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Finding Missoula residents' willingness-to-pay for a public transportation system

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Finding Missoula Residents' Willingness-To-Pay for a Public Transportation System

By

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Finding Missoula Residents' Willingness-To-Pay for a Public Transportation System

Director: Richard Barrett RNB

This thesis finds Missoula residents' willingness-to-pay for a public transportation system. The public transportation system studied was the Mountain Line bus system, operated in Missoula, Montana. The contingent valuation method was used in order to find this estimate. Missoula residents were surveyed regarding their willingness-to-pay for the Mountain Line through local property taxes. A total willingness-to-pay was derived from the average willingness-to-pay estimate.

The estimated mean willingness-to-pay for a household was $100.76 per year in property taxes. When multiplied by the number of households in Missoula County, the total willingness-to-pay was found to be $3,873,113.64. This is compared to the $1,210,000 that residents of Missoula County are currently paying per year to fund the Mountain Line. Only a few variables in the multivariate model, including the highest range of income and an attitude scale considering the funding of public goods through taxation, were found to be statistically significant. This suggests that, in this study, the bid level was the only independent variable that significantly affects willingness-to-pay for public transportation.

While this study estimated the willingness-to-pay for a public transportation system, specifically that of the Mountain Line, it did not directly account for the environmental benefits created by the reduction of air pollution and traffic congestion that can be realized through the use of public transportation.

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Chapter 1: Introduction

1.1. Thesis Objective

The purpose of this study is to determine the economic value of a public transportation system, specifically that of the Mountain Line, a public bus system in Missoula, Montana. I assess this value by determining the willingness-to-pay for it expressed by the entire community. I also determine what characteristics may lead individuals to be more or less likely to ride the bus, or support it in general.

For this study, 6 interviewers including myself conducted 300 random telephone surveys. The respondents interviewed were presented with a hypothetical scenario attempting to elicit their willingness-to-pay for a public transportation system. Also included in the survey were questions regarding respondents' bus-riding habits, environmental and political attitudes about the bus, and socioeconomic characteristics. Missoula residents' willingness-to-pay for the Mountain Line bus system was derived from this analysis.

Besides the obvious environmental benefits of system of public transportation, there are also local policy implications for funding the system. Because of the assumed non-market nature of this service, a substantial subsidy covers most all of the costs of operating the bus. While sizable support comes from the state and federal government, the local government funds a majority (approximately 58 percent) of the subsidy through property taxes. If it can be shown that there are sufficient public benefits of Mountain Line, then this subsidy is justified. Also, the willingness-to-pay for Mountain Line found in this study may serve as a benchmark for changing the funding or operation of Mountain Line in the future.

The remainder of this chapter provides an introduction to public transportation, including a discussion of such public benefits as decreased pollution and congestion. Also included is background on the Mountain Line bus system with a comparison to other bus systems. The last section provides an outline for this thesis.

1.2. Introduction to Public Transportation

In the past 50 years, automobile use and traffic have increased significantly. Cobb (1999) argues that this increase has caused excessive environmental, social, economic, and political damage. In the face of this damage, public transportation has become an increasingly important form of alternate transportation. The American Public Transportation Agency reports that there are almost 6 billion annual bus trips nationally and approximately 14 million people use the bus each weekday.

Because of the benefits that are realized above and beyond the actual private benefits that individuals obtain by opting to use public transportation, it is often considered a public good. Public transportation, as is usually the case with public goods (discussed below), is chronically under-produced in private markets. The government, therefore, steps in to provide this good. Public transportation, however, is an interesting case because it is also creates private benefits for the actual users. Riders pay a price to obtain transportation services. Therefore, two forms of value (public and private) are derived from the use of public transportation. This study, however, is only concerned with the public benefits of a public transportation system.

Because of the two defining characteristics of public goods, non-excludability and non-rivalry, there is no discernible market for such goods, which therefore tend to be under-produced. In these cases, many argue that government intervention can rectify the problem and produce the good at the socially optimal level. But because there is no efficient market that relays consumer preference and demand back to the producers, some other form of valuation needs to be employed to determine the value of public goods. Typically a contingent valuation survey, discussed in the next section, is used for this purpose.

Because public transportation has many benefits beyond the private value placed on it by riders, the government largely subsidizes it. Furthermore, individuals do not need to actually ride the bus to derive these benefits. Society benefits from public transportation because it decreases the number of cars on the road, which in turn decreases pollution and congestion.

One problem with public transit is that there has been a steady decline in its use since the 1980s. One reason is that public transportation is usually viewed as an inferior good, meaning that as income increases, consumption of the good decreases, all else constant. There has been an upward trend in income since the 1980s, which correlates to an almost one-third decrease in ridership. In 1980, 6.4 percent of all workers commuted by public transit, while in 1990 only 5.3 percent commuted (Voith 1994). The decreased ridership corresponds to an increase in the number of cars on the road. This increase leads to many environmental concerns.

1.2.1. Air Pollution

Air pollution is the main concern resulting from the increased number of cars on the road. Air pollution has many lasting effects on both health and agriculture. Cobb (1999) found that transportation in the United States, mostly by passenger vehicles, is responsible for 66 percent of carbon monoxide emissions, 43 percent of nitrogen oxide emissions, and 48 percent of volatile organic compounds. Pollution from light passenger vehicles directly causes, in 1995 dollars, $56 billion in annual health damages, $3 billion in damages to crops, and $3 billion damage in loss of visibility. Emission of nitrogen oxide causes lung tissue damage, difficulty breathing, irritated eyes, changes in the ozone, and damaged crops. Hydrocarbons can cause irritation of the respiratory tract and eyes, coughing, and chest pains. High emissions of carbon monoxide cause dizziness, headaches, and limit the blood's ability to transport oxygen to body tissues (Artunian 1995). Driving also causes water pollution from acid rain, runoff from chemicals deposited on the pavement, and road salt. Health problems resulting from noise pollution contribute to the total damages caused by driving as well (Cobb 1999).

Using public transportation, therefore, can decrease the damaging effects of these pollutants. According to the American Public Transit Association, one person switching to public transportation (from a private automobile) can have a significant effect. With this switch, riding mass transit on average can have a per-passenger mile reduction in:

- Hydrocarbon emissions that produce smog of 90 percent
- Carbon monoxide of more than 75 percent
- Nitrogen oxide by a range of 15 percent to 75 percent.

1.2.2. Congestion

Congestion is another problem resulting from too many vehicles on the road. One characteristic of traveling that many people find important is comfort level. This is one reason that many people drive their own cars to a destination rather than taking the bus. However, when the roads are heavily congested, the discomfort of sitting in traffic and gridlock also becomes a factor. According to the Public Transportation Partnership for Tomorrow, nearly half of all Americans believe that traffic is a serious problem where they live.

Time is another component that usually weighs heavily on a driving decision. Many drivers feel that they can decrease their travel time by taking their own cars. But again, when the roads are congested, considerable time is wasted when a driver is stuck in heavy traffic. Studies done by the Texas Transportation Institute found that half the drivers surveyed spent the same amount of time stuck in traffic as they did on vacation. Both of these considerations (comfort and time) supposedly favor using private cars but should instead increase the incentive to use public transportation and clear the roads. However, the benefits of public transportation can only be realized if more people take public transit rather than driving, because public transit will also be time consuming and uncomfortable if the same number of cars remain on the road. Thus typically there is a lack of incentive to ride public transportation. For example, if one person uses the bus and nobody else does, he gains nothing, and thus there is no incentive for him to ride public transportation. On the other hand, if everyone decides to use public transportation, the roads clear up and one person's use of his car is going to be much more efficient, again creating a lack of incentive for him to use public transportation.

1.3. Mountain Line

Mountain Line, a not-for-profit organization, provides the main form of public transit in Missoula, Montana. The guiding body, the Missoula Urban Transportation District, was created in June 1976, and Mountain Line was established soon after in September 1977. Service began on three routes using four buses in December 1977, with a fare of only $0.25. Now, Mountain Line offers 12 routes, extending coverage to all of Missoula and many outlying areas. While fares have increased to $0.85, there are discounts for senior citizens and children under the age of 18. Daily tickets or monthly passes are also available to help defray the cost of riding the bus. Additionally, by an arrangement with the University of Montana, all students, faculty, and staff ride for free. The University's Office of Public Safety, through parking fees, pays Mountain Line $135,000 per year for this arrangement.

The following comparison of Mountain Line with other bus systems in cities in the Northwest shows that while Mountain Line has a relatively high standard fare, it also has a relatively low cost per rider (measured in operating costs per unlinked trip). One conclusion that can be drawn from this comparison is that the Mountain Line subsidy is relatively low. The subsidy is discussed further with the results found in Chapter 4.

Tables 1.3.1. and 1.3.2 summarize this comparison. The cities used in the comparison are all found in Washington, Oregon, Idaho, and Montana, and are all relatively small (Spokane is the largest with 370,210 people in the service area). The reported population is of the total service area, not solely the population within the city limits. Populations were found using 1990 census data; all other figures were derived from the 2000 National Transit Database. Table 1.3.1. shows that, as expected, there is a positive relationship between total population in the service area and operating costs. While Missoula ranks eighth in population among the 10 cities, it ranks ninth in annual revenue hours with 35,766 hours. It remains near the bottom of the 10 cities when comparing annual operating expenses, operating expenses per revenue hour, and operating expenses per unlinked trips. Other bus systems in the table are not as consistent. For example, Salem, OR ranks fourth in service area population yet is second for total annual operating expenses and has the most expensive operating expenses per revenue hour. Great Falls, MT ranks ninth in service area population but has the second highest operating expenses per unlinked trip. These results suggest that Mountain Line has relatively low expenses compared to population, annual revenue hours, and unlinked trips.

