Estimating the Potential Passenger Demand of a Proposed Aerial Ropeway Transit System along Katipunan Avenue, Quezon City

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Abstract: This study proposes an Aerial Ropeway Transit (ART) system along Katipunan Avenue with the objective of introducing another mode of transport that could help reduce the volume of motorized vehicles along the Avenue. Katipunan Avenue is home to higher education facilities such as the Ateneo de Manila University, Miriam College, and University of the Philippines Diliman as well as several commercial and residential establishments. Stated and revealed preference surveys using face-to-face interview where conducted. Data showed that the main mode of transportation used along the study area is the jeepney followed by private vehicles. Several multinomial logit models were developed using discrete choice modeling. The revealed preference logit model results showed that the significant variables include travel time, affordability of the alternative mode, and its cost per kilometer variables. The stated preference logit model also showed that travel time and affordability variables are significant including the booking time in lieu of the cost per kilometer variable. The SP responses show that on average, 71.30% of private car users are willing to shift to the ART system while Grab/taxi, Angkas/motorcycle, tricycle, and public utility jeepney users' willingness-to-shift rate are 62.62%, 60.29%, 70.67% and 58.36%, respectively. Resulting to an ART SP mode share of 64.65% which shows a positive ridership consideration for the proposed ART.

Keywords: ART, discrete choice models, stated preference, revealed preference

1. INTRODUCTION

Based on data from the MMDA, the road with first and second highest annual average daily traffic (AADT) being EDSA and Commonwealth Avenue, respectively, already have existing and on-going construction of mass transit lines, namely: MRT-3 and MRT-7. Coming in third is Katipunan Avenue which has only has one (1) existing public transportation mode.

Katipunan Avenue, the study area and one of the major avenues in Quezon City, runs from Tandang Sora Avenue in the north, intersecting with Aurora Boulevard and Colonel Boni Serrano Avenue, to White Plains Avenue in the south. Most of the section of Katipunan Avenue has three lanes expanding to four lanes or narrowing to two lanes in select areas.

The study area is home to higher education institutions such as the University of the Philippines, Ateneo de Manila University, and Miriam College. It is also home to the Metropolitan Waterworks and Sewerage System and UP Town Center.

In addition to the existing LRT-2 station at Katipunan Avenue, several rail projects are being implemented at present and two (2) will have stations along Katipunan Avenue: Tandang Sora Station of MRT-7 and Katipunan Station of the Metro Manila Subway. All these rail projects

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may be connected by a new form of transportation to provide comfort for the traveling population and improve the transport network in the area. The figure below shows the proposed alignment and possible connections to the mentioned rail stations.

