Multinomial Logit Modeling of Transportation System of Tubungan, Iloilo

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Abstract: Transport models provide an analytical framework for assessing passenger demands of existing transportation systems and estimating future demands as determinant of an area's capacity for development. A mode choice analysis is done to understand how the travelling population decides on their transportation modes which is vital in efficiently managing a transportation network. This study covers the development of a logit choice model of the municipality of Tubungan, Iloilo travelling population. Revealed preference survey is used to capture the travel characteristics and perceptions of sample respondents. Distances for both private and public modes were measured using Google Earth. Additional travel alternatives were added based on available public routes. Information from the survey was used as a replication of the actual market share condition, given that the data is collected on a representative sample of the population. The calibration of the model was done using the LIMDEP software, NLOGIT 3.0. Goodness of fit measures was covered by the use of the software as well as the rho-squared and chi-squared tests. It was found that the main factors affecting travel mode choice are total travel time and total travel cost/fare of using the mode. Furthermore, the time coefficient is slightly negatively higher than the cost coefficient, which would mean that, on the average, commuters consider travel time more important than the total travel cost/fare in their decision to choose a transport mode. Thus, in terms of hierarchy, Tubungan travelers consider the travel time more than the travel cost. Both variables were determined to provide the correct coefficient signs that are within the required confidence interval of 95% (statistically significant).

Key Words: Logit model; Sampling population; Revealed preference; Total travel time; Total travel cost

1. INTRODUCTION

1.1 Background of the study

The Municipality of Tubungan is located in the southwestern part of Iloilo province, and is geographically located at 10°46' North (N) Latitude and 122°19' East (E) Longitude. Elevation at these coordinates is estimated at 108.4 meters (m) or 355.4 feet (ft.) above mean sea level. It is bounded on the north by the Municipality of Leon; on the south by the Municipalities of Guimbal and Tigbauan, and on the west by the Municipality of Igbaras. It is a 4th class municipality having a total of forty-eight (48)

barangays with a total land area of 85.18 square kilometers (km^2), representing about 1.68% of the total provincial land area of 5,079.17 km^2.

Fig. 1. Location Map of the study area

According to the 2015 Philippine Statistics Authority (PSA) Census, Tubungan has a total population of 22,449 all of which resides on rural areas. The median age of 27 indicates that half of the entire population of Tubungan are aged less than 27 and the other half are over the age of 27.

By analyzing what people prefer and how they decide on their mode of transportation can aid in the formulation and implementation of transportation policies, addressing the need for an efficient, economical, and dependable transportation system. The populace is likely to be satisfied with recommendations for improving travel conditions based on travelers' preferences. As a result, the ideal method to manage a transportation network is to first understand the population using it and furtherly moving from there, constantly considering how they would respond.

This paper aims to generate multinomial logit model of transportation of residents from Tubungan to Iloilo City, Oton, New Lucena, Guimbal, Leon, Miagao, Leganes, and Maasin of Iloilo Province. Both private and public transportation modes are considered on this study. Traveling through motorcycles, jeepneys, tricycles, private cars, public utility bus (PUB), and UV express were the stated transportation modes of Tubungan residents.

1.2 Theory

Every traveler in the decision-making process is assumed to follow the economic consumer theory, which analyzes how individuals spend money based on personal preferences and budget limits. It demonstrates how people make decisions based on their financial resources and service costs in order to optimize their travel utility.

The modeling will be probabilistic as long as the individual's choice is established under random conditions that never occur identically. Nobody can exactly forecast an individual's choice, but the modeler can estimate the probability of that choice based on the choice conditions and the individual's socioeconomic characteristics. As a result, we can use the multinomial logit model to predict the probability that a traveler i will utilize an alternative j in given conditions describing the environment of choice. This utility can be written as a linear function of all the factors that make up this particular environment (X_k). This utility is written as follows:

$$U_{ij} = \sum_{k=1}^{K} a_k X_k + \mathcal{E}_{ij} \qquad \text{(Eq. 1)}$$

where:

U_{ij} = probability that a traveler i chooses the transportation mode choice j.
a_k = Coefficient/unknown for parameter k to be estimated
X_k = Parameter or explanatory variable k
$\mathcal{E}_{ij}$ = Hidden components unobservable by the modeler (random component of the utility)

Since six (6) travel modes are considered on this study, then K=6.

