A Stated Preference Study to Determine Demand Shift for a Proposed Expressway Along C5

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Abstract: Various measures have been proposed in previous studies to address Metro Manila's traffic congestion including an expressway along Circumferential Road 5 (C5). C5 traverses seven (7) cities and one municipality and serves as a vital thoroughfare which is complementary to Circumferential Road 4 or EDSA. This study utilized Stated Preference data through administered questionnaires to C5 users. Respondents were given nine (9) scenarios of varying combinations of toll fee and time reduction selecting whether to take the expressway or retain their current route for each scenario. A multinomial logit model was then estimated to establish the behavior of road users if the alternative of an expressway was introduced.

Keywords: stated preference, C5, expressway, choice model

1. INTRODUCTION

Traffic congestion along Metro Manila's major thoroughfares is symptomatic of the increasing transportation demand in the Philippines. Metro Manila's current road network is comprised of a series of arterial and circumferential roads which form a radial pattern around the Metropolis. The most prominent and heavily traversed of these roads are Circumferential Road 4, better known as Epifanio de los Santos Ave. (EDSA) and Circumferential Road 5 which is shown in Figure 1. The present alignment of C5 passes through the cities of Las Piñas, Makati, Marikina, Paranaque, Pasig, Quezon City and Taguig as well as the municipality of Pateros beginning at the Manila-Cavite Expressway (CAVITEX) and terminating at the North Luzon Expressway (NLEX). The roadway currently has missing links particularly in the areas of Paranaque and Quezon City.

C5 was intended to serve as a peripheral road complementary to EDSA and was envisioned as a six lane roadway. Recent observations at select intersection have shown significant increases in vehicular volume such as Kawabata (2008) which observed values ranging from 80,000 vehicles per day (C5-Boni Serrano) to 158,000 (C5-Ortigas). The most common causes were attributed to lack of grade separation along its major intersection as well as the growing demand due to population growth.

Previous comprehensive studies have been commissioned by the Government to address the Metropolis' congestion problem, notably, the Urban Transport Study in the Metro Manila Area (UTSMMA) in 1973 and Metro Manila Urban Transport Improvement Study (MMUTIS) in 1996. MMUTIS projected a volume-capacity ratio of 2.3 (signifying extreme congestion) by 2015 if no additional infrastructures are provided (MMUTIS, 1999). The study has suggested a series of interventions ranging from mass transits to the expansion of Metro Manila's urban expressway system which includes the construction of an expressway along C5.

The concept of the proposed expressway was so that the alignment would absorb traffic generated from the major hubs of Makati, Ortigas, Cubao and Manila as well as to supplement the so called North-South Axis of expressways comprised of Skyway, North Luzon Expressway (NLEX) and South Luzon Expressway (SLEX) (MMUTIS, 1999). As of 2014, The National Economic Development Authority (NEDA) has included the C5 expressway in its Mega Manila Transport Dream Plan for 2030.

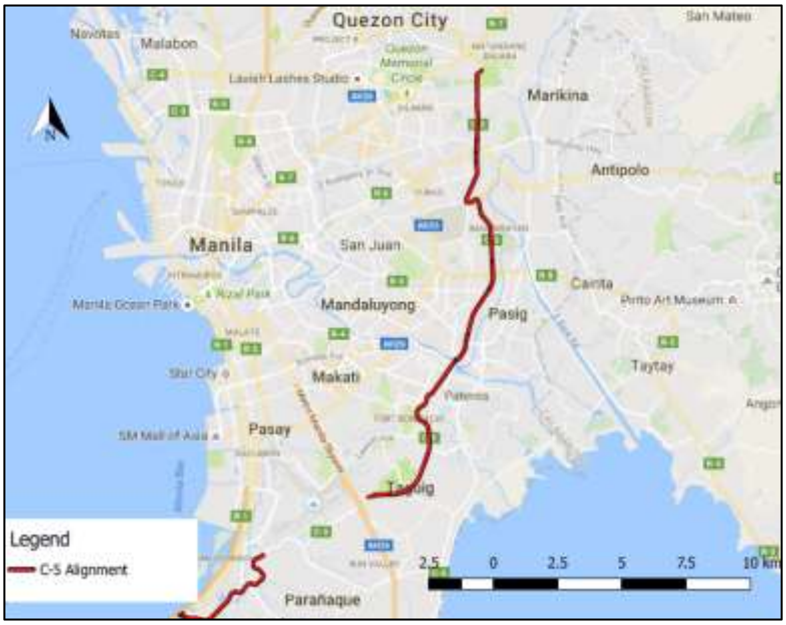

Figure 1. Vicinity Map of C5

This study aims to determine the effectiveness of a grade separated expressway along C5 by developing a model which would estimate a potential shift by C5 users to the expressway. Additionally the study also seeks to determine the value of time (VOT), of motorists who utilizes C5. This paper is organized as follows; the succeeding section reviews the related literature applicable to this study. The following section discusses the methodology used by the study to collect data and explain the developed model. The final section discusses the conclusions and recommendations made by this study.