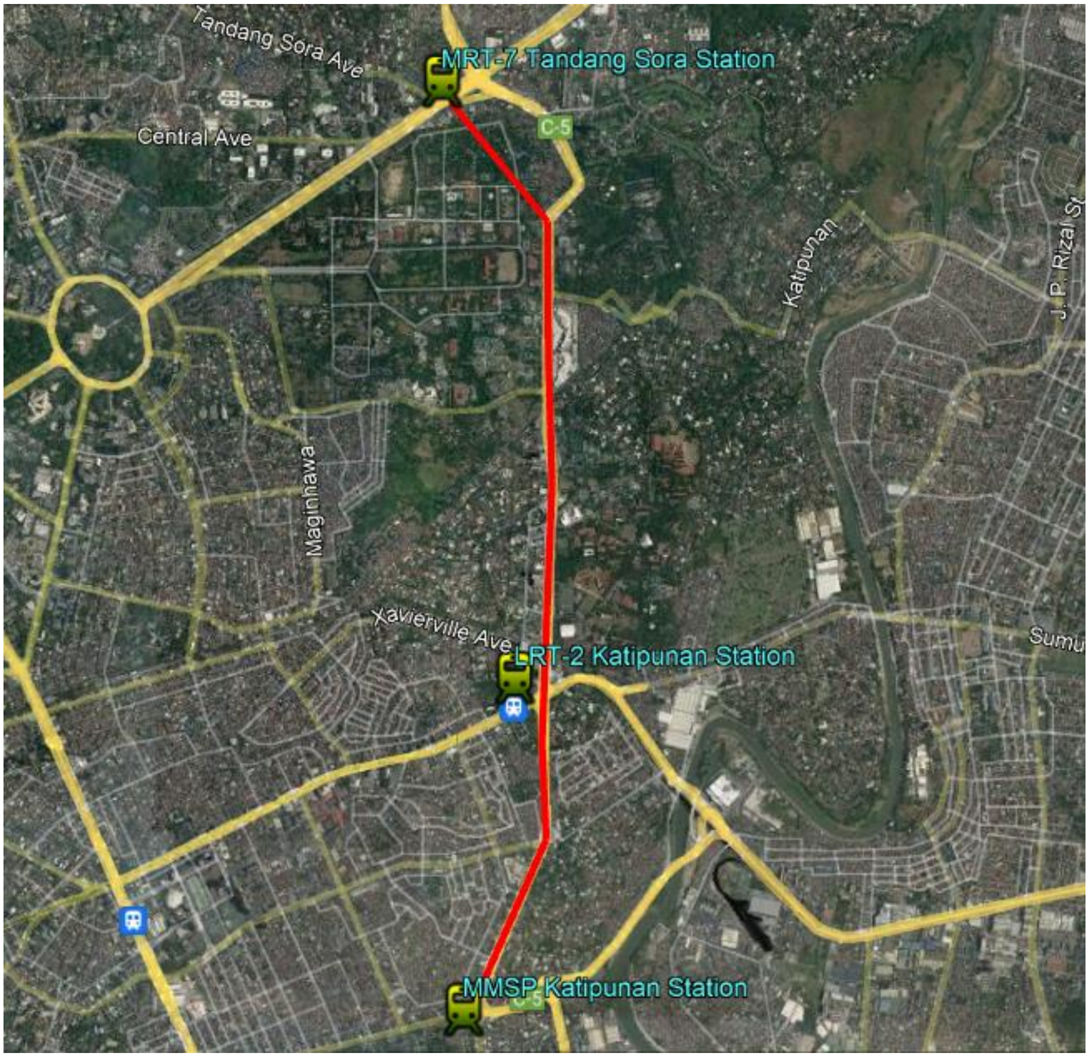

Figure 1. Proposed Alignment and Connections

Currently, the only public transportation mode that operates along the identified alignment, Katipunan Avenue, are public utility jeepneys (PUJ). The lack of public transportation alternatives is seen to contribute to the increase in the use of private cars as shown in the AADT along Katipunan Avenue (MMDA, 2017). The AADT counts on C-5 Katipunan Avenue/ C.P. Garcia Avenue shows that on average, 62.47% of daily traffic along the avenue are cars or private vehicles while less than 5% use public transportation (See Table 1).

To address these problems, this study is proposing a new public transportation mode along Katipunan Avenue to encourage car users to shift to this new mode to reduce the number of travelers using private vehicles.

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Table 1. Annual Average Daily Traffic Along Katipunan Avenue

	2014	2015	2016	2017	2018	AVE	SHARE (%)
Car	127,594	134,939	154,037	133,171	133,427	**136,634**	62.74
Motorcycle	38,401	46,149	49,277	57,881	73,169	**52,975**	24.32
Truck	10,508	10,458	12,411	10,121	12,624	**11,224**	5.15
UV	-	-	-	8,442	6,886	**7,664**	3.52
Taxi	-	-	-	7,293	6,552	**6,923**	3.18
PUJ	812	985	950	923	1,378	**1,010**	0.46
PUB	194	662	373	221	908	**472**	0.22
Trailer	914	922	1,101	680	790	**881**	0.40
Tricycle	6	4	6	19	10	**9**	0.0041
TOTAL	178,429	194,119	218,155	218,751	235,744	**217,792**	-
% INCREASE	-	8.79%	12.38%	0.27%	7.77%	**7.30%**	-

The main objective of this study is to estimate the potential passenger demand of the proposed aerial ropeway transit system (ART) along Katipunan Avenue. Specific objectives are:

- To determine and analyze the mode choices of the travelers along the study area.
- To estimate the possible mode shift of travelers to the proposed ART.
- To determine the significant variables that affect mode choices of individuals in the area.
- To estimate the expected reduction in private vehicle trips due to the proposed ART system.

1.2. APPLICABILITY OF ART ALONG KATIPUNAN AVENUE

ART is a transportation system that uses gondolas to convey passengers from an origin to a destination. The system consists of stations and towers, cabins or cars, grips, cables, and other elements. Stations are elevated and have a minimum footprint of 2,000 sq.m.. Towers are located in between stations to provide support to the cables. The design may vary from cantilever, whalebone, box, arch or single (see Figure 2). The cabins are used as vessels that transport the passengers from one station to another. It can cater to as low as 4 up to 220 passengers depending on the technology used (Doppelmayr, N.D.).

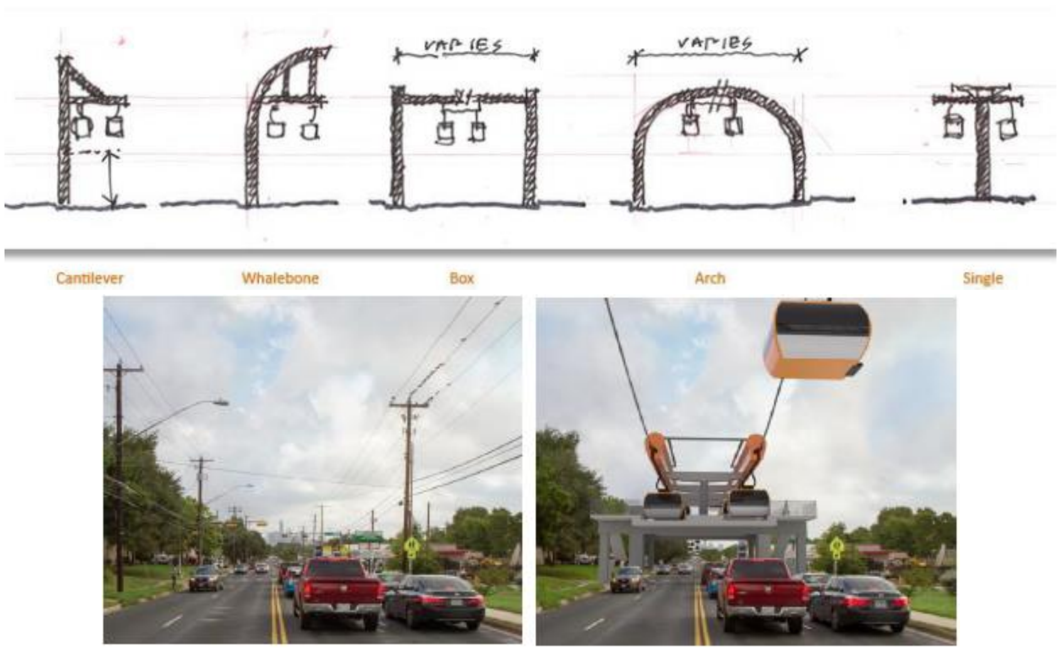

Figure 2. Tower Alternatives
Source: Parsons Brinckerhoff & Texas A&M Transportation Institute (2015)

All ART systems propel their cabins using a steel rope which is called a haul rope. At each station the haul rope passes around a large wheel called the bull wheel. Some ART systems have an additional type of rope called track ropes which are fixed and provide additional support for the cabins (Doppelmayr, ND).