Mountain Line does not, however, have a standard adult fare commensurate with its size. Most bus systems in the sample have a standard adult fare of $0.75, while Mountain Line has an adult fare is $0.85. Table 1.3.2. compares the adult fares for the 10 Northwest bus systems. Mountain Line ranks second among the different bus system while the other smaller population cities charge up to $0.20 less per trip (Great Falls = $0.75 and Pocatello = $0.65). The bus system in Yakima, WA charges the smallest adult fare at $0.50 per trip. Yakima ranks seventh, just above Missoula in total service area population.

Table 1.3.1. A Comparison of Northwest Bus Systems

City	Total Population in Service Area*	Annual Revenue Hours**	Annual Operating Expenses	Operating Expenses per Revenue Hour**	Operating Expenses per Unlinked Trip
Spokane, WA	370,210	336,401	$25,600,378	$76.10	$3.06
Olympia, WA	210,200	121,346	$9,471,336	$78.05	$3.78
Richland, WA	160,800	131,108	$7,576,466	$57.79	$2.31
Salem, OR	160,000	158,053	$13,102,682	$82.90	$2.96
Boise, ID	148,600	71,595	$4,393,511	$61.37	$3.97
Billings, MT	81,151	40,410	$2,204,537	$54.55	$3.38
Yakima, WA	71,845	45,016	$3,427,379	$76.14	$2.67
Missoula, MT	***65,930***	***35,766***	***$1,647,593***	***$46.07***	***$2.38***
Great Falls, MT	63,506	36,322	$1,654,845	$45.56	$3.80
Pocatello, ID	53,392	21,512	$640,761	$29.79	$1.64

Data source: 2000 National Transit Database
** 1990 census data*
*** Revenue hours are measured as the time a bus in operation, from its starting point until ending point during the day. Therefore, annual revenue hours would be the total hours each bus was operating during the year.*

Table 1.3.2. A Comparison of Standard Adult Fares

Spokane, WA	$1.00	Boise, ID	$0.75
Missoula, MT	***$0.85***	Billings, MT	$0.75
Olympia, WA	$0.75	Great Falls, MT	$0.75
Richland, WA	$0.75	Pocatello, ID	$0.60
Salem, OR	$0.75	Yakima, WA	$0.50

1.4. Thesis Outline

This thesis contains five chapters. The second chapter is the literature review. It discusses the current literature regarding the valuation of non-market goods including the contingent valuation method and the dichotomous choice format. It also details the methods used to estimate the models used in this study. At the end of the chapter two recent public transportation studies are reviewed. The first study is a Mountain Line service analysis conducted by the Missoula Urban Transportation District. The second is a Federal Transit Administration study focused on measuring the benefits of public transportation. The third chapter discusses the model used in this study and the variables used to explain willingness-to-pay. It also presents the design of the survey instrument and the descriptive statistics of the data. The fourth chapter discusses the econometric model estimation and the calculation of benefits. This includes the bivariate, full multivariate, and reduced multivariate model results as well as a measure of average willingness-to-pay. It also reveals the final estimate of the value that Missoulians place on Mountain Line, i.e. how much they are willing to pay for Mountain Line. In addition to an average willingness-to-pay estimate, chapter 4 also presents a total willingness-to-pay estimate. The final chapter of this thesis reports the conclusions of this study and ideas for future research on valuing public transportation.

Chapter 2: Review of Literature

2.1. Introduction

This chapter reviews the economics literature on valuing non-market goods, including different methods and possible problems associated with the valuation process, the methodology behind estimating a welfare measure, and relevant studies of the value of public transportation services.

2.2. Valuing Non-Market Goods

As environmental issues have become increasingly important to economists, so has the development of methods for valuing those non-market environmental goods and services. Several approaches, including market-based, hypothetical market, and revealed preference methods, exist for valuing these goods. This study relies on contingent valuation, a hypothetical market approach. Contingent valuation, discussed below, is the most common hypothetical market technique used to measure the value of public goods.

2.2.1. Contingent Valuation

The contingent valuation method uses survey techniques to determine the value placed on a non-market good. By creating hypothetical markets through the use of survey questions, an individual's WTP for a commodity, or willingness-to-accept (WTA) compensation for its loss, reveals his preference for a non-market good. Duffield and Patterson (1991) state that contingent valuation's use is widespread and has been approved by the U.S. Water Resources Council (1983) for the evaluation of recreation benefits and by the U.S. Department of Interior (1986) for evaluation of natural resource damages incurred under the "Superfund" legislation. Contingent valuation is also often used when revealed-preference techniques cannot be because observations on actual choice data are inadequate or unavailable (Mitchell and Carson 1989).

A critical aspect of any contingent valuation study is the format of the valuation scenario established by the survey instrument. Valuation can be posed as an open-ended question, a bidding game, or as a payment card where the respondent selects his maximum WTP from a list of values, but the most popular approach to contingent valuation is dichotomous choice. In this case, respondents are only offered one bid level, which varies across the sample. Respondents answer positively if they accept the bid and negatively if they do not. For example, a valuation question may ask, "Would you be willing to pay $x to reintroduce wolves into Yellowstone Park?" In this case, x varies over the sample. It is assumed that each individual has a true WTP and will respond positively to a given bid only if it is less than or equal to his true WTP. Dichotomous choice is often the favored method because it most closely resembles a market situation or voting referendum.

Studies have favored dichotomous choice for other reasons as well. Duffield and Patterson (1991) prefer dichotomous choice because they found it is free of starting bid bias. Starting bid bias is typically found in the bidding game format, where respondents are given a starting point bid and the bids are subsequently increased or decreased until a maximum WTP is obtained. If the starting point is higher or lower than the respondent's true WTP, then the good may be overvalued or undervalued, respectively. They also found that dichotomous choice has a lower administration cost and successfully elicits participation. Boyle et al. (1996) find that a sample obtained with the open-ended approach may be subject to invalid responses and thus needs to be screened. Screening includes eliminating protest bids of zero, adjusting high bids, and statistically searching for outlying bids, which is important because the high bids can impact the estimated means and standard deviations (Boyle et al. 1996). Finally, a panel of experts assembled by the National Oceanic and Atmospheric Administration (Arrow et al. 1993) to assess contingent valuation also recommended the dichotomous choice format; this panel's other recommendations are discussed in greater detail in section 2.3 below.

2.2.2. Sources of Bias

There are many potential sources of bias present in contingent valuation surveys. Reliable estimates of welfare measures cannot be derived if the respondents have poor information. Respondents may have their own interpretation of the survey questions and will possibly answer differently than if they had been well informed. This is a form of design bias. Other sources of bias include the respondent's belief that his answer will have no significant effect on the outcome and thus fails to answer truthfully, the respondent being ill-informed about the context and circumstance of the study, and the respondent feeling social pressure within the interview to answer "correctly" (Arrow et al. 1993).

2.3. Other CV Design Issues: The Report of the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation

In 1993 NOAA formed a panel to determine the reliability of the contingent valuation method. In particular, the agency was interested in determining whether this method accurately measures passive-use values of non-marketable goods. Passive-use value is defined as non-use value, or more specifically the value that a person places on a good without actually using it. An example of passive-use value is a New Yorker deriving satisfaction from the Amazon rain forest. While he may never actually go to the forest, he still values its existence. The NOAA report gives general guidelines for conducting a legitimate contingent valuation study, as well as techniques for avoiding possible biases that may be encountered.

While face-to-face interviews are the most preferred method of surveying because coverage and response rates are usually the highest, the NOAA report also supports telephone interviews. The advantages of using a telephone survey include lower interviewing costs and possibly more precise estimates than face-to-face interviews of the same size. The report recommends against using mail surveys because response rates are low, it is impossible to guarantee random selection within the household or to confine answering to a single individual, and it is difficult to control question-order effects.

It is essential that, while the design of the survey remains conservative in order to avoid an over estimation of WTP, respondents are provided with an accurate and clear description of the good or policy (Arrow et al. 1993). Also, pretesting is necessary in order to discern early problems or clarify unclear material in the survey. To eliminate hypothetical bias, the survey's goal should be to produce a realistic and well-conceived hypothetical scenario for the respondent.

When formulating the valuation scenario, the report recommends against using the open-ended format (where respondents are asked to state their maximum WTP) because it invites strategic overstatement and might be a costless way to make a point about an issue. An open-ended valuation question may lack realism because individuals are rarely asked to state a value of any good, public or private. While the open-ended format may be unrealistic and biased, the report finds on the other hand that the dichotomous choice approach is realistic because it closely resembles a referendum and it is not unusual for individuals to vote on the provision of non-marketable goods. While the report states that respondents should not have any strategic reason to answer untruthfully, the interviewer should persuade the respondent to take the questions seriously.

2.4. The Bivariate Model

A bivariate model can be used to estimate willingness to pay from contingent valuation survey data. Generally this involves specifying a functional form for the distribution of willingness-to-pay, evaluating the parameters of the distribution function, and determining a willingness-to-pay measure based on the estimated model.

