FEASIBILITY OF AERIAL TRAMWAY AT BOISE STATE UNIVERSITY

by

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The following individuals read and discussed the thesis submitted by student Majed Alsaqyani, and they evaluated his presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

This research is dedicated to King Abdullah, for providing me opportunities to advance my education, and for being an inspiration to the people of Saudi Arabia and the world. Without the support of King Abdullah, this project would not have been possible. King Abdullah was a model for living a righteous and productive life, and his goodness lives on today as an inspiration to his people.

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ABSTRACT

The use of aerial tramways is becoming common in cities as a way to provide reliable, safe, sustainable, and cost-effective mass transportation. The aerial tramway is especially effective in the most congested areas of major cities. The growth of Boise State University (BSU) and downtown Boise makes this location especially attractive for a tramway. Moreover, based on data collected for this analysis, it is clear that the BSU community is open to using the tramway instead of more traditional modes of transportation.

The viability of the tramway is further enhanced because the computer science department has moved to City Center Plaza, which is located near the intersection of Main Street and Capitol Boulevard, in the middle of downtown Boise. BSU students, staff and faculty need a convenient mode of transportation to travel between the BSU campus and the Computer Science building. People currently incur substantial costs, both in terms of parking fees and time spent commuting a relatively short distance. Parking in downtown Boise is difficult to find and expensive.

Travel between the BSU campus and downtown is not limited to activities of the students and staff of the university. Several large sporting and cultural destinations are located in the area. While the traffic congestion in Boise does not compare with that of other large Western United States and Canadian cities, it is clear that there is room for improvement as Idahoans incur an opportunity cost of $16.79 for every hour they spend stopped in traffic

The aerial tramway, although not new, has been recently popularized because of the well-known tram in nearby Portland. Trams have a reputation for safety and reliability and can accommodate large numbers of trips at very low incremental cost. As utilization increases, the fixed costs are spread among more riders and the tram's profitability can be substantial. Trams can become a key component of an area's mass transit infrastructure.

This study finds that an aerial tramway is feasible and economically viable based on data collected from students, faculty, and staff of BSU. A survey of 1430 respondents about the perceived convenience and costs relative to other transportation modes indicates a significant demand for tram services. Even though there is no historical demand for tram services at BSU, a stated preference approach allows the researcher to ask hypotheticals about the factors that are most closely tied to the viability of the project. Survey responses were statistically analyzed using descriptive statistics and logistic modelling with regression analysis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

1.1 Background

The reduction of transfer time has a direct impact on the quality of life of people. Adequate mobility is the key for access to employment, education, and health services, particularly for those who do not have a vehicle to travel or prefer the use of more environmentally friendly means of transport. To respond to the challenges of growth and mobility, urban planners have begun to consider alternatives to traditional modes - buses, trains, metros - of urban transport. Alternatives considered include cable cars, traditionally associated with ski resorts (Davila and Daste, 2011).

In the last decade, many cities around the world have built aerial tramway networks to improve urban mobility - including Portland, Oregon (USA); Roosevelt Island, NY (USA); Medellin (Colombia); Caracas (Venezuela); Hong Kong; Lagos (Nigeria); Constantine (Algeria); Rio de Janeiro (Brazil); Koblenz (Germany); Maokong (Taiwan); and La Paz-El Alto (Bolivia). In several studies evidence was collected to calculate that travel times of people using this type of transport around the world are reduced in average by up to 22% (Garsous, Suarez-Aleman, and Serebrisky, 2015). Similarly, aerial tramways also provide benefits in terms of environmental protection thanks to the fact that they do not generate emissions of gases derived from fossil fuels and that they present a lower risk of accidents, this in comparison with traditional systems such as buses and automobiles (Alshalalfah, Shalaby, Dale, and Othman, 2012).

As a part of my Master of Science thesis in Civil Engineering, I am conducting a feasibility study to implement an aerial tramway system between the Boise State University campus and downtown Boise with the primary goal to improve transport conditions for students, teachers and, in general, the entire University community. This report presents the results of a survey designed and executed to assess the willingness of students, faculty, and staff to use the proposed aerial tramway based on specific factors. The factors include efficiency of the aerial tramway, capacity of the carriers, environmental concerns, security vulnerabilities, and terminal locations.

Those results were obtained from the analyses of the survey data using the statistical software IBM SPSS under the logistic regression technique or logit model. Logistic regression, also called a logit model, is used to model dichotomous outcome variables. In the logit model, the log odds of the outcome are modelled as a linear combination of the predictor variables (Harrell, 2001). The use of this model has been selected since the variable of interest is categorical and specifically dichotomous, in addition to being of a qualitative nature. In this scenario, the logit regression model is the most appropriate to obtain an accurate analysis according to the data collected in this study (Hoetker, 2007).

1.2 Study Motivation

The information below describes the main motivations that led to propose a study for the start-up of an aerial tramway connecting Boise state campus to Boise downtown. These motivations are based on the benefits that this type of transportation provides to the community.

1.2.1 Connect Two Main Economic Areas in Boise

People move between the Boise State campus and Boise downtown not only to carry out activities related to students and staff of the university, but also to attend sporting and cultural events that take place at the different locations.

1.2.2 Decrease Traffic Congestion

While traffic congestion in Boise does not compare with that of large cities, it is clear that there is room for improvement as Idahoans lose $16.79 for every hour they spend stopped in traffic (Logan, 2018). Plus, Boise as any growing city must face a future and an inevitable problem: the lack of capacity of the means of transport available to meet mobility needs efficiently.

1.2.3 Increase Economic Base

The construction project will boost Boise's economy by creating temporary jobs as well as income for local companies that can join the project. In addition, in order to maintain and operate the aerial tramway, it is necessary to generate new jobs in the city. A third point will be the opportunity to hold more sporting and cultural events on the campus of the university thanks to the fact that there will be a transportation system that will increase the flow of visitors to and from campus. The mentioned economic revitalization derived from the implementation of an aerial tramway has been proven in the different success cases worldwide, Medellin in Colombia being the best example of this, where this system has operated successfully for more than 13 years (Goodship, 2015).

1.2.4 Reduce Environmental Pollution

One of the most significant benefits of an aerial tramway is the positive impact on the environment due to the reduction of pollution from fossil fuel residues; there would be less need to use buses and other types of vehicles driven by this type of fuels to support the growth in the demand for transport services (Arvidsson, 2010).

1.2.5 Positive Image for Boise

Reviewing the success stories in the United States, there are few for the various benefits provided by an aerial tramway as the increase in accessibility to employment (Kawabata, 2009). Therefore, Boise can become an example of technological progress and especially be a pioneer city in the implementation of alternative and environmentally friendly mass transport systems.

1.2.6 Increase Transport Safety

The aerial tramway is a system in which each transport unit is compact to allow a continuous flow of passengers. For example, in Medellin, Colombia each of the two aerial tramway lines operating in the city have the capacity to transport 1,200 people per hour, while in Caracas (Venezuela) the capacity reaches 3,000 people per hour using slightly larger trams, and in Koblenz Germany this figure rises to 3,600 people per hour (Schittich, 2013).

These figures become more relevant when reviewing the statistics of accidents and/or fatalities of the aerial tramways around the world since these remain the lowest compared to other means of transport. For example, according to Switzerland's Office Fédéral de Statistique OFS, the aerial tramways occupy first place in terms of fewer accidents, as well as first place in people injured from such accidents, and tied in first place with funiculars in terms of deaths caused by accidents with an index of 0.000000 deaths by accident in a scenario in which rail accidents have an index of 0.000065 (Gondolaproject.com, 2016). In this sense, the risk of accidents in the Boise area can be reduced to the extent that people begin to use the aerial tramway instead of other less safe means of transport.

1.3 Problem Statement

Due to the move of the Computer Science department to City Center Plaza (CCP), located on Main Street in downtown Boise, there is a need for students, staff, and faculty to go back and forth between the Boise State campus and the Computer Science building. People who have to make this trip incur extra costs and time expenditure

The second reason to study the feasibility of aerial tramway at Boise State is the lack of parking on the Boise campus and downtown because it is difficult and expensive to park in these areas. The third reason is traffic congestion which is already bad and it is going to be worse in the future due to the population growth in Boise, as population feeds into the congestion problem ("Boise Valley Demographics", 2018). There is an extra reason and it is the number of entertainment events that are held on campus. These events attract a lot of people. Events such as concerts and other art and cultural gatherings demand a good and comfortable transport method for all the visitors.

In this scenario, an aerial tramway that connects the Boise State campus to Boise downtown represents a practical solution to these four concerns. My research is based on providing benefits in terms of reducing the time of transfers, reducing emissions from fossil fuel residues, reducing the risk of traffic accidents, and providing an improvement in the infrastructure of the area (Arvidsson,and Browne, 2013).

1.3.1 Comparison of Current Transport Modes

Currently, we have four modes of transport available to travelers between the campus and downtown Boise: car, shuttle, bicycle, and walking. People who travel between these locations make their trip using one of these modes. This section presents a brief comparison between two of the most-used modes in terms of duration of travel.

1.3.2 Car Route

There are two car routes that are commonly used by travelers going to Boise downtown from the campus; they are shown in the following figures. The first route starts from the Environmental Research building (ERB) on campus, proceeds towards Broadway Ave, and then to Front St until it reaches the final destination. This route has 16 signalized intersections and its length is 1.83 miles. This route does not have any stop signs. Figure 1 depicts this route.