ART systems are slowly being a catalyst in urban development. This relatively cheap and slow but steady form of green transportation is helping in the development of many cities around the world (El-Jouzou, 2016). Urban ART systems can be constructed in less than a year since heavy civil works are not required compared to MRT, LRT, Monorail systems. Majority of the component of the ART system are constructed off-site and are ready for installation on-site. In addition, the whole system is powered by electricity alone making it one of the greenest forms of urban transportation mode.

Compared to conventional transportation modes such as bus rapid transit (BRT) and light rail transit (LRT), as well as a non-conventional Monorail technology, ART is the most suitable alternative for the alignment based on the physical characteristics summarized in the table below.

Table 2. Characteristics of ART and Conventional Transportation Modes

MODE	STATION SIZE	TOWER FOOTPRINT	TOWER SPAN	Right-of-Way
LRT	3000 sq. m.	2.0m by 2.0m	20 to 30 meters	Elevated, dedicated
BRT	12- to 18-m bus stops	n/a	n/a	Road-based, dedicated
Monorail	2000 sq.m.	1.5m to1.8 m diameter	20 to 30 meters	Elevated, dedicated
ART	2000 sq.m.	Min.0.6m diameter	300 meters	Elevated

For the LRT, the station size was measured using Google Earth with LRT-2 Recto Station as basis. According to the LRT-2 Extension Project (JICA, 2011), the dimension for the towers is 2.0m by 2.0m with viaducts spanning 20 to 30m. The alignment and right-of-way of the rail system uses the at-grade portion as plant boxes. This feature consumes two to three meters of the road width which limits the movement of road-based transportation modes.

Similar to the LRTs in the Philippines, Monorail technology is elevated having its own right-of-way. The span of guideway beams for Monorail ranges from 20 meters to 30 meters (MDOT, 2021; Naeimi et al., 2015). This technology has piers or columns with diameter ranging from 1.5 to 1.8 meters. Using the Monorail design criteria by the Maryland Department of Transportation, a station with two (2) trains has a station size of 2000 sq.m (MDOT, 2021).

Compared to the LRT and Monorail technology, ART has a smaller station size, smaller pier or column footprint, and longer column-to-column span. This means less construction cost and more at-grade space.

On the other hand, BRTs occupy a dedicated right-of-way for its alignment to avoid traffic congestion and establishes the stations to the center of the street to avoid being delayed by turning vehicles. In the BRT Planning Guide by the Institute of Transportation & Development Policy (ITDP), a station is usually 5m wide and 10m long and has an optimal space of 450m.

The required alignment width for a two-way BRT system is 11 meters including the stop (ITDP, N.D.). This poses a problem especially in the area of St. Ignatius and White Plains where the carriageway width ranges from 13 to 15m (See Figure 3). Establishing a BRT alignment will significantly limit the movement of the vehicles coursing the area.

Figure 3. Katipunan Avenue (White Plains Area)

2. RELATED LITERATURE

2.1. Urban Integrated ART Systems

Many countries have considered ART as an alternative urban transport mode. In Latin America, the city of Medellin in Columbia and La Paz, Bolivia have successfully integrated ART in their transportation system.

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Medellin, Columbia can be considered as the birthplace of ART systems as mode of transportation. The first of its three lines, Line K, became operational in 2004. It consists of three stations and has a total length of 2 km. The second line, Line J, started its operation in 2008 and similar to Line K, the system has three stations with a line length of 2.9 km. The most recent line to be included in the system is Line L, installed in 2014, which acts as a tourist attraction rather than a public transport system. Table 3 shows the summarized the details of the Metrocable Medellin.

According to Davila & Daste (2011), between the year 2000 and 2005, the travel time of commuters was reduced from an average of two hours to one hour and five minutes. In 2010, According to Brand & Davila (2013), the construction of the ART system resulted in a boost in the real estate market and also created job opportunities. Commune 13 in Medellin experienced a growth rate in the service sector by 890% from 2004 to 2007 (Coupe & Cardona, 2013).

Table 3. Information on Metrocable Medellin System
Source: Brand & Davila, 2013

METROCABLE MEDELLIN	**Line K**	**Line J**	**Line L**
Operational Year	2004	2008	2010
Construction Time	14 months	15 months	10 months
Line Length	2.072 km	2.782 km	4.469 km
No. of Stations	4	4	2
Towers	20	31	25
Speed (kph)	18	18	22
Cabins (8 seated, 2 standing)	93	119	27
Estimated CAPEX	US$ 24-M (2003 exchange rate)	US$ 47-M (2007 exchange rate)	US$ 21-M (2007 exchange rate)
Cost/Km	US$ 11.6-M	US$ 16.9-M	US$ 4.7-M

During interviews, it was revealed that the usual walking time of people willing to walk to the station is 10 to 15 minutes. According to the respondents interviewed, cost is the main driving factor in their travels (Heinrichs & Bernet, 2014).