2. REVIEW OF RELATED LITERATURE

2. 1 Route Choice

Traditionally, models used for route choice modeling have been based on the random utility theory on the assumption that travelers are rational and would seek to maximize their utility by selecting the best alternative to achieve this (Ortuzar and Willumson, 2011). Various factors influence an individual's decision which are not only limited to trip related aspects for both public (i.e. travel time, access time and comfort etc.) and private (i.e. tolls, parking fees and fuel costs etc.) modes, but also the individual's socioeconomic profile (i.e. gender, income etc.) and demographics which complicates attempts to model a traveler's decision makin (Raveau *et al.*, 2011). These factors were grouped by Jan *et al.* (2000) into three categories namely: traveler characteristics, route characteristics, trip characteristics and circumstances of the trip. Factors such as gender are known to have significant influence over route choice such as cases of females preferring toll roads more than men (Brownstone and Small, 2005, Knorr *et al*., 2014)

Zhang and Levinson (2008) observed that trip purpose together with the expected route characteristics was influential in route selection. Drivers were found to prefer routes with high speeds, reduced travel times, fewer stops, more efficient, easier drives and better aesthetics. The importance of attributes also varied with regards to trip purpose. Attributes relevant to route efficiency such as travel time, distance and number of stops were given more importance by work/event driven trips (visits, commutes, events) as compared to leisure trips.

2. 2 Value of Time

Another critical component with regards to route choice is the value of time (or value of travel time savings) which has been studied vigorously in various works. Cost-benefit analyses make significant use of travel time savings which are revealed in VOT studies as it reflects the benefits obtained by the users of transportation systems (Beaud, *et al*., 2016). More specifically, the value of time is critical for several reasons such as being a part of decision making, being a necessary piece for travel demand modeling, and answers questions on human behavior which are utilized in economics (Small, 2005). Previous studies have also utilized VOT in order to assess toll and road pricing policies as well as congestion charges (Alvarez *et al*., 2007; Brownstone and Small, 2005; West *et al*., 2016). The study of Alvarez *et al*. (2007) determined VOT based on the selection by road users between a faster more expensive toll road and a slower but cheaper trunk road.

Several studies have shown that other factors which affect a traveler's value of time. Borjesson and Eliasson (2014) found that VOT varied based on income, employment, trip purpose etc as well as number of children in a household. The study by Tseng and Verhoef (2008) observed that gender played a key role with women drivers having higher values of time compared to men. Brownstone and Small (2005) and Knorr *et al* (2014) relate the value of time with reliability which was surmised to be caused by additional gender related activities such as child care which reduces their flexibility in scheduling. Huang (2002) identified the significance of employment as professional and self-employed individuals have higher VOT but flexible work hours suggesting more willingness to spend in order to avoid congestion compared to lower income earners. Similar observations were found in Tseng and Verhoef (2008) where higher income suggests more willingness to pay for travel time and low income suggests tighter constraints in schedules. Hensher (2008) found that vehicle occupancy decreased average travel time savings as the number of passengers increase. Ho *et al.* (2016) on the otherhand conducted a comparative to study of the value of travel time savings between a lone driver, a passenger and a car with two (2) occupants (i.e. the driver and the passenger). It was revealed that vehicular value of time was better used compared with obtaining the VOT of the occupants separately as these were non-additive.