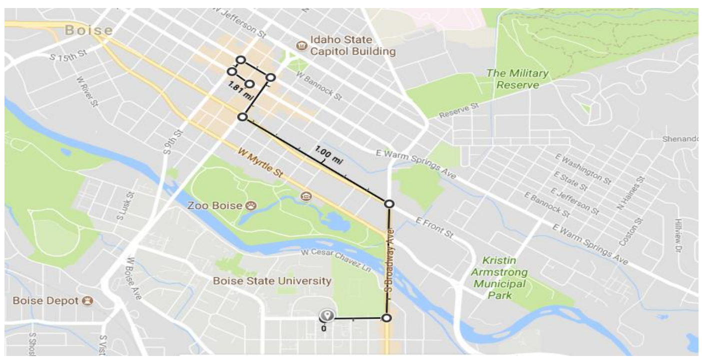

Figure 1. Car Route 1

The second route also starts from the ERB, proceeds westward along University Drive, and turns right into Capital Blvd and reaches the CCP on Main St by way of Idaho St. This route has 4 stop signs and 16 signalized intersections. The length for this route is 1.95miles.

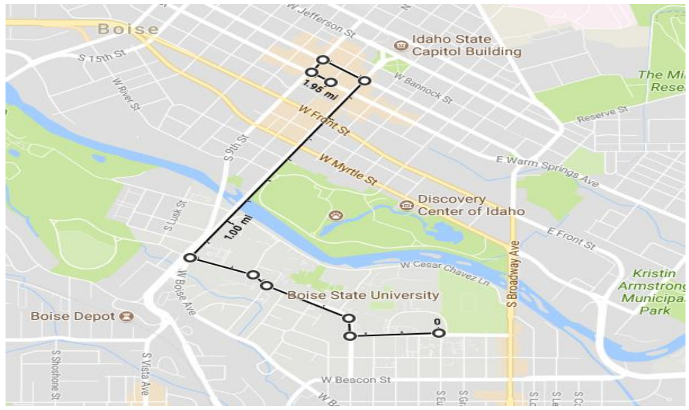

Figure 2. Car Route 2

I made multiple trips on these routes to determine the travel time between the ERB on campus to the CCP on Main St, Boise. Ten trips each were made along these routes. Trips were made on different days at approximately the same time to check a possible variance between the days. Below are the results.

Table 1. Route times in minutes by car

Trip number	Travel time in minutes Route (1)	Travel time in minutes Route (2)
1	10	10
2	8	11
3	9	8
4	11	11
5	10	9
6	10	8
7	11	8
8	9	9
9	8	7
10	9	11

Parking fees may be a reason why people will look for different transportation modes when traveling between these locations. Cost of parking per semester at BSU is listed below:

- East stadium: $ 118
- West stadium: $ 354
- Lincoln garage: $ 333

Parking in downtown is not as comfortable as it is even costlier than parking on campus.

<u>1.3.3 Shuttle Routes</u>

Below is a depiction of the Shuttle route, which is a loop between the campus and downtown Boise.

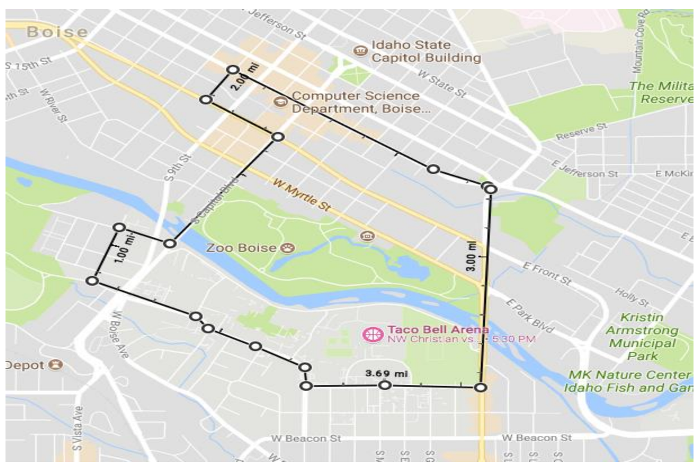

Figure 3. Shuttle Route

While the Shuttle is free there are disadvantages associated with it as listed below:

- Pick up and drop off. The constant stops made by the Shuttle can lead to delays. On average, the travel time between the ERB and CCP is 23 minutes.

- Waiting and frequency. Having to wait for the Shuttle to arrive and the continuous stop make the travel last 23 minutes on average, which is a lot compared with the car times and even more when compared with bicycle.
- Weather plays a major role on the frequency for the shuttle trips. For example, during winter time the trip takes much longer.

1.3.4 Network Simulation Model:

To estimate travel times in the future a network simulation model was developed. This process started with the modeling of the current signalization at each intersection along the routes using the PTV-Vistro software (Vision-traffic.ptvgroup.com, 2018). A schematic of the network is shown in Figure 4.

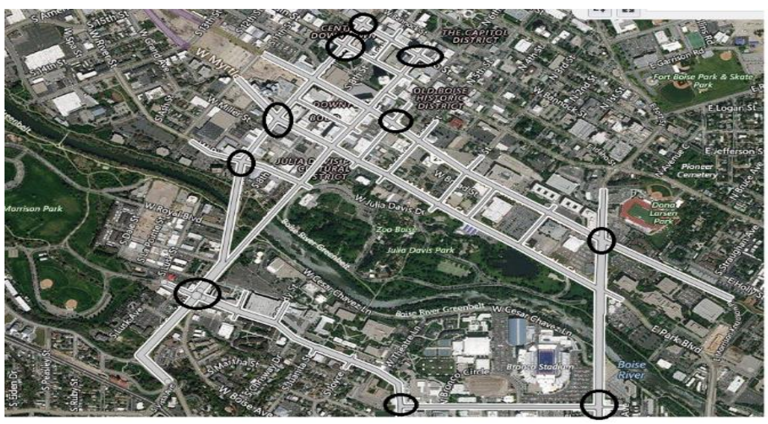

Figure 4. Network Simulation Schematic

The circled intersections in Figure 4 are the intersections at the boundary of the network that feed traffic into the network. To project traffic volume into the design year of 2040 the anticipated growth had to be estimated. The growth factor for the network was estimated by calculating the difference in traffic volume at each boundary intersection between the years 2014 and 2016. After getting the growth factor for each intersection, an average was computed and applied to the entire network. Growth was found to be 2.62 %

per year, on average, and the 2017 volume was projected using this rate. To calibrate the network simulation model, travel times were computed using the PTV Vissim program and compared with the times obtained from the field trips reported earlier. The network attributes and the level of service for the boundary intersections in 2016 and 2017 are shown below.

Table 2. Network Attributes

Number of intersections	35
Number of Links	164
Total Link Length (miles)	16.5

Table 3. Intersection Performance

Intersection	2016		2017	
	Level of Service	Delay (s/veh)	Level of Service	Delay (s/veh)
Broadway & University Dr	B	16.14	B	16.80
Lincoln & University Dr	B	17.90	C	28.16
Front St & Broadway	B	15.3	B	15.7
Capitol Blvd & University Dr	B	19.96	C	26.46
Myrtle& 09th St	E	58.62	C	31.85
W Main St & 09th St	C	25.00	C	26.62
Capitol Blvd & W Idaho St	C	32.78	E	66.38
09th St & W Idaho St	D	51.09	E	62.15
W River St & 09th St	C	27.18	D	36.40

The Vistro network was exported to the Vissim network simulation software (Vision-traffic.ptvgroup.com, 2018) to estimate travel times along the two route

Figure 5. Vissim Perview

The routes were divided into segments in the Vissim software to collect the travel time between the ERB and the CCP on Main St. The travel times from the simulation model for each of the segments were summed to get the total travel time between the two locations. The travel times between the two locations could not be estimated directly as the probability of a vehicle traveling from the ERB to the CCP was low in the simulation model. The results for 2016 and 2017 from the Vissim program are shown below.

Table 4. Vissim Software Results

Intersection	2016		2017	
	Route 1	Route 2	Route 1	Route 2
1	9	8	9	8
2	9	8	9	7
3	8	8	8	8
4	8	8	8	7
5	9	8	8	9
6	8	8	8	7
7	9	9	9	9
8	8	8	9	11
9	8	8	9	9
10	8	7	9	8

Accuracy of those results for 2017 was checked by comparing them with the times of the car field trips made by the researcher. A t-Test (Limentani et al., 2005) was performed to ensure that the means of travel times estimated from Vissim and measured during the field trips were statistically the same. The null hypothesis (H_o) of the test is that the means of each group of observations are statistically equal. The alternative hypothesis (H_a) is that the means of each group of observations are statistically different.

Table 5. Observation Groups Comparison

Observation	Car field trip Route 1	Vissim Route 1	Car field trip Route 2	Vissim Route 2
1	10	9	10	8
2	8	9	11	7
3	9	8	8	8
4	11	8	11	7
5	10	9	9	9
6	10	8	8	7
7	11	8	8	9
8	9	9	9	11
9	8	9	7	9
10	9	9	11	8

Table 6. Independent Sample Test for Route1

	F	p-value	T	df	p-value
Route 1 Equal Variances assumed	6.4	0.021	2.37	18	0.029
Equal variances not assumed			2.37	12.91	0.034

As it can be seen in the table 6, the p value of the t-Test is less than 0.05 meaning that the null hypothesis is rejected at the 5% level of significance. There is sufficient evidence to say that the means are different. This result was obtained for the group of observations of the Vissim software and Route 1.

