.004 - 1.496\,\text{Owned Car} - 1.677\,\text{Male} - 0.728\,\text{Apartment} + 0.786\,\text{Timber House} + 3.028\,(\text{Below 18}) + 0.782\,(19-60) - 1.743\,(<15\,\text{min}) - 0.755\,(15-30\text{min}) \quad (4)$$

$$y_{\_Two\text{-}wheel} = -2.876 - 2.052\,\text{Owned Car} + 0.529\,\text{Male} - 1.192\,\text{Apartment} + 1.408\,\text{Timber House} + 2.019\,(\text{Below 18}) + 2.951\,(<15\,\text{min}) + 2.132\,(15-30\text{min}) + 0.909\,(30-45\text{min}) + 0.754\,(45-60\,\text{min}) \quad (5)$$

The above equations show the utility function for each mode and based on these functions, the probability of each mode can be calculated as equation (6) while the probability for private car which is taken as the reference category can be calculated as equation (7).

$$P(Y_i) = \frac{\exp(Y_i)}{1 + \exp(Y_{PT}) + \exp(Y_{Ferry}) + \exp(Y_{Two-Wheel})} \quad (6)$$

$$P(Y_{pc}) = 1 - (P(Y_{PT}) + P(Y_{Ferry}) + P(_{Two-Wheel}) \quad (7)$$

In this study, the dependent variable is the mode choice (private car, public transportation, two wheels and ferry service). Private car usage is considered as the reference category of the base category. A positively estimated coefficient implies an increase in the likelihood of choosing mode such as public transportation, ferry or two wheel. A negative estimated coefficient indicates that there is less likelihood of choosing public transportation, ferry or two wheel.

Based on the estimated results from Table 7, it was shown that predictor variables such as car ownership, gender, timber house, the age below 18 and 19-60 age groups and the travel time groups which are below 15 mins and 15-30 mins are statistically significant for all categories. However, the house type, apartment, variable is not statistically significant for public transportation mode while travel time groups- 30-45 mins and 45-60 mins- are not statistically significant for ferry mode.

First of all, the chance to use public transportation usage is compared to the passenger car usage which is the reference category. The gender, car ownership and the travel time variables have negative coefficients which means that these groups prefer to use passenger car usage than the public transportation. The men prefer to use passenger car rather than the public transportation. As a person owns a car or more, he/she would like to use passenger car mode more than using public transportation. As the passenger car saves time consuming and it does not have waiting time to depart as in public transportation, most of the people would like to use passenger car in order to save travel time. But the people living in the timber building prefer to use public transportation as public transportation is a type of mode with affordable cost for low income people. The younger people who are below 18 years old have tendency to use public transportation rather than the passenger car whose coefficient is about 2.532.

Also for the people whose age is between 19 to 60 years old, public transportation is a preferred mode in compared with using passenger car. The second mode choice model is ferry service which are provided from the offices and companies in order to transport the employees and staffs. In this case, the people living in the apartment prefer to use passenger car than the ferry provided from their respective offices as the coefficient of house type 1 has negative coefficient. But the people who live in timber building prefer to use ferry service.

Like the previous public transportation model, the people who owned a car or more would like to use passenger car more than ferry service. For a people with longer travel time prefer to use ferry service in compared with the passenger car. According to age, the younger people prefer to use ferry than the passenger car as it has a positive relationship with the ferry usage. But the male prefer to use passenger car than using ferry service as it has negative relationship with the ferry usage.

The last mode in this study is the two-wheel vehicles which are bicycle and motorbike. The people who owned car are less likely to use two-wheel vehicles in compared with the passenger car. Male would like to use two-wheel vehicles about 1.6 times than the female as shown Table 6. Although the people living in the apartment are less likely to use two-wheel, the people living in the timber buildings are more likely to use two-wheel vehicles. Younger aged people prefer to use two-wheel than the elder people. People would like to use two-wheel vehicles in order to reduce the travel time and the shorter the trips, the more prefer to use the two-wheel vehicles.

The results of this research have been gathered from a complex comparative study of mode choice. The dataset utilized to create the analysis was based on the 2014 Census and the JICA Survey data (2013). It was found that the mode choice of people mainly concerns with their car ownership, travel time, age and the house type. This study has a range of outcomes that could be useful for recommendations and practical application in Yangon City.

6. Conclusion

The results of this research have been gathered from a complex comparative study of mode choice. The mode choice study focused on the travel behaviors across land use, transport and socioeconomic criteria in Yangon City. The dataset utilized to create the analysis was based on the JICA survey data. Four types of transport mode are considered in this study, namely: private car, public transportation, ferry and two-wheel vehicles. Based on this model, it can be clearly seen that most of the people would like to use the private car for a shorter travel time.

As the public transportation has longer travel time in compared with private car, people prefer to use private vehicles to reduce their time wasted on roads. As a consequence, most of the roads are congested with the traffic in peak hours, which have negative impact on both public transportation and private car users. Another factor which significantly affects the usage of private car is the car ownership. It is clear that the person who has private car prefer to use his car to travel rather than choosing public transportation. The number of vehicles increased dramatically after the relaxation of car import policy in 2011. According to the statistics from the Road Transport Administration Department, the number of registered vehicles in 2015 is more than double the registration in 2011. Therefore, increasing number of car ownership is also an influenced factor to use the private car mode over public transportation.

The timber house type variables were identified as having a positive effect on decisions made by commuters to use public transportation instead of their cars. An increased travel time between work and home corresponds to a decreased capacity of household to use public transportation. The tendency of public transportation is increased with the increased number of younger age variables. An increased number of households in apartments and condominium corresponds to an increased usage of passenger car and the male prefer to use passenger car rather than the public transportation. Besides the increase in car ownership, due to the poor service and weakness in public transportation, many people in high income and medium income households would like to own and use passenger car rather than public transportation.

In order to change the mode of transport from the passenger car usage to public transportation, the models for modal shift need to be analyzed and based on the factors got from that model, the policies to reduce the passenger car usage can be developed.

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