Mode Choice Analysis of Passengers and Vehicle Traffic Between Davao City and Island Garden City of Samal

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Abstract: In the Philippines, one of the proposed bridges that will undergo implementation is the Samal Island – Davao Connector (SIDC) Bridge. This study aims to analyze the mode choice of water-transport users once the bridge is built using logit models from stated preference surveys conducted in the ferry ports of Davao and Samal which will determine the factors that will influence on choosing the bridge or ferry. A survey will also be done to businesses to determine location factors on establishing offices/branches in Samal. Results showed that overall, cost is a consistent significant factor. Probability curves showed that higher cost lowers the probability of shifting to the bridge option and people will revert to the ferry. However, higher travel time gives higher chance of shifting to the bridge. For companies and businesses, the high-scoring factors are road access and basic public services such as reliable electricity, water supply, and internet services.

Keywords: Transport, Asia, Mode Choice, Interisland Bridges

1. INTRODUCTION

The geographic features of Philippines as an archipelago naturally result to the fragmentation of the land transportation network and territorial discontinuities, resulting to limited access and movement for people, goods and resources which result to imbalanced economic growths between islands. Due to absence of links such as bridges and/or tunnels between islands in the country, these are connected by complex system of water transportation modes or by air transportation (Bouquet, 2012).

Water-borne transport modes are mostly used to connect islands because of their low investment requirement. However, as times go by, water transport modes face several issues such as increasing fuel prices, breakdowns due to outdatedness and unreliability during adverse weather conditions (Knowles, 1996) and become less efficient as compared to land-based transport modes. Many countries have built fixed link infrastructures such as bridges and tunnels to connect their islands and experienced rapid development and population growth within a few years after construction of fixed links (Leung *et al*., 2017). Yet, some countries have opposed the construction of fixed links to preserve the islands' environment and social fabric (Vannini, 2011) and its identity.

As part of the Build, Build, Build program of the Philippine government, many large-scale inter-island bridges were conceptualized and planned for construction by the Department of Public Works and Highways (DPWH) to improve the infrastructure and connectivity in the country. However, after undergoing preliminary feasibility studies, some bridge proposals were deemed infeasible due to technological limitations for engineering complexities such as significantly deep foundations and extensive spans (DPWH, 2018). This resulted to only three

(3) out of seven (7) bridge projects passing the feasibility study stage and will undergo detailed engineering design (Rivas, 2019). These bridges alone will entail high investment costs for the construction and maintenance of the project. One of the bridges that are undergoing detailed design is the Samal Island – Davao City (SIDC) Bridge Project costing to PHP 23 Billion. The SIDC Bridge shall be a fixed link connecting Davao City to Samal Island, across the Pakiputan Strait. Currently, people cross via passenger ferries and RoRo vessels.

Figure 1. Location of SIDC

In the future when new technologies are developed such that the remaining proposed bridges become technically feasible, there is still a need to answer whether these bridges are necessary considering the high investment costs or is water transportation sufficient to meet demand in those regions. This is also considering that improvement of the ports and water transports are relatively cheaper than constructing a bridge. With the high investment cost put into these large-scale bridge projects, there is a need to determine if these bridges will be fully utilized. One way is to determine the mode choice of water-transport users once a bridge is built in a specific crossing. In order to describe the behavior of the traveling population and see the factors affecting their mode choice, the logit model can be done for discrete choice modelling (Hensher and Greene, 2003).

A fixed link connecting an island to a mainland can also greatly affect and change the land use, boost tourism and increase stress in the ecosystem of the island (Xie *et al.*, 2017). This can be observed for Mactan Island which was once a sleepy fishing village but when a bridge was built connecting Mactan to Cebu in 1979, the Mactan Export Processing Zone was opened and divided Mactan into an industrial and tourism area (De Villa, 2019). Future use of the bridge can also be determined if businesses and developers will relocate and build their businesses in the island given a new bridge. The potential development of the island may be determined through the location choice factors that will influence businesses and companies to have an office, branch, plant, and others at the island in the future given the construction of the bridge.

This study aims to analyze the mode choice of water-transport users, passengers and vehicle-users, once the SIDC Bridge is built and operational using the Logit model. The study will give information on what are the factors that will influence the mode choice of passengers and vehicles on whether to continue traveling via ferry or use the SIDC Bridge when it is built.

With the factors determined, possible preparations can be done on how to improve or maintain the transportation system in the areas where the bridge will be built. This information can give clearer indicators on whether an expensive bridge is necessary or not and facilitate the planning of future bridge projects. Results of the location choice factors will also be helpful for the future planning especially for Samal in the development of the island as well as maintaining its environment and roots.

This study will focus on the factors and mode choice analysis for both passengers and vehicle-users in the existing terminals of Davao City and Island Garden City of Samal (IGaCOS). The model will be based on the data gathered on the conducted stated preference survey last 2019 before the start of this study. A quantitative analysis will be done for the location choice survey which will be conducted to randomly selected firms and businesses operating in Davao and nationwide.

2. REVIEW OF RELATED LITERATURE

2.1 Mode Choice Analysis

Several studies have conducted discrete choice modeling such as Binary Choice Logit Model, Multinomial Logit Model, Nested Logit Model and others to examine the mode choice behaviors of travelers within a study area.

Roxas Jr. and Fillone (2015) formulated a multinomial logit (MNL) model derived from stated preference data to determine the mode shift behavior of passengers once the proposed Panay-Guimaras-Negros (PGN) Bridge is constructed. Choices include water transportation and land transportation using the bridge. The results showed that travel time, travel cost, number of vehicles and comfort will affect mode choice. A similar study was made by Roquel and Fillone (2013) for the PGN Bridge and found out that total travel time on land and total cost of the travel are found out to be significant factors. Other factors that were significant are income and age or respondents.

Alijarad and Black (1995) analyzed two intercity mode choices in the Saudi Arabia-Bahrain corridor using logit model. The two models developed is the Riyadh-Bahrain corridor and the Eastern Province-Bahrain corridor. Water transportation, air transportation, and land transportation via the causeway were all considered as the main modes. The results showed that the significant variables such as immediate decision time is applicable to the Riyadh-Bahrain corridor while the variables duration of stay and out-of-pocket cost is applicable only to Eastern Province-Bahrain corridor.

Other mode choice studies were done by Diaz (2011) who identified the determinants and passenger characteristics of inter-island travel from air and sea travelers between Manila and Busuanga Island using binary choice logit model. The impact of fare differences, trip characteristics and socio-economic attributes on the respondents' mode choice were evaluated and the most significant determinants are fare level, traveler income and trip purpose. Another is by Ortuzar and Gonzalez (2002) who used Multinomial Logit Model and Nested Logit Model to analyze the mode choices of ferry, jet-foil and plane for travelling between Gran Canaria and Tenerife islands. Their study showed that passengers are more sensitive to quality of service such as travel time than fare changes.

2.2 Logit Model

The Logit Models for the study will be determined through the stated preference survey data obtained in this study. A stated preference survey is the most suitable for transport purposes

and is mainly used for hypothetical scenarios where there is no real-world data existing yet for the use of the bridge (Andrejszki *et al.*, 2015).