Table 7. Independent Sample Test for Route2

	F	*p-value*	T	df	p-value
Route 2 Equal Variances assumed	0.78	0.39	1.47	18	0.159
Equal variances not assumed			1.47	17.53	0.159

For Route 2, the null hypothesis is not rejected because the p value exceeds 0.05. There is insufficient evidence to conclude that means for Route 2 are not equal. Therefore, we do not reject the claim of equality of means, which indicates that we are not able to reject a claim that the Vissim and car field trip are the same for Route 2. For practical purposes Vissim can be viewed as accurately simulating existing conditions for Route 2 for traffic operations in the base year of 2017.

Given that BSU and Boise are growing, some attempt to estimate medium and longer-term traffic patterns and congestion is useful. An attempt to project out twenty plus years into the future is included, as 2040 projections are as shown below. It should be noted, however, that any attempt to project estimates for twenty years would present challenges, especially in a growing community. In 2017, Idaho was the fastest growing state in the United States.

The projected values were then used as inputs to the developed simulation model and levels of service for 2040 were estimated. Results of this step are shown in Table 8 below.

Table 8. Projected Intersection Performance (2040)

Intersection	2040	
	Level of Service	Delay (s/veh)
Lincoln & University Dr	F	94.69
Capitol Blvd & University Dr	F	159.32
Myrtle& 09th St	F	208.00
W Main St & 09th St	F	638.67
Capitol Blvd & W Idaho St	F	247.09
09th St & W Idaho St	F	331.65
W River St & 09th St	F	170.67

The 2040 results represent a continuation of existing trends, which is not necessarily what will actually happen. The substantial delays shown would almost certainly result in commuters finding alternate routes, modes of travel, or when they choose to make their trips. However, the results illustrate the strong growth trend that currently exists. Travel times along the two routes for 2040 were then estimated using the VISSIM model. They are depicted in Table 9.

Table 9. Projected Vissim Software Results(2040)

	Travel Times in 2040
Intersection	Route 2 (minutes)
1	19
2	18
3	18
4	18
5	19
6	17
7	18
8	18
9	18
10	17

There are viable options for reducing travel times around Boise State. The question is whether there is a demand for these improved commuting options. The analysis below indicated that the Boise State community would welcome new options that would improve convenience and reduce delays.

1.4 Report Structure

As is well known, models that we call regression are based on a series of observable and, a priori, independent characteristics of an individual under analysis. The independent characteristics are described by explanatory variables, which are used to explain some observed behavior of the individual. The variable that captures the observed behavior is called a response variable (Montgomery, Runger & Hubele, 2009). In this report, we will introduce the logistic regression model as a predictive model that can predict an individual's response given the observed values for a set of explanatory variables pertaining to the individual. In many cases, either the dispersion of the data or its particular organization will prevent us from using linear regression models, as they will not serve to satisfactorily adjust the data, and the predictions obtained from them will not be accurate (Montgomery, Peck & Vining, 2012).

1.4.1 Binary Response Models

Binary response models are based on considering a response variable, Y, which can take only two values. In this situation, we assign Y = 1 to the case of interest and Y = 0 to the opposite case. The type of variable that supports an expression based on the previous description is called dichotomous (Davidson & MacKinnon (2004)). A variable, Y, with these characteristics would have a Bernoulli distribution $E[Y] = P[Y = 1] = p$ in which $p \in (0,1)$. (Hilbe, 2011).

$$E[Y|\, X = x] = P[Y = 1|\, X = x] = px$$

In this case, we have arrived at the clear dependence of the response variable with respect to the explanatory variable. Considering this, we look for a model of the form.

$$Y(x) = F(\alpha + \beta x) + \varepsilon(x),$$

where $\varepsilon(x)$ are independent random variables of zero hope and the parameters of the model are $\alpha, \beta \in \Re$. The model can also be expressed as:

$$p(x) = F(\alpha + \beta x),$$

where F is a strictly increasing distribution function which, in turn, can be expressed in the form:

$$\boldsymbol{F^{-1}\big(p(x)\big) = \alpha + \ \beta X}$$

1.4.2 Main Problems of Linear Probability Models

In this model, we have to realize that there are ambiguities when it comes to putting it into practice. Let us assume a simple case of a random response variable, $\boldsymbol{Y}$, in terms of an explanatory random variable, $\boldsymbol{X}$. The model to be considered, as described above, would be (Christensen, 2006):

$$\boldsymbol{Y(x) = \alpha + \beta x + \varepsilon(x),}$$

Where; the errors $\boldsymbol{\varepsilon(x)}$ are non-observable random variables, independent, with zero expectation, whose distribution is also Bernoulli with values:

$$\boldsymbol{\big(1 - (\alpha + \beta x)\big)\ if\ Y = 1\ with\ probability\ p(x),}$$

$$\boldsymbol{-(\alpha + \beta x)\ if\ Y = 0\ with\ probability\ \big(1 - p(x)\big)}$$

Given that $\boldsymbol{\varepsilon(x)}$ has null hope, we then have a linear regression model of the form:

$$\boldsymbol{E[Y|\, X = x] = p(x) = \alpha + \beta x,}$$

As one can see, the fact that a probability depends on a variable that is not bounded creates a conflict with its definition. The main problems with this formulation are listed below (Raudenbush & Bryk, 2002):

1. Probabilities take values between 0 and 1, inclusive. However, the above model allows for a wider range of possible predicted values. The model will be effective and meaningful only if it is modified such that predictions are bounded by zero and one, the range of possible probabilities.
2. The homoscedasticity condition is not satisfied since the variance of the response variable is not constant over the observed values of the explanatory variable.
3. Since Y does not have a normal distribution, the sample distributions of the ordinary least squares estimators cannot be used to make inference about the model.
4. The linear model implies equal variations of the probability of response against equal variations of the explanatory variable. This is not realistic since the changes produced in $\boldsymbol{X}$ should have less impact on p when the probability of response is close to zero or to one that when it is close to 0.5.

Because of this, we set out to specify a nonlinear model that implies a relation between $\boldsymbol{x}$ and $\boldsymbol{p}(\boldsymbol{x})$ that is curvilinear, monotonous and bounded between zero and one. This is how logistic regression models arise, where the logarithm and exponential functions eliminate the problems caused by a linear model (Guido et al., 2006).

1.4.3 Simple Logistic Regression Model

The so-called logit model is the simple logistic regression model and consists of the following expression for the probability:

$$\boldsymbol{p}(\boldsymbol{x}) = \frac{\boldsymbol{exp}(\boldsymbol{\alpha}+\boldsymbol{\beta x})}{\mathbf{1}+\boldsymbol{exp}(\boldsymbol{\alpha}+\boldsymbol{\beta x})} = \frac{\mathbf{1}}{\mathbf{1}+\boldsymbol{exp}[-(\boldsymbol{\alpha}+\boldsymbol{\beta x})]}$$

The model can be described equivalently as:

$$\boldsymbol{ln}(\boldsymbol{x}) = \left[\frac{\boldsymbol{p}(\boldsymbol{x})}{\boldsymbol{1}-\boldsymbol{p}(\boldsymbol{x})}\right] = \boldsymbol{\alpha} + \boldsymbol{\beta x},$$

where said transformation,

$$\boldsymbol{ln}(\boldsymbol{x}) = \left[\frac{\boldsymbol{p}(\boldsymbol{x})}{\boldsymbol{1}-\boldsymbol{p}(\boldsymbol{x})}\right],$$

receives the name of *logit* and

$$\frac{\boldsymbol{p}(\boldsymbol{x})}{\boldsymbol{1}-\boldsymbol{p}(\boldsymbol{x})}$$

represents the response advantage Y = 1 for the observed value x.

In order to check if the problems mentioned above have been corrected, let's look at the main characteristics of the logistic response curve (Kulkarni, 2016):

1. The logistic curve implies a monotonic relationship between the probability of response and the explanatory variable, and has the form of S with values in the interval [0; 1].
2. The probability function $\boldsymbol{p}(\boldsymbol{x})$ is bounded between the constant functions y = 1 and y = 0. In addition, the sign of the $\boldsymbol{\beta}$ parameter determines the growth or decrease of the function.
3. The rate of change in $\boldsymbol{p}(\boldsymbol{x})$ ceases to be constant.

$$\boldsymbol{p}'(\boldsymbol{x}) = \boldsymbol{\beta p}(\boldsymbol{x})\left(\boldsymbol{1}-\boldsymbol{p}(\boldsymbol{x})\right)$$

4. When the model is verified with $\boldsymbol{\beta} = \boldsymbol{0}$, the logistic curve is a straight line. This tells us unequivocally that the variable Y is independent of the variable X.