The success of the Metrocable in Medellin, Colombia resulted in the incorporation of ART in Latin American transportation system. In 2012, the Bolivian Government signed a contract with an Australian cable car contractor, Dopplemayr, to design and develop an ART system that will connect La Paz and El Alto (Martinez, et. al, 2018f; Garsous, et. al, 2017). Prior to the construction of the ART system, the only modes of transportation available are buses and minibuses, that usually get stuck in traffic congestion (Martinez, et. al, 2018; Garsous, et. al, 2017). Due to the success of the ART system, the Bolivian Government announced a second phase to build additional lines. As of today, La Paz-El Alto ART system or Mi Teleferico is considered as the highest and longest urban ART system in the world.

The fare cost of Mi Teleferico is approximately US$ 0.40 per ride which have been set be competitive with the local buses. According to Martinez et. al (2018), each line can transport up to 6,000 passengers per hour having a headway of 12 seconds. Estimations show that the line reduces the travel time between La Paz and El Alto from one hour to ten minutes (Garsous, et.al, 2017).

2.2. Factor Affecting Mode Choice

Many studies found that the characteristics of the city including its density and land use affect the mode choice of travelers and that these characteristics are shown to make people prefer non-motorized modes of travel (Hu et. al., 2018). In the studies by Wang & Zhou (2017) and Kwoka, et. al. (2015), it was found that compact and clustered developments with high job opportunities and accessibility has a positive impact in the use of public transportation. In addition, access to public transportation was deemed significant in the research of Wibowo & Chalermpong (2010).

A study by Shen et. al (2016) shows that the monthly income of an individual proves to be a significant factor in the analysis. Higher income, job status, and car ownership are associated with higher probabilities of car use (Wibowo & Chalermpong, 2010; Schwanen, et. al., 2004; Abdel-aty, 2001). Factors such as gender, household composition, and educational attainment were found to affect travel mode choices (Schwanen, et. al., 2004; Abdel-aty, 2001). Also, in the study by Abdel-aty (2001), age was considered as a significant factor affecting travel mode choice.

Lastly, trip characteristics were determined to be significant. Studies show that that access time, travel time, and travel cost are significant factors affecting the mode choice of travelers (Dilay, 2015).

2.3. Mode Shift

A study by Kwan, et. al (2018) used travel surveys, on a weekday and a weekend, to understand the trip characteristics of private and public transport users in Kuala Lumpur with the intention to induce the shift from private vehicle to rail mode, if available. Among the interviewed individuals, only 15% were public transport users. However, 48% of those interviewed during the weekday and 39% during the weekend intended to shift to the rail mode. Significant variables during the weekday include trip duration, distance, purpose, vehicle occupancy and the presence of child passengers while during the weekend only trip duration and presence of child passengers were significant.

Sohoni et. al (2017) conducted a study that aimed to investigate the mode shifting behavior of commuters towards a newly operational metro rail mode in Mumbai, India. NLOGIT Results showed the potential shift to rail mode: overall, 54.22%; public transportation users, 51.21%; and private vehicle users, 56.2%. Waiting time, travel time, travel cost and discomfort were significant.

Research conducted by Dilay (2015) utilized SP surveys to determine the mode shift of bus passengers to a to-be-repaired/rehabilitated rail line traveling from Metro Manila to Bicol, Philippines. A total of 900 bus passengers were interviewed. Samples were analyzed using NLOGIT. Using an SP model with 43.66% accuracy, 87.97% of the bus passengers would shift to the rail service. Access time, travel time and cost over income were determined to be significant and disutility to the modes. Interaction between travel time and access time was also significant such that the travelers would choose a mode even with a longer access time as long as the in-vehicle time is faster.

Sarmiento et. al carried out a stated preference (SP) survey that gathered a total of 392 responses (187 for Metrocable Line J and 205 for Metrocable Line K). The results showed 62.9% and 50.6% of commuters are willing to use Line K and Line J, respectively. It was found that travel cost, access time, waiting time, and in-vehicle travel time were significant variables.

A study by Estrella et. al in 2017 found that Baguio residents have a high acceptance for a hypothetical aerial ropeway transit. Using logistic regression, it was determined that travel cost, access time, in-vehicle travel time, egress time, and comfort are significant factors.

2.4. Synthesis

Discrete choice models were developed using the revealed preference (RP) data in order to determine the significant variables that affect the mode choices of the travelers along Katipunan Avenue which is similar to the various studies reviewed under Section 2.2. Similar to Kwan, et. al (2018), Sohoni et. al (2017), and Dilay (2015), the researcher used the SP data to develop discrete choice models to estimate the potential shift of passengers to the proposed ART system.

3. METHODOLOGY

3.1 Survey and Secondary Data Collection

A survey was conducted in September 2019 through online and face-to-face approaches. The targeted respondents were travelers that traverse Katipunan Avenue at least once a week. The questionnaire was used to gather information regarding the respondents' socio-economic and trip characteristics, as well as their willingness to shift to the ART system.

Secondary data such as the location of the study area were obtained using Google Earth. Data such as land use map, AADT, and population were obtained from the Quezon City Government, Metropolitan Manila Development Authority, and Philippine Statistics Authority, respectively.