It is assumed that the choice of the passengers follows the economic consumption theory wherein the individual will choose the alternative with highest utility. This utility can be expressed as:

$$U_n(i) = V_{in} + \varepsilon_{in} \quad (1)$$

where V is the deterministic or observable component and ε represents as a random and unobservable component. The component V can be further expressed as a function of the factors and its coefficients as shown in equation 2.

$$V_i = \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_n X_{in} \quad (2)$$

The alternative with the highest utility shall have the highest probability of being chosen. Assuming that the random error ε, is identically and independently Gumbel distributed, the probability of choosing mode *i* is shown in equation 3.

$$P(i) = \frac{\exp(U_i)}{\sum_{i'=1}^{I} \exp(U_{i'})} \quad (3)$$

Through this, a logit model can be estimated given the acquired data which assigned the probability of an individual travelling from one point to another choosing the mode i. The said model will be able to capture the relevant factors influencing choice decisions (Hensher *et al.*, 2005).

To determine the overall significance of the model, the log likelihood (LL) function is used to measure how well a particular model fits the data and is compared with the LL function of the base model or the null model (using zero values). If the LL function of the estimated model can be shown as a statistical improvement of the LL function of the base model, such as statistically closer to zero, then the model can be thought of statistically significant overall.

The software used for this study is the Apollo Choice Modelling which is developed and released by the University of Leeds. Apollo is a freeware package that relies on R (Hess and Palma, 2022). Apollo also reports the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The score obtained from the AIC is minimized and the model with the smallest AIC over a set of models gets selected. Meanwhile, the BIC is another model selection criterion in which it imposes greater penalty on the number of parameters. The score obtained from the BIC equation is also minimized wherein the model with lowest BIC is selected (Brownlee, 2019).

2.3 Location Choice and Land Use of Study Area

One study applicable to the location choice to be conducted in this research is by Herrin and Pernia (1986) who conducted a survey of 100 randomly-selected firms in the Philippines to determine the factors affecting their choice of location. For future location decisions, "government bans" as government intervention was considered a highly important factor. Seven decisive factors that influence location decision were determined namely: (a) closeness to major customers (b) easy road access; (c) reliable electrical power; (d) adequate telephone services; (e) availability of sustainable plot of land; (f) availabiSlity of suitable building; and (g) adequate space expansion.

These preferences are also similar to the study by Rahman and Kabir (2019) shows that small and medium enterprises in Bangladesh prefer low-cost spaces and large open spaces in non-residential areas with sufficient transportation, utilities and access.

The Davao Region Physical Framework Plan (DRPFP), 2015-2045 of the Regional Development Council XI (RDC XI) – Davao Region have shown that the Land Classification in Davao City and most of IGaCOS are Alienable and Disposable which is defined as land "of public domain and declared as not needed for forest, mineral purposes or national parks". It

was also stated that IGaCOS is a well-known tourist spot hosting to many white sand beaches and caves. Based on the DRPFP, the medium to long term plan of the region involves the establishment of IGaCOS as the hub of the Davao Gulf trading activities by constructing a sea and RoRo port at the eastern side of the island and establishing an industrial center or economic zone in conjunction with the construction of the SIDC Bridge. With these plans, it was envisioned that the Davao Gulf shall be an alternative logistics hub center establishing the Davao Gulf Integrated Port Complex in Samal Island for the long term spatial strategy.

3. METHODOLOGY

3.1 Description of the Study Area

As shown in Figure 2, the left side is Davao City and the right side is IGaCOS with the Pakiputan Strait separating the two. The current mode of transport between the two cities is through passenger ferries and RoRo ferries. There are three ports in the Davao side: DavSam Ferry Terminal, Sasa Ferry Terminal and Samal Ferry Wharf, and two ports in the Samal side: Babak Ferry Terminal and Samal Ferry Terminal. The routes of Samal Ferry Wharf to Samal Ferry Terminal and DavSam Ferry Terminal to Babak Ferry Terminal, provide RoRo ferries, which cater to walk-in passengers and vehicle-users. The Sasa Ferry Terminal connecting to Babak Ferry Terminal operate ferries exclusively for passengers. During peak times, the terminals operate with a 15 minute headway for both passenger and RoRo ferries. There is another port located at the south of Davao City which connects to the southern portion of Samal Island.

Figure 2. Location of the bridge and ports from the Feasibility Study of SIDC

The landing point of the bridge is approximately 4.5 kilometers away from the Samal Ferry Wharf via the R. Castillo Street in Davao City and 2.5 kilometers away from Samal Ferry Terminal via the Circumferential Road in IGaCOS.

The RoRo ferries used in the two routes are in the form of barges that can carry up to 18 light vehicles plus motorcycles and/or bicycles. The average travel time of the barge is 15

minutes excluding the queuing and boarding time. The passenger ferry or locally known as "motorbanca" or "lantsa" can carry a passenger capacity of 165 passengers and has an average travel time of 10 minutes excluding the waiting time. The RoRo ferry terminals in Davao side have specified terminals with clear access roads, the Sasa Ferry Terminal for the passenger ferry is located within a market with no clear direct access for vehicles.

3.2 Data Gathering and Analysis for Mode Choice

The stated preference (SP) survey data were obtained from the transportation survey conducted during the implementation of the Feasibility Study of SIDC last June 2019 for the Department of Public Works and Highways (DPWH). An updated survey during the implementation period of this study was prohibited because of the restrictions imposed due to the COVID-19 pandemic. As such, the SP data from the SIDC Bridge's feasibility study was requested and obtained from DPWH. The survey was conducted at the five terminals mentioned in 3.1. Two separate surveys were done, one for passengers that walked-in, meaning those that did not bring any vehicles, and the other one is for vehicle users using the RoRo ferries.

The SP survey form for passengers contained scenarios varying the journey time and fare for the option of Vehicle Connection with one or two transfers, and the option of Ferry Service which should be same with the current trip. For the purpose of this study, only the Vehicle Connection Option considering two transfers and Ferry Service Option were considered. A total of six scenarios were indicated in the questionnaire varying the cost and journey time which includes the waiting time and on-board time. The SP survey form for vehicle users also contained six different scenarios varying the journey time and cost when choosing the options of either using the ferry or a bridge. Cost is varied based on the existing the ferry rate of the vehicle (i.e. 50% more on the existing, double the existing, etc.). Other factors that were contained in the questionnaire were the origin and destination, purpose of travel, type of vehicle used, queuing time and age of respondent.

Using the SP data, the best Logit model will be determined. The Apollo Choice Modelling Package using R interface was used for the obtaining the models from the data from the survey.

3.3 Location Choice Survey

The questions in the location choice survey were based on the study of Herrin and Pernia (1986) which asks the respondent to rate the importance of different factors that will influence their business to establish a branch or office in IGaCOS. The ratings of were "Decisive," "Major Importance," "Some Importance," and "Unimportant" where in the respondent shall only choose one for each factor.

The respondent was also asked to identify the type of industry is their business is and other characteristics such as whether it is locally-owned or foreign-owned, location of main branch, presence of multiple businesses, and others.