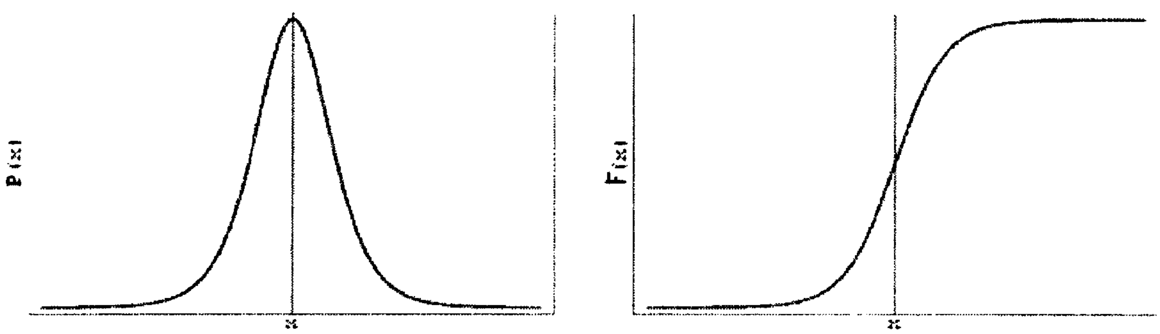
2.4.1. Measure of Surplus and the Logit Model

Willingness-to-pay is assumed to follow a probability distribution (see figure 2.1., P(x)). This distribution in turn provides a cumulative distribution function (see figure 2.1., F(x)) that is estimated using survey data. The probability, P(x), of accepting a given bid level, x, can be seen as the probability that the respondent's WTP is larger than that bid level (Hanneman, 1984). This probability is then a function of F(x):

2.1. $P(x) = 1\text{-}F(x)$

where F(x) is the cumulative distribution function of WTP values over the population.

Figure 2.1. The Probability Density Function (PDF), P(x), and the Cumulative Distribution Function (CDF), F(x).



If it is assumed that F(x) is a logistic cumulative distribution function (CDF) with mean α, scale parameter κ, $\alpha\nu\delta$ standard deviation is $\kappa\pi/(3^{1/2})$, then the probability that a respondent will accept the given bid level can be written as:

2.2. $P(x) = \exp(b_0+b_1x)/(1+\exp(b_0+b_1x)) = 1+\exp(-b_0-b_1x)^{-1}$

where x is a specified bid amount and b_0 and b_1 are functions of the mean and standard deviation of the logistic distribution. Thus $b_0 = -\alpha/\kappa$ and $b_1 = 1/\kappa$ and are parameters to be estimated from the data. Equation 2.2. can be rearranged and written as the standard logit model with a single explanatory variable:

2.3. $L(x) = \ln(P(x)/(1\text{-}P(x))) = b_0 + b_1 x$

where L is the log of the odds ratio. The odds ratio states the odds in favor of a "yes" answer to the valuation scenario. It is expressed as the probability that the respondent will accept the bid divided by the probability that the respondent will reject the bid, or P/(1-P). Equation 2.3. states that L is a linear function of the explanatory variable (or variables). Often, however, this model does not properly fit contingent valuation because the logistic distribution is symmetric, while willingness to pay is generally positively skewed and includes only values greater than zero. To address this problem, x can be replaced with ln(x) which leads to:

2.4. $L(x) = \ln(P(x)/(1\text{-}P(x))) = b_0 + b_1 \ln(x)$

A multivariate model, expressed in terms of the probability, can be used to incorporate auxiliary information into the model:

2.5. $P(x) = \exp(b_0 + b'X)/(1 + \exp(b_0 + b'X)) = 1 + \exp(-b_0 - b'X)^{-1}$

where X is a vector of explanatory variables, including the bid amount and auxiliary information such as income, education, etc., and b' is a vector to be estimated from the data.

2.4.2. Estimation Techniques and Benefit Measures

Maximum likelihood estimation (MLE) is typically the favored method for estimating logit models. The maximum likelihood method allows for the estimation of the parameters for practically all analytical specifications of the probability function (Cramer, 1991), although this study uses only the logit. The maximum likelihood method is also preferred over generalized least squares because of its flexibility (Hanemann, 1984).

Once the function is estimated, it is necessary to derive from it some measure of WTP (on a per household basis); the mean, the median, and the truncated mean are the three different measures used for this purpose. There is disparity of opinions as to which of these should be used. While Hanemann (1984) argues that choosing the correct measure is a value judgment, Duffield and Patterson (1991) list three criteria to consider when choosing a welfare measure: consistency with theoretical constraints, statistical efficiency, and ability to be aggregated. Although only the truncated mean is used in this study, each measure is discussed briefly for comparison.

The Mean

The mean is the expected value of the population WTP from the distribution. Because the right tail of the logistic distribution extends to infinity, the mean is heavily influenced by these upper values and tends to overstate the true WTP. Duffield and

Patterson (1991) found that the mean fails on two of the three critical standards. It is inconsistent with theoretical constraints because it contradicts the assumption in consumption theory that the upper limit of the WTP distribution should not be infinity but instead something less than income. It is also difficult to estimate exactly, is sensitive to the model chosen, and typically requires extrapolating beyond the range of data because of the influential upper tail. However, the mean can be aggregated to estimate a total WTP for the entire population. The mean will not be used to find an estimate of WTP in this study.

The Median

The median is the value of the cumulative distribution below which half of the probability lies. It is found by setting the probability of a yes response to .50 and solving for the bid level. Hanemann (1984) finds that the median tends to be more robust with respect to the errors and outliers in the responses. However, it fails on one of the criteria; it cannot be aggregated over the entire population. While the truncated mean, discussed below, will be the primary measure of average willingness-to-pay used in this study, the median will also be calculated as a measure of central tendency. The expression for the median in the bivarite model is:

2.6. $$Median^{biv} = \exp(-b_0/b_1)$$

The Truncated Mean

Because respondents are limited by their budget constraint, it is not logical to integrate over the entire range of the data to infinity. Using a truncated version of the distribution, usually terminated at the maximum bid level, has been proposed (Hanemann 1984). This "truncated mean" is found by integrating the PDF (see equation 2.2.) from 0 to the maximum bid level and setting every value greater than this equal to the maximum bid level. This greatly reduces the influence of the upper tail of the distribution and keeps all values below the maximum amount offered to respondents. Some critics of this method claim that it seriously underestimates the true mean, but in that case it would provide a conservative, minimum estimate of the mean. The truncated mean, however, does meet each of the requirements set forth by Duffield and Patterson (1991) and is therefore often the most favored welfare measure. The following equation is used for the calculation of the truncated mean:

2.7. $$\text{Truncated mean}^{\text{biv}} = \int_0^T (1 - F(x))dx$$

where $F(x) = 1 / [1 + \exp(-(b_0 + b_1\log(x)))]$. The integral in the equation for the truncated mean is evaluated from zero to T, where T is the truncation point (which in this study is the maximum bid level).

Confidence Intervals

By obtaining the standard error of the truncated mean, a confidence interval is found. The confidence interval expresses the accuracy of the estimate. Because conventional methods do not apply when finding the standard error of the truncated mean, a different technique is needed. Bootstrapping (Efron and Tibshirani 1991) is the newest and most efficient method employed to estimate the variance of the truncated mean so that a confidence interval can be determined. It was originally introduced as a tool for approximating the standard error for estimators other than the mean (Efron and Tibshirani 1991). It utilizes bootstrap samples, which are a sample of size *n* drawn with replacement from the original data set, to obtain a confidence interval for the estimator in question (the truncated mean in this case).

Efron and Tibshirani (1991) lay out the bootstrapping method as follows: (i) a large number *B* of independent bootstrap samples, each of size *n*, is generated using a random number generator, (ii) the model is estimated and the truncated mean is calculated for each bootstrap sample, and (iii) the empirical standard deviation of the *B* bootstrap truncated means is the bootstrap estimate of the standard error for the original truncated mean. To find a 100(1-α)% confidence interval, the bootstrap means are sorted from lowest to highest and the mean at the $(\alpha/2)*B$ level is the lower bound and the mean at the $(1-(\alpha/2))*B$ level is the upper bound. These bounds can be multiplied by the population to obtain a 100(1-α)% confidence interval for the total WTP of the population. It was found that bootstrapping gave a more efficient estimate of the variance than the usual delta method approximation (Bateman et al. 1998). The following equation may be used to compute the confidence intervals:

2.8. $$CI = \text{truncated mean} \pm SE_M * t_{.05/2,\, n\text{-}k}$$

where t is the t-statistic at the 5% error level and with n-k degree of freedom.

2.5. Related Studies

A 1994 Mountain Line service analysis conducted by the Missoula Urban Transportation District (MUTD) and a 2000 policy analysis on transit benefits conducted by the Federal Transit Administration (FTA) contributed information relevant to this study. The Mountain Line service analysis was based on two surveys that served as references in writing the survey used for this study and provided valuable insight into the functioning of the Mountain Line. The FTA analysis dealt with different ways to measure the benefits created by instituting or improving mass transit in large cities.

2.5.1 Service Analysis of Mountain Line Conducted in 1994 by the MUTD

In 1994, Mountain Line conducted a comprehensive service analysis of current fixed-route transit services operated by the MUTD. Part of this analysis included conducting two surveys: one was administered to on-board passengers and the other to the general population, via telephone. The purpose of the on-board survey was to acquire data regarding rider characteristics and trip-making behavior, and to obtain current riders' ratings of Mountain Line's service. The telephone survey was used to determine the general public's ridership and to gain information on travel characteristics, socioeconomic backgrounds, and opinions regarding transit issues of commuters.

<u>On-Board Passenger Survey</u>

The on-board survey consisted of two main parts. The first asked the rider about the particular trip he was on. More specifically, it asked about the route the rider was on, any transfers he may have made or would make, how he paid for the fare, the purpose of the trip, and how frequently he used Mountain Line. The second part asked more personal questions, including such typical socioeconomic characteristics such as gender, age, employment status, and income. In addition, it attempted to uncover how the rider rated various aspects of Mountain Line and what improvements could be made. Another important question asked about the number of vehicles in operating condition at the rider's household. This question helped the surveyors determine if the rider had a vehicle available for the trip or was transit dependent.