Survey results were transformed into Excel format that is accepted by the NLOGIT software to be utilized and were used to develop multinomial logit models.

3.2 Discrete Choice Modeling (Logit Models)

Logit models are the most used modal split models in transportation planning. These models possess the ability to analyze and present the complex travel behaviors of any population with simple mathematical techniques. The probability of an individual i to select a mode n, out of m number of existing and available modes, is given as:

$$P_{in} = \frac{e^{U_{in}}}{\sum_{m \varepsilon M} e^{U_{im}}}$$

Where: U_{in} = utility function of mode n for individual i
U_{im} = utility function of any mode m in a choice set for individual i
P_{in} = probability of individual i choosing mode n
M = total number of modes in the given choice set

The utility equation includes two components: deterministic and an error or random component.

$$U_{it} = V_{it} + \varepsilon_{it}$$

Where: U_{it} = perceived utility of individual of alternative t to individual i
V_{it} = deterministic portion of the utility estimated by the analyst
ε_{it} = error or random component

The deterministic component of the utility can be expressed as a function of attribute Xn of the alternative or the individual. The impact of each attributes to the individuals perceived utility is indicated by the values of β2, β3 … βn and β1 is a constant:

$$V_{it}= \beta_1+\beta_2(X_1)+\beta_3(X_2)+\dots$$

Logit models are generally classified into two categories: binary and multinomial models (MNL). However, for this study, MNL models were used since there are more than two (2) alternatives presented to the survey respondents.

The data from the surveys were used to come up with different combinations of variables to develop the MNL models. The following parameters were obtained from the models: coefficients to the factors, p-values, likelihood function, goodness-of-fit, accuracy, and other significant factors that may affect the mode shift. Models with least number of errors were taken to accurately design and model the travel population. The flow of the research methodology is shown in the figure below.

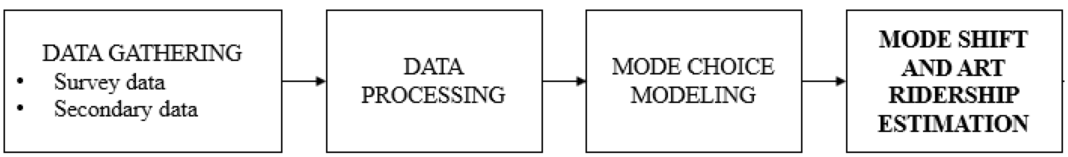

Figure 4. Summary of Procedure

4. RESULTS AND ANALYSIS

4.1. Survey Results

The researcher was able to gather 676 valid samples. Majority of the respondents use public utility jeeps (PUJ) as their main mode of transportation. Table 4 shows the mode share of travelers along the study area.

Table 4. Mode Share for Survey Results

Main mode	Samples	Percentage
Private car	144	21.30
Grab/Taxi	107	15.83
Motorcycle/ Angkas	54	7.99
Tricycle	50	7.40
PUJ	321	47.49
TOTAL	**676**	**-**

4.1.1 Socio-Economic Characteristics

The results of the surveys show that the average age of the respondents is 30.02 years old, the youngest age for the respondents is 13 years old while the oldest is 75. Majority of the respondents are from the working age range of 20-40 years old contributing 65% of the samples. Most respondents are female comprising 52.81% of the samples while the male participants make up 47.19%. Majority of the respondents are single comprising 71.60% . Half of the respondents attained college level education followed by the high school level respondents at 36.69%.

Majority or 45.27% of the respondents are employed followed by 21.01% students while self-employed respondents contribute 19.67%. The total employment percentage corresponds to the working age range of the samples.

For the gross monthly income, the maximum, average, and minimums are Php 155,000, Php 17,899.41, and Php 5,000, respectively. Majority of the respondents have gross monthly incomes below 10,000. This is highly related to the unemployment and student percentages of the respondents. Majority of the respondents do not have a car available for use. A total of 198 respondents owns one (1) car. The monthly income and vehicle ownership variables are positively correlated. As the income of the respondent increases the number of vehicles owned also increases.

Table 5. Socio-Economic Characteristics of the Respondents

SOCIO ECONOMIC CHARACTERISTICS					
AGE	**FREQ/VALUE**	**%**	**INCOME**	**FREQ/VALUE**	**%**
< 20 years	114	16.86	< 10,000	298	44.08
20 - 30 years	293	43.34	10,000 to 20,000	178	26.33
31 - 40 years	153	22.63	20,001 to 30,000	87	12.87
41 - 50 years	78	11.54	30,001 to 40,000	54	7.99
51 - 60 years	25	3.70	40,001 to 50,000	24	3.55
> 60 years	13	1.92	50,001 to 60,000	11	1.63
Minimum	13	-	60,001 to 70,000	8	1.18
Maximum	75	-	70,001 to 80,000	6	0.89
Mean	30.02	-	80,001 to 90,000	2	0.30
Std. Deviation	11.23	-	90,001 to 100,000	2	0.30
CIVIL STATUS	**FREQ**	**%**	100,001 to 130,000	1	0.15
Single	484	71.60	130,001 to 150,000	2	0.30
Married	192	28.40	> 150,000	3	0.44
CARS OWNED	**FREQ**	**%**	*Minimum*	5,000.00	-
None	353	52.22	*Maximum*	155,000.00	-
One	198	29.29	*Mean*	17,899.41	-
Two	77	11.39	*Std. Deviation*	19,545.47	-
Three	37	5.47	**GENDER**	**FREQ**	**%**
Four	10	1.48	Male	319	47.19
Five or more	1	0.15	Female	357	52.81
EMPLOYMENT	**FREQ**	**%**	**EDUCATION**	**FREQ**	**%**
Unemployed	95	14.05	Elementary	37	5.47
Employed	306	45.27	High School	248	36.69
Self-employed	133	19.67	Bachelor’s	341	50.44
Student	142	21.01	Graduate Degree	50	7.40