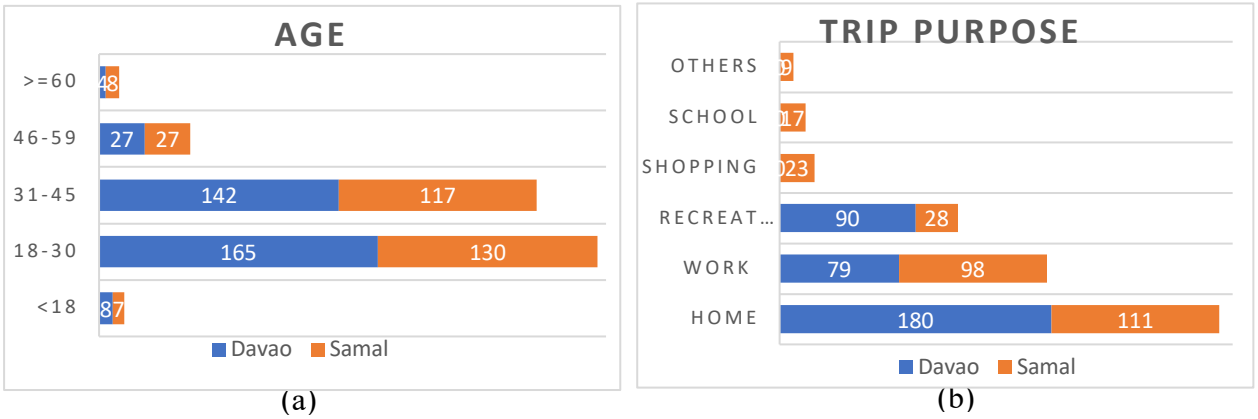
This survey was sent out to multiple businesses belonging to different types of industries. The survey focused more on businesses that already established multiple branches. Businesses home grown in Davao were also preferred considering their proximity to the island.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

A total of 635 respondents were interviewed for the passenger survey. The respondents are classified based on age groups and trip purpose. As shown in Figure 3(a), 295 respondents were aged 18-30 years old which make up most of the respondents, followed by 259 respondents aged 31-45 years old.

As shown in Figure 3(b), most of the sample's trip purpose is going home with 291 respondents followed by going to work with 177 respondents and then followed by going for recreation with 118 respondents. The least shares are those going for shopping with 23 respondents, going to school with 17 respondents and lastly are 9 respondents that have other trip purpose not mentioned in the questionnaire such as going to the hospital or visitations. There are relatively more coming from Davao with trip purpose of going home or recreation while those coming from Samal is relatively more for the work trip purpose. Further, only those coming from Samal have trip purposes of school, shop and others. This shows that people from Samal go to Davao for work, school, and shopping while people from Davao go to Samal for recreation.



(a) (b)

Figure 3. Descriptive Statistics for Passenger Survey

Queuing time including the waiting time before boarding the ferry ranges from a minimum of one minute to maximum 60 minutes. A total of 547 passengers queued for less than 15 minutes with share of 86.14% while 3 passengers queued for more than 30 minutes. Average queuing time is 13.82 minutes.

For the vehicle user survey, a total of 385 respondents were interviewed. As shown in Figure 4(a), 106 respondents were aged 18-30 years old, 205 respondents were aged 31-45 years old, 65 were aged 46-59 years old and 9 were aged equal or greater than 60 years old, and more than 50% of the respondents were between 31 to 45 years old.

In Figure 4(b) showing the trip purpose, most of the respondents are going home making up 43.12%, followed by those for recreation with 27.53%, and going to work with 16,88% and going shopping with 7.79%. Fifteen respondents, which make up 3.90%, have other purpose not mentioned in the questionnaire such as going to the hospital, visiting someone or delivering something. Lastly, only three respondents have the trip purpose of going to school. Most for those going shopping and all going to school originated from Samal while there are relatively more going home and for recreation coming from Davao.

Figure 4(c) shows the type of vehicle the respondent is using while using the ferry. A total of 139 respondents were using motorcycles and 133 were using private vehicles which make 36.10% and 33.77% respectively. Next were the drivers of heavy trucks with 73 respondents (18.96%), then are drivers of light cargo vehicles with 31 respondents (8.05%), followed by 10

tricycle drivers (2.60%) and 2 taxi drivers (0.52%).

At the time of the survey, 287 respondents have less than 15 minutes queuing time, followed by 62 respondents who experienced 16-30 minutes, 24 who waited 30-45 minutes and 12 who waited 46 to 60 minutes. Maximum waiting time noted was 60 minutes while the minimum was one minute. The average queuing time is 13.82%.

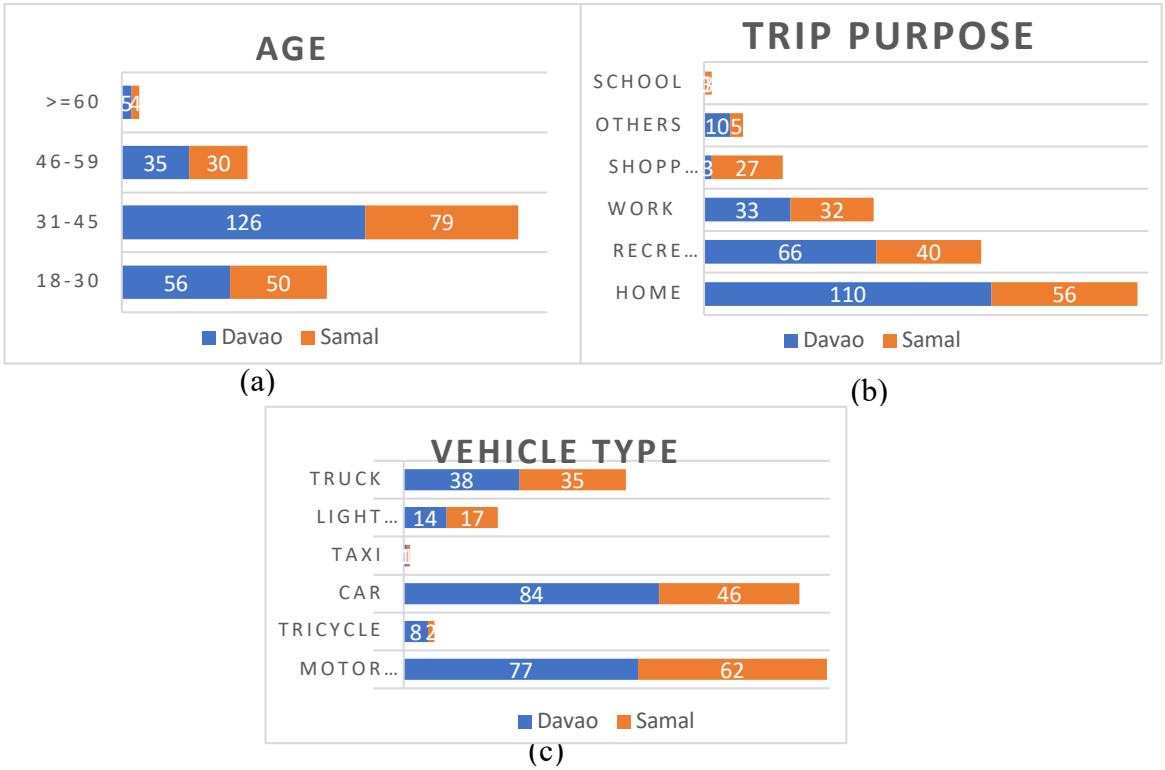


Figure 4. Descriptive Statistics for Vehicle-User Survey

4.2 Logit Choice Model

4.2.1 Passenger Model

For the passenger model, out of the 3,810 total choices available from the Passenger SP data, the vehicle option was chosen 2,903 times which constitutes to being 76.19% chosen overall while the ferry option was chosen 907 times which is 23.81%. From the data obtained, several logit models were examined and Table 1 shows the final model developed.

