

DEVELOPMENT AND APPLICATION OF TRAVEL MODE CHOICE MODELS FOR SCHOOL STUDENTS IN METRO MANILA

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Abstract

A sound understanding of determinants of travel mode choice is an efficient way to design proactive transportation policy and urban planning to encourage non-motorized mode trips in the metropolitan area. The thrust of this study is to develop and apply travel mode choice models for basic education school students in Metro Manila. The study used two different discrete choice models, i.e., multinomial logit (MNL) and multinomial probit (MNP), by taking account of socioeconomic characteristics and urban form attributes. The Person product-moment correlation coefficient function was applied to control co-linearity among explanatory variables. The correlation coefficients implied that household income, travel distance from home to school, and the presence of commuters were the potential factors for the development of travel mode choice models. The findings highlighted that school students with high income and the presence of commuters are most likely to travel by private mode. Respondents located close to schools have the highest likelihood to travel by non-motorized mode. Also, the MNL-based travel mode choice model was applied to simulate the percentage changes of the travel mode choice in response to changes in household income and travel distance.

Keywords: Travel mode choice, discrete choice analysis, school students, metro Manila

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Introduction

Metro Manila, the national capital region of the Philippines, is marked as the second most congested traffic metropolitan area in the southeastern region of Asia after Jakarta (Numbeo, 2018), and about 50% of the roads operate at a volume/capacity (V/C) ratio above 0.80 in the metropolis (ALMEC, 2014). Average travel time of one person trip was 1.17 hours in 2014, and it goes up to 1.33 hours in 2030 in case of no intervention from the government (ALMEC, 2014). Car trips increased by 15%, while public transport trips (Jeepneys and Buses) fell by 7% (ALMEC, 2014) from 1996 to 2012. In 2014, car trips accounted for 71.30% in terms of vehicles (ALMEC, 2014). The projected growth of private car usage is expected to saturate the roads. Okamura *et al.* (2013) mentioned that people tend to shift public transport modes to cars after having their own private cars. A sound understanding of determinants of commute mode choice decision can assist policymakers to design consistent, effective policies to suppress private car usage.

Some previous studies have been conducted to address the issues stated above in Metro Manila. Improvement of rail station accessibility and transfer terminals between urban rail transit and road public transport modes was expected to increase in public transport mode share (Okada *et al.*, 2003). Improvement of amenity and level of urban rail service also encourage rail transit mode usage (Okada *et al.*, 2003). De-Guzman and Dias (2005) studied the relationship between travel patterns and willingness to ride carpooling to increase the car load factor, and the result highlighted that operation cost became significant for further consideration, and the implementation of plate number coding scheme discouraged private vehicle dependency, thereby improving traffic flow. Accessibility of private car parking is associated with private car choice (De-Guzman and Dias, 2005). Gas price and in-vehicle travel time had a negative significant effect on private mode choice, but higher-income commuters were more likely to choose car (Fillone *et al.*, 2007).

Fillone *et al.* (2007) investigated the impact of gas price changes on travel mode choice, while Rith *et al.* (2018) simulated the impact of gas price increase on reduction in private car usage (vehicle kilometer traveled). 25% and 50% gas price increase would reduce the vehicle usage by 7.1% and 23%, respectively (Rith *et al.*, 2018). Expansion of some railway lines and development of new railway systems were found to improve traffic flow by attracting some passengers out of cars, reducing private vehicle-based travel distance, and improving travel time (Regidor *et al.*, 2017; Fillone *et al.*, 2007). Okamura *et al.* (2013) tried to understand the perception and behavioral intention of different lifestyle passengers to the service items of the dominant urban transit mode (i.e., Jeepney). The findings highlighted that respondents consider the Jeepney as a familiar, easy, and cheap public transport mode but a noisy, dirty, and dangerous transport mode. The passengers prefer Jeepney for short trip to for long trip (Okamura *et al.*, 2013). Roxas *et al.* (2018) empirically showed that an increase in the level of comfort, reliability, and speed of public transport mode could attract commuters out of cars. However, all the refereed works have focused on adult commuters, while the travel mode choice among basic education school students has remained largely unexplored in Metro Manila.