1.4.4 Multiple Logistic Regression Models

In line with the previous section, if we consider *R* explanatory variables $\boldsymbol{X_1, \ldots, X_R}$, then for each combination of these variables, we have the response variable Y, which follows a Bernoulli distribution (Tabachnick & Fidell, 2007).

$$\boldsymbol{Y|(X = x_1, \ldots, X_R = x_R) \sim B\big(1, p(x_1, \ldots, x_R)\big)}$$

From this, we are interested in modelling the conditioned hope,

$$\boldsymbol{E[Y \mid X_1 = x_1, \ldots, X_R = x_R] = P[Y = 1 \mid X_1 = x_1, \ldots, X_R = x_R] = p(x_1, \ldots x_R)}$$

In order to use this formula later, it is convenient to express in matrix terms as:

$$\boldsymbol{p(x) = \frac{e^{\beta x^t}}{1+e^{\beta x^t}}},$$

$\boldsymbol{Where\, x = (x_0, x_1, \ldots, x_R) and\; \beta = (\beta_0, \beta_1, \ldots, \beta_R)}$.

As in the previous case, we can modify the expression to perform the regression in a polynomial expression, since:

$$\boldsymbol{ln\left[\frac{p(x)}{1 - p(x)}\right] = \sum_{r=o}^{R} \beta_r x_r}$$

In the case that all the parameters $\boldsymbol{\beta_t}$ are null except $\boldsymbol{\beta_0}$, it is verified that the variable *Y* is independent of the explanatory variables.

1.4.5 Adjustment of Logit Models

We will now address the problem of estimating the parameters of the logit models. The data consists of a sample of size $\boldsymbol{N}$ of the random response variable, $\boldsymbol{Y}$. That is, we have $\boldsymbol{N}$ observations of the response variables that have an independent Bernoulli distribution, where each one corresponds to a combination of values $\boldsymbol{x_0, x_1}, \ldots, x_{\boldsymbol{R}}$ of the $\boldsymbol{R}$ explanatory variables $\boldsymbol{X_1, \ldots, X_R}$ (Cramer, 2003); the first variable, $\boldsymbol{X_1}$=1.

Denoting $\boldsymbol{x_q = (x_{q0}, x_{q1}, \ldots, x_{qR})'}$, with $\boldsymbol{q = 1, \ldots, Q} \in \aleph$, as the $\boldsymbol{q-th}$ combination of values of the sample explanatory variables $\boldsymbol{R}$, two situations may occur (Hosmer Jr et al., 2000):

1. For each sample individual, there is a different combination of levels of the R explanatory variables, or what is the same, $Q = N$. This means that there is a single observation of the random response variable, Y, in each combination of explanatory variables. This event normally occurs when all the explanatory variables are continuous.
2. For each sample individual, there is an equal number of combination of values of the explanatory variables, that is, $Q < N$. This leaves us with more than one observation of the random response variable in each combination of values of the explanatory variables.

If we denote as $\boldsymbol{n_q}$ the number of sample observations with $\boldsymbol{X = x_q}$ and for $\boldsymbol{y_q}$ the number of answers $\boldsymbol{Y = 1}$ of those $\boldsymbol{n_q}$ observations, we have a sample of $\boldsymbol{Q}$ independent random variables $\boldsymbol{Y_q}$ with distributions$\boldsymbol{B\,(n_q, p_q)}$, where:

$$\boldsymbol{p_q = P[Y = 1 \mid X = x_q]}$$

Therefore, we have:

$$\boldsymbol{E[Y_q] = n_q p_q},$$

$$\boldsymbol{\sum_{q=1}^{Q} n_q = N}$$

From this, the sample logistic regression model is of the form:

$$\boldsymbol{p_q = \frac{e^{\sum_{r=0}^{R} \beta_r x_{qr}}}{1 + e^{\sum_{r=0}^{R} \beta_r x_{qr}}}}$$

We can also transform it into its linear form,

$$\boldsymbol{L_q = ln\left[\frac{P_q}{1-P_q}\right] = \sum_{r=0}^{R} \beta_r x_{qr}}$$

Finally, we can consider its equivalent matrix form:

$$\boldsymbol{L = X\beta},$$

Where,

$\boldsymbol{L} = (\boldsymbol{L_1}, \dots, \boldsymbol{L_Q})'$is the vector of logit transformations,

$\boldsymbol{\beta} = (\boldsymbol{\beta_0}, \boldsymbol{\beta_1}, \dots, \boldsymbol{\beta_R})'$ is the vector of parameters and

$$\boldsymbol{X} = \begin{pmatrix} \boldsymbol{x_{10}} & \boldsymbol{x_{11}} & \dots & \boldsymbol{x_{1r}} & \dots & \boldsymbol{x_{1R}} \\ \boldsymbol{x_{20}} & \boldsymbol{x_{21}} & \dots & \boldsymbol{x_{2r}} & \dots & \boldsymbol{x_{2R}} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{q0} & x_{q1} & \dots & x_{qr} & \dots & x_{qR} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{Q0} & x_{Q1} & \dots & x_{Qr} & \dots & x_{Qr} \end{pmatrix}$$

<u>1.4.6 Estimation by Maximum Likelihood</u>

One of the most important steps when adjusting a logistic regression model, whether simple or multiple, consists in the estimation of the parameters that affect the model. There are numerous procedures for the estimation of these parameters, among which we can highlight the estimation by maximum likelihood (Myung, 2003).

It is well known that the maximum likelihood estimators are the values of the parameters that give maximum probability to the observed data. In order to calculate them, the likelihood function of the data under study is used with respect to the parameters to be estimated (Banerjee et al., 2008).

Now, according to the above and in order to apply these concepts in a practical way in the present study, all the estimates of the logistic regression and the estimators of the model itself are recreated using IBM SPSS. Descriptive statistics such as mean, standard deviation and significance will be obtained using IBM SPSS as well. However, chart and numeration to proper screening will be conducted using Microsoft Excel.

CHAPTER TWO: LITERATURE REVIEW

2.1 Literature Review

Tramways are inspired by "ropeways", which were introduced in 1868 for moving miners to difficult-to-reach locations (Dwyer 1988). The ropeways were initially designed to be people movers rather than material movers. The first ropeway moved up to 16 people at a time across the Tennessee River in Knoxville. This Knoxville, Tennessee ropeway opened in 1893. Other early ropeways include the one at Niagara Falls, New York (1912), and continuous-loop chair lifts installed at ski resorts in the 1930s and 1940s.

A well-used tramway operates at Roosevelt Island in New York City. This tramway was built in 1976 to connect Roosevelt Island with Manhattan. The tramway offered a public transportation alternative that had been absent since 1957, when an old trolley system ceased operation. The Roosevelt Island Tramway proved popular. The city of New York had planned to shut it down in 1989 when subway lines were extended to the area. However, public support for the tramway convinced the city to keep it open even after the subway service became available (N.D. Lea & Associates 1979). The tramway today is a popular tourist attraction that provides transportation service to area sporting events. The popularity of this tramway should encourage other communities to consider tramways as a supplement to public transportation alternatives. Another factor lending support to tramways is the relatively low cost of construction. The cost of the Roosevelt Island Tramway was only $6.25 million (1976 dollars). The Roosevelt Island Tramway was the first aerial ropeway dedicated to mass transportation in North America. By 2010, the tram had provided more than 26 million trips since 1976 (Roosevelt Island Operating Corporation 2011).

Another popular tramway operates in Portland Oregon, where it is considered a city landmark. The Portland Aerial Tramway was built in 1999 to connect different portions of the Oregon Health & Science University's (OHSU) extensive campus. The tramway made good sense because of the extremely hilly terrain of the campus and the need to control traffic at a facility serving 200,000 patients per year. (Portland Aerial Tram 2011). Like OHSU, Boise State and the Boise downtown are growing areas with growing traffic issues. What works well in Portland may be very well-suited for BSU and downtown Boise.

California's High Speed Rail Authority is planning the United States' first high speed rail system. The Authority's current goal is to initiate service between Los Angeles and San Francisco by 2029. The high speed train will travel at speeds exceeding 200 miles per hour, which will allow one to travel between Los Angeles and San Francisco in around three hours. Service will eventually be extended to San Diego and Sacramento. The completed system will have 800 miles of track, with 24 planned stations.

Work on the project has been slow. The Authority was formed in 1996, and a bill authorizing a $9.95 billion bond issue was passed in 2000. Submission of the bond issue to California voters was delayed for several years. Finally, in November 2008, Proposition 1A was approved by state voters, the first voter –approved financing for high speed rail in the United States.

Supporters cited the growing population and crowded California roadways and airports as justification of the project. Additionally, the project will support new jobs and stimulate the economy in depressed areas. Work is already underway on the first section in the Central Valley.

The train is especially popular in the Central Valley cities of Fresno, Bakersfield and Merced. In March 2018 the mayor of Merced lobbied politicians in Sacramento to make sure that Merced remains on the main route. For a city like Merced, the train brings jobs and visibility for the community. The Central Valley's economy has historically been agriculture-based, and the train allows for more economic diversification. Merced is the site of the newest campus of the University of California.

California's high speed train has been plagued by cost overruns. The cost of the project now is expected to exceed $70 billion. That's around $2,000 per person for each resident of California. The high cost is attributable to environmental studies, protecting historic and cultural sites, including Native American sites, and working around existing right of way (California, S. O. (n.d.).

The California High Speed Rail and the Boise tramway are vastly different in size, scale, and even purpose. However, similarities exist. The main similarity between the California high speed rail project and Boise's tramway is that both are aimed at reducing traffic congestion. Both projects take commuters out of their cars and place them into alternative transportation modes. Each project promotes jobs, and economic development around stations. Property around Boise tramway stations is likely to become more valuable because commercial opportunities increase. Property owners who stand to benefit from the tramway are likely to become more vocal supporters, much like the Merced mayor supports the high-speed train. The Boise tramway also has an advantage in that there are likely to be fewer environmental and cultural issues.