3. METHODOLOGY

3. 1 Methodology

This study utilized a Multinomial Logit model based on Stated Preference (SP) data in order to determine the conditional probability of a traveler's selection between two alternatives, namely, the expressway and the current route. As mentioned in the previous section random utility dictates that traveler's would always seek to maximize their utility which is subject to constraints such as social, income, physical or a combination of these conditions (Ortuzar and Wilumson, 2011). The deterministic utility equation utilized by Alvarez *et al* (2007) shown in equation 1, expresses the utility between two alternatives based on the variables of time and cost.

$$V_1 = \alpha_T T_1 + \alpha_C C_1$$
$$V_2 = \alpha_T T_2 + \alpha_C C_2 \qquad eq.(1)$$

where,

V_1: Deterministic utility of alternative 1
V_2: Deterministic utility of alternative 2
T_i: Time variable for alternative i
C_i: Cost variable for alternative i
α_T: parameter for time variable
α_c: parameter for cost variable

The general equation utilized by studies such as Alvarez *et al*. (2007) and Ortuzar and Willumson (2011) to determine choice probability for the MNL model is given in equation (2) with the assumed Gumbel distribution or Extreme Value Type 1 (EV1) for residuals/errors.

$$P_{in} = \frac{\exp(V_{in})}{\sum_{j=1}^{J} \exp(V_{jn})} \qquad eq.(2)$$

where,

V_{in}: Systematic utility of chosen alternative i
V_{jn}: Systematic utility of alternatives j

Likewise, computation for value of time is shown in equation (3), as used by Antoniou *et al*. (2007) wherein VOT is expressed in terms of \$/hour, hence the multiplier of 60 in the equation.

$$VOT = \frac{\beta_{time}}{\beta_{cost}} x\ 60 \quad \left(\frac{utils/min}{utils/\$} = \$/min\right) \qquad eq.(3)$$

where,

β_{Time}: Coefficient of travel time
β_{Cost}: Coefficient of travel cost

3. 2 Experimental Design

The SP component of this study was defined in terms of the expressway's toll fee and the travel time reduced both as attributes of cost and time respectively. Each attribute was assigned three (3) levels which are shown in Table 1. A total of nine (9) scenarios were generated for the SP experiment as shown in Table 2.

The levels of toll were presented on a per kilometer basis and were derived from the existing fares of the Metro Manila Skyway system (due to schematic similarities) with PhP 10/km serving as the base value. The low and high levels for toll represented a 25% decrease and increase from the base value respectively.

Time reduction for this study was limited to the reduction provided by the expressway along C5 only, with the assumption that the entry and exit times from origin and destination would remain unchanged. The levels of time reduction was established at 50% as a minimum given the natures of high speed roadways with unimpeded travel. The high value of 70% was considered to be plausible given that reduction was on C5 only and that reduction is generally dependent on a several factors such as the number of intersections and stops encountered by the motorist as well as the traffic conditions on the at-grade.

Table 1. Attribute Levels

Attributes	**Unit**	**Level**		
		0	**1**	**2**
Travel Time Reduction along C5	%	50	60	70
Toll Fee	Php/km	7.50	10	12.50

Table 2. Generated set combinations from experimental design

Combination	**Travel Time Reduction**	**Toll Fee**
1	1	0
2	0	0
3	0	1
4	2	0
5	1	2
6	1	1
7	2	2
8	2	1
9	0	2

3. 3 Data Collection

Data was obtained through a survey questionnaire which was divided into three (3) parts namely; trip information, the SP experiment and respondents socio-economic characteristics. Trip information included trip frequency, purpose, vehicular occupancy, trip costs (parking, fuel and toll) and travel time to destination (total travel time), as well as the intersections used to enter and exit C5 and the corresponding entry and exit times. Socio-economic characteristics included age, gender, civil status, size of household, seniors, working adults, children in household, education, employment vehicle ownership and individual and household incomes. The stated preference component were based from nine (9) generated scenarios each with varying combinations of travel time reduction along C5 and toll fee from the previous section. A sample of the questionnaire is shown in Appendix A.

The survey covered the cities bordering C5, with offices and residential areas being considered. Survey was distributed in offices at the major hubs of Ortigas, Bonifacio Global City, Eastwood and Cubao as these were likely to generate trips along C5. Residential surveys were also distributed in the suburban areas of Paranaque, Las Pinas, Pasig and Quezon City (i.e. Better Living, BF Homes etc.) with additional data being taken from outlying cities of Cainta and Antipolo. The study projects to collect data for a sample size of 300 respondents, selection of which was limited to private vehicle users (specifically cars, SUVs, vans etc.) who would use C5 to reach their destination regardless of frequency of travel.

3. 4 The proposed expressway

The proposed expressway adopted by this study is shown in Figures 2 below, where the alignment follows that of the existing C5 road. A total of sixteen (16) entry/exit ramps were situated along major intersections with each assumed to have full access for both northbound and southbound directions of the expressway. Toll fee levels, as previously discussed in Section 3.2, were based on a per kilometer basis, as such; matrices were developed for the three (3) levels and were presented to respondents in order to indicate their toll depending on their selected entry and exit points.