Correspondingly, this study intends to develop and apply the travel mode choice models of school students taking account of socioeconomic characteristics and urban form attributes in Metro Manila. The primary sample data of 1,211 respondents studying at kindergarten, primary, and secondary schools were gathered through various areas in 2017. Two discrete choice regressions, i.e., multinomial logit (MNL) and multinomial probit (MNP), were employed to develop and compare the travel mode choice models. The best-fitted model was then applied to simulate percentage changes in travel mode choice in response to varied some explanatory variables. The empirical findings of the study are highly expected to provide innovative perspectives

and assist the local policymakers to design consistent transport policy to encourage non-motorized mode choice among basic school students to achieve sustainable urbanism and mobility.

The remainder of the paper is organized as the following. Section 2 overviews the data source and methodology. Section 3 provides the empirical results and applies the developed models. Section 4 concludes the findings and gives a direction for future research.

Data Source and Methodology

Data Source

Metro Manila consists of sixteen cities and one municipality (Figure 1). The metropolitan area is home to 12,877 thousand people, and 26.54% of those are 5-19 years old (PSA, 2017). The total number of kindergarten, primary, and secondary schools located in the national capital region is 3,666, including private and public schools (PSA, 2017). A simple random sampling technique was carried out to gather the data sample of students studying at basic education (K-12) schools (i.e., kindergarten, primary, and secondary schools) through various traffic analysis zones (TAZs) within the metropolis in 2017 because the baseline data of travel mode choice among the K-12 school students had not been known. Moreover, this technique provides the respondents with an equal

probability of being selected. The guardians of the children answered the questionnaire instead of the children, and the questionnaire form is based on the revealed preference (RP) approach. After data collection and removal of incomplete questionnaire forms, the sample data consist of 1,211 respondents. The sample size provides a confidence level of 95% and a margin of error of 2.82% if a standard deviation is assumed to be 50% (a typical value), based on the Cochran approach. The commute mode choices from home to school were classified into three main categories: non-motorized mode (i.e., walking and cycling), public transport mode (i.e., urban rail transit mode, bus, school bus/van, Jeepney, tricycle, and pedicab), and private mode (i.e., motorcycle and car). For the private mode, it means that the students are escorted by their household adult member. The percentage share of each transport mode is tabulated in Table 1. The public transport mode account for the largest share (52.93%), followed by the non-motorized mode (41.62%), and the smallest percentage share of the private mode (5.37%).

Table 1. Distribution of the travel mode choices among K-12 school students

Mode	Description	Counts	% share
Non-motorized	Walking and cycling	505	41.62
Public	Train, Jeepney, bus, tricycle, and Pedicab	641	52.93
Private	Motorcycle and car	65	5.37

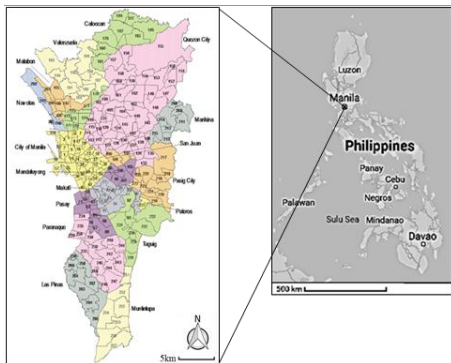


Figure 1. The map of Metro Manila (adopted from MUCEP, 2015)

The descriptive statistics of the independent variables are presented in Table 2. The data of socioeconomic characteristics are obtained from the surveyed respondents, while the home and school address of the respondents are used to merge the secondary data of the urban form attributes. The distance from home to school was obtained using the Google Map to approximate the distance, while the distance from home to a central business district (CBD) and an urban train station was calculated using the CDXDistance2WP function of the