2.2 Stated Preferences

Economists find estimating demand conditions accurately to be a challenging statistical exercise. The problems are made more complex when the product of interest is new, and there is an absence of historical sales and marketing data. One solution to this problem is an estimation process known as stated preferences. Estimating demand for the BSU tramway is an example of a new product that will lend itself to the stated preference approach.

Traffic congestion and delays are increasing between the BSU campus and Downtown Boise. The proposed research focuses on implementing an aerial tramway system, which would provide service for members of the BSU community who currently drive, walk, bike or shuttle back and forth among the Boise State University and Downtown terminals.

The tramway would enable more than 22,000 students, faculty and staff to commute with ease from the campus to downtown Boise (Boise State University, 2018). This research explores the feasibility of the tramway based on the willingness of students, faculty, and staff to use the proposed tramway. The study compares the cost and convenience of the tramway to existing modes of transportation. Further, a growing population will reduce the total cost per rider, as fixed costs are spread among more riders. In addition, the tramway's capacity may exceed some others conventional transportation systems, such as shuttles. The tramway is safe and environmentally friendly. In contrast with traditional transportation systems, having two main terminal locations would simplify the transportation of BSU community members and their possessions.

Previously, tramway systems have been developed in several parts of the world including Belgrade, Serbia. The Belgrade tram system is the world's largest urban transportation mass transit system with about 12 lines that cover a total of 1,273 kilometers in length (Živanović et al. 2017). The system serves over two million passengers per day. Within Belgrade, key reasons behind the adaptation of the tramway include the aspiration to overcome the topographical and geographical barriers such as valleys, mountains, water in the Belgrade region (Živanović et al. 2017). In addition, the economic and technological aspects of the tramway facilitate efficiency and environmental sustainability.

For the stated preference survey, we categorize population on the basis of their affiliation with Boise State University, including freshman or sophomore undergraduate student, junior or senior undergraduate student, graduate student, faculty and staff member. Further, the survey will be based on the how frequently they travel from BSU campus to downtown Boise. Based on the frequency of travelling, their preference for the tramway will be based on its cost relative to the existing travelling mode, its convenience, and the willingness of the community to try a new mode of transportation. The possible modes of travel include shuttle, car, bicycle and walking.

The increased use of tramways in various parts of the world allow the projection of increased demand for the proposed tramway in BSU. There is no doubt that tramways are a technological innovation that are popular in several cities that have built them. Tramways can be cost effective and profitable, and cost effectiveness increases over time as ridership grows. (Težak, Sever & Lep, 2016). This survey will definitely help us to assess all of the possible factors, which can help determine whether the tram is feasible.

CHAPTER THREE: METHODOLOGY

3.1 Survey Design

The survey consisted of 18 questions, 13 were closed-ended questions (people had to choose between options) and 5 were open-ended questions (people were allowed to write their answers). Questions were divided into five sections: general data (type of affiliation (e.g., student, faculty), transport mode), a separate car section (e.g., car cost, time, convenience), plus separate shuttle, walk, and bicycle sections (also with cost, time, convenience). Some questions used in this study are:

Q3 What is your affiliation with Boise State University?

a. Undergraduate student – freshman or sophomore (1)

b. Undergraduate student – junior or senior (2)

c. Graduate student (3)

d. Staff (4)

e. Faculty (5)

Q28 What mode of travel did you use?

Car (1)

Shuttle (2)

Bicycle (3)

Walk (4)

Q13 If an Aerial Tramway were available for a trip between the campus and downtown Boise and you had to make a trip to downtown Boise, would you take the Aerial Tramway for each of the nine combinations of cost and convenience of the Aerial

Tramway relative to your mode of travel.

Table 10. **Q13**

I would take the Aerial Tramway	I would not take the Aerial Tramway
Costlier but more convenient (1)	Costlier but more convenient (1)
Costlier but equally convenient (2)	Costlier but equally convenient (2)
Costlier and less convenient (3)	Costlier and less convenient (3)
Same cost but more convenient (4)	Same cost but more convenient (4)
Same cost and convenience (5)	Same cost and convenience (5)
Same cost but less convenient (6)	Same cost but less convenient (6)
Less costly and more convenient (7)	Less costly and more convenient (7)
Less costly but equally convenient (8)	Less costly but equally convenient (8)
Less costly and less convenient (9)	Less costly and less convenient (9)

The survey was sent to a random sample of faculty, staff, and students. It was conducted using Qualtrics. The survey instrument can be reviewed in Appendix 1.

3.1.1 Data Collection and Sample

The survey was designed to determine the community's opinion regarding the need for and feasibility of an aerial tramway that would connect the Boise State University campus and the downtown Boise. All the data used in the study is obtained from the responses given by the Boise State community students, faculty and staff.

Once the data was compiled in a .CSV file, it could be analyzed using the IBM SPSS software. The database was constructed from responses to questions submitted to approximately 8,000 individuals. There were nonresponse issues and the final database consists of 1473 responses from the BSU community. The database used for the regression analysis only used valid and non-blank responses for Question 13. This narrowed the valid responses to 970. This sample size is considered sufficient to perform a binomial logistic regression analysis using the logit model. This is supported by the literature and specifically in the article by Hsieh, Bloch and Larsen (1998) on the size of samples using this kind of regression analysis.

To ensure the validity and reliability of this research, only complete data on the variables necessary for this study will be used for the sample.

3.1.2 Response Variables

As seen in the theoretical framework this variable identifies the study object belonging to one of two possible categories, identifying with the number 1, if the individual belongs to the characteristic of interest whose probability will be estimated in the model. The element that does not have the characteristic of interest is identified with 0, whose probability is also estimated with the model (Agresti, 2003). For the specifics of this case, the response variable is the willingness of the BSU community to use an aerial tramway, a value of 1 implies that the community would use it and 0 that the community would not use it. In our survey, respondents were asked if they would use an aerial tramway under the nine different scenarios described earlier and also listed below, relative to currently available modes of transport: costlier but more convenient, costlier but equally convenient, costlier and less convenient, same cost but more convenient, same cost and convenience, same cost but less convenient, less costly and more convenient, less costly but equally convenient, and less costly but less convenient.

For this report, these nine items will be analyzed only for Question 13 (Q13), which is the key question in the survey. Q13 deals with respondents who travel from campus to downtown in the last 30 days, the actual mode of transport currently used, and the willingness of respondents to take the tram under varying conditions. The study focuses on people who cover the route most often, and who would be the ones who benefit most from a possible aerial tramway. Moreover, a new variable, Q13Summary, is created to provide a global answer regarding whether people would or would not take the aerial tramway. This variable is categorical and dichotomous and is obtained by counting the number of positive and negative answers for each of the nine items of the Q13 question. If there are more positive answers the global answer would be a "yes" for taking the aerial tramway. On the other hand, if there are more negative answers then the global answer would be a "no" for taking the aerial tramway. Neutral responses (equal yes and no responses) were not considered in the analysis.

3.1.3 Explanatory Variables

These are the variables that allow discriminating between the groups and that determine the belonging of an element to a group or another. They can be measured in nominal, ordinal, interval or ratio scales (Blanchet et al., 2008). In the present work, the variable constructed from Q29, the question that asked if the respondent has travelled from the BSU campus to downtown Boise in the last 30 days, has an important role in evaluating the feasibility of the aerial tramway for people who do indeed travel in the proposed route. People who answered "Yes" to Q29 were the people who answered our response variable Q13.

The type of the affiliation with BSU (Q3) and the current mode of travel (Q28) are the explanatory variables. To determine the variables in the model that are not important to determine variations in the response variable, the Wald statistic is calculated. The scale of measurement must be determined because the Wald statistic varies if the variable is categorical or non-categorical (Field, 2009). In our case, all the explanatory variables are categorical, so the Wald statistic is of the form:

$$Wald_i = \frac{\hat{\beta}_i^T - \hat{\beta}_i}{Standard\ error_i}$$

3.1.4 Modeling and Analysis

In this situation, one wants to explain a variable associated with two qualitative options called success or failure, which are given values of 1 and 0, respectively. Under the above situations, Y_i is defined as a dichotomous variable that takes the value 0 if the respondent would not take the tram and 1 if they would take it. We define the matrix X as the matrix of independent variables that denotes the attributes of the respondents, and we define β as the parameter vector that measures the impact of the attributes on the probability of enrolling, so the related model would be defined in the following form:

$$Y_i = X_i \beta + \varepsilon_i$$

In this way, a linear probability model is generated, but as seen in the previous chapter this would lead to the calculation of probabilities greater than 1 or less than 0. To solve the problem, the logit transformation is performed:

$$\widehat{Y_i} = \widehat{\pi_i} = \frac{1}{1 + e^{(X_i' \widehat{\beta})}}$$

Where Y_i is the response variable which is the global valuation of the BSU community's interest in using an aerial tramway and X_i' is the transposed vector of explanatory variables.

Table 11. Independent variable

$X_1 = Q3$: Type of affiliation with Boise State University	1: Undergraduate Student – Freshman and Sophomore
	2: Undergraduate Student – Junior or Senior
	3: Graduate Student
	4: Staff
	5: Faculty
$X_2 =$ Q28 : Transport mode	1: Car
	2: Shuttle
	3: Bicycle
	4: Walk

CHAPTER FOUR: RESULTS

4.1 Descriptive Statistics

The descriptive statistics of the response and explanatory variables are shown in the following figures.