Table 1. Summary of final model chosen from the Passenger SP Survey

Variable	Definition	Estimate	P-value
ASC_VEH	Alternative specific constant for vehicle option	1.466754	0.00000
ASC_FER	Alternative specific constant for ferry option	0.000000	NA
TT_OB	Travel time while onboard a vehicle or ferry	-0.007260	0.02261
COST	Cost	-0.068216	0.00000
PUR_HOME	Purpose of trip is home	0.195086	0.01252
PUR_REC	Purpose of trip is recreation	0.219661	0.02628
Goodness-of-fit Measure			

Rho-square	0.251
Log likelihood	-1977.93
AIC	3965.86
BIC	3997.08

As shown in the model, the alternate specific constant for the ferry was fixed to zero and the travel time overboard (TT_OB) and cost (COST) were used as general deterministic variables. In addition, PUR_HOME and PUR_REC constants were only assigned to the vehicle alternative. The alternative specific constant was considered zero for the ferry (ASC_FER) which gave a positive sign for ASC_VEH. When both are considered non zero, ASC_FER gives a negative value while ASC_VEH still gives a positive value which shows that passengers prefer the vehicle option. All the P values of the variables are below 0.05 which means that the null hypothesis that the estimated model is no better than the base comparison model is rejected.

The resulting utility functions from the model are shown below.

$$U_{veh} = 1.466754 - 0.00726 * TT\_OB_{FER} - 0.068216 * COST_{FER} + 0.195086 * PUR_{HOME} + 0.219661 * PUR_{REC} \quad (4)$$

$$U_{fer} = -0.00726 * TT\_OB_{FER} - 0.068216 * COST_{FER} \quad (5)$$

The negative signs of on-board travel time and cost shows that these are disutilities for both vehicle and ferry options. The positive sign for the purpose variables for home and recreation shows those traveling with these purposes prefer to travel via the vehicle option than the ferry. Considering that the vehicle option is with two transfers, people who are going home or going for recreation still prefer to ride vehicles rather than getting off at the ferry terminal, ride a ferry and then ride another vehicle at the other terminal.

During the development of the model, it was found out that the variables of total travel time and the time walking and waiting are found to be insignificant. Age and purpose of work, school, and shop were also found to be insignificant.

Aside from having all the variables' p-values are less than 0.05, the chosen model has the highest rho-square value, log-likelihood closest to zero, and lowest AIC and BIC values. Table 2 shows the goodness of fit values: rho-squared, log-likelihood, AIC and BIC of the chosen model and other models developed and considered.

Table 2. Goodness of Fit Comparison of the Developed Passenger Models

	Chosen Model	**Model P1**	**Model P2**	**Model P3**
Rho-square	0.2510	0.2496	0.2499	0.2485
Log likelihood	-1977.93	-1986.71	-1980.85	-1981.71
AIC	3965.86	3975.42	3973.71	3969.42
BIC	3997.08	4012.9	4011.18	3988.16

4.2.2 Passenger Model by Cost

Logit models based on cost and travel time were also developed according to age group and trip purpose. The probability curves for choosing the vehicle option were then computed and plotted. Table 3 shows the model results for the overall base model considering cost. A probability curve was also plotted for this and included in the curves per age group, purpose and vehicle type for comparison.

Table 3. Passenger Model - Logit model results for cost only

Age group	Base Model
Number of observations	3,810
ASC_VEH (p-value)	1.61623 (0.000)
COST (p-value)	-0.06662 (0.000)

Figure 5(a) shows the probability curves for the five age groups and overall base model considering cost of the vehicle against a fixed cost of PHP15 for the ferry.The resulting models show that the higher the cost, the less probability to shift to vehicle option. The p-values for the COST coefficient are considered significant for the three age brackets from 18 to 60. For fare of PHP15.00 and below, the probability for those aged 18-60 are relatively the same while those aged below 18 and greater than 60 have lower probabilities and less elastic.

Figure 5(b) shows the probability curves for the five purposes and overall base model considering cost of the vehicle against a fixed cost for the ferry. The same negative sign on the COST variable for both models show that cost has a negative effect on shifting to vehicle mode. Overall trend shows that the higher cost for the vehicle will result to lower chance of shifting to vehicle mode. All p-values of the coefficients are less than 0.05 which shows that the results are significant. For the vehicle cost of PHP30.00 and below, the probability of shifting to vehicle in decreasing order is for the purpose of Recreation, Home, Work, Shop and lastly School. For cost of above PHP30.00, the probability of Recreation decreases drastically. It can also be observed that those who travel for school has a relatively low probability of shifting to vehicle travel compared to the others.

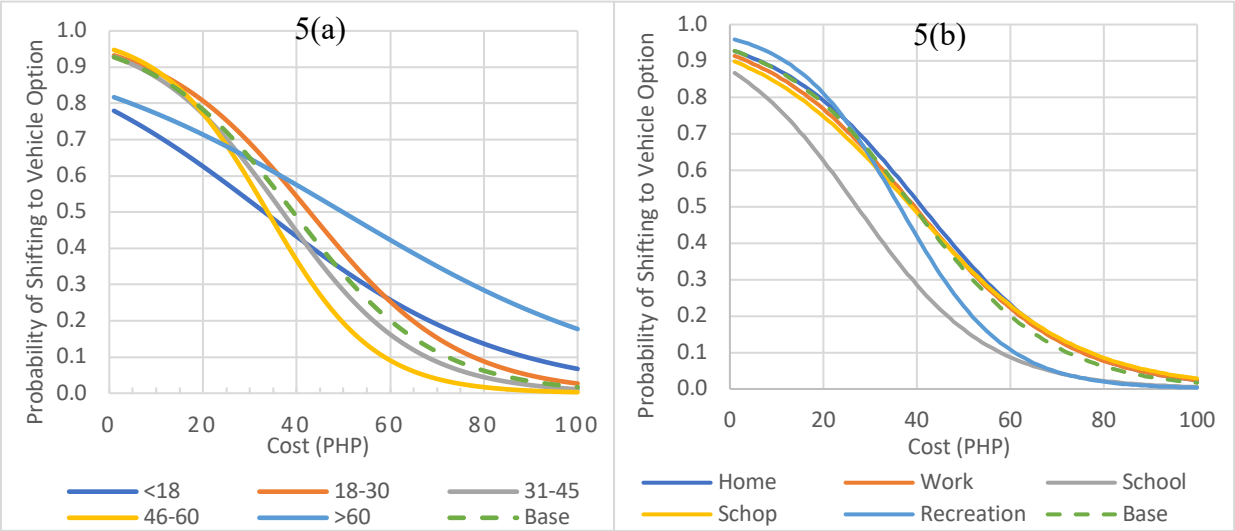


Figure 5(a). Passenger Model - Probability curves based on cost by age group (LEFT)
Figure 5(b). Passenger Model - Probability curves based on cost by purpose (RIGHT)

4.2.3 Passenger Model by Travel Time

Next will be getting the binomial models per age and purpose considering travel time. When only travel time is considered, total travel time shows to be significant when compared to using on-board travel time. Table 4 shows the model results for the overall base model considering travel time.