Table 2. Descriptive statistics of the independent variables

Variable	Description	Mean	SD	Min	Max
Socioeconomic					
Sex	1 = if male, and 0 = otherwise	0.487	0.500	0.000	1.000
Age	Age of student (years)	12.572	3.652	4.000	21.000
Family size	No. of household members (persons)	4.514	1.324	2.000	11.000
Working adult	No. of working adults in a family (persons)	1.717	0.712	0.000	5.000
K-12 school children	No. of K-12 school children in a family	1.969	0.947	0.000	5.000
Household income	Monthly household income (10 ⁴ PHP/month)	5.658	5.048	0.250	30.000
No. of passengers	No. of commuters going to school (persons)	1.582	0.754	1.000	4.000
Urban form attributes					
Distance to school	Distance from home to school (km)	1.824	2.165	0.100	31.100
CBD	Distance from home to CBD (km)	4.849	2.424	0.361	19.088
Train station	Distance from home to train station (km)	0.417	0.465	0.093	5.606
Line density ^{a, b}	Road public transport line density (10 km/km ²)	2.416	2.447	0.000	15.422
Population density ^{a, b}	Population density (10 ⁴ persons/km ²)	4.348	1.637	0.197	10.647

a at Traffic Analysis Zone (TAZ) level

b adopted from MUCEP (2015)

CDXZipStream tool. This method is more accurate than the Euclidean and Manhattan methods.

Methodology

Selection of Explanatory Variables

As stated in section 1, the study intends to explore determinants of travel mode choice among K-12 students using the two different discrete choice models. After that, the developed models were applied to simulate percentage changes in mode choice for a given change in some explanatory variables of interest. The procedure of the study is illustrated in Figure 2. The correlation of each explanatory variable with each output variable was firstly calculated using the Person product-moment correlation function. Only the

explanatory variables having a moderate and high correlation with the output variables were considered for the development of travel mode choice models. Then, the correlation function was used to capture the correlation among the explanatory variables. If some explanatory variables are highly correlated with one another, we choose only one explanatory variable having the highest correlation with the output variables. This is a good way to control the multicollinearity problem among the explanatory variables because the high correlation among the explanatory variables might provoke insignificant factors to become significant and significant factors to appear insignificant. The correlation coefficient ρ is calculated using Equation 1 (Hensher *et al.*, 2005):

$$\rho = \frac{cov(X_1, X_2)}{\sigma_{X1} \sigma_{X2}} \quad (1)$$

Where $cov(X_1, X_2)$ is the covariance between variables X_1 and X_2 , and σ_{X1} and σ_{X2} are the standard deviations of random variables X_1 and X_2 , respectively.

Finally, the correlation function-based explanatory variables were selected for consideration of model development. The multinomial logit and probit regressions were

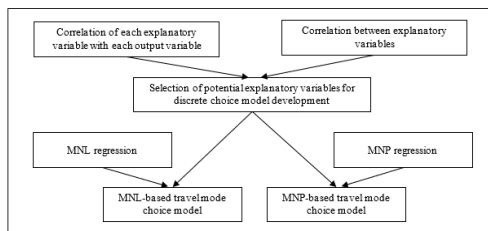


Figure 2. The procedure of travel mode choice model development

utilized for data modeling taking account of the selected explanatory variables.

Multinomial Logit (MNL) Regression

The utility function of an alternative made by a choice maker is written as Equation 2:

$$U_{nt} = \beta_t' x_{nt} + \varepsilon_{nt} \quad (2)$$

where x_{nt} is a column vector of explanatory variables including a constant, β_t is a column vector of the corresponding coefficients, and ε_{nt} is the unobserved term.