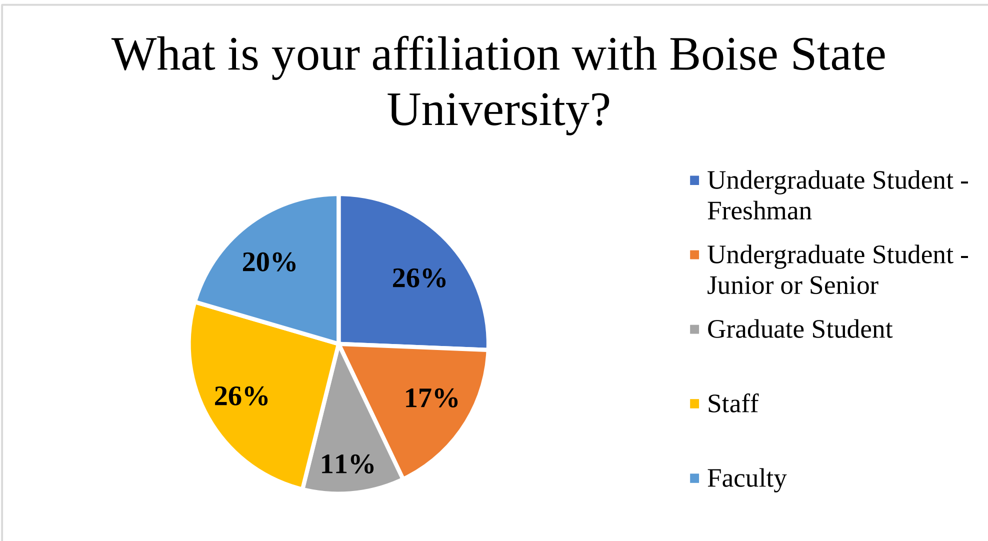

Figure 6. Profile of the surveyed

The surveyed people are well distributed among staff, faculty, and students, so it is important to evaluate if the type of affiliation is a significant variable to predict the probability of the willingness to take a possible aerial tramway.

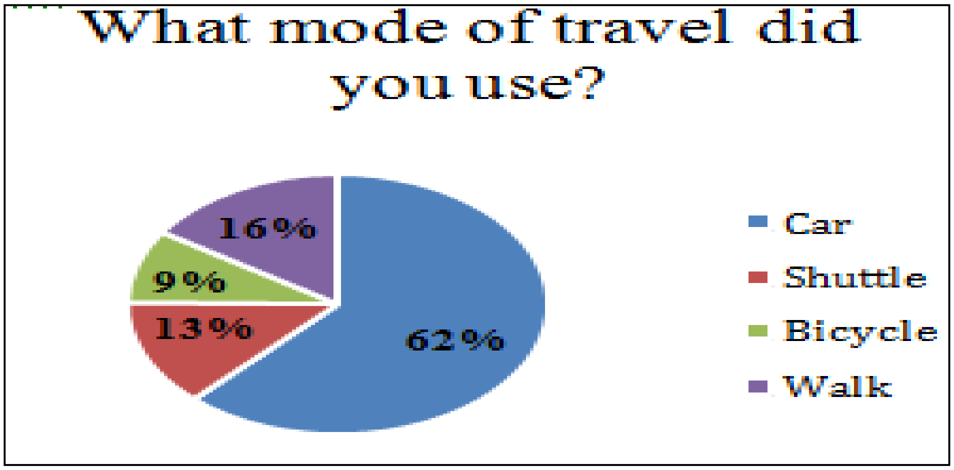

Figure 7. Existing Travel Modes

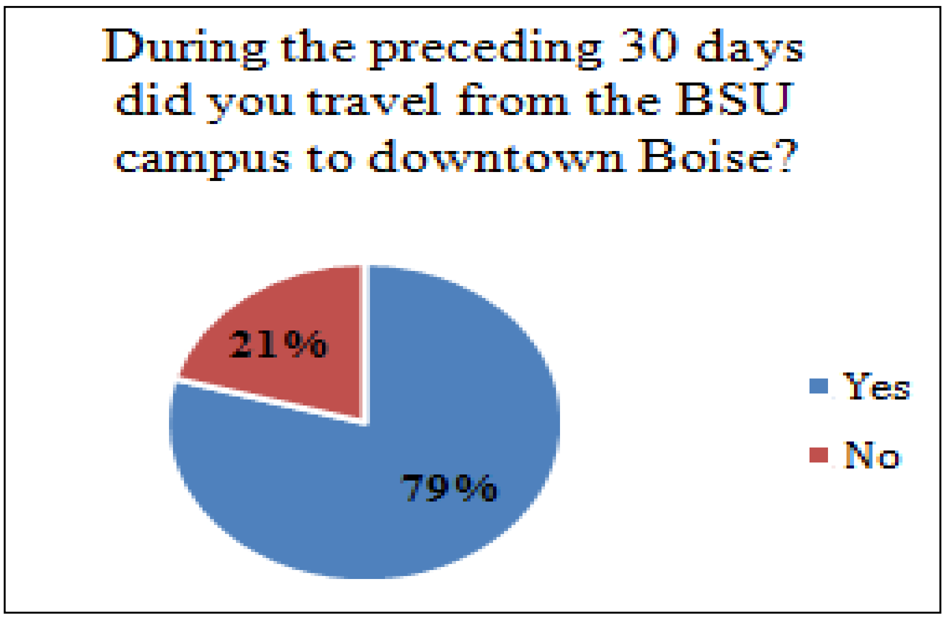

Figure 8. % Making the Trip

The other explanatory variables are depicted in Figures 7 and 8. These variables are the mode of transport (mode) and whether the respondent has travelled between downtown and campus in the last 30 days (travel). A large majority of the respondents used the car and has travelled the route that the aerial tramway would be covering. The mode and travel variables are expected to be significant in the model and to affect decisions about taking the aerial tramway.

Table 12. Descriptive for Explanatory Variables

	N	*Mean*	*Std. Deviation*
Q29	1464	1.21	0.404
Q3	1470	2.98	1.508
Q28	1162	1.78	1.137

The mean for the explanatory variable that tell us if people have travelled from campus to downtown is 1.21, meaning that 21% of the people have not covered that route in the last 30 days. The 79% of people have covered the route and they represent our focus regarding the willingness to take the aerial tramway. In the following section, those answers will be presented and analyzed to determine if there's a real need for implementing this new mode of transport.

Table 13. Descriptive Statistics- Response variable and supplementary

Descriptive Statistics - Response variable and supplementary				
Question	*N*	*Range*	*Mean*	*Std. Deviation*
Q13RANK1	911	1	.55	.498
Q13RANK2	848	1	.24	.428
Q13RANK3	877	1	.05	.211
Q13RANK4	883	1	.94	.246
Q13RANK5	835	1	.82	.386
Q13RANK6	822	1	.15	.359
Q13RANK7	914	1	.95	.223

Q13RANK8	831	1	.88	.324
Q13RANK9	843	1	.29	.455
QSUMMARY	970	1	.65	.478

Fifty-five percent would use the aerial tramway because it is ‘Costlier but more convenient’, which implies that 45% would not use it based on this same reason. Considering the reason: ‘Costlier but equally convenient’, 24% would use it while 76% would not. So, convenience is a significant factor even if the transport method is costlier. Five percent would use it based on it being ‘Costlier and less convenient’.

The ‘Same cost but more convenient’ and ‘Less costly and more convenient’ showed the highest favourable inclination towards the use of the aerial tramway, with 94% and 95% respectively. Likewise, only 15% of people would use the aerial tramway based on it being 'the Same cost but less convenient'. Similarly, 'Less costly and less convenient' has 29% preference based on it and 71% against, which is not surprising given the inconvenience of this option. 'Same cost and convenience' and 'Less costly but equally convenient' have similar acceptance with 82% and 88%, respectively.

Finally, when summarizing all the answers by Yes and the No, it was found that 65% of the people would be willing to use the aerial tramway service to access the University. However, it is clear that the convenience is the most important factor. This convenience needs to be analyzed further and estimate its principal factors to evaluate which ones have more importance within it. Further studies about travel times, comfort, overall experience, and the ability to share a transport mode (e.g., carpool) can be performed.

Now, a brief overview of the actual travel times and the convenience and cost of each transport mode the community is currently using will be presented.

Table 14. Descriptive Statistics- Duration travel times for each transport method

	N	*Mean*
Q9 (Car)	719	15.03
Q14 (Shuttle)	153	19.14
Q18 (Bicycle)	105	11.90
Q24 (Walk)	182	18.93

The above table shows the average times of different modes of transport. This data is useful for comparing the specific benefits in time savings and the cost of using an aerial tramway service. For example, a car trip to cover the route to the University takes an average of 15.71 minutes, so the aerial tramway, according to previous studies (Garsous, 2015), should take a shorter time to cover the same route. And as said before, this duration of travel times could be related to the perception of convenience.