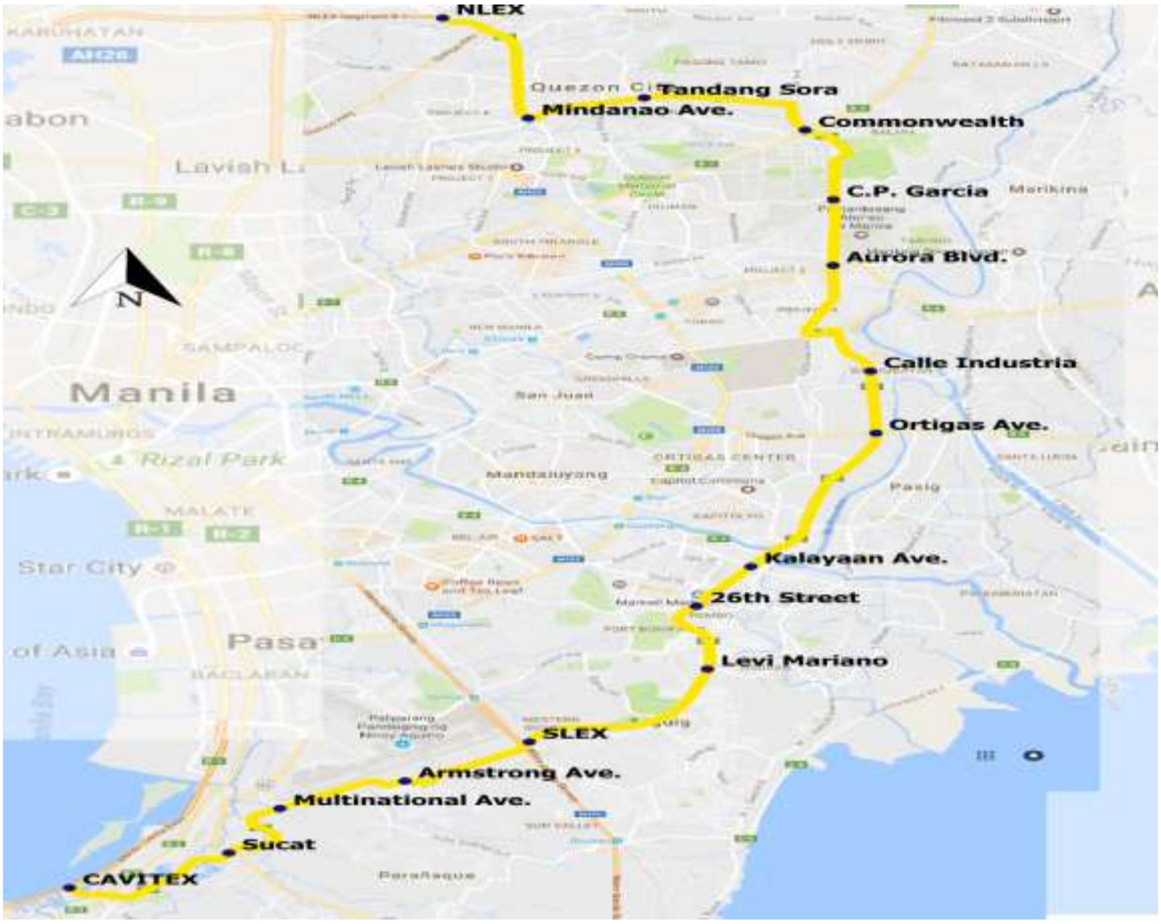

Figure 2. The Proposed Expressway along C5

4. RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Respondents

The socio-economic characteristics of C5 users were established based on data collected from 140 samples collected with inconsistent responses being discarded. The age of the respondents varied, ranging from 19 to 75 years old, with most falling under the 20 to 30 (36%) and 31 to 40 (34%) age groups which fall in the working age. This is further reinforced by the employment status of respondents of which 75% were employed individuals with the remaining being either, self-employed (17%), students (5%), retirees (2%) and others (1%). Additionally, majority of the respondents were college educated (76%) and male (71%) with half (50%) of the sample being married. The obtained individual monthly incomes of the respondents indicate that majority (70%) of the respondents fell within the 15,000 to 99,999 range indicating mid-level earners. Household incomes on the other hand were more distributed, with households earning 15,000-99,999 accounting for half (50%) with higher incomes of 100,000-500,000 comprising 47%, with the remaining 3% for low income earners.