For the MNL regression, the unobserved component is assumed to be identically and independently distributed (IID) Type I Extreme-Value (McFadden, 1974), and the probability of an alternative made by a choice maker is written as Equation 3:

$$P_n(t) = \frac{\exp(\beta_t' x_{nt})}{\sum_T \exp(\beta_T' x_{nT})} \quad (3)$$

where T (T=1,2,...) is the index representing alternatives and $t \in T$.

The MNL model has been widely applied because it takes a closed form, and it is simple in the interpretation of the model estimation results. Furthermore, it provides some merits, such as 1) it represents systematic taste variation that relates to observed characteristics of the decision-maker, 2) the logit model suggests proportional substitution across alternatives, and 3) the MNL model can capture the dynamics of repeated choice only if the unobserved factors are independent over time (Train, 2003).

Multinomial Probit (MNP) Regression

Even though the MNL model provides some advantages, there are also some limitations to the logit model (Train, 2003). First, the logit model cannot represent random taste variation. Second, the logit model imposes restrictive substitution patterns in view of the independence from irrelevant alternatives (IIA) property. Third, the logit model cannot capture the dynamics of repeated choice if the unobserved factors are not

independent over time. The MNP model can handle all three issues. For the MNP model, the joint distribution of the error terms $\varepsilon'_n = \langle \varepsilon_{n1}, \dots, \varepsilon_{nT} \rangle$ is assumed to be a multivariate normal with mean zero and a matrix of covariance Ω . The density of the unobserved term ε_n can be written as Equation 4:

$$\phi(\varepsilon_n) = \frac{1}{(2\pi)^{\frac{T}{2}} |\Omega|^{\frac{1}{2}}} e^{-\frac{1}{2} \varepsilon_n' \Omega^{-1} \varepsilon_n} \quad (4)$$

The choice probability based on the MNP model is detailed by Train (2003).

Modeling Tool

The package *mlogit* of R programming language was employed to model the data. The programming language was written to estimate the model, and a Core i7 laptop with a 4 GB random access memory (RAM) was used to run the model.

Results and Discussion

Correlation

The correlation of each explanatory variable with each output variable is tabulated in Table 3. It is noteworthy that only three explanatory variables, i.e., household income, a number of passengers, and distance from home to school, were found to have a moderate correlation with the output variables, while the correlation of the other explanatory variables with the output variables was very trivial. Those correlation coefficients imply that household characteristics (exclusive household income) have no impact on travel mode choice among K-12 school commuters. The distance from home to the shortest train station had a trivial correlation with the travel mode choice, and this could be explained that the urban train mode share is only 5.91% in terms of passenger kilometer traveled (ALMEC, 2014), while the rest is the road-based public transport mode. A non-existent relationship of urban form attributes (i.e., distance from home to CBD, road-based public transport line density, and population density) with the travel mode choice made by K-12

Table 3. Correlation between the independent variables and the dependent variables

Variable	Non-motorized	Public	Private
Sex	0.06	-0.05	-0.03
Age	-0.09	0.09	-0.01
Family size	0.01	0.01	-0.02
Working adult	-0.04	0.05	-0.02
K-12 school children	0.04	-0.04	0.01
Household income	-0.26	0.10	0.30
No. of passengers	-0.07	-0.15	0.48
Distance to school	-0.40	0.29	0.20
CBD	0.02	-0.05	0.05
Train station	-0.06	0.06	-0.01
Line density	-0.03	0.02	0.01
Population density	0.09	-0.02	-0.14

school students could highlight that the travel mode choice among the students are primarily influenced by distance from home to school, household income, and number of commuters, not by urban from attributes.

Table 4 shows the correlation between the explanatory variables. The correlation between the three explanatory variables mentioned above was marginal. Therefore, these three explanatory variables were considered for the development of travel mode choice models.