4.1.1 Car

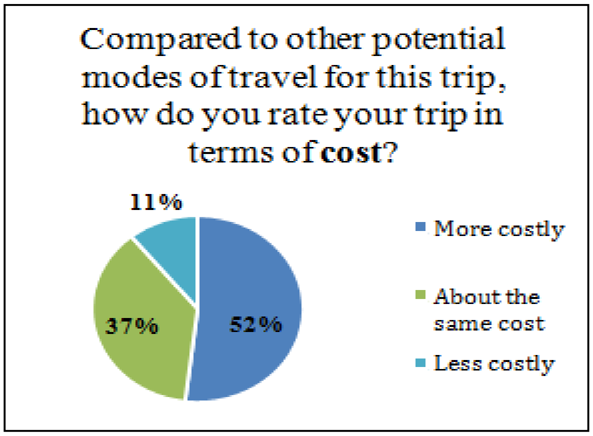

Figure 9. Trip Cost for Car

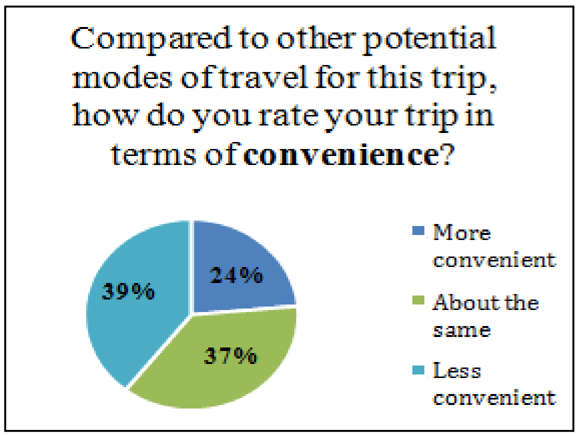

Figure 10. Trip Convenience for Car

The two charts above show that most people believe that – relative to cars - there are less expensive modes (37% of respondents) and more convenient modes (24% of respondents) of transportation. Some results are difficult to understand. In this case, people say cars are less convenient yet they use them. One possibility is that cars have some other attribute that is not captured in the survey. For example, some people like having their own personal vehicle, even if it is costly and less convenient. Not all effects can be controlled in a statistical study.

4.1.2 Shuttle

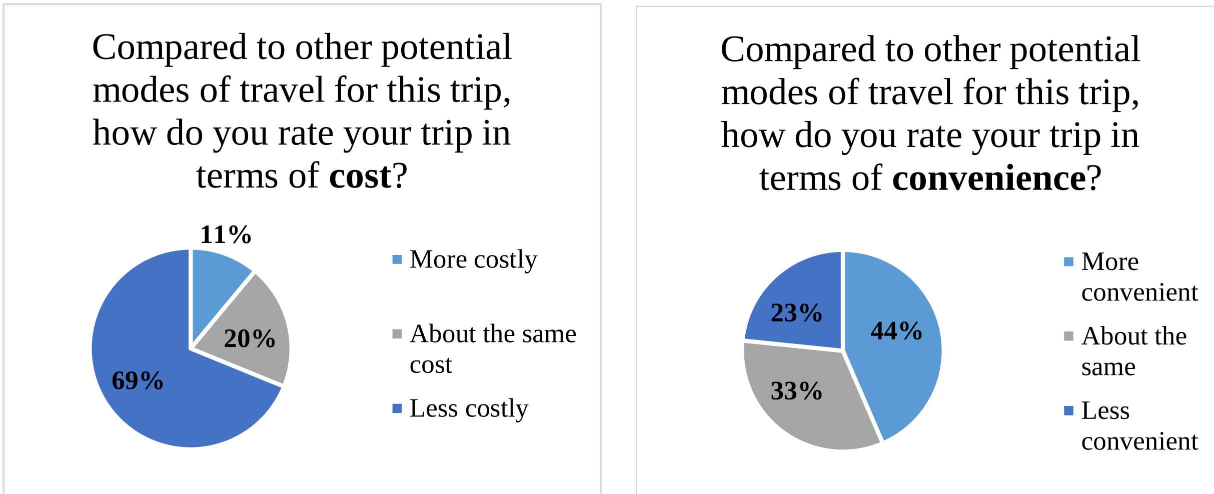

Figure 11. Trip cost and convenience for shuttle

Sixty-nine percent of people consider that a shuttle is a less expensive means of transport while 44% consider it more convenient. However, it has one of the highest average travel times with 18.93 minutes.

4.1.3 Bicycle

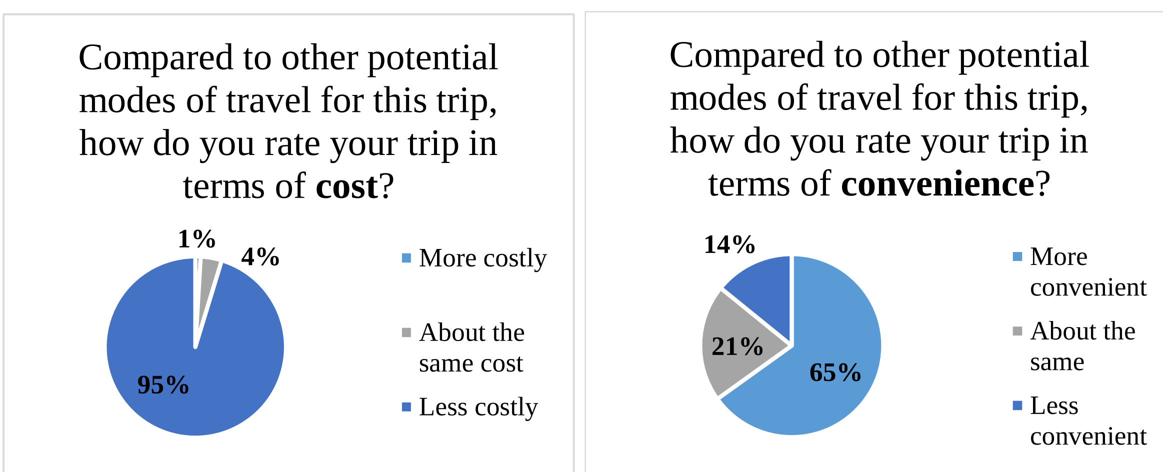

Figure 12. Trip cost and convenience for bicycle

The bicycle is the means of transport that is more convenient and one of the less costly for the respondents, and it has is also the lowest travel time with an average of 11.90 minutes to cover the route object of this study.

4.1.4 Walk

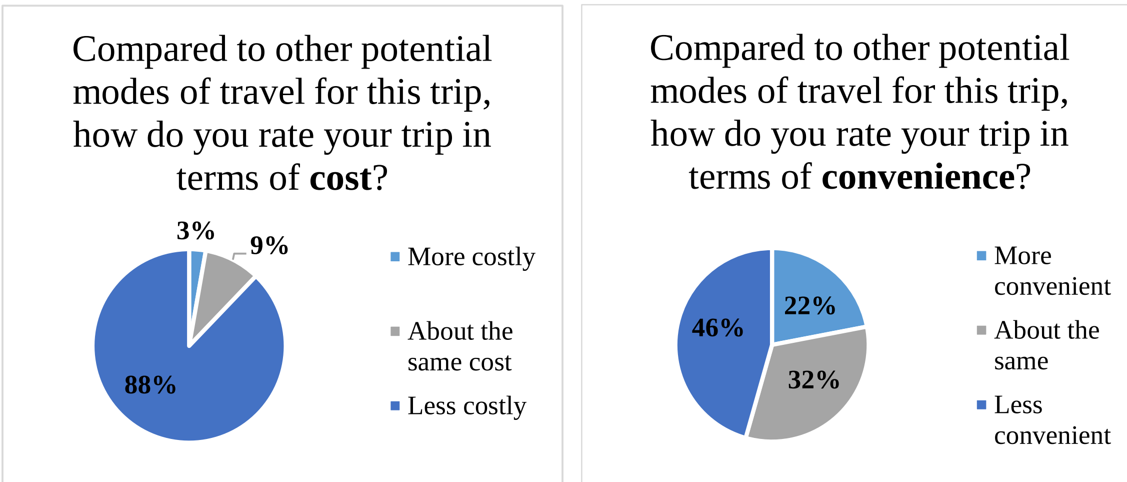

Figure 13. Trip cost and convenience for walk

Despite being considered as the cheapest means with 88% preference, walking is considered by 46% of the respondents as less convenient. For convenience, the aerial tramway would be an excellent choice for respondents and that was reflected when asked if they would or not would take such a transport mode.

4.2 Correlation Analysis

A Chi-Square test is used to test the statistical association between two or more categorical variables. This test is represented in the table 15 and table 16 through the Contingency Table which summarizes the distributions of the analyzed variables.

Table 15. Correlations Chi-Square Tests (Qsummary * Q3)

	value	*df*	*P value*
Pearson Chi-Square	*7.751*	*4*	*0.10*
Likelihood Ratio	*7.809*	*4*	*0.09*
Linear-by-linear Association	*5.572*	*1*	*0.01*
N of Valid Cases	*970*		

Table 16: Correlations Chi- Square Tests (Qsummary* Q28)

	value	*df*	*P value*
Pearson Chi-Square	*11.095*	*3*	*0.01*
Likelihood Ratio	*10.730*	*3*	*0.01*
Linear-by-linear Association	*0.761*	*1*	*0.38*
N of Valid Cases	*970*		

For evaluating the association between question 3 (affiliation) and Qsummary, the chi-square test statistic indicates borderline significance at 0.10 alpha. The Pearson chi-square p-value is right at 10%. The likelihood ratio p-value for Chi-Square is 0.09, less than alpha. This significant result means that certain affiliations are more likely to use the tramway.