The on-board survey produced a total sample size of 640. Overall, the return rate (or response rate) of the survey was 38.4 percent, but varied greatly by route. Because the response rate for this survey was so poor, the following numbers may not be completely representative of the bus-riding community. Results from an analysis of the survey showed that of the 640 respondents, 66.8 percent were employed either full or part-time, 54.8 percent had used the bus for more than three years, 63.7 percent were female, and 65.7 percent reside in a household with a total income of less than $20,000 per year. Also, 65.8 percent of the riders did not have a car available for their trip.

The surveyors also discovered that 18 to 24-year-olds represented the largest age category (21.4 percent), which could be an indication that students are major users of Mountain Line. In fact, the service analysis found that University personnel—students, faculty, and staff—comprise 29.67 percent of the total rides but pay only 3.75 percent of the total operating costs. This is problematic in that Mountain Line receives a small payment for a large volume of service. The report highlights this problem as one that should receive immediate attention.

General Public Survey

Random-digit dialing was used for the general public survey to obtain a representative sample of the population, which consisted of all households in the Mountain Line service area and only individuals who were over 18 years of age. The general public survey also collected information on socioeconomic characteristics and bus ridership. It asked about commuter home-to-work trips, such as time spent on the trip and type of transportation used, and attempted to gain information on respondents' opinions regarding transit issues. Some of the important and relevant questions involved asking respondents if tax dollars should be used to make improvements and whether or not they would vote for an increase in taxes to fund public transportation. The survey also attempted to uncover respondents' environmental attitudes about the bus.

The surveyors obtained a sample size of 216 and found that the majority of those surveyed were current non-riders. The characteristics of those surveyed are summarized below:

- Over 58 percent of the respondents are employed full or part-time.
- Almost 74 percent of the employed respondents drive alone to work; 7.9 percent drive or ride with one or more people.
- Over 66 percent travel to work in 15 or fewer minutes.
- Just over 45 percent of the employed respondents indicated needing their vehicle during the day for work-related trips.
- Around 43 percent of all the respondents have a bus stop available within one block of their home; nearly 19 percent indicated a bus stop is not available (within ½ mile of their home).

- Almost 44 percent of the respondents have used Mountain Line at one time or another.

Respondents' opinions about transit service issues are summarized below:

- Over 63 percent thought additional tax dollars should be used to make improvements to the transit system.
- Over 56 percent of the residents stated they would be somewhat likely or very likely to start riding a bus or ride more often if improvements were made to the transit system.
- Nearly 80 percent of the respondents indicated a good public transportation system is important to the economic health of the area.
- Almost 41 percent indicated they would vote positively for an increase in taxes to fund future improvements to public transportation.
- Almost 72 percent indicated that alternative forms of public transportation should be supported.

Table 2.5.1. below shows a crosstabulation of the question, "Should additional tax dollars be used to make improvements?" with respondent's history of Mountain Line transit usage. Almost 67 percent of the current riders felt tax dollars should be used to make improvements compared to 60.7 percent of current non-riders. Even with this difference, the majority of both categories of riders support using additional tax dollars, which points to a general backing of the transit system.

Table 2.5.2. crosstabulates the question, "Would you vote for an increase in taxes to fund future public transportation improvements?" with the respondent's history of Mountain Line transit usage. An important finding is that while 54.5 percent of the

Table 2.5.1. "Should Additional Tax Dollars be Used to Make Improvements?" by History of Mountain Line Transit Usage

History of Mountain Line Transit Usage	Should Additional Tax Dollars be Used?							
	Yes		No		Don't Know		Total	
	#	%	#	%	#	%	#	%
Recent rider	22	66.7	2	6.1	9	27.3	33	15.3
Past rider	41	67.2	8	13.1	12	19.7	61	28.2
Non-rider	74	60.7	23	18.9	25	20.5	122	56.5
Total	137	63.4	33	15.3	46	21.3	216	100

current riders would vote yes, only 47.5 percent of the past riders and 33.9 percent of the non-riders would vote yes. This may indicate that while non-riders do feel taxes should be used for public transportation, they simply do not want the tax burden themselves. This could also be an indication that, regardless of ridership status, respondents are more willing to have additional money spent on the bus system than they are willing to pay more taxes in order to have the additional money to spend. This appears to mean that either they would be willing to spend more on the bus and less on something else, or that they are not really aware that the government has a budget constraint.

In addition to the questions regarding the funding of Mountain Line, respondents were also asked about their opinions regarding the various uses or additional benefits of public transportation. For example, 93 percent of the individuals surveyed felt that public transportation will get people to jobs. In an environmental context, 90 percent of the respondents believed that public transportation reduces congestion and 85 percent believed that it would improve the environment. Additionally, 71 percent felt that public transportation will promote attractiveness of the community and 64 percent believed that it would promote tourism.

Table 2.5.2. "Would You Vote for an Increase in Taxes to Fund Future Public Transportation Improvements?" by History of Mountain Line Transit Usage

History of Mountain Line Transit Usage	Would You Vote to Increase Taxes?							
	Yes		No		Don't Know		Total	
	#	%	#	%	#	%	#	%
Recent rider	18	54.5	6	18.2	9	27.3	33	15.3
Past rider	29	47.5	21	34.4	11	18.0	61	28.2
Non-rider	41	33.9	51	42.1	29	24.0	121	58.5
Total	88	40.9	78	36.3	49	22.8	215	100

2.5.2 A Public Choice Policy Analysis by the Federal Transit Administration

The Federal Transit Administration (FTA) suggests in this analysis that the measurable benefits of, and public support for, transit can be translated into the budgetary process. The Administration believes that the value of the benefits can be accurately measured in real dollars and used to influence public policy, or more specifically can influence the amount of money used to subsidize public transit. The FTA report concluded that a subsidy was indeed justified by the benefits realized from public transit.

Table 2.5.3. presents the 1995 estimated benefits of public transportation by market niche. The study divided public transit into three main "policy functions," which include basic mobility, location efficiency, and congestion relief. Basic mobility is the mass transit function that serves households who cannot afford an automobile and elderly or children who cannot drive. Location efficiency serves households that can afford an automobile but chose not to own one. The last function, congestion relief, is the goal for households that own one or more automobiles but choose to ride mass transit anyway.

Also provided in Table 2.5.3. are the three different measurements used to estimate the policy functions. The table shows that riders who are using mass transit for basic mobility accumulated the largest amount of benefits per year. The report found that the 1995 aggregate benefits for basic mobility, as found by econometric consumer surplus analysis, was $23 billion. Location efficiency benefits, based on auto ownership cost savings, and congestion relief benefits, based on total travel time saved using mass transit on congested highways were $20 billions and $15 billion, respectively.

Table 2.5.3. Transit's Estimated Benefits by Market Niche, 1995

Transit Policy Function	Aggregate Benefits (Billions)	Measurement Used*
Basic Mobility	$23	Consumer Surplus
Location Efficiency	$20	Auto Costs
Congestion Relief	$15	Travel Time

The study then compared the per trip cost of each function to the per trip benefits (Table 2.5.4). The findings imply that for all transit policy functions the benefits exceed the costs. Also, net user benefits and subsidies depend on and vary according to the specific function in question. The findings indicate that the value of a basic mobility trip may be twice that of a congestion bypass trip. This result is expected because riders using mass transit for basic mobility depend entirely on an alternative form of transportation, while riders using mass transit as congestion reduction also have a car available for their trip. Table 2.5.4. also reports the per trip subsidy paid to each function. Location efficiency as a policy function generates the greatest return for the smallest subsidy. The results indicate that subsidies are indeed justified by the large net user benefits realized by each function.

Table 2.5.4. Cost-Benefit Table of Different Transit Policy Functions

Transit Policy Function	Cost	Subsidy	User Benefit	Net User Benefit
Basic Mobility	$1.96	$1.01	$8.40	$6.44
Location Efficiency	$1.85	$0.85	$11.66	$9.82
Congestion Relief	$3.29	$2.29	$6.37	$3.07

Source: FTA Analysis of 1995 NPTS Database

The FTA also conducted door-to-door interviews to obtain travel modes and measures of travel time, which were then used to model public transit's impact on other modes of transportation in the given corridor. The FTA defines a corridor as a principal transportation artery into the central business district. Through this study, FTA enabled local planners to calculate transit's highway benefits for policy planning purposes. Travelers in the featured corridors that had mass transit as an alternative save 60,000 hours of travel, which the researchers found to be worth $225 million, annually. Their findings suggest that measures should be taken to implement transit operations where it is suspected to influence highway travel demand because the benefits again outweigh the costs.

Another section of the analysis developed an annual congestion index in order to quantify the impact of mass transit on congestion in urban areas. The authors tested the method in two corridors (in Washington D.C. and Sacramento, CA) served by urban rail systems. They found that in 1999 the MetroRail Red Line in Washington D.C. saved four million person-hours of delay, which was worth approximately $62 million in fuel, time, and other highway user costs. This figure can be compared to the $25 million paid by taxpayers that year, which shows that benefits in this case greatly outweigh the costs. The results for the Butterfield light rail corridor are similar: 860,000 person-hours are saved, which corresponds to a savings of $13 million. Table 2.5.5. summarizes these findings.

Another study conducted in the FTA analysis uses a 1996 report finding the economically optimal transit subsidies in the United States and updates it with 1999 data. The 1996 report established a way to determine this optimal level, which arises because of the absence of congestion pricing on the nation's highways. By showing the non-excludability of road travel, and the subsequent under-pricing of it, the authors prove that there is no inherent encouragement for travelers to correct the congestion problem and therefore justify subsidizing public transit. They argue that the subsidy draws travelers away from their cars and to mass transit, thus preventing further congestion. The findings justified an efficient subsidy, which occurs when the marginal traveler switches to mass transit and the subsidy exactly offsets the additional congestion costs had that traveler not decided to use mass transit, because increased mass transit use subsequently reduces the congestion externality.