2. METHODOLOGY

2.1 Data Gathering

The survey was conducted in Tubungan, Iloilo in 2018. Questionnaires were utilized to capture information on the traveling population's preferences where Revealed Preference survey is used to obtain the perceptions of the traveling population. This entails gathering data on people's preferred transportation mode based on actual market circumstances. It includes obtaining the individual's perceptions on various parameters for all travel mode choices, both chosen and non-chosen. Given that the

data is obtained on a representative sample of the population, it is regarded as a replication of the real market share condition. As a result, a model built using revealed preference data can be utilized to represent the actual market.

The survey questionnaire included questions on trip characteristics such as trip purpose, trip origin and destination, transportation mode (primary and secondary choices), access/egress characteristics. It also included the traveler's socio-demographic information such as gross monthly income, civil status, gender, age, vehicle & license ownership, number of owned vehicles (motorcycle & private cars), etc. It also included information on total travel cost and total travel time that the traveler spent to complete the trip. Total travel time is the sum of the perceived processing and waiting time and in-vehicle travel time. As for travel cost, it includes the travel costs to and from the terminals from the origin and to the destination respectively, in addition to the travel cost of the transport mode used.

Distances for both private and public modes were measured using Google Earth. Additional travel alternatives were added based on available public routes. The information included point-to-point travels, available alternative modes, disaggregate access and egress distances, the nearest available transit stations/stops, transfer information, among others. Inputs with similar origin and destination points were grouped together to provide values on responses with vague value.

Given that some respondents gave incomplete to almost no answers to certain important variables, their respective questionnaire forms were simply rejected. Responses with only one choice were also excluded. Hence, out of 238 original samples, only 231 samples were used in the choice modeling analysis.

2.2 Model Development

The LIMDEP program (NLOGIT 3.0) was used to calibrate the model. The software utilized also included goodness of fit measures, such as rho-squared and chi-squared values. The choice probabilities among the alternatives in the choice set were modeled using choice-based sampling.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

A total of 231 samples were gathered for the study. Motorcycle users leads the user count with a count of 139. This could be attributed to the convenience of riding a motorcycle, and its lower capital cost than a private car. Tubungan has a large land area and travel distances can span up to kilometers (not suitable for walking). Traveling can also start from unpaved roads with small road width (not suitable for private cars), and this municipality do not have a good network of paved streets (compared to Metro Manila). Jeepney comes next at a count of 81. This could be attributed to jeepneys being the primary travel mode of respondents not owning either motorcycle/private car, and jeepneys offer lower fares. Tricycle comes third (3rd) with a count of seven (7) and is just considered for trips within the municipality. Private Car and Public Utility Bus comes 4th and 5th, with the UV having no count. The low count of the PUB and UV comes from the fact that their route coincides with the route of the Jeepney (on the Iloilo-Antique Road) and another transfer of travel mode would just add to the total travel cost and waiting time of the respondents. Private Cars are options for respondents having to own one/multiple of them.

As seen in Figure 2, respondents aged from 41 to 50 make up most of the respondents (23.810%). Those aged 51 to 60 make up 22.078%. Those aged 21 to 30 and 31 to 40 make up 20.346%. Those aged 20 and below, 61 to 70, and above 71 make up 2.597%, 9.091%, and 1.732%, respectively. The computed median age of the sampling population is 44, indicating that the sampling population is relatively older (comparing to PSA's median age of Tubungan residents at 27).