Table 4. Passenger Model - Logit model results for travel time only

Age group	Base Model
Number of observations	3,810
ASC_VEH (p-value)	1.46992 (0.000)
TT (p-value)	0.04533 (0.000)

The positive sign for the coefficient of travel time (TT) means that the higher the travel time, the higher the probability of passengers to shift to vehicle option. This may be since the average on-board travel time of using the ferry is only 15 minutes, the rest of the travel time falls on the queuing and waiting time. Passengers prefer to use the vehicle or public transport with longer the travel time onboard since they are already sitting in a moving vehicle and not waiting stationary in a terminal. Based on the origin of the respondents, an approximate 27.24% came from the districts and barangays that are near the terminals while the rest originated from other parts of Davao City or IGaCOS, hence, travel time on-board may be of no issue to them unlike having to add additional waiting or queuing time when in a terminal.

Another factor that may have caused the positive value for travel time and positive trend on the probability curves is the limitation of the scenarios in the questionnaire used from the Stated Preference Survey. There was only one scenario with the travel time higher for the vehicle option with lower cost, no other scenarios were made with higher travel time. It was also noted that out of the 635 interviewees, 74 or 11.65% have chosen the ferry for all six scenarios however no trend was found based on their socio-demographic factors.

Figure 6(a) shows the probability curves for the five age groups and base model considering the increase of travel time. Travel time for the ferry option was fixed as 45 minutes. The positive signs for the coefficient of travel time (TT) means that the higher the travel time, the higher the probability of passengers to shift to vehicle option. This may be since the average on-board travel time of using the ferry is only 15 minutes, the rest of the travel time falls on the queuing and waiting time. Passengers prefer to use the vehicle, the longer the travel time may be because they are already sitting in a moving vehicle and not waiting stationary in a terminal.

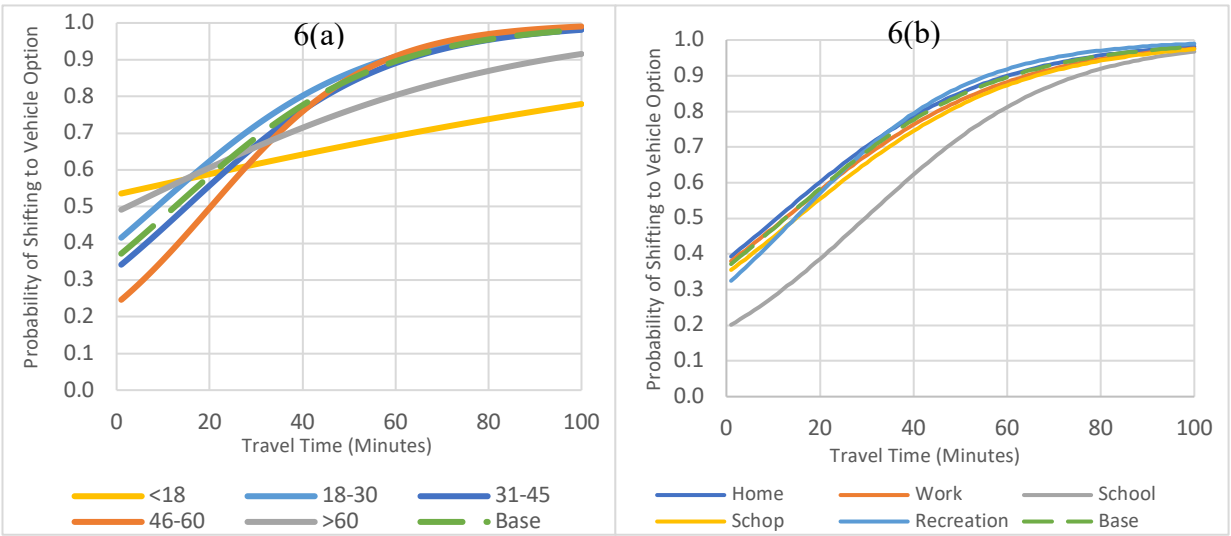


Figure 6(a). Passenger Model - Probability curves based on travel time by age group (LEFT)
Figure 6(b). Passenger Model - Probability curves based on travel time by purpose (RIGHT)

Figure 6(b) shows the probability curves for the five purposes and overall base model considering travel time. The same positive trend is consistent with the previous model in which the higher the travel time, the higher the probability of shifting to vehicle option. The curves are relatively the same for the base model and the purpose of home, work, shop and recreation.

The probability curve for the school purpose is relatively lower which is similar to the observation with cost.

4.2.4 Vehicle Model

For the vehicle-user model, out of the 2,310 total choices available from the Vehicle-User SP data, the vehicle option was chosen 1,587 times or 68.7% overall and the ferry was chosen 723 times or 31.3% overall. From the data obtained, following logit model was developed as shown in Table 5.

Table 5. Summary of final model chosen from the Vehicle SP Survey

Variable	Definition	Estimate	P-value
ASC_BRG	Alternative specific constant for bridge option	3.009399	1.3781e-04
ASC_FER	Alternative specific constant for ferry option	0.000000	NA
TT_BRG	Total travel time for vehicle users to cross the bridge	-0.017780	0.006865
TT_FER	Total travel time using ferry	0.017646	4.4830e-05
COST	Cost	-0.009331	0.00000
VEH_TYPE	Vehicle type	0.081443	0.001423
AGE	Age	-0.015570	9.5387e-04
PUR_HOME	Purpose of trip is home	-1.398063	0.019548
PUR_WORK	Purpose of trip is work	-1.443607	0.017484
PUR_SCHOOL	Purpose of trip is school	-2.498040	5.6804e-04
PUR_SHOP	Purpose of trip is shop	-2.145378	0.001564
PUR_REC	Purpose of trip is recreation	-1.634849	0.008406
Goodness-of-fit Measure			
Rho-square	0.2246		
Log likelihood	-1241.58		
AIC	2505.15		
BIC	2568.35		

All the p-values of the variables are below 0.05 which means that the null hypothesis that the estimated model is no better than the base comparison model is rejected. The resulting utility equations of the alternatives based on the vehicle-user model are as follows:

$$U_{BRIDGE} = 3.009399 - 0.01778 * TT_{BRG} - 0.009331 * COST_{VEH} + 0.081443 * VEH_{TYPE} - 0.01557 * AGE \quad (6)$$

$$U_{FERRY} = 0.017646 * TT_{FER} - 0.009331 * COST_{FER} - 1.398063 * PUR_{HOME} - 1.443607 * PUR_{WORK} - 2.49804 * PUR_{SCHOOL} - 2.145378 * PUR_{SHOP} - 1.634849 * PUR_{REC} \quad (7)$$

The variable for travel time was considered as alternative specific while the variable for cost was used as a general deterministic variable for both equations. Vehicle type and age were considered as continuous variables that were only applied for the vehicle utility equation while the purposes were applied for the ferry utility equation. Inverse signs on the travel time with negative sign on the TT_BRG shows that travel time is a disutility for the option of using the bridge with their vehicle while the positive sign on TT_FER shows that it has a positive effect for the ferry option. The negative sign on COST is consistent with being a disutility for both

options and with the passenger model however, the value is relatively small compared to the other coefficients although it should be noted that the cost considered in the model ranges from PHP 100 and higher. The alternative specific constant for ferry, ASC_FER was configured to remain zero which gave a positive ASC_BRG. All the variables for each purpose and age are all significant and have negative utility for the ferry option.

Aside from having all the variables' p-values are less than 0.05, the chosen model has the highest rho-square value, log-likelihood closest to zero, and lowest AIC and BIC values. Table 6 shows the goodness of fit values: rho-squared, log-likelihood, AIC and BIC of the chosen model and other models developed and considered.