Model estimation results

The model estimation results of the MNL model (the third column) and the MNP model (the last column) are shown in Table 5. The non-motorized mode was selected as the reference category. It was noteworthy that the MNL-based travel mode choice model was superior to the MNP-based travel mode choice model for school students in Metro Manila in terms of model fit (i.e., McFadden R^2 , Log-likelihood value at the convergence, and likelihood ratio test), see the last three rows of Table 5. The parameter estimates of the MNL model and the corresponding standard errors were found to be much higher than those of the MNP model; however, the parameter estimates of the MNL and MNP models are in the same trend.

The non-motorized was used as the reference category, which means that all the corresponding coefficients are zero. The

intercept coefficients have no interpretable meaning, but they are included to capture the average unobserved effect (Train, 2003). The coefficients of household income are positive for both the private and public modes and are found higher for the private mode relative to the public mode. The mentioned coefficients suggest that students with high household income are most likely to go to school by private mode, followed by public transport mode and non-motorized mode. A similar finding reported that adult commuters with high household income are more likely to make trips by car choice, followed by public transport mode (Fillone *et al.*, 2007). The impacts of distance from home to school on public and private transport modes are reasonably comparable for either the MNL model or the MNP model, and respondents residing closer to school have the highest likelihood to travel by non-motorized mode, followed by public transport mode and private mode (the coefficients of the public and private modes are positive). The coefficient of the number of passengers is positive for the private mode and negative for the public mode, for both the two discrete choice models. Those coefficient imply that students with the presence of commuters are most likely to travel by private mode, followed by non-motorized mode and public transport mode. It is noteworthy that the impact of the presence of commuters on the private mode is statistically insignificant for the MNP model,

Table 4. Correlation between the independent variables

Independent variable	Sex	Age	Family size	Working adult	K-12 school children	Household income	No. of passengers	Distance to school	CBD	Train station	Line density	Population density
Sex	1											
Age	0.07	1										
Family size	0.00	0.00	1									
Working adult	0.00	0.16	0.28	1								
K-12 school children	0.02	-0.04	0.69	-0.01	1							
Household income	-0.01	0.12	-0.02	0.09	-0.13	1						
No. of passengers	0.02	-0.14	0.26	0.01	0.43	0.12	1					
Distance to school	-0.04	0.13	-0.02	-0.01	-0.06	0.29	0.06	1				
CBD	0.02	0.03	0.04	-0.02	0.00	-0.03	0.10	-0.01	1			
Train station	0.00	0.05	-0.12	0.06	-0.12	0.03	0.04	-0.09	-0.18	1		
Line density	-0.05	0.04	-0.05	0.01	-0.04	0.16	0.02	-0.03	-0.27	0.02	1	
Population density	0.02	-0.03	0.14	-0.01	0.08	-0.21	-0.28	-0.10	-0.08	-0.09	-0.14	1

Table 5. Model estimation results – coefficient (standard error)

Parameters	Transport mode	MNL	MNP
Intercept	Public	-3.054 (0.292)***	-1.624 (0.159)***
	Private	-12.522 (0.911)***	-3.923 (3.222)
Household income	Public	0.075 (0.02)***	0.044 (0.011)***
	Private	0.206 (0.032)***	0.074 (0.044)
Distance to school	Public	2.682 (0.192)***	1.356 (0.047)***
	Private	2.794 (0.2)***	1.383 (0.058)***
No. of passengers	Public	-0.131 (0.118)	-0.054 (0.082)
	Private	2.372 (0.278)***	0.551 (0.814)
Public:Private		—	0.895 (0.234)***
Private:Private		—	0.471 (0.672)
McFadden R ²		0.41	0.40
Log-likelihood		-613.56	-628.74
Likelihood ratio test		852.06	821.70

* significant at the 5% level, ** significant at the 1% level, *** significant at the 0.1% level

The non-motorized mode was used as the reference category.

but significant for the MNL model. Regarding the correlation approach, the number of commuters has a moderate correlation with the private mode, thereby implying that the MNL model outperformed the MNP mode in terms of coefficient estimation.