The FTA policy analysis is important because it shows another approach to measuring the benefits of public transportation. It attempts to measure the benefits by assigning monetary value to different aspects of traveling such as time saved commuting. While this study did not use this approach in valuing public transportation, the results

Table 2.5.5. Results of Congestion Index Test Done on Two Corridors

	Without Transit	With Transit	Difference
I-270-Washington D.C. Corridor			
Annual Person Hours of Delay (millions)	15	11	-4
Annual Cost Due to Congestion (millions of dollars)	247	185	-62
Butterfield-Sacramento Corridor			
Annual Person Hours of Delay (millions)	2.61	1.75	-0.86
Annual Cost Due to Congestion (millions of dollars)	43	30	-13

from the FTA analysis help validate it. The FTA analysis found, through other methods, that mass transit has many benefits that can be realized if it is utilized more. The difference in approaches between this study and the FTA analysis are discussed more in Chapter 5.

Chapter 3: Model Specification and the Data

3.1. Introduction

This chapter presents the bivariate and multivariate model specifications, information on the design and administration of the survey, and descriptive statistics for the data obtained. The survey was designed following the suggestions put forth by the NOAA report (Arrow et. al 1993) and the format of surveys done by Duffield et al. (1999 and 2000). The survey was administered between May 1, 2003 and May 20, 2003. During that time, a total of 300 households were contacted by telephone using random sampling from the phone book. The adult (over 18 years of age) in the household with the most recent birthday was interviewed. Only 2 surveys were incomplete, generating a response rate of 99.33 percent for contacted, participating households. A copy of the survey instrument can be found in Appendix A.

3.2. Model Specification

This section presents the bivariate and multivariate models used to estimate willingness-to-pay for the Mountain Line bus system. When the bivariate model is estimated, the two measures of central tendency used in this study (the median and the truncated mean) can be calculated. The mean willingness to pay can be multiplied by the number of households in Missoula County to obtain a measure of total willingness to pay for the Mountain Line bus system.

The bivariate model used in this study is shown below:

3.1. $$\text{Log}(P/(1-P)) = b_0 + b_1*\log(BID)$$

where:

P = Probability of a yes response (respondent is willing to pay bid amount).

BID = Hypothetical random dollar amount the respondent is asked to pay.

($5, $10, $20, $30, $60, $100, $200).

Equation 3.1 can also be found in Chapter 2 as equation 2.4. In this model, the probability that a respondent accepts the bid level is a function only of the bid amount itself. This bivariate model will be used for calculating the median and truncated mean of willingness to pay.

However, many other variables can affect willingness to pay. This auxiliary information is incorporated into the multivariate model. The multivariate model is expressed below:

3.2. $$\text{Log}(P/(1-P)) = b_0 + b_1*(BUSSTOP) + b_2*(RIDER) + b_3*(RIDEOC) + b_4*(RIDEOF) + b_5*\log(BID) + b_6*(CARS) + b_7*\log(YRSRES) + b_8*(MARSTAT) + b_9*(RNTOWN) + b_{10}*\log(AGE) + b_{11}*\log(EDU) + b_{12}*(GENDER) + [\Sigma(i = 1,2,3)\Sigma(j = 1,2,3,4)\ \gamma_{ij}*EATT_{ij}] + [\Sigma(i = 1,2,3)\ \psi_i*INC_i]$$

where:

P = Probability of a yes response.

BUSSTOP = Dummy variable equal to 1 if respondent lives within walking distance of a bus stop; and otherwise 0.

RIDER = Dummy variable equal to 1 if respondent rides bus rarely; and otherwise 0.

RIDEOC = Dummy variable equal to 1 if respondent rides bus occasionally; and otherwise 0.

RIDEOF = Dummy variable equal to 1 if respondent rides bus often; and otherwise 0.

BID = Hypothetical random dollar amount the respondent is asked to pay ($5, $10, $20, $30, $60, $100, $200).

$EATT_{ij}$ = Measures the respondent's level of agreement, j, with the attitude statement, i. Attitude statement 1 is "Increased bus ridership has a positive environmental impact on the community," 2 is "It is the local government's responsibility to provide the community with a form of public transportation," and 3 is "Mountain Line should be funded through tax dollars." Levels of agreement 1, 2, 3, and 4 are "disagree," "indifferent," "agree," and "strongly agree," respectively.

CARS = Number of cars in the household.

YRSRES = Number of years living in Missoula.

MARSTAT = Dummy variable equal to 1 if respondent is single; and equal to 0 if married.

RNTOWN = Dummy variable equal to 1 if the residence is owned; and equal to 0 if rented.

AGE = Age of the respondent.

EDU = Years of formal education.

INC_i = Measures the respondent's income bracket, i. Bracket 1 is income between $20,000 and $50,000, 2 is income between $50,000 and $100,000, and 3 is income more than $100,000.

GENDER = Dummy variable equal to 1 if respondent is male; and otherwise 0.

3.3. Survey Instrument

The survey instrument was first pre-tested to obtain a bid range and to make sure all the survey material, in particular the valuation scenario, was clear and understandable. The survey was given to twenty people, who were asked the valuation question in an open-ended format and thus were free to state any value they felt was their true willingness to pay for Mountain Line. Based on these twenty amounts, 7 bid levels were chosen ranging from $5 to $200.

The survey consisted of four main parts. The first section was designed to get the respondent thinking about Mountain Line and to determine if he was a rider or non-rider. The respondent was asked if he is familiar with Mountain Line, if he lives within walking distance of a bus stop, and the frequency with which he rides the bus. If the respondent stated that he never rides the bus, a follow-up question was asked to determine the reason.

The next section contained the valuation question, but before it was asked the respondent was read a brief statement to introduce him to the scenario and keep in mind the public benefits of the bus when answering. The introductory statement read as follows:

> "Many people believe that a public bus provides benefits to the community in addition to the transportation provided to the bus riders. For example, the bus system may help conserve energy and reduce traffic congestion and air pollution. In fact, Mountain Line is funded in part through local property taxes."

The respondent was then told that the typical household in Missoula pays approximately $1360 per year in property taxes. This was done so that he had a reference point for how much he may pay in total property taxes. This statement was also a way to remind the respondent of his budget constraint, which in this case is a total property tax constraint. The respondent was then told that he may pay more or less than that amount and if he is not a homeowner, he may pay the taxes through his rent. He was then asked to consider how much of his household's annual property taxes he felt should go towards funding Mountain Line. Bus riders were asked to consider only the benefits to the community and not any personal benefits so that the question would measure the value to them of Mountain Line only as a public good.

The valuation question was asked in the dichotomous choice format. The respondent was presented a bid from the following bid range: $5, $10, $20, $30, $60, $100, or $200. The question asked,

> "Do you feel that Mountain Line is worth *$x* of your

household's annual property taxes?"

where *$x* is the bid amount that varies over the bid range.

The third section of the survey contained three environmental or political attitude questions. The respondents were asked to state whether they "strongly agree," "agree," "not sure," "disagree," or "strongly disagree" with the three following statements:

(1) "Increased bus ridership has a positive environmental impact on the community,"

(2) "It is the local government's responsibility to provide the community with a form of public transportation,"

and

(3) "Mountain Line should be funded through tax dollars."

The purpose of the first statement was to measure an environmental attitude of the respondent, while the second two attempted to determine the respondent's attitude about the funding of pubic goods and taxes.

The last section of the survey elicited socioeconomic information about the respondent, including number of years lived in Missoula, home ownership status, marital status, age, years of education, income, and gender. These characteristics were thought to have a possible impact on bus ridership and willingness to pay for public transportation.

3.4. Data Collection

The NOAA report argues that probability sampling is essential in obtaining a representative sample of the population. Quota and convenience sampling can bias the results by inferring generalizations for the population as a whole from a nonrepresentative sample. Therefore, a form of random probability sampling should be employed. While random-digit dialing in a telephone survey, because it has the ability to capture unlisted numbers, is usually preferred, simple or systematic random sampling from the phone book can also be used to obtain a sample of the population; this is the procedure I used. I started with the name at the bottom of each column. If that number was a business, I skipped to the fifth number above that and so on until a residential number was found.

Each interviewer received a script along with the questionnaire. To avoid interviewer bias, the interviewer was told not to deviate from the script. A total of 6 interviewers were used, and each passed the University of Montana Institutional Review Board (IRB) research ethics course and test for dealing with human subjects. The interviewers were also given a review of the study so they understood the questions asked on the survey.

Interviews were conducted from May 1, 2003 until May 20, 2003. The calls were usually made from 5:00 p.m. until 9:00 p.m., except on the weekend when calls were made from 12:00 p.m. until 5:00 p.m. The interviewers called from either the Economics Department or their own homes. A total of 750 residences were called, with at least one callback attempt at each phone number. Of these residences, 360, or 48 percent, were contacted. Of these, 60 households chose not to participate in the survey, which yielded a 16.67 percent refusal rate among households contacted. This left a total sample size of 300, or 40 percent of the total number of households called.

There may be problems associated with this method of surveying, which have only surfaced recently. An increasing number of telephone subscribers are choosing to have unlisted numbers, and many more households use a form of caller identification which allows a person to screen unwanted calls. Another problem which is emerging rapidly is the use of cellular phones. A recent article in the Washington Times (Associated Press, Aug. 5, 2003) states that as many as 7.5 million Americans no longer use a "landline" and use only a cellular phone. Also, cellular phones now comprise about 43 percent all U.S. phones, a 16 percent increase since 2000, and landline phones have dropped by 5 million, or nearly 3 percent, since 2000. Because cellular phone users are not listed in the phone book, a number of people in the population may not get sampled. These problems can lead to an unrepresentative sample, which is discussed later in this chapter and in the conclusions found in Chapter 5.