Table 6. Goodness of Fit Comparison of the Developed Vehicle-User Models

	Chosen Model	**Model V1**	**Model V2**	**Model V3**
Rho-square	0.2246	0.2196	0.2029	0.2198
Log likelihood	-1241.58	-1253.95	-1276.32	-1249.31
AIC	2505.15	2519.9	2558.65	2514.62
BIC	2568.35	2554.37	2575.88	2560.58

4.2.5 Vehicle Model by Cost

Logit models based on cost were developed according to age group, trip purpose and vehicle type. The probability curves for choosing the bridge option were then computed and plotted resulting to the following figures. Table 7 shows the model results for the overall base model considering cost. A probability curve was also plotted for this and included in the curves per age group, purpose, and vehicle type for comparison.

Table 7. Vehicle Model - Logit model results for cost only

	Base Model
Number of Observations	2,310
ASC_BRG (p-value)	1.978936 (0.000)
COST (p-value)	-0.006567 (0.000)

All probability curves have a negative trend in which the higher the cost, the lower the probability of shifting to the bridge option. This also means that if the bridge will not charge any toll fee, there is a high probability that vehicle users will shift to the bridge option.

Figure 7(a) shows the probability curves for the four age groups and overall base model considering cost of the vehicle against a fixed cost of PHP200 for the ferry. No model was derived for those aged below 18 years old since there were no respondents. The age group of 18-30 has the relatively highest rho-square value compared to the other groups.

Figure 7(b) shows the shows the probability curves for the five purposes and overall base model considering cost of the vehicle against a fixed cost for the ferry. For the probability curves, the model for purpose, School has generally the highest probability curve which contradicts the trend for the Passenger Model. Although it should be noted that the observation size for School is relatively low. The purpose, Home, has the relatively lowest probability curve which may show that it is the most considerate of cost as compared to Shop and Recreation.

Figure 7(c) shows the probability curves for the five vehicle types and overall base model considering cost of the vehicle against a fixed cost for the ferry. No model was developed for the Taxi/Grab given that there were only two respondents or 12 observations. The figure shows that the curve for "Truck" is relatively the highest. This may be because the cost difference for

the RoRo and bridge is relatively low. The curve for the "Tricycle" also differs however this can be caused by the low observations for this vehicle type. The rest of the vehicle types have relatively similar curves.

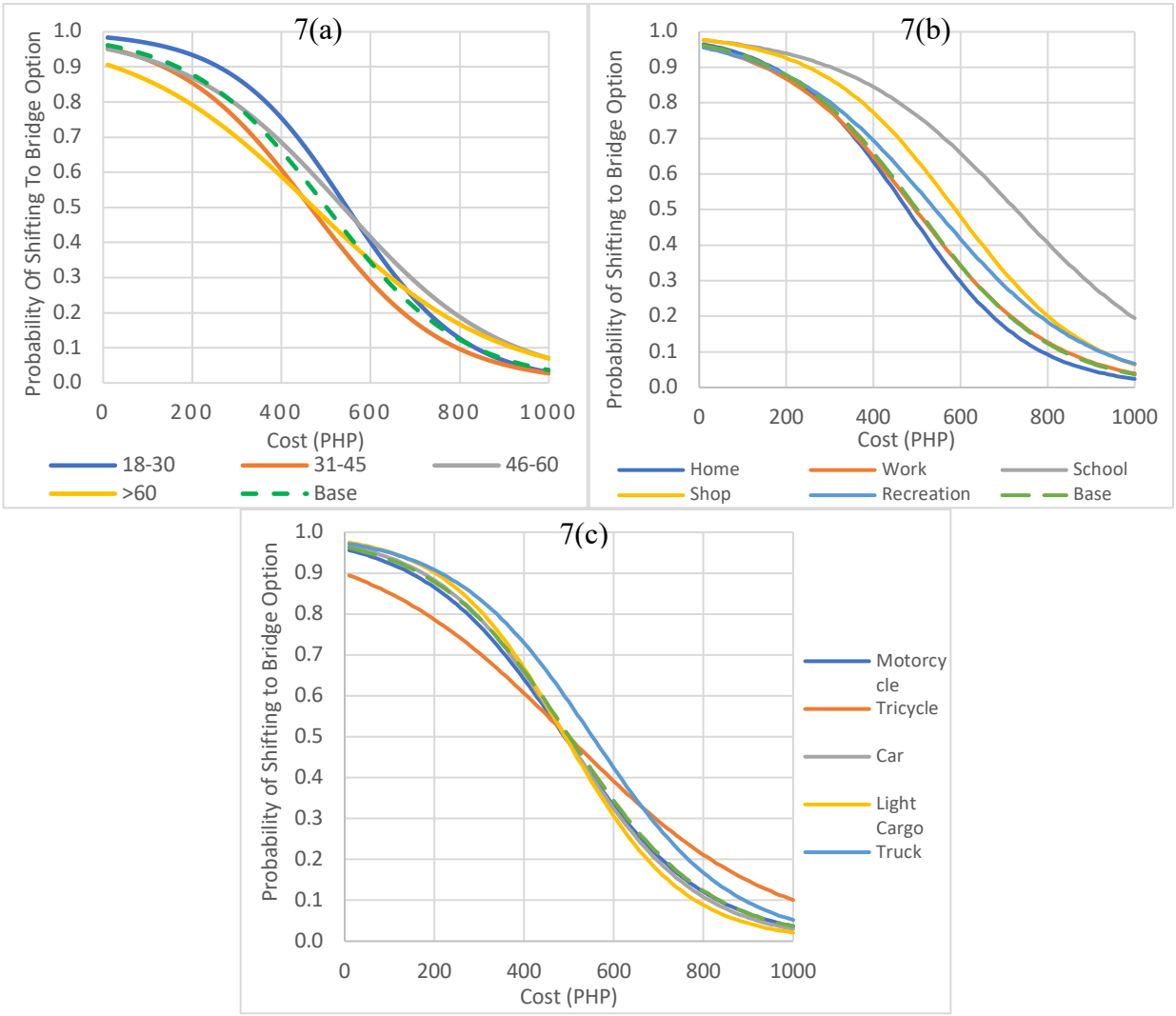


Figure 7(a). Vehicle Model - Probability curves based on cost by age group (TOP LEFT)
Figure 7(b). Vehicle Model - Probability curves based on cost by purpose (TOP RIGHT)
Figure 7(c). Vehicle Model - Probability curves based on cost by vehicle type (BOTTOM)

4.2.6 Vehicle Model by Travel Time

Logit models based on travel time were developed according to age group, trip purpose and vehicle type. The probability curves for choosing the bridge option considering increasing travel time for the vehicle as compared to the average travel time for the RoRo of 58 minutes were then computed and plotted resulting to the following figures. Table 8 shows the model results for the overall base model considering travel time. A probability curve was also plotted for this and included in the curves per age group, purpose and vehicle type for comparison.