Now, with regards to question 28, which refers to the means of transport currently used by a person, the test statistic indicates significance both at 0.05 and 0.10 alphas (p-value is 0.01). This significant result means that once the aerial tramway shows more convenience and comfort related benefits, one expects the community would use the tramway.

4.2.1 Logit Model and Regression Analysis

In a dichotomous logit model, the result of the analysis is a vector of parameters with numerical values, which are the coefficients for each of the mentioned explanatory variables that are part of the model. (Hanemann et al., 1991). The following are the results obtained using the SPSS software.

Table 17. Variables in the Equation

		B	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Step 1[a]	Q3	-.106	.044	5.749	1	.016	.899
	Q28	-.059	.060	.955	1	.329	.943
	Constant	1.023	.186	30.332	1	.000	2.782

a. Variable(s) entered on step 1: Q3, Q28.

Table 18. Model Summary

Step	*-2 Log likelihood*	*Cox & Snell R Square*	*Nagelkerke R Square*
1	1252,578[a]	0.27	0.29

Table 19. Hosmer and Lemeshow Test

Step	*Chi-square*	*df*	*Sig.*
1	9.214	7	0.238

Logistic regression modeling indicates that only question 3 (affiliation) is significant, based on the p-value of 0.016, which is less than .05. For question 28, the p-value is 0.329, which greater than .05, which indicates that question 28 is not significant. Logistic regression yields the following equation:

$$\widehat{Y_i} = \widehat{\pi_i} = \frac{1}{1 + e^{(1.023 - 0.106 X_2)}}$$

The probability of having a positive or negative answer in regards to the use of the aerial tramway would be given for the above formula, which depends on the type of the affiliation the respondent has with BSU. The regression confirmed that the actual type of transport the community is using does not have an impact on such answers.

The measurement of the goodness-of-fit of the calculated model was performed with the Hosmer - Lemeshow statistic as shown in table 19 since it helps to determine if the model adequately describes the data (Lemeshow & Hosmer, 1982). This statistic is the most reliable diagnostic model for fitting the binary logistic regression in SPSS. For practical aspects and with the aim of offering greater clarity, it can be said that the Hosmer

- Lemeshow statistic indicates a poor adjustment if the p-value of the statistic is statistically significant (less than 0.05). The p-value obtained for our model was 0.238.

Complementing the Hosmer - Lemeshow statistic, we have the Cox & Snell R Square and the Nagelkerke R Square with values of 0.272 and 0.292 respectively, meaning that the model adjustment is explaining a 27% and 29% of the variance under each statistic. The model does have an adequate goodness-of-fit though, which suggests that the significant relationship between the type of the affiliation with the BSU University and the willingness to take or not an aerial tramway is valid. However, conclusions may be still more assertive improving the R Square values through further research. For example, including other explanatory variables such as demographic characteristics that may influence the use or not of such transportation method, characteristics as gender, age range, income or even if there is a fear of heights on those surveyed; could improve the model fit and its indicators.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

This analysis shows that 65% of people would be willing to use an aerial tramway as their preferred means of transportation between the Boise State University campus and downtown Boise. A person's affiliation with the university – student, faculty, or staff – is the key determinant of whether the subject is inclined to take the tram. Specifically, the students are most likely to take the tramway. This is not surprising given that students are less likely to have their own cars and need some form of alternative transportation. Students are also most likely to follow the route of the tramway. Also, students are most likely to support a form of transportation that is environmentally friendly and can be shared among community members. Overall support for the tramway is relatively strong, but it is strongest among students.

The logit model produced reliable and satisfactory results for the study. In future research, demographic and economic variables should be incorporated. For example, tram use could be closely tied to variables such as gender, age and average income for both the BSU community and central Boise. These modifications may help generate a better goodness of fit for the model. Any of the previously mentioned variables could significantly affect people's choice regarding the use of an aerial tramway. Once the economic viability – the existence of a strong demand for the tramway – is established, the next step is to ensure that the project is technically feasible and that right-of-ways can be obtained. These civil engineering considerations must be addressed in a more detailed study.

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APPENDIX A

Survey

Feasibility of Aerial Tramway

Start of Block: Default Question Block

Q1

Q2 Dear Respondent: I am a Master of Science student in Civil Engineering and, as a part of my MS thesis, I am conducting a feasibility study to implement an aerial tramway system between the Boise State University campus and downtown Boise. The primary objective of this survey is to assess the willingness of students, faculty, and staff to use the proposed aerial tramway based on specific factors. The factors include efficiency of the aerial tramway, capacity of the carriers, environmental concerns, security vulnerabilities, and terminal locations. Your response will help us to gather accurate, reliable, and relevant information that will assist decision-makers in deciding whether to proceed with the implementation of the system.

Q3 What is your affiliation with Boise State University?

- ○ a. Undergraduate student – freshman or sophomore (1)
- ○ b. Undergraduate student – junior or senior (2)
- ○ c. Graduate student (3)
- ○ d. Staff (4)
- ○ e. Faculty (5)

Q29 During the preceding 30 days did you travel from the BSU campus to downtown Boise?

○ Yes (1)

○ No (2)

End of Block: Default Question Block

Start of Block: No

Q6 If an Aerial Tramway were available for a trip between the campus and downtown Boise and you had to make a trip to downtown Boise, would you take the Aerial Tramway for each of the nine combinations of cost and convenience of the Aerial Tramway relative to the most likely mode of travel available to you for the trip. Drag each of the items to one of the two boxes on the right, depending on your choice.

I would take the Aerial Tramway	I would not take the Aerial Tramway
______ Costlier but more convenient (1)	______ Costlier but more convenient (1)
______ Costlier but equally convenient (2)	______ Costlier but equally convenient (2)
______ Costlier and less convenient (3)	______ Costlier and less convenient (3)
______ Same cost but more convenient (4)	______ Same cost but more convenient (4)
______ Same cost and convenience (5)	______ Same cost and convenience (5)
______ Same cost but less convenient (6)	______ Same cost but less convenient (6)
______ Less costly and more convenient (7)	______ Less costly and more convenient (7)
______ Less costly but equally convenient (8)	______ Less costly but equally convenient (8)
______ Less costly and less convenient (9)	______ Less costly and less convenient (9)

End of Block: No

Start of Block: End

Q7 Thank you for taking the time to respond to the survey. Your participation will help us to better address the future transportation needs of our community. Go Broncos!

End of Block: End

Start of Block: Choice

Q28 What mode of travel did you use?

○ Car

(1
)

○ Sh
uttle
(2)

○ Bi
cycle
(3)

○ W
alk
(4)

End of Block: Choice

Start of Block: Walk

Q24 How many minutes did it take you?

____

Q25 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of cost?

○ a) More costly (1)

○ b) About the same cost (2)

○ c) Less costly (3)

Q26 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of convenience?

○ a) More
convenient (1)

○ b) About the same (2)

○ c) More inconvenient (3)

End of Block: Walk

Start of Block: Tramway Comparison

Q13 If an Aerial Tramway were available for a trip between the campus and downtown Boise and you had to make a trip to downtown Boise, would you take the Aerial Tramway for each of the nine combinations of cost and convenience of the Aerial Tramway relative to your mode of travel. Drag each of the items to one of the two boxes on the right, depending on your choice.

I would take the Aerial Tramway	I would not take the Aerial Tramway
______ Costlier but more convenient (1)	______ Costlier but more convenient (1)
______ Costlier but equally convenient (2)	______ Costlier but equally convenient (2)
______ Costlier and less convenient (3)	______ Costlier and less convenient (3)
______ Same cost but more convenient (4)	______ Same cost but more convenient (4)
______ Same cost and convenience (5)	______ Same cost and convenience (5)
______ Same cost but less convenient (6)	______ Same cost but less convenient (6)
______ Less costly and more convenient (7)	______ Less costly and more convenient (7)
______ Less costly but equally convenient (8)	______ Less costly but equally convenient (8)
______ Less costly and less convenient (9)	______ Less costly and less convenient (9)

End of Block: Tramway Comparison

Start of Block: Bike

Q18 How many minutes did it take you (include the time to park your bicycle and walk to your destination)?

____

Q19 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of cost?

- a) More costly (1)
- b) About the same cost (2)
- c) Less costly (3)

Q20 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of convenience?

- a) More convenient (1)
- b) About the same (2)
- c) More inconvenient (3)

End of Block: Bike

Start of Block: Shuttle

Q14 How many minutes did it take you (include the time to walk to your destination) ?

____

Q16 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of cost (consider factors like wait time)?

- a) More costly (1)
- b) About the same cost (2)
- c) Less costly (3)

Q17 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of convenience (consider factors like parking, traffic congestion, etc.)?

○ a) More convenient (1)

○ b) About the same (2)

○ c) More inconvenient (3)

End of Block: Shuttle

Start of Block: Car

Q9 How many minutes did it take you (include the time to find parking and walking to your destination)?

Q10 How much did you pay for parking ($)?

____

____

Q11 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of cost?

○ a) More costly (1)

○ b) About the same cost (2)

○ c) Less costly (3)

Q12 Compared to other potential modes of travel for this trip, how do you rate your trip in terms of convenience (consider factors like parking, traffic congestion, etc.)

○ a) More convenient (1)

○ b) About the same (2)

○ c) More inconvenient (3)

End of Block: Car