Model application

As stated earlier, the MNL-based travel mode choice model was superior to the MNP-based travel mode choice model in terms of model fit and coefficient estimation. The MNL model, therefore, was applied to simulate

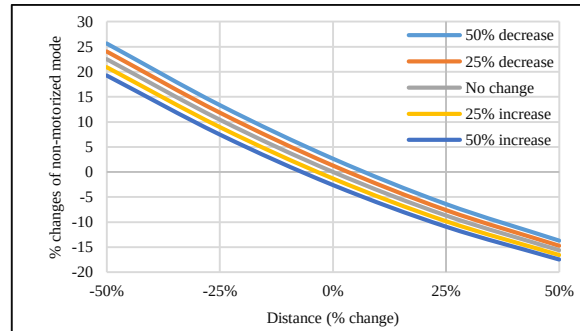


Figure 3. Percentage changes in non-motorized mode in response to household income

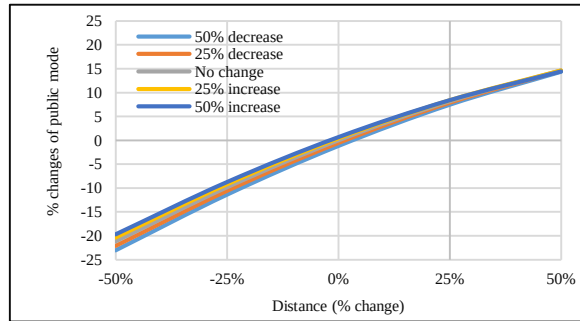


Figure 4. Percentage changes in public transport mode in response to household income

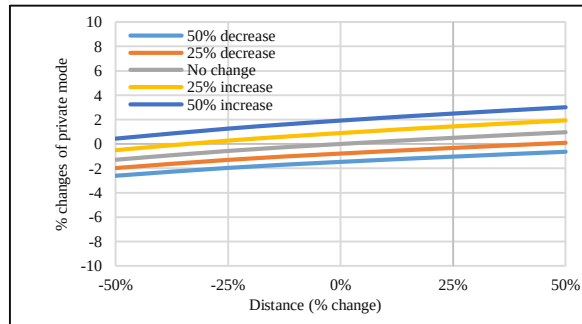


Figure 5. Percentage changes in private transport mode in response to household income

percentage changes of the alternatives in response to variation in some variables of interest (i.e., household income and distance from home to school). Figures 3, 4, and 5 present the percentage changes of non-motorized mode, public transport mode, and private mode, respectively. The legends on the figures refer to the percentage changes in monthly household income, while the x-axis

presents the percentage changes in distance from home to school 50% decrease, 25% decrease, no variation, 25% increase, and 50% increase.

Evident from Figures 3 and 4, students are much more responsive to changes in distance from home to school than changes in household income for non-motorized and public transport mode choices. The percentage

change of non-motorized mode decreases with an increase in travel distance. By contrast, the percentage change in public transport mode goes up in response to an increase in travel distance. Figure 5 implies that an increase in household income and travel distance triggers an increase in percentage share of private mode.

In fact, the annual average household income growth is 2.154% in Metro Manila (PSA, 2017), and this income growth is an indication of an increase in private mode choice for school students. However, the reduction in travel distance from home to school is the most efficient way to promote non-motorized mode choice among K-12 students. Travel distance from home to school can be reduced by building more schools, especially in communities with a lack of schools. The government can also encourage the private sector to invest in the education service by building more primary schools, lower secondary schools, and upper secondary schools, especially in suburban areas with very few schools.

Conclusions and Recommendations

This study intends to develop and apply the travel mode choice models for school students taking account of socioeconomic characteristics and urban form attributes in Metro Manila. First, the Person product-moment correlation function was used to control multicollinearity among explanatory variables, and it was found that only household income, travel distance, and a number of commuters were considered for model development. After that, the two discrete choice models were applied: MNL and MNP. The empirical findings highlighted that the MNL-based model was superior to the MNP-based model in terms of model fit and coefficient estimation. However, the parameter estimates of the two models are in the same trend even though the parameter estimates and standard errors of the MNL model were greater than those of the MNP model. Based on the model estimation results, students with high household income and living further from

schools are more likely to travel by public and private modes. Students with the presence of commuters prefer private mode to public transport and non-motorized modes. Reduction in travel distance from home to school through building more schools in communities with a lack of schools is the most efficient way to promote non-motorized mode trips.