Table 8. Vehicle Model - Logit model results for travel time only

Purpose	**Base Model**
Number of observations	2,310

ASC_BRG (p-value)	1.79839 (0.000)
TT (p-value)	0.04106 (0.000)

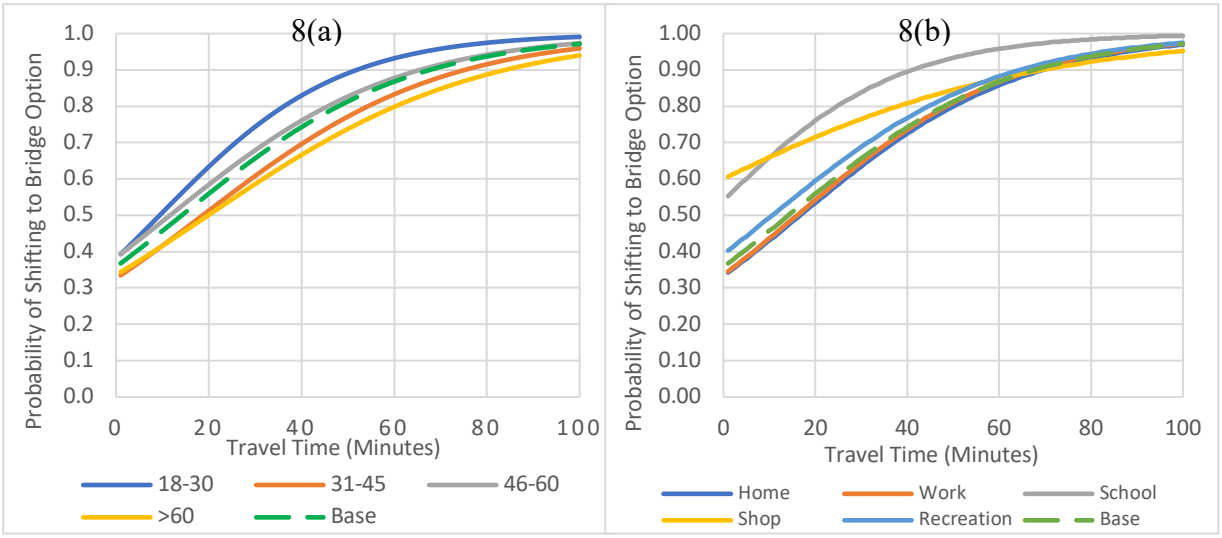
Probability curves per age group were developed and are plotted as shown in Figure 8(a). The positive trend and positive value of the travel time coefficient are similar with the Passenger Model in which the higher the travel time, the higher probability of shifting to the bridge option. Explanation may be also similar to the Passenger Model wherein the Vehicle users prefer to be in their vehicle moving instead of queuing for the RoRo.

Given that only 34.08% of the respondents originate at districts near the terminals, the rest originated from other parts of Davao City of IGaCOS hence, they have experienced longer travel time driving in their vehicles and would rather continue on driving and use the bridge rather than queuing in the RoRo terminals.

It should also be noted that the questionnaire used in the stated preference survey for the vehicle-users did not contain any scenarios wherein the travel time of using the bridge is greater than using the ferry. Models were also developed using only data of those near the terminals but it also provided positive travel time variable.

Figure 8(b) shows the probability curves considering travel time for different purposes. The probability curves for Home, Work and Recreation are relatively the same as compared to School and Shop. This may be due to the low observations for the latter two purposes. It should also be noted that the general that for a travel time of 15 minutes, which is the average travel time for the RoRo, there is already a minimum of 50% chance of shifting to the bridge option.

Figure 8(c) shows the probability curves for the five vehicle types and overall base model considering cost of the vehicle against a fixed cost. The Trucks and Light Cargo have relatively highest probability curves when it is beyond the 30 minute mark. The figure also shows that probability for 60 minutes of travel time is at 85% of using the bridge.



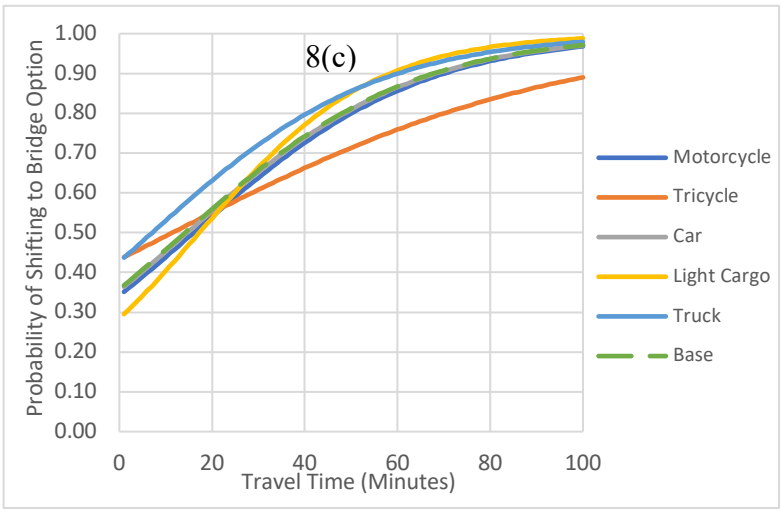


Figure 8(a). Vehicle Model - Probability curves based on travel time by age group (TOP LEFT)
Figure 8(b). Vehicle Model - Probability curves based on travel time by purpose (TOP RIGHT)
Figure 8(c). Vehicle Model - Probability curves based on travel time by vehicle type (BOTTOM)

4.3 Comparison with other models

When compared to the logit models derived for the Panay-Guimaras-Negros Bridge (Roxas and Fillone, 2015), the signs for TRAVEL TIME differ to the models of this study. Difference may be because this study only has two options while the former has five options as well as the treatment of the coefficients as alternative specific and generic. Further, the difference may be noted as difference in preference the people located in each location.

It was noted that for the Passenger model, on-board travel time was deemed significant unlike the waiting time similar to the study of Roquel and Fillone (2013). In addition, AGE is similarly significant for the Vehicle Model. The COST is consistent with being a significant factor with a negative disutility for the options.

It is difficult to compare with the studies of other countries such as the study of Aljarad and Black (1995) considering that the resulting models of their study have considered several factors and assumptions that were not considered in this study. Although it should be noted that out-of-pocket cost was found out to be significant to Eastern Province-Bahrain corridor crossing which involved the use of the causeway. No similarity was noted with the study of Ortuzar and Gonzales (2002) in which significant factor was quality of service such as travel time than fare changes.

4.4 Location Choice Result

Although more than 200 companies were reached out for the survey, only 10 were able to respond. the set deadline due to the multiple transfers to different departments or offices to be able to reach to the appropriate officer that can respond to the survey. A direct interview may be more effective however this cannot be done by the researcher due to the limited time to make the connections for the interview and the restrictions imposed due to Covid-19.

Profile of the sample firms shows that out of the 11, nine are locally owned or owned by a Filipino citizen while two are foreign-owned. Five of the companies have their main office or branch located in Metro Manila while the remaining six have their main office located in Davao region. Figure 8 summarizes the types of industry each firm belongs to. The firms were classified based on the feedback in the survey according to the types of industry stated in the Philippine Statistics Authority.