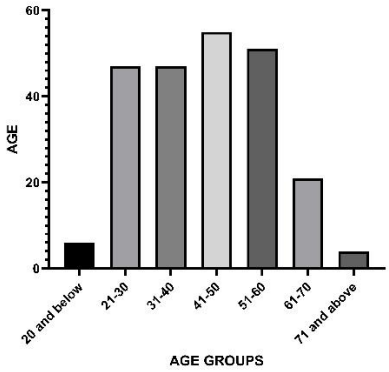

Fig. 2. Age groups of the sampling population

As for the gender distribution, sampling population is dominated by females comprising 60.606% with males at 39.394%. Married/widowed respondents also dominates the sampling population at 68.831% compared to 31.169% of single respondents.

As shown in Figure 3, majority of the respondents have incomes below Php 5,000, with those belonging to the 5-10k bracket making up 19.048% of the respondents. Those belonging to 10-15k, 15-20k, and above 20k brackets make up 3.896%, 3.463%, 0.866%, respectively. The computed average income of the whole sampling population is at Php 5,017.316.

Average income per travel mode is highest on private car users, followed by motorcycle users & jeepney users. Tricycle users resulted to the lowest income group among these four (4) modes.

Table 1. Average Personal Income and Average Age per travel mode users

Variables	Average Personal Income	Average Age
Motorcycle	4,881.295	42.446
Jeepney	4,790.123	43.790
Tricycle	3,750.000	53.857
Private Car	14,583.333	59.667
PUB	22,500.000	64.000
UV Express	-	-

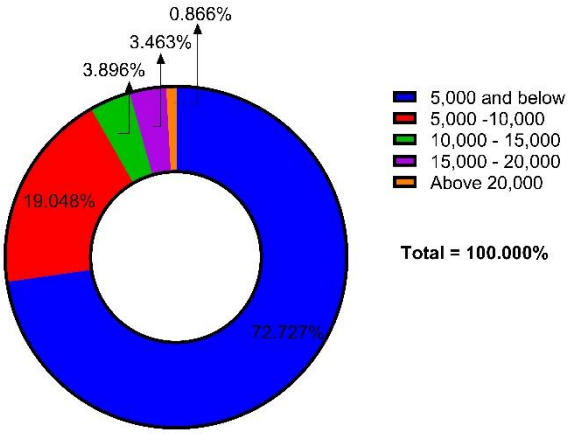

Fig. 3. Income brackets of the sampling population

Data for Tubungan residents leaving before 7:00 AM is slightly higher than those leaving after 7:00 AM with their count at 52.831% and 47.619%. Moreover, other trip-purpose (which is mainly identified as shopping either for Neighborhood Retail Shops (aka "Sari-Sari Stores") or Leisure Shopping Trips) dominated the data set at 66.234% versus the work-related trips at 33.766%.

Highest statistic for frequent travelers is the private car & tricycle users while highest statistic for weekly travelers is the motorcycle users. This is mainly due to the privilege of not having access/egress, & waiting times. Thus, they are more inclined to travel more since it is a much comfortable trip being on a private transportation mode.

Table 2. Frequency of travel

Variables	Frequent Traveler		Weekly Traveler	
	Yes	No	Yes	No
Motorcycle	93.53%	6.47%	71.22%	28.78%
Jeepney	97.53%	2.47%	65.43%	34.57%
Tricycle	100%	0%	57.14%	42.86%
Private Car	100%	0%	66.67%	33.33%
PUB	100%	0%	100%	0%
UV Express	-	-	-	-

3.2 Logit Choice Model

Initial screenings were conducted to exclude variables resulting to low confidence interval and incorrect signs of the coefficients. Identifying the group of significant variables is an iterative process until correct coefficient signs and high significance of each variable in the developed utility model is satisfied. After several simultaneous & individual iterations, it was revealed that the total travel time and total travel cost (which are both route specific variables) both provided the correct coefficient signs that are within the required confidence interval of 95% (statistically significant).

Table 3. Logit choice model estimation results considering time & cost

Variables	Coefficient	T-Stat	P-Value
Total travel time	-0.14534	-4.76171	1.92E-06
Total travel cost	-0.08203	-3.32973	0.000869288
Pseudo R^2			0.82391
Adjusted R^2			0.82320
Log-Likelihood			-72.56818

As shown on Table 3, time has a negative coefficient, which means that the longer the travel time, whether using any of the modes, the higher the disutility. Same observation is made on the cost (also having a negative coefficient) since higher travel costs also corresponds to the disutility of the travel mode.