4.1.2 Trip Characteristics

Based on the responses gathered, the sample is composed of respondents with trip purposes of 50.00% being work or business trips, 22.85% school trips, 7.42% leisure trips, 7.27% shop/market trips, and 12.46% for others. The high percentage of work or business trips and school trips are understandable given that the study area has many commercial establishments and is home to major education institutions.

Among the respondents, 51.25% have either their origin or destination along the study area, 41.83% internal trips or both origin and destination along the study area, and 6.93% have neither origin nor destination along the study area and only pass-by. From the origin and destination data, 81% are in relation with Quezon City, followed by 13% involving cities and municipalities to the east e.g., Pasig City, Marikina, and cities and municipalities in Rizal.

As for the weekly trip frequency, majority or 25.88% travel five times a week along the corridor followed by once a week trips that comprise of 16.42% of the samples. Respondents that travel daily, four times, twice and six times make up 13.31%, 12.28%, 12.27% and 9.32% of the samples, respectively.

The travel distance values were not asked during the surveys but were obtained using the origin and destination data of the respondents which were entered in Google Maps. The shortest distance traveled was 400m and the farthest was 40.70 km. The average travel distance was found to be 8.40 km.

During the surveys, the respondents using private cars were asked how much they spend on their car considering fuel, parking fee, and maintenance on a weekly basis. This was done because estimating the daily costs of using a car may be difficult. Thus, the weekly cost was divided to the weekly trip frequency of the respondent to obtain the daily cost of using the mode. This was done for private cars only since daily costs of using the other alternatives may be given by the respondents easily. Considering this, the daily costs of the respondents were obtained. It was determined that the lowest cost was 7.20 pesos and the highest is 701.20 pesos. The average cost of all alternatives is 106.13 pesos.

The data has a minimum and maximum TOTTIME value of five (5) and 183 minutes, respectively, with an average of 66.74 minutes.

Majority of the respondents said that they use PUJs for their trips with 47.49% mode share, seconded by car users which contributes 21.30% and followed by motorcycle users with 7.99%. The details of the mode share can be seen in Table 6.

Table 6. Revealed Mode Share of the Respondents

Modes	**Count**	**Percentage**
Car	144	21.30%
Grab/taxi	107	15.83%
Angkas/Motorcycle	54	7.99%
Tricycle	50	7.40%
PUJ	321	47.49%
TOTAL	**676**	100.00%

In the SP part of the survey, the respondents were asked if they are willing to shift to the ART. The respondents were shown pictures of ART and how it would look if it were to be constructed along the study area for them to clearly understand the alternative. There was a total of nine (9) SP scenarios presented which can be seen in Table 7.

Table 7. Stated Preference Survey Scenarios

Scenario	Station to station travel time (mins)	Fixed Cost in pesos
1	4	15
2	5	15
3	6	15
4	4	20
5	5	20
6	6	20
7	4	25
8	5	25
9	6	25

Table 8 (illustrated in Figure 5) shows the mode segregated numbers and percentages of respondents that are willing to shift to ART per scenario.

Table 8. Results of Stated Preference Survey

	CAR		GRAB/TAXI		ANGKAS/MC		TRICYCLE		PUJ	
	Shift	**%**	**Shift**	**%**	**Shift**	**%**	**Shift**	**%**	**Shift**	**%**
SCE_1	135	93.75	97	90.65	46	85.19	50	100.00	289	90.03
SCE_2	122	84.72	90	84.11	42	77.78	47	94.00	257	80.06
SCE_3	106	73.61	69	64.49	35	64.81	45	90.00	214	66.67
SCE_4	114	79.17	71	66.36	37	68.52	35	70.00	203	63.24
SCE_5	101	70.14	67	62.62	37	68.52	35	70.00	187	58.26
SCE_6	87	60.42	55	51.40	30	55.56	32	64.00	154	47.98
SCE_7	97	67.36	59	55.14	25	46.30	25	50.00	147	45.79
SCE_8	86	59.72	52	48.60	21	38.89	25	50.00	127	39.56
SCE_9	76	52.78	43	40.19	20	37.04	24	48.00	108	33.64