4.2 Results of Stated Preference Survey

Results of the stated preference experiment are shown below in Table 3 based from a total of 140 responses presently collected with the remaining balance still undergoing processing. It can be observed from the results that majority of the respondents have selected the low level of cost (at PhP 7.50/km) regardless of the time reduction offered. Only one combination involving the mid and high level of toll were selected by respondents which was Scenario 8 at PhP 10/km (mid) and 70% reduction (high). This would suggest that respondents are not willing to pay more than the mid-level cost for anything less than the maximum reduction in travel time.

Table 3. SP Results

Scenario	**Take Expressway**		**Retain Current**	
	Frequency	%	Frequency	%
Php 7.50/km, 60% Time Reduction	119	85%	21	15%
Php 7.50/km, 50% Time Reduction	100	71%	40	29%
Php 10/km, 50% Time Reduction	57	41%	79	59%
Php 7.50/km, 70% Time Reduction	114	81%	26	19%
Php 12.50/km, 60% Time Reduction	48	34%	92	66%
Php 10/km, 60% Time Reduction	65	46%	75	54 %
Php 12.50/km, 60% Time Reduction	49	35 %	91	65%
Php 10/km, 70% Time Reduction	80	57%	60	43%
Php 12.50/km, 50% Time Reduction	39	28%	101	72%

4.3 Model Estimation

The utility equations for both the expressway and current route are reflected in equations 4 and 5. An alternative specific constant was assigned to the expressway for the specific model which given by the variable ASCEXPRESS. Variables which were considered as generic to the two alternatives are total travel time (TTIME) and total travel cost (TCOST). Another specified generic variable was the interaction between the traveler's total travel cost and individual income which is denoted by INCOME. Additional variables were included in the model such as vehicular occupancy in the vehicle during the trip (OCC), and respondent's age (AGE) both of which were assigned to the expressway alternative. All of the mentioned variables are scale variables.

U(EXPRESS)=ASCEXPRESS+COST***TCOST**+TIME***TTIME**+INCOME***CSTINC**+ AGE***AGE**+OCC***OCCUPANCY**

$$eq. (4)$$

U(CURRENT)=COST***TCOST**+TIME***TTIME**+INCOME***CSTINC**

$$eq. (5)$$

Table 4. Model Estimation Results

	Coeff.	**Std.Err.**	**t-ratio**	**P-value**
Alternative Specific Constant				
ASCEXPRESS	-1.13172	0.227577	-4.9729	6.60E-7
Generic				
COST	-0.00739	0.001152	-6.4156	1.40E-10
TIME	-0.01503	0.003479	-4.3199	1.56E-5
INCOME	34.6965	17.7705	1.9525	0.050881
Specific to Expressway				
OCCUPANCY	0.286155	0.051435	5.56343	2.65E-8
AGE	0.029766	0.005254	5.66502	1.47E-8
R Squared	0.07043			
Adjusted R Squared	0.06575			
Log likelihood	-771.2630			
Chi-squared	109.94359			

It can be observed from the correlation matrix shown in Table 5, that most of the variables have weak correlation with each other with the highest being Cost-Income and Total Cost interaction which is likely due to the Cost-Income variable being dependent on the Total Cost of the trip. Given the small sample size of the model and the general low values, correlation values may rise once additional samples are included in the analysis.

Table 5. Correlation Matrix

	TTIME	TCOST	OCC	AGE	CSTINC
TTIME	1.00	0.36	0.12	0.07	0.11
TCOST	0.36	1.00	0.02	0.09	0.48
OCC	0.12	-0.07	1.00	0.07	0.04
AGE	0.07	0.09	0.07	1.00	-0.11
CSTINC	0.11	0.48	-0.04	-0.11	1.00

The current results below show that the model has a generally good fit with all variables being statistically significant. The utility or disutility of each variable is given by the corresponding sign of its coefficient. It can be observed from the results that age and occupancy have positive coefficients. This would indicate users who are older more likely to utilize the expressway which corresponds with works by Knorr et al. (2014), Vreeswijk et al.(2014) and Zhou et al. (2014) where was related to the traveler's risk taking behavior where young people were found to be more risk-averse and are less likely to select a new route. Similarly, trips with high number of passengers would likely use the expressway as suggested by the model with likely due to reasons such as shared cost for the trip among others. The small r-squared value can be attributed to the relatively small size of the sample. Based from the model's coefficients of cost and time, the VOT was derived using equation (3) which yielded a value of PhP 122/hr.