Same observation is obtained on mode choice analysis paper of Roquel, K. & Fillone, A. (2013) where it was found that the total time spent travelling on land is one of the significant factors the travelers take into consideration in the decision-making process. Furthermore, it was also explained on the study that cost is an important factor in decision-making as per an individual's perception of his/her money's worth.

Similar results were also obtained by Wibowo, S. & Chalermpong, S. (2009) where it was concluded that total travel time and total travel costs were two (2) of three (3) factors with significant influence in decision making regarding transport modes.

With this, the utility model developed which relies heavily on travel time and costs is as follows:

$$U_{mode} = -0.14534(TTM) - 0.08203(TTC) \quad \text{(Eq. 2)}$$

where:

U_{mode} = Utility function of a specific travel mode
TTM = Total travel time of using the travel mode
TTC = Total travel cost of using the travel mode

The time coefficient is slightly negatively higher than the cost coefficient, which would mean that, on the average, commuters consider travel time more than the total travel cost/fare in their decision to choose a travel mode. Thus, in terms of hierarchy, Tubungan travelers consider the travel time more than the travel cost.

This reinforces the study of Al-Salih, W. & Kiss, D. (2021) where it was concluded that travel time significance has a higher order in the hierarchy of list of decisive factors of an individual when making a mode choice than the travel cost.

The two primary modes on the study (Motorcycle and Jeepney users) obtained individual accuracies of 94.93% and 70.37%, respectively which are the highest accuracy among the six (6) travel choices. They are followed by Tricycle and Car Users at 57.14% and 33.33%. Out of 231 inputs, 193 were correctly predicted (which corresponds to total model accuracy of 83.55%).

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the descriptive statistics results, motorcycles are the main mode used which could be attributed to the convenience of riding a motorcycle, and its lower capital cost than a private car. Jeepney comes next since it is the primary transport mode of respondents not owning either motorcycle or private car, and it offers lower fare. The low counts of the PUB and UV users were noted since these modes are for inter-municipality or provincial routes.

Moreover, the sampling population is

relatively older, and that shopping either for neighborhood retail shops (aka "Sari-Sari Stores") or leisure shopping trips) dominated the data set. Highest statistic for frequent travelers was found to be the private car & tricycle users while highest statistic for weekly travelers was found to be the motorcycle users. This could be attributed to the privilege of not having access or egress & waiting times, thus inclining to travel more due to higher comfortability of being on a private transportation mode.

Total travel time and total travel cost (both route specific variables) provided the correct coefficient signs that are within the required confidence interval of 95%. Both resulted to negative coefficients since any increment in these variables would correspond to disutility of the travel mode. The time coefficient is slightly negatively higher than the cost coefficient, which would mean that, on the average, commuters consider travel time more than the total travel cost/fare in their decision to choose a transport mode.

In conclusion, it can be noted that the model developed followed the expected outcomes with regard to the signs of the coefficients of the variables, taking time and cost spent as disutilities to the individual. The model is found to be 83.91% accurate, which is already very satisfactory.

It is recommended that future researches include detailed waiting time and travel time and fare differentials per travel mode. The private mode users could also be further subdivided into two types of travelers - the driver and the passenger. Inclusion of qualitative variables such as comfort, convenience, and accessibility that are expressed in terms of quantifiable variables is also recommended.

In addition, as the travel behavior of travelers may change over time, this may imply some limitations of the results. Therefore, it would be beneficial to run the models on a fresh and full dataset in the future. Another limitation is the size and range of the useful dataset.

In the filtering process, several trips had to be discarded because of missing information. As future research, extended analysis to a large dataset will be useful for further identifying various variables considering the effect on mode choice.

Overall, the study provided promising insights into the mode choice behavior of travelers from Tubungan, Iloilo.

5. ACKNOWLEDGMENTS

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