Although this study explored determinants (i.e., socioeconomic characteristics and urban form attributes) of travel mode choice for basic education school students, further research effort is required. The sidewalk and bike lane features should be considered for future research work, e.g., walking lane density, sidewalk's width, protection fence, security, and the presence of tree shade along the sidewalk.

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References

- Regidor, J.R., Fillone, A.M., Aloc, D.S., and Lucas, K.J. (2017). What if Metro Manila Developed a Comprehensive Rail Transit Network? Proceedings of the Eastern Asia Society for Transportation Studies, 11. Ho Chi Minh City.
- ALMEC. (2014). Roadmap for transport for infrastructure development for Metro Manila and its surrounding areas. Final Project Report-Technical Report No. 2- Submitted to Japan International Cooperation Agency (JICA) and

- the National Economic Development Authority (NEDA). Retrieved from <http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-TR2-TECHNICAL-ANALYSIS.-12149639.pdf>
- De-Guzman, M.P. and Diaz, C.E. (2005). Analysis of mode choice behavior of students in exclusive schools in Metro Manila: The case of Ateneo De Manila University & Miriam College. *Proceedings of the Eastern Asia Society for Transportation Studies*, p. 1,116-1,131.
- Fillone, A.M., Montalbo-Jr, C.M., and Tiglao, N.C. (2007). Transportation mode choice models for Metro Manila and urban transport policy implications. *J. Eastern Asia Soc. Transport. Stu.*, 7:454-469.
- Hensher, D., Rose, J., and Greene, W. (2005). *Applied choice analysis*. Cambridge: Cambridge University Press.
- McFadden, D. (1974). *Conditional Logit Analysis Of Qualitative Choice Behaviour*. (P. Zarembka, Ed.) NY: Academic Press.
- MUCEP. (2015). The project for capacity development on transportation planning and database management in the republic of the Philippines. Technical Report: Transportation Demand Characteristics Based on MUCEP Person Trip Survey Submitted to Japan International Cooperation Agency (JICA) and Department of Transportation and Communication (DOTC). Retrieved from http://open_jicareport.jica.go.jp/pdf/12247623.pdf
- Okada, H., Doi, K., Gaabucayan, M.S., and Hosomi, A. (2003). Quantification of passengers' preference for improvement of railway stations considering human traits: A case study in Metro Manila. *J. Eastern Asia Soc. Transport. Stu.*, 05:1,408-1,421.
- Okamura, T., Kaneko, Y., Nakamura, F., and Wang, R. (2013). Passengers' attitude to the service items of Jeepneys in Metro Manila by different lifestyles. *J. Eastern Asia Soc. Transport. Stu.*, 10:1,384-1,395.
- PSA (Philippine Statistics Authority). (2017). *Philippines Statistics Yearbook*. Quezon City, Philippines: PSA. Retrieved from <http://lto.gov.ph/transparency-seal/annual-reports.html>
- Rith, M., Biona, J.B., Fillone, A., Doi, K., and Inoi, H. (2018). Joint model of private passenger vehicle type ownership and fuel consumption in Metro Manila: Analysis and application of discrete-continuous model. *Philippine Transport. J.*, 1(2):32-47.
- Roxas, N.R., Fillone, A.M., and Roquel, K.I. (2018). Estimating the environmental effects of the car shifting behavior along EDSA. *International J. GEOMATE*, 14(44):8-14.
- Train, K. (2003). *Discrete choice methods with simulation*. NY: Cambridge University Press.