3.5. Descriptive Data

The descriptive statistics for the independent variables (excluding BID) are discussed in this section. The original sample contained observations from 300 households. However, because 2 respondents declined to divulge the total household income, the sample shrunk to 298 households. Table 3.5.1. summarizes the descriptive statistics for the sample. Note that the mean of the dummy variables denotes the percentage of respondents answering yes to the question. For example, the mean of the first variable, "lives within walking distance of a bus stop," is .832, indicating that over 83 percent of households in the sample live within walking distance of a bus stop.

Table 3.5.1. Descriptive Statistics for Telephone Survey of Missoula Households

Variable Name	Number	Mean	Stand. Dev.	Minimum	Maximum
BUSSTOP*	298	.83221	.37430	0	1
RIDEN*	298	.7791	.99804	0	1
RIDER*	298	.15101	.35866	0	1
RIDEOC*	298	.09732	.29689	0	1
RIDEOF*	298	.06376	.24473	0	1
EATT1SA*	298	.36913	.48338	0	1
EATT1A*	298	.54698	.49863	0	1
EATT1I*	298	.04362	.20460	0	1
EATT1D*	298	.03356	.18039	0	1
EATT1SD*	298	.00771	.04245	0	1
EATT2SA*	298	.20470	.40416	0	1
EATT2A*	298	.46980	.49993	0	1
EATT2I*	298	.12416	.33032	0	1
EATT2D*	298	.16107	.36822	0	1
EATT2SD*	298	.04027	.12651	0	1
EATT3SA*	298	.12081	.32645	0	1
EATT3A*	298	.47651	.50029	0	1
EATT3I*	298	.19128	.39397	0	1
EATT3D*	298	.18121	.38584	0	1
EATT3SD*	298	.03019	.07089	0	1
CARS	298	2.0872	1.1659	0	7
YRSRES	298	19.594	17.826	0.25	75
MARSTAT*	298	.47987	.50043	0	1
RNTOWN*	298	.58054	.49430	0	1
AGE	298	42.856	17.953	18	89
EDU	298	15.154	2.4825	9	22
INCL*	298	.29195	.39002	0	1
INCML*	298	.40268	.49126	0	1
INCMH*	298	.22148	.41594	0	1
INCH*	298	.08389	.27769	0	1
GENDER*	298	.46644	.49971	0	1

* The mean represents the percentage of individuals that responded yes to the question.
** Definitions of the variables can be found on pages 33-34.

The typical respondent in the sample never rides the bus. In fact, 206 of the 298 people surveyed, about 69 percent, said that they never ride Mountain Line. Forty-four of the people surveyed, or about 15 percent, ride the bus rarely. Twenty-nine respondents, or about 10 percent, ride the bus occasionally and only 18 respondents, or about 6 percent, ride the bus often.

The majority of respondents agreed with the first statement ("Increased bus ridership has a positive environmental impact on the community"), indicating that on average, the respondents feel the bus is an important tool in decreasing pollution and improving the environment. A majority of respondents also agreed with the second statement ("It is the local government's responsibility to provide the community with a form of public transportation"), which could be an indication that respondents feel the bus is indeed a public good. For the last statement ("Mountain Line should be funded through tax dollars"), the majority agreed, although this statement had the highest percentage of disagrees and second highest percentage of strongly disagrees.

Respondents were asked to place themselves in one of four income brackets. This was done for convenience and time, as well as to increase the response rate. Typically, respondents are more likely to answer the potentially threatening demographic questions if they are allowed to pick a bracket encompassing their answer, rather than state an exact figure. The income brackets were: 1, less than $20,000; 2, $20,000 to $50,000; 3, $50,000 to $100,000; and 4, more than $100,000.

Table 3.5.1. presents the means for each of the income brackets. Because the

brackets are represented as dummy variables, the mean of a given bracket translates into the percentage of respondents that fit into that bracket. The percentage of respondents in brackets 1, 2, 3, and 4 was 29.2, 40.3, 22.1, and 8.4, respectively.

3.6. Comparison of Census Data and Sample Data

To test the representativeness of the study sample, descriptive statistics for the sample were compared with statistics derived from the 2000 census for Missoula, Missoula County, and Montana. Table 3.6.1. shows these comparisons of demographic characteristics of the city of Missoula, Missoula County, the state of Montana, and the sample population. The second comparison contrasts the number of vehicles per household using 2000 census data with the number of vehicles per household using the sample data. Table 3.6.2. summarizes this comparison.

According to 2000 Census results, the home ownership rate in the sample population is much lower than the overall home ownership rate for Missoula County or the state of Montana. However, the sample rate is much closer to the rate of home ownership in the city of Missoula. Also, the percentage of respondents in the sample 65 years old or over is larger than the percentage of people 65 years or older in Missoula, Missoula county, and Montana. Both education percentages (high school graduates and college graduates) are larger than the three census data percentages, although of these, the city of Missoula has the largest percentage of college graduates. The median household income from census data is consistent with the results of the sample population. Over 40 percent of the households in the sample population claimed to earn between $20,000 and $50,000 last year before taxes. The percentage of female respondents in the sample (55.4 percent) is also higher than the percentage of females in the city of Missoula (50.3 percent), Missoula County (50.0 percent), or the state of Montana (50.2 percent).

Unfortunately the sample seems to be a poor representation of the population of Missoula County, even though approved survey techniques were used in the administration. One possible explanation is households are using unlisted numbers, caller identification, or cell phones more frequently, thus a truly representative sample

Table 3.6.1. Comparing the Characteristics of the City of Missoula, Missoula County, the State of Montana, and the Sample Population.

Census Characteristic	Missoula	Missoula County	Montana	Sample
Population, 2000	57,053	95,802	902,195	298
Home ownership, percent, 2000	50.2%	61.9%	69.1%	42%
Persons 65 years old or over, percent, 2000	10.4%	10.0%	12.9%	16.7%
High school graduates, percent of persons age 25+, 2000	91.5%	91.0%	87.2%	98.3%[1]
Bachelor's degree or higher, percent of persons age 25+, 2000	38.0%	32.8%	24.4%	50.7%[1]
Median household money income, 1999	$30,366	$34,454	$33,024	Occurs in the $20,000 - $50,000 range
Female persons, percent, 2000	50.3%	50.0%	50.2%	55.4%

[1] Represents the percentage of all college graduates in sample, not just those over 24 years of age.

may be hard to obtain using a telephone survey. Problems resulting from this are discussed further in the conclusions found in Chapter 5.

Table 3.6.2. compares the number of vehicles per household in Missoula County found using 2000 Census data with the number of vehicles per household found in the sample. For both Missoula County and the sample, the average number of vehicles per household is approximately 2 (2.08 in the case of the sample, see Table 3.5.1). In terms of vehicle ownership, the sample also seems to be fairly representative of the entire population.

Table 3.6.2. Comparing the Number of Cars in a Household for the Sample and Missoula County.

Number of Vehicles in Household	Missoula County	Sample
0	6.2%	4%
1	31.4%	26%
2	40.1%	45%
3+	22.3%	25%

3.7. Bus Rider Descriptive Statistics

The descriptive statistics of the bus riders are shown in Table 3.7.1. Only 92 respondents from the sample reported riding the bus. Note that the mean of the dummy variables denotes the percentage of respondents answering yes to the question.

The average number of bus rides per month for riders in the sample is 9.5462. Respondents reported riding the bus as few as .25 times a month to as many as 60 times a month. Almost 73 percent of the respondents reported that they do indeed pay to ride the bus (as opposed to the 27 percent who can be assumed to be students, faculty, or staff of the University of Montana). Of the 92 bus riders in the sample, about 56.5 percent do not receive a discount (those receiving a discount are senior citizens, students, faculty, and staff of the University of Montana, and children under 18, who were not sampled in this study). A random fare increase, ranging from $0.15 to $2.00, was presented to the respondents, and they were asked if this increase would affect how often they rode the bus.

Table 3.7.1. Bus Rider Descriptive Statistics

Variable Name	Number	Mean	Stand. Dev.	Minimum	Maximum
Number of bus rides per month	92	9.5462	13.009	.25	60
Respondent pays to ride bus[1]	92	.72826	.44729	0	1
Respondent does not receive a discount[1]	92	.56522	.49844	0	1
Fare increase would affect ridership[1]	92	.95978	.65739	0	1
Number of bus rides per month with fare increase	92	7.2201	11.698	0	60

[1] The mean represents the percentage of individuals that responded yes to the question

Table 3.7.2. crosstabulates the respondents' income with how often they ride the bus. The table shows that income bracket 1 (less than $20,000) has the highest percentage of "rides often" riders compared to the other income brackets. It also has the highest percentage of "rides occasionally" but is second in "rides rarely" riders to bracket 2. This is most likely because lower income families are less likely to have access to a car or multiple cars, and are thus more likely to use an alternate form of transportation. Also supporting this is the fact that only 3 respondents from bracket 4 reported riding the bus, and all three fell in the rides rarely category.

Table 3.7.2. Bus Rider Frequency by Income Bracket.