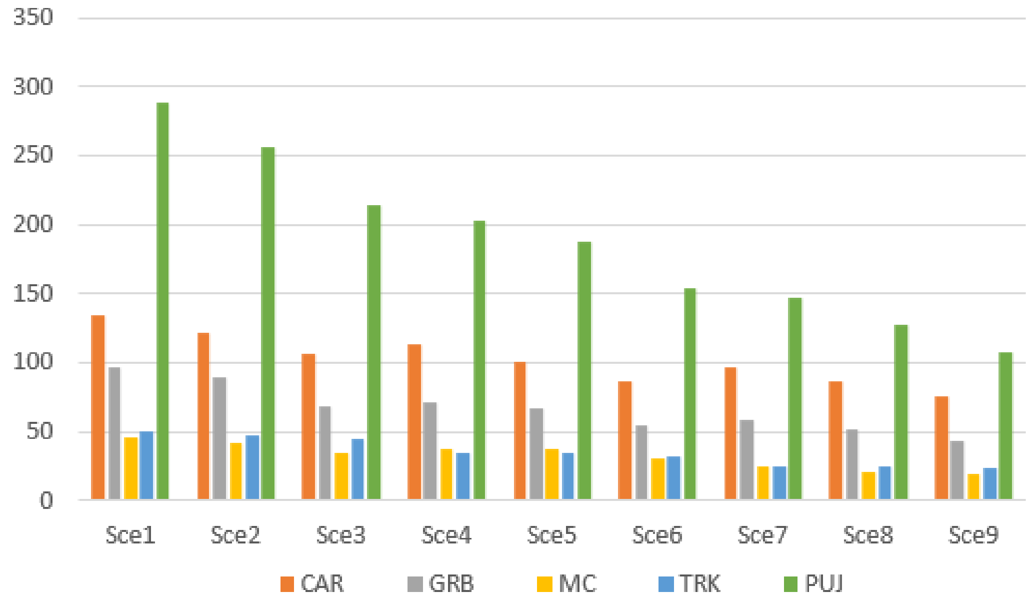

Figure 5. Stated Shifts Per Mode Per Scenario

4.2. Discrete Choice Modeling

Several multinomial logit models were developed using different sets of deterministic and socio-economic variables. The goodness-of-fit of the models were improved by adding more specific deterministic variables.

4.2.1 Revealed Preference Model

There were two (2) models developed using the revealed preference dataset along with the base model. The resulting models were labeled as RMNL-1 and RMNL-2. Table 9 shows the details of the models developed.

The first model, RMNL-1 utilized the deterministic variables: time outside Katipunan (TO), affordability of the alternative or cost over income (CT_INC), and cost per kilometer (CT_DIST). The second model, used TO, booking time (BOOKT), and cost outside Katipunan (CO) as its variables. All of the deterministic variables showed negative coefficients which means that all are disutilities to the traveler.

For both models, the alternative specific constants (ASC) of CAR and GRB give positive coefficients with GRB having the higher value. This indicates that the two alternatives are the most attractive given a setting where all other variables are equal or zero. This also shows that the traveling population of Katipunan Avenue tends to use private mode of transportation rather than public.

The goodness-of-fit measures of the models were checked to identify the best fitting model. First, the log likelihood values were compared. Having a value closer to zero would mean a better fit. The log likelihood values of the models at zero parameter ($L(0)$) and with alternative specific constants only ($L(C)$) are -1,087.98 and -773.27, respectively. Looking at the log likelihood values considering the deterministic variables ($L(\beta)$), RMNL-1 is the best among the listed models in the table having a value of -681.92.

All of the models have P-values between 0.20 and 0.40 which indicates a good model fit. It is also to be noted that all passed the 95% confidence level.

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Table 9. Revealed Preference Models

VARIABLES	BASE		RMNL-1		RMNL-2	
	Coefficient	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
A_CAR	0.265	2.262	1.209	5.673	0.407	2.811
A_GRB	-1.086	-9.725	1.620	3.980	0.702	2.009
A_MC	-1.770	-12.031	-1.063	-5.092	-0.827	-2.580
A_TRK	-1.358	-8.724	-1.231	-7.464	-1.376	-8.427
TO	-	-	-0.0283	-7.7820	-0.0322	-8.8050
BOOKT	-	-	-	-	-0.1060	-3.2310
CO	-	-	-	-	-0.0042	-5.3540
CT_INC	-	-	-73.0280	-6.1010	-	-
CT_DIST	-	-	-0.0238	-3.9740	-	-
GOODNESS-OF-FIT MEASURES						
L(0)	-1,087.98					
L(C)	-773.27					
L(β)	-		-681.92		-687.91	
-2[***L(0)- L(β)***]	-		812.11		800.14	
-2[***L(C)- L(β)***]	-		182.70		170.73	
Chi-squared	-		487.47		475.50	
ρ^2	0.28926		0.37322		0.36772	
adj. ρ^2	0.28789		0.37111		0.36559	

Note: all passed 95% confidence level

The researcher also compared the percentage of correct prediction of all the models using the CROSSTAB command in NLOGIT. Table 10 shows the result of the crosstab for RP MNL models. The count or *n* columns show the number of correct predictions of the model per mode and for the total sample size. It can be seen that RMNL-1 and RMNL-2 correctly predicts 47.63% and 46.89%, respectively.

Table 10. Revealed Preference, Percentage of Correct Predictions

MODEL	CAR		GRB		MC		TRIKE		JPN		TOTAL	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
RMNL-1	77	53.47	34	31.78	8	14.81	8	16.00	195	60.75	322	47.63
RMNL-2	77	53.47	24	22.43	10	18.52	8	16.00	198	61.68	317	46.89

Considering all of the discussed statistical measures, RMNL-1 is identified as the best fitting model. RMNL-1 is represented by the equation below.

U = -0.0283(TO) – 73.028(CT_INC) – 0.0238(CO) + ASC

4.2.2 Stated Preference Model

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Two (2) models were developed for the stated preference portion of the study. The same procedures were done as the ones in the revealed preference portion.

The deterministic variables used were disaggregated time and cost, and affordability variables. Specifically, TO, BOOKT, in-vehicle travel time (TRAVT), CO, cost inside Katipunan (CIN), and CT_INC. All of which showed negative coefficients and are disutilities to the user.