Considering the two alternatives model accuracy for the data was estimated to be at 55%. Choice probability was given as 53.801% and 46.199% for the expressway and current route respectively.

5. SUMMARY OF FINDINGS

Important findings established from the results of the above model include utility/disutility of variables and the computed value of time. The signs of the coefficients of each variable revealed its utility/disutility for using the expressway. The expected contributors of disutility were cost and time while the cost-income interaction, vehicular occupancy and age contributed to its utility. The R-squared and Correlation between variables of the model were found to be weak, although this can be attributed to the small sample size of 140, these values are expected to improve once the study has obtained its projected 300 samples. The model also allowed for the computation of the C5 users VOT which was derived to be at PhP 122/hr. The computed VOT would be favorable with regards to the proposed expressway as this suggests users placing a high premium on time.

6. APPENDIX A. SAMPLE QUESTIONNAIRE

Ref No. ________ Date: ________

TRIP INFORMATION

Please specify the Origin and Destination of the trip in which you use C-5

Place of Origin: ____________________
(Village/Barangay/Street name) (City)

Place of Destination: ____________________
(Village name/Barangay/Street name) (City)

Number of people in vehicle : ________

Trip Frequency

How often do you use C-5 to reach your destination?

- ☐ Daily
- ☐ 6 times a week
- ☐ 5 times a week
- ☐ 4 times a week
- ☐ 3 times a week
- ☐ 2 times a week
- ☐ Once a week
- ☐ Monthly
- ☐ Once in 2 months
- ☐ Once in 6 months
- ☐ Annually
- Others : ________

Trip Purpose

What is the most frequent purpose of the trip?

- ☐ To Work
- ☐ To Home
- ☐ To Business
- ☐ To School
- ☐ To Shop/Mall
- ☐ To Market
- ☐ To Social event
- Others: ________

Cost of Trip:

What are the costs involved when you travel in C-5?

Toll Fee: ________
Others (please specify): ________
Parking: ________
Fuel Expense: ________

Travel Time to destination:

What is the usual travel time for you to reach your destination?

- ☐ Less than 10 mins
- ☐ 10 to 20 mins
- ☐ 20 to 30 mins
- ☐ 30 to 40 mins
- ☐ 40 to 50 mins
- ☐ 1 hour
- ☐ 1 to 1.5 hours
- ☐ 1.5 to 2 hours
- ☐ More than 2 hours

What intersection do you use to ENTER C-5?

Enter: ____________________
Time to C5 from Origin (in mins) ________

What intersection do you use to EXIT C-5?

Exit: ____________________
Time from C5 to Destination (in mins) ________

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Figure A.1. Trip Information portion of the Questionnaire