Income Bracket	Bus Rider Frequency									
	Rides Never		Rides Rarely		Rides Occ.		Rides Often		Total	
	#	%	#	%	#	%	#	%	#	%
Bracket 1 (less than $20,000)	54	62.1	13	14.9	11	12.6	9	10.4	87	29.2
Bracket 2 ($20,000-$50,000)	79	65.8	19	15.9	13	10.8	9	7.5	120	40.3
Bracket 3 ($50,000-$100,000)	51	77.3	9	13.6	5	7.6	1	1.5	66	22.1
Bracket 4 (more than $100,000)	22	88.0	3	12.0	0	0.0	0	0.0	25	8.4
Total	206	69.1	44	14.8	29	9.7	19	6.4	298	100

Table 3.7.3. crosstabulates the number of cars in a household with the how often the respondents ride the bus. As expected, households with no cars also have the highest percentage of respondents who ride the bus often (41.6 percent). Only 25 percent of the households without a car do not ride the bus and presumably have found other modes of transportation such as walking, riding a bike, or carpooling. While 71.1 percent of the households with 3 or more cars never ride the bus, 22 individuals surveyed from these

households ride the bus rarely to often. Almost 45 percent of the households in the survey have 2 cars, but these households have the lowest percentage of "rides occasionally" and "rides often."

Table 3.7.3. Bus Rider Frequency by Number of Cars in the Household.

Number of Cars in the Household	Bus Rider Frequency									
	Rides Never		Rides Rarely		Rides Occ.		Rides Often		Total	
	#	%	#	%	#	%	#	%	#	%
0	3	25.0	2	16.7	2	16.7	5	41.6	12	4.0
1	54	70.1	7	9.1	11	14.3	5	6.5	77	25.9
2	95	71.4	26	19.6	8	6.0	4	3.0	133	44.6
3 +	54	71.1	9	11.8	8	10.5	5	6.6	76	25.5
Total	206	69.1	44	14.8	29	9.7	19	6.4	298	100

Chapter 4: Model Estimation and Calculation of Benefits

4.1. Introduction

This chapter focuses on the model estimation and calculation of benefits. The first section concentrates on the estimation of the bivariate and multivariate models of willingness to pay. Using the most statistically significant variables from the multivariate model, a reduced multivariate model is also estimated. This section also presents the marginal effects and elasticities of all three models. The second section is concerned with the calculation of benefits determined from the bivariate model. The last section presents a measure of total willingness to pay, which is found by multiplying the truncated mean by the number of households in Missoula County.

4.2. Model Estimation

The equation for the bivariate model can be found in section 2.4.1. (equation 2.2.). Table 4.2.1. presents the estimated coefficients, standard errors, t-ratios, and the marginal effects and elasticities at the means of the bivariate model. The elasticity measures the responsiveness of the dependent variable to one of its determinants. The likelihood ratio test was also performed. The calculated chi-square statistic for the bivariate model was 69.22, which can be compared 3.84, the chi-square statistic (with one degree of freedom) at the 5 percent error level. The results of this test for the bivariate model suggests that the null hypothesis ($\beta_{LBID} = 0$) can be rejected.

Table 4.2.1. Bivariate Model: Analysis of Results from Telephone Survey of Missoula Households; Dependent Variable is the Probability of a Yes Response

Variable Name	Estimated Coefficient	Standard Error	T Ratio	Marginal Effect	Elasticity
CONSTANT	4.3299	.54543	7.9385		1.2375
Log(BID)	-.98557	.13616	-7.2835	-.05752	-.97577

The marginal effects of BID in the bivariate model at each bid level are shown below in Table 4.2.2. The marginal effects at the means were found by taking the derivatives of equation 2.2.:

$$2.2.\quad P = \exp(b_0+b'X)/(1+\exp(b_0+b'X)) = 1+\exp(-b_0-b'X)^{-1}$$

which is found in section 2.4.1. (see p.15). The derivative of this equation, with respect to x_j, is expressed as:

$$4.1.\quad \delta P/\delta x_j = [\exp(b_0+b'X)/(1+\exp(b_0+b'X))][1/(1+\exp(b_0+b'X))]*b_j$$

Equation 4.1 is equivalent to:

$$4.2.\quad \delta P/\delta x_j = P(1-P)b_j.$$

The marginal effect of an independent variable measures the result of a unit change in that variable on the probability of a yes response to the mean bid amount. The marginal effect is not independent of the value of x, in that $\delta P/\delta x$ varies with x. Also shown in Table 4.2.2. are the probabilities that a respondent accepts the given bid amount.

The probabilities at each bid level, shown in Table 4.2.2., are consistent with economic theory. It is expected that most people will accept low bids and few will accept high bids. Table 4.2.2. shows that almost 94 percent of the respondents would accept a bid of $5 while about 29 percent would accept a bid of $200. Because the rate of change increases as the bid amounts increase, the marginal effects should decrease as BID increases. If a respondent were offered a bid amount of $100, his answer would probably not change given a one unit increase or decrease (a 1 percent change) in the bid amount. However, if a respondent were offered a bid amount of $5, his response is more likely to change given a one unit increase or decrease (a 20 percent change) in the bid amount.

Table 4.2.2. Marginal Effects and Probabilities at the Bid Level

	BID=$5	BID=$10	BID=$20	BID=$30	BID=$60	BID=$100	BID=$200
Marginal Effects at BID	-.01119	-.00988	-.00793	-.00653	-.00402	-.00244	-.00102
Probability Accepting BID	.93956	.88701	.79858	.72667	.57314	.44799	.29071

Table 4.2.3. shows the estimated coefficients, standard errors, t-ratios, and the marginal effects and elasticities at the means of the multivariate model. The independent variables in the multivariate model consist of the log of the bid level, as well as variables found in the literature that are thought to influence willingness-to-pay for a public good. There are also variables that are thought to specifically influence willingness-to-pay for a

public transportation system. Variables with t-ratios with absolute values larger than 1.6507|are statistically significant at the 95% confidence level in the multivariate model.

The coefficients on dummy variables measure the effect relative only to the omitted case. For example, the omitted base case associated with the income variables is income less than $20,000. The households in the other income ranges are compared only to the omitted base case. For example, the households in the medium low and medium high ranges do not appear willing to pay more for Mountain Line than households in the low income range. The only significant income range was the highest, and thus only high income households are willing to pay more than low income homes.

Equation 4.2. does not apply when calculating the marginal effects of a dummy variable, and thus a different method needs to be used. The probability with the dummy variable equal to 0 is subtracted from the probability with the dummy variable equal to 1. The marginal effect is then the difference between these two probabilities. The marginal effects of dummy variables, however, are still dependent on the values of the independent variables.

Surprisingly, not many variables in the multivariate model were statistically significant. As stated above, the highest income bracket (more than $100,000) was the only statistically significant income variable, stressing the importance of a high income on the household's willingness-to-pay for Mountain Line. Education was also statistically significant, but the coefficient had a negative sign. Therefore, the idea that increased education has a positive effect on willingness-to-pay is false, at least when

Table 4.2.3. Multivariate Model: Analysis of Results from Telephone Survey of Missoula Households; Dependent Variable is the Probability of a Yes Response

Variable Name	Estimated Coefficient	Standard Error	T Ratio	Marginal Effect	Elasticity at means
CONSTANT	8.8172	5.5177	1.5980		2.0520
Log (BID)	-1.1784	.18157	-6.4900*	-.06007	-.94998
BUSSTOP	.63622	.45360	1.4026	.12574	.12322
RIDER	.04777	.51743	.09232	.00845	.00168
RIDEOC	-.12598	.66634	-.18906	-.02310	-.00285
RIDEOF	1.0691	.90707	1.1786	.14482	.01586
EATT1SA	-.04250	4.3752	-.00971	-.00761	-.00365
EATT1A	-.37232	4.3679	-.08524	-.06584	-.04740
EATT1I	-.83415	4.4058	-.18933	-.17617	-.00847
EATT1D	.10445	4.4609	.02341	.01816	.00082
EATT2SA	.90076	1.2507	.72023	.13820	.04291
EATT2A	.14900	1.1403	.13066	.02654	.01629
EATT2I	-.47321	1.2004	-.39421	-.09224	-.01367
EATT2D	-.67727	1.1265	-.60122	-.13488	-.02539
EATT3SA	3.5220	1.5667	2.2480*	.30349	.09902
EATT3A	2.8266	1.3751	2.0556*	.47381	.31346
EATT3I	2.4294	1.3768	1.7645*	.28478	.10815
EATT3D	1.3455	1.3197	1.0195	.18749	.05674
CARS	-.13462	.14871	-.90524	-.02403	-.06539
Log (YRSRES)	-.13249	.17210	-.76985	.00911	-.07390
MARSTAT	-.22353	.41917	-.53327	-.04000	-.02496
RNTOWN	-.33987	.44761	-.75928	-.05978	-.04592
Log (AGE)	-.02953	.55135	-.05356	-.00012	-.02523
Log (EDU)	-2.3137	1.1511	-2.0100*	-.02726	-1.4564
INCML	.74536	.46352	1.6081	.12782	.06985
INCMH	.91695	.57680	1.5897	.14160	.04726
INCH	1.8598	.86192	2.1578*	.20943	.03631
GENDER	.34355	.35130	.97796	.06095	.03729

* Values are significant at the 95% level

** Definitions of variables can be found on pages 33-34.

education is independent of income. The negative sign on education may indicate that higher levels of education cause the respondents to more accurately assess exactly how much public benefit is being provided.

The only opinion question that had any significance (and only if the respondent strongly agreed, agreed, or was indifferent) in the model was the third. It stated, "Mountain Line should be funded through tax dollars." One would expect that if a respondent strongly agreed or agreed, the probability that he accepted the bid level would increase relative to a respondent who strongly disagreed with the statement.

The reduced model was derived from the multivariate model, and only used the statistically significant variables, as well as some other theoretically important variables, from the multivariate model in order to establish an improved model. It included all the variables regarding the third attitude question and income (even though "disagree" and income between $20,000 and $50,000 and income between $50,000 and $100,000 were not found to be significant). It also included education and gender, because while they were not found to be important in the full model, the literature describes them as important variables in estimating willingness-to-pay.