Looking at the log likelihood values, the value of the log likelihood of the models at zero parameter ($L(0)$) is -10,901.06 and the value with alternative specific constants only ($L(C)$) is -7182.50. Also, based on the $L(\beta)$ the best among the models is model SMNL-2 having a value of -7,000.82. Lastly, the P-values of the variables were checked to see if it will pass the 95% confidence level and it was found that all of them passed. Table 11 shows the details of the models developed.

Table 11. Stated Preference Models

VARIABLES	**BASE**		**SMNL-1**		**SMNL-2**	
	Coefficient	**T-stat**	**Coefficient**	**T-stat**	**Coefficient**	**T-stat**
A_CAR	-1.136	-22.293	-0.817	-14.365	-0.978	-18.414
A_GRB	-2.049	-40.279	-1.067	-11.949	-0.513	-3.354
A_MC	-2.724	-39.322	-2.506	-34.754	-1.710	-11.844
A_TRK	-2.778	-31.228	-2.771	-31.099	-2.766	-31.029
A_PUJ	-0.910	-28.546	-0.948	-25.121	-0.834	-25.032
TRAVT	-	-	-0.006	-6.128	-	-
TO	-	-	-	-	-0.016	-13.914
BOOKT	-	-	-	-	-0.106	-7.133
CO	-	-	-0.002	-9.126	-	-
CIN	-	-	-0.005	-7.857	-	-
CT_INC	-	-	-	-	-16.555	-7.369
GOODNESS-OF-FIT MEASURES						
L(0)	-10,901.06					
L(C)	-7,182.50					
L(β)	-		-7,081.53		-7,000.82	
-2[***L(0)*- *L(β)***]	-		7,639.07		7,800.49	
-2[***L(C)*- *L(β)***]	-		201.94		363.36	
Chi-squared	-		1,093.56		1,254.98	
ρ^2	0.34112		0.35038		0.35779	
adj. ρ^2	0.34099		0.35017		0.35758	

Note: all passed 95% confidence level

The percentage of correct predictions were also obtained, and the results can be seen in Table 12 below.

Table 12. Revealed Preference, Percentage of Correct Predictions

MODEL	PERCENTAGE OF CORRECT PREDICTIONS						
	CAR	GRB	MC	TRK	JPN	ART	TOTAL
SMNL-1	17.22%	9.86%	3.60%	3.76%	23.46%	56.21%	**39.30%**
SMNL-2	17.84%	8.94%	5.41%	3.76%	24.98%	56.27%	**39.73%**

Considering all of the discussed statistical measures, the researcher identifies the SMNL-2 model as the best among the models listed in Table 26. The general utility is shown below.

U = -0.016(TO) – 0.106(BOOKT) – 16.555(CT_INC) + ASC

5. CONCLUSION AND RECOMMENDATIONS

The study focused on estimating the potential passenger demand of a proposed ART system along Katipunan Avenue. A total of 676 respondents were obtained from the surveys. Once validated, the responses were analyzed using NLOGIT to develop discrete choice models.

The socio-economic characteristics of the respondents show majority of the population are from the young professionals age bracket of 20-30 years old (43.34%). Majority were female (52.81%), single (71.60%), attained college level (50.44%) and employed (45.27%) with an average income of 17,900 pesos.

Most of the respondents travel five times a week (25.88%) with average travel distance, cost, and time of 8.40 km, 106.13 pesos and 35.47 minutes, respectively.

From the RP portion of the survey, it was found that PUJs are the dominant mode of transportation in the area having a mode share of 47.49%. Other modes such as private car, Grab/taxi, Angkas/motorcycle, and tricycle have mode shares of 21.30%, 15.83%, 7.99% and 7.40%, respectively.

The SP responses show that on average, 71.30% of the private car users are willing to shift to the ART system. It is also important to note that Grab/taxi, Angkas/motorcycle, tricycle, and PUJ users' willingness-to-shift rate are 62.62%, 60.29%, 70.67% and 58.36%, respectively. Resulting to an ART SP mode share of 64.65% which shows a positive ridership consideration for the proposed ART.

The best fitting RP model used significant variables such as travel time outside the study area, cost over income, and cost per kilometer. All the variables have p-values less than 0.05, thus, passing the 95% confidence level. The model also has a rho-squared value within the range of 0.20 and 0.40 which indicates a good model fit. Lastly, it has an accuracy of 47.63%.

The best fitting SP model has a rho-squared value of 0.358 and it utilized the travel time outside the study area, booking time and cost over income as variables. All passed the 95% confidence level and the model has an accuracy of 39.73%.

With the conclusions stated above, the researcher recommends the following:

1. The SP model has a low accuracy of 39.73%. This can be improved by redesigning the attribute levels.
2. Another way of improving the questionnaire is by adding more variables such as number of transfers and comfort level for the SP scenarios, socio-demographic variables such as household size and household income, and trip itinerary.

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3. Most importantly, it is recommended that the city do additional traffic surveys along the study area such as volume counts, passenger occupancy, travel time and delay, boarding and alighting, and origin-destination surveys. These activities, along with updating the revealed and stated preference surveys, are essential in order to model the study area and provide a robust ridership forecast using the four-step travel demand model.

However, due to the current situation under the COVID-19 pandemic, it is expected that the mode shift to the ART will be significantly reduced due to social distancing and also considering the fact that passengers will be in a confined space increasing the risk of infection.

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