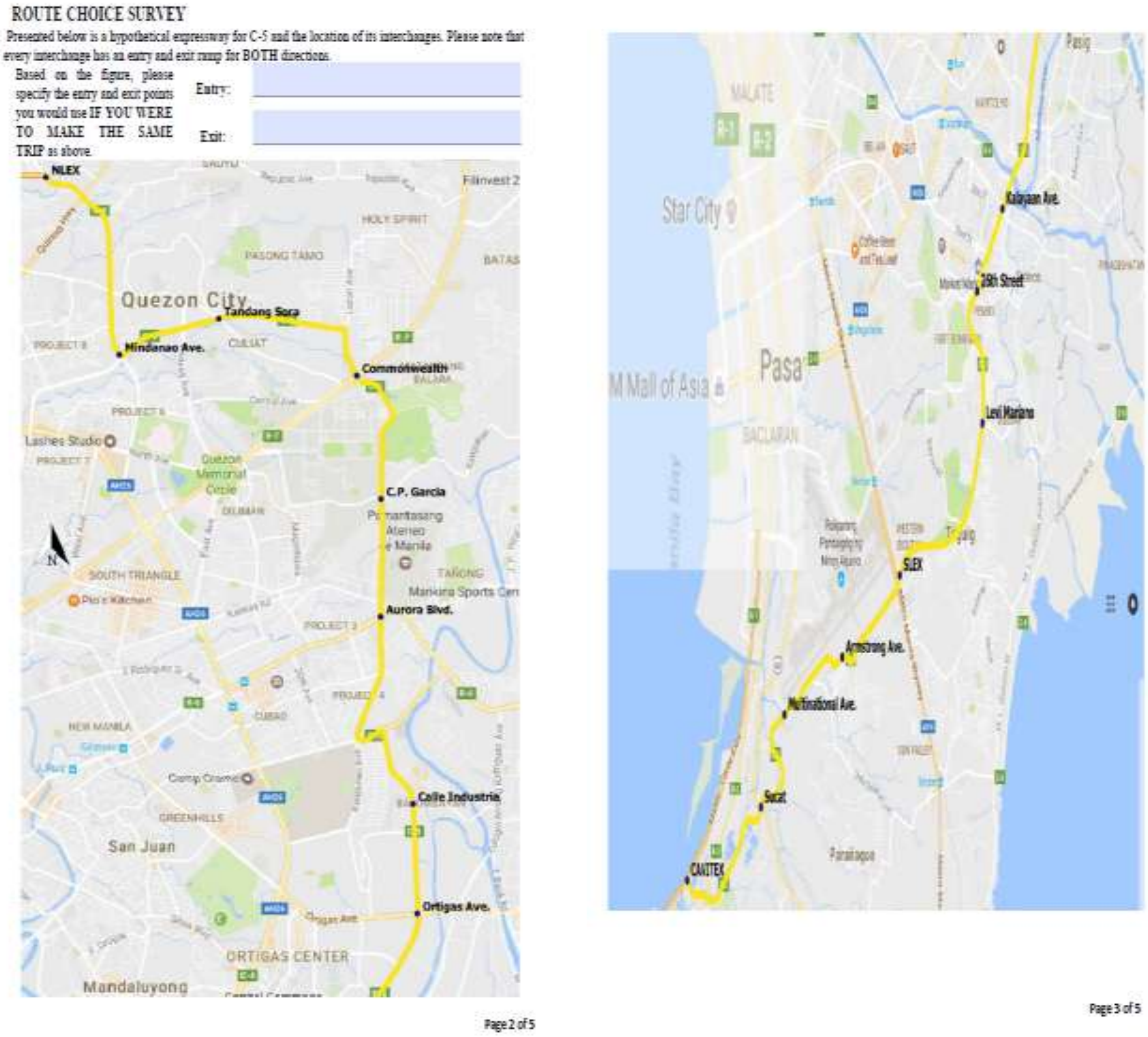

Figure A.2. Route choice portion of the Survey

Below are nine (9) scenarios with varying combinations of travel time reduction and toll fee. For EACH scenario, kindly select whether you would choose to the take the expressway or remain with your current route. Please refer to the attached TOLL MATRIX for your corresponding toll.

Scenario 1	**Expressway**
Toll Fee	Php 7.50 per kilometer
Travel Time	60% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 2	**Expressway**
Toll Fee	Php 7.50 per kilometer
Travel Time	50% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 3	**Expressway**
Toll Fee	Php 10.00 per kilometer
Travel Time	50% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 4	**Expressway**
Toll Fee	Php 7.50 per kilometer
Travel Time	70% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 5	**Expressway**
Toll Fee	Php 12.50 per kilometer
Travel Time	60% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 6	**Expressway**
Toll Fee	Php 10.00 per kilometer
Travel Time	60% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 7	**Expressway**
Toll Fee	Php 12.50 per kilometer
Travel Time	70% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 8	**Expressway**
Toll Fee	Php 10.00 per kilometer
Travel Time	70% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

Scenario 9	**Expressway**
Toll Fee	Php 12.50 per kilometer
Travel Time	50% reduction from Travel Time in C5
☐ Take Expressway	☐ Retain current route