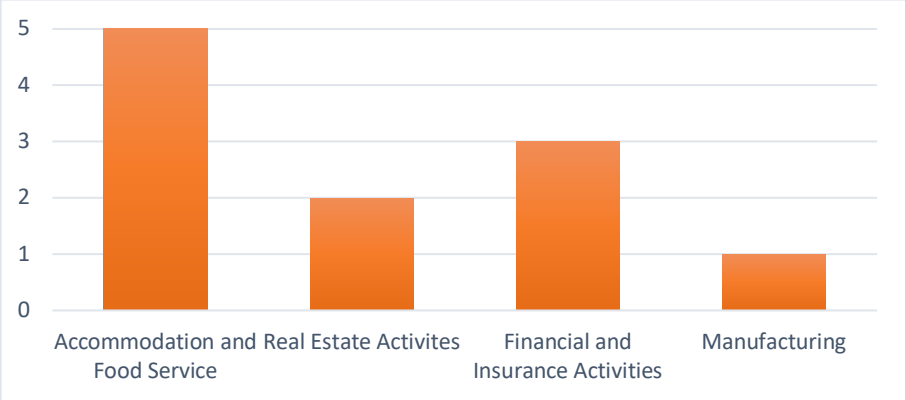


Figure 9. Types of Industry for the sample firms

The mean index score was calculated based on the scoring similar to the study of Herrin and Pernia (1986). The scoring are as follows: 4 = decisive; 3 = major importance; 2 = some importance; 1 = unimportant. The factors with mean index score of 3.0 or greater, ranked from highest to lowest, are shown in the table below.

Table 9. Factors with mean index score of 3.0 and higher

Factors	Mean Index Score
Accessibility [Easy road access]	3.45
Urban/Public Services [Reliable electrical power]	3.36
Urban/Public Services [Public water supply]	3.27
Accessibility [Close to major customers]	3.27
Site Condition [Suitable plot of land]	3.20
Urban/Public Services [Disposal of waste]	3.18
Site Condition [Low cost of land]	3.09
Urban/Public Services [Public transportation to site]	3.09
Urban/Public Services [Telephone/internet services]	3.09
Site Condition [Suitable building]	3.09
Labor Supply [Labor with required skills]	3.00
Urban/Public Services [Health facilities]	3.00

The mean index scores per industry type were also computed as shown in Figure 10. The figure shows that some factors are deemed important or decisive by one industry while deemed unimportant for other industries. The factor, low cost of land has the relatively highest mean score for the Accommodation and Food Service Industry while it was deemed unimportant for the Manufacturing Industry. Other factors that scored only "1" or unimportant for the Manufacturing industry are: labor with required skills; suitable building; and, suitable plot of land. It is noted that suitable plot of land has a mean score of 4 for Real Estate Industry.

The factors that were deemed decisive or scored "4" for Manufacturing are public transportation to site and easy road access. This may be that manufacturing industries can adapt to different type of land conditions and since they need plenty of workers for their industry hence the importance of the accessibility and public transportation factors. Although it should be noted that only one Manufacturing firm answered the survey hence this observation may not be of much significance.

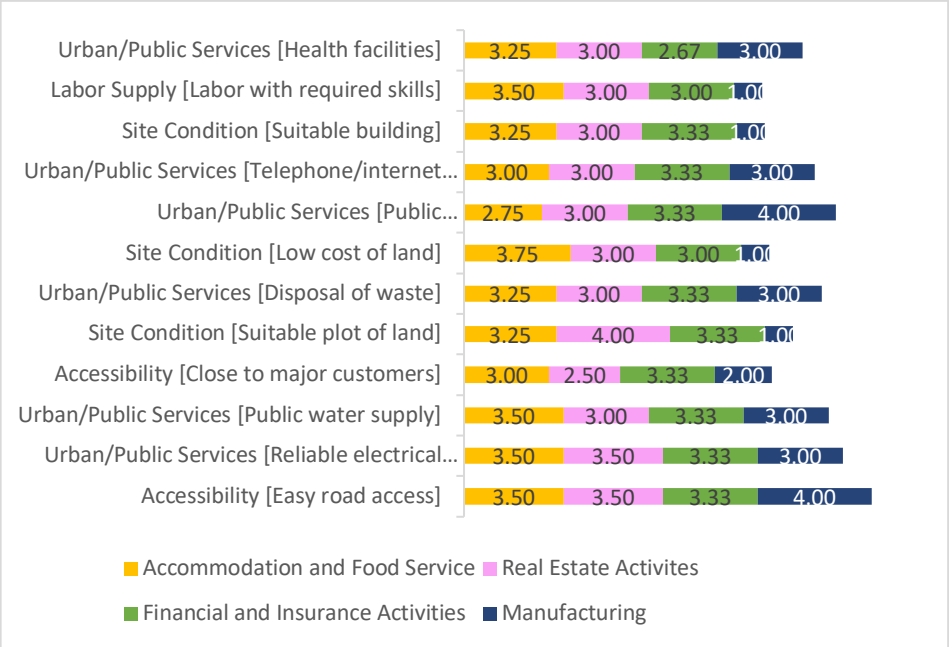


Figure 10. Mean index scores per industry

Among the 12 factors, five have mean scores of 3.00 or greater for the four industries. These factors are: (1) easy road access, (2) reliable electrical power, (3) public water supply, (4) disposal of waste, and (5) telephone/internet services. This means that aside from having accessibility with easy road access, having all the necessary basic urban needs for a firm to function such as electricity, water, internet and waste disposal are of major importance. Considering the plan for the bridge is to also carry utilities such as power and water from Davao to Samal Island (DPWH, 2019), the factors that are deemed important for firms to build a branch or office in Samal may be achieved.

As part of the survey, the companies were asked to rank how likely they will be establishing their business in the island with 10 being the highest and zero as the lowest. The mean scores per industry are shown in the table below.

Table 10. Likelihood Score of Establishing in IGaCOS

Industry Type	Mean Score
Accommodation and Food Service	9.20
Real Estate Activities	4.50
Financial and Insurance Activities	7.67
Manufacturing	5.00
Overall Average	7.5

Overall, most surveyed industries have given a high score in the possibility of establishing their business in the island. Further, if the Medium and Long Term Plan of the Regional Development Council XI of establishing an industrial and economic zone in the island is implemented and realized, then there will be high possibility that a lot will be using the bridge given there will be more businesses established in the future.

5. CONCLUSION

Overall, the most consistent factor will be the cost of the people crossing the area. Adding cost when crossing the bridge may be a huge factor for the decision making of people. Cost in using the bridge may be in the form of imposed toll given that the maintenance of the bridge is planned to be a Private-Public Partnership. Other costs may be an additional environmental fee imposed or the increase in fare or fuel consumption.

Probability curves showed that higher cost lowers the probability of shifting to the bridge option and people will revert to riding the ferry. However, higher travel time gives higher chance of shifting to shifting the bridge option.

Age does not have much difference for vehicle-users but for passengers, those aged below 18 and greater than 60 are less elastic compared to those aged 18-60. Trip purpose and vehicle type also have significance especially for vehicle users.

Out of all the options given to respondents, the percentage of choosing the bridge option were 76.19% for the passengers and 68.7% for the vehicle-users.

For companies and businesses, the most considered factors are easy road access and mostly basic public or urban services such as reliable electricity, water supply, waste disposal and internet services.

6. RECOMMENDATIONS

Further study of the mode choice with more than two options or combination of commuters or passenger-ferry users and vehicle-users can be done to have further understanding of the factors that affects the mode choice between bridge and ferry. More complex models may also be used such as nested-logit model to also include revealed preference survey data. It is also recommended that other factors such as comfort, income class and others should be considered in other studies. The models can also be compared with the value of time for the locations for further studies.

A separate and more focused study on the preference of companies on location choice when it comes to bridge versus water transport scenarios can also be explored to further understand the important factors for these businesses.

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