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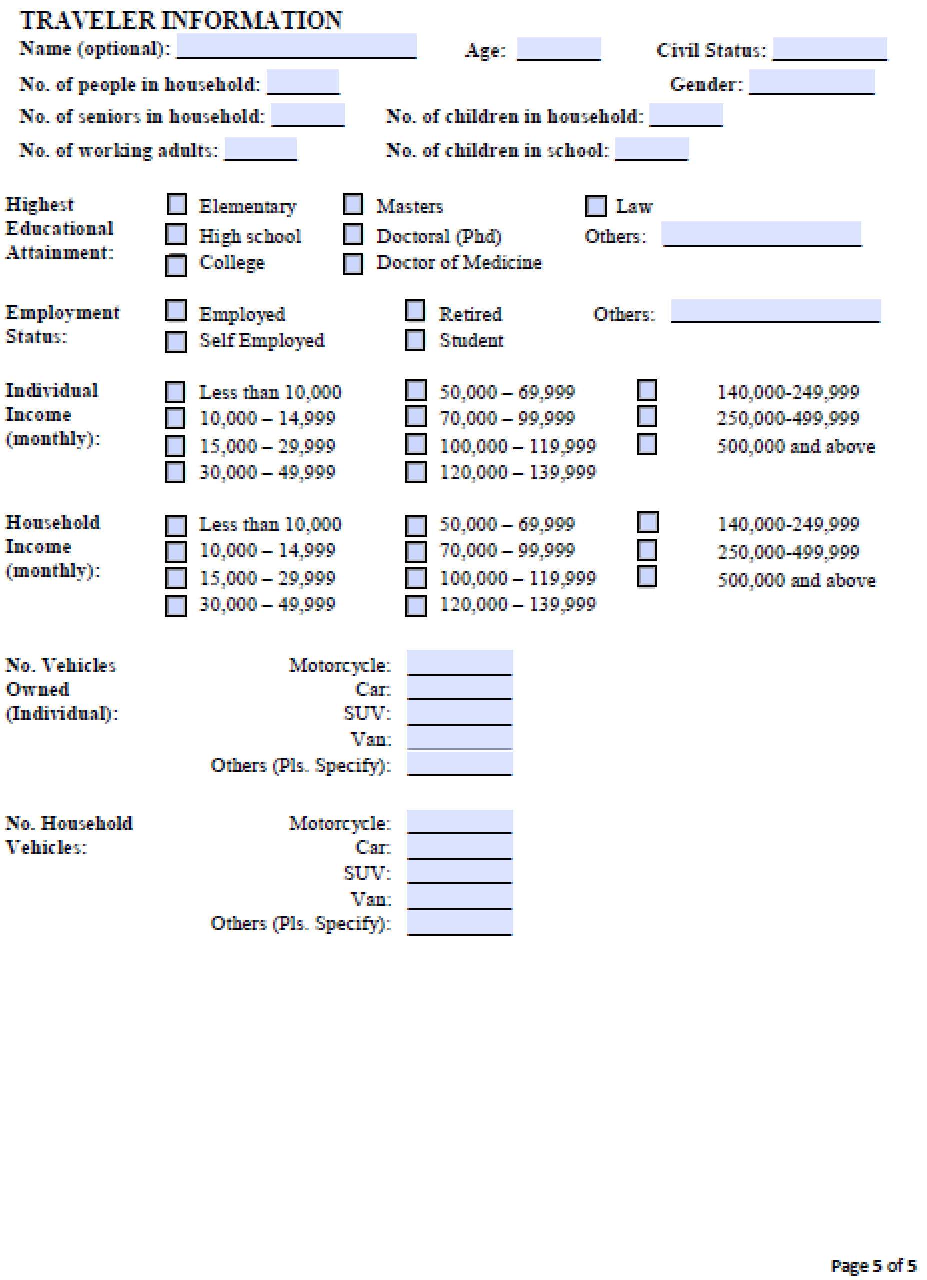
Figure A.3. Route choice portion of the Survey


TRAVELER INFORMATION

Name (optional): ______ Age: ______ Civil Status: ______

No. of people in household: ______ Gender: ______

No. of seniors in household: ______ No. of children in household: ______

No. of working adults: ______ No. of children in school: ______

Highest Educational Attainment: ☐ Elementary ☐ High school ☐ College ☐ Masters ☐ Doctoral (Phd) ☐ Doctor of Medicine ☐ Law Others: ______

Employment Status: ☐ Employed ☐ Self Employed ☐ Retired ☐ Student Others: ______

Individual Income (monthly): ☐ Less than 10,000 ☐ 10,000 – 14,999 ☐ 15,000 – 29,999 ☐ 30,000 – 49,999 ☐ 50,000 – 69,999 ☐ 70,000 – 99,999 ☐ 100,000 – 119,999 ☐ 120,000 – 139,999 ☐ 140,000-249,999 ☐ 250,000-499,999 ☐ 500,000 and above

Household Income (monthly): ☐ Less than 10,000 ☐ 10,000 – 14,999 ☐ 15,000 – 29,999 ☐ 30,000 – 49,999 ☐ 50,000 – 69,999 ☐ 70,000 – 99,999 ☐ 100,000 – 119,999 ☐ 120,000 – 139,999 ☐ 140,000-249,999 ☐ 250,000-499,999 ☐ 500,000 and above

No. Vehicles Owned (Individual): Motorcycle: ______ Car: ______ SUV: ______ Van: ______ Others (Pls. Specify): ______

No. Household Vehicles: Motorcycle: ______ Car: ______ SUV: ______ Van: ______ Others (Pls. Specify): ______

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Figure A.4. Traveler Information/Socio Economic portion of the survey

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