The estimated coefficients, standard errors, t-ratios, marginal effects, and elasticities at the means of the reduced multivariate model are found in Table 4.2.4. Variables with t-ratios with absolute values larger than 1.6503 are statistically significant at the .05 error level in the reduced model.

Again, not many variables were found to be important in the reduced multivariate model. Education was statistically significant and, as in the full model, its sign was negative. The third attitude question (with the exception of "disagreed") was significant in the reduced model as well. The reduced model does not appear to represent a significant improvement over the full multivariate model.

Table 4.2.4. Reduced Multivariate Model: Analysis of Results from Telephone Survey of Missoula Households; Dependent Variable is the Probability of a Yes Response

Variable Name	Estimated Coefficient	Standard Error	T Ratio	Marginal Effect	Elasticity at means
CONSTANT	6.0166	3.0491	1.9733*		1.5171
Log (BID)	-1.1002	.16218	-6.7836*	-.00344	-.96096
EATT3SA	4.9073	1.3202	3.7171*	.37437	.14948
EATT3A	3.6700	1.1724	3.1304*	.61257	.44095
EATT3I	2.7918	1.1812	2.3635*	.33106	.13464
EATT3D	1.5124	1.1840	1.2774	.21819	.06910
Log (EDU)	-1.8175	1.0515	-1.7285*	-.02262	-1.2396
INCML	.62928	.38148	1.6496	.11485	.063894
INCMH	.56077	.43688	1.2836	.09737	.03132
INCH	1.1433	.70637	1.6185	.16487	.02418
GENDER	.37436	.32239	1.1612	.07010	.04403

*Values are significant at the 95% level
** Definitions of variables can be found on pages 33-34.

The likelihood ratio test was also performed for the full and reduced multivariate models. The calculated chi-square statistic for the multivariate model was 143.06, which can be compared 40.11, the chi-square statistic (with 27 degrees of freedom) at the .05 error level. The calculated chi-square statistic for the reduced multivariate model was 125.42, which can be compared 18.31, the chi-square statistic (with 10 degrees of freedom) at the 5 percent error level. In both cases, the tests show that the null hypothesis (all betas equal to zero) can be rejected. One other likelihood ratio test was performed for the full and reduced model. The null hypothesis for this test stated that all coefficients, except for BID, are equal to zero. It was found that the null hypothesis for the LR test on both the full and the reduced model could be rejected.

4.3. Benefit Estimation

The bivariate model was used for estimating the willingness-to-pay for Mountain Line. It has been argued that the willingness-to-pay distribution can be approximated using the bivariate model, assuming that the bivariate model fits the data well (Duffield and Patterson 1991). Eliminating any auxiliary information simplifies the calculations and interpretations of the estimates.

The median and truncated mean were the two measures used for estimating willingness-to-pay. For the estimation of the truncated mean, the highest bid amount ($200) was used as the truncation point. The median and truncated mean were found using equations 2.6. and 2.7. in section 2.4.2. The standard errors for the truncated mean were found using the bootstrapping technique with 1000 iterations. Table 4.3.1. below shows the median and truncated mean derived from the bivariate model.

Table 4.3.1. Median and Truncated Mean for the Bivariate Model

Model	Median	Truncated Mean
Value	80.91	100.76

The confidence interval for the truncated mean may be calculated by using the standard errors derived from the bootstrapping method and the equation found in section 3.3.1. The confidence interval for the truncated mean can be found in Table 4.3.2.

Table 4.3.2. Confidence Interval for Truncated Mean

95 % Confidence Interval for Truncated Mean
87.52 – 114.66

4.4. Total Valuation

To find the total value that Missoulians place on the Mountain Line bus system, the confidence interval for the truncated mean needs to be aggregated. Because the units observed in this study were households, the mean willingness-to-pay can be multiplied by the number of households in Missoula County to find the total valuation. The 2000 Census report calculated the number of households in Missoula County as 38,439, although the sample in this study only included areas of the county that Mountain Line reaches. The 95% confidence interval found for the truncated mean can be multiplied by the number of households to find a 95% confidence interval for the total willingness-to-pay. This confidence interval, as well as the aggregated mean, may be found below in Table 4.4.1.

Table 4.4.1. also compares the total willingness-to-pay with the total amount of funding Mountain Line receives from local property taxes. Mountain Line received

$1,210,000 in the 2001 fiscal year, which amounts to a difference of $2,663,113.64. The results of this study seem to indicate that Missoulians value Mountain Line more than what they are paying for it.

Table 4.4.1. Total Willingness-to-Pay

Total WTP	Total WTP at 95% Confidence Interval	Actual Amount Paid
$3,873,113.64	$3,364,181.28 – $4,407,415.74	$1,210,000

Chapter 5: Conclusions and Future Research

5.1. Overall Conclusions

The bus has many added benefits besides being a form of transportation. It reduces pollution and congestion by decreasing the number of drivers on the road, although more people need to ride public transportation in order for these benefits to be realized. There is a free rider problem associated with the bus because there is no way to extract payment from people enjoying these added benefits that accrue not only to the actual users but also to society as a whole. Because of these added benefits to society, public transportation is seen largely as a non-market good.

Because public transportation falls under the category of public goods, it is necessary to determine the value that individuals place on it and the benefits they receive from it through other mechanisms besides the market. This study found this value through a dichotomous choice contingent valuation survey. The demand for the Mountain Line bus system was found by calculating the probability that a survey respondent will accept a given dollar (bid) amount.

The results of the study were summarized in chapter 4. The median willingness-to-pay per year, derived from the bivariate model, was $80.91. The average willingness-to-pay per year was $100.76 and the confidence interval for this truncated mean was $87.52 – $114.66. When the truncated mean was aggregated, the total willingness-to-pay was $3,873,113.64 and the confidence interval for this total was $3,364,181,28 – $4,407,415.74.

Only two economic variables were found to be significantly affect willingness-to-pay in the full multivariate model: income and education. Specifically, households in the highest income bracket (more than $100,000) were willing to pay significantly more than those in the lowest income bracket (less than $20,000). Education had the opposite effect, i.e. more highly educated households are willing to pay less than less educated ones. The only conclusion arising from this variable is that the premise that educated people value public transportation more than uneducated ones is false

The third attitude scale was also found to be statistically significant, with the exception of EATT3D, which was the dummy variable for a respondent disagreeing with the third opinion question. The third opinion question stated, "Mountain Line should be funded through tax dollars." One would expect that if a respondent strongly agreed or agreed, the probability that he accepted the bid level would increase, relative to a respondent who strongly disagreed with the statement.

In the reduced multivariate model, education was the only significant economic variable. The third attitude scale was also statistically significant (with the exception of disagreed). This analysis indicates that it does not necessarily improve the results to include in a reduced model only the economically or statistically significant variables from the full multivariate model.

There are several potential problems with bias in this study. One problem is that the top bid amount, $200, had a 29 percent acceptance rate, which is fairly high for a contingent valuation study. Typically, the top amount offered should have a much lower acceptance rate in order to fit a logistic distribution. From this, the estimate of mean willingness-to-pay may be artificially low. This shows that the top bid should have been set higher than $200.

Another source of potential bias is that the descriptive statistics found in chapter 4 show that the sample was not completely representative of the population of Missoula County. The sample's rate of home ownership was much lower than the true population. Although home ownership was not found to be statistically significant, the sign on the coefficient was negative, indicating that renting has a negative impact on the willingness-to-pay for Mountain Line. Because a higher percentage of renters were represented in the sample than in the true population, there could be downward bias on willingness-to- pay.

Also, the sample was represented by larger percentage of individuals over the age of 65 and females than in Missoula County. The coefficient on gender had a positive sign, indicating that if a respondent was male, he was more likely to be willing to pay for Mountain Line. This sample had a higher percentage of females than reported in Missoula County Census data, which also could have created downward bias on the willingness-to-pay estimates. However, gender was also not found to be a statistically significant variable.

The percentage of high school and college graduates was also higher in the sample. Because the sign on the coefficient on education was negative, the high percentage of graduates in this study may have lowered the estimate of willingness-to-pay. Because of this, and the other causes of downward bias mentioned above, the mean willingness-to-pay is most likely underestimated.

The unrepresentative sample may be due to the fact that it is becoming increasingly difficult to obtain a representative sample out of the phone book. As discussed in Chapter 3, unlisted numbers, caller identification, and the use of cellular phones as a substitute for landline phones causes many households to be left out of the sampling procedure. Also, some groups of the population may be more likely to fall into these categories than others. For example, students, recent graduates, and young professionals make up the majority of cell-phone-only households (AP, Aug. 5, 2003). Senior citizen households may be less likely to spend money on phone features like caller identification and cellular phones. This could explain why respondents over the age of 65 were overly represented in this sample. These factors seem to point at one conclusion: telephone surveys that randomly select respondents from the phone book are becoming obsolete.

In addition, it should be noted that many of the households included in the original random sample ultimately were not contacted; in general, only one follow-up attempt was made to call households that failed to answer the first call. Thus those households whose occupants were not at home and answering the phone during the interviewing hours were not included in the completed sample. These households could differ significantly from those that were included in the completed sample in one or more of the characteristics relevant to willingness to pay for public transportation. It should be possible to eliminate this problem by allowing for a larger number of follow-up calls to non-answering households.

5.2. Future Research

While researching for this project, I found it was difficult to locate similar studies of other public transportation systems. For this reason, there are many possible extensions of this study that have seldom been implemented. The remainder of this section discusses three topics for possible future research.

The results found in chapter 5 suggest that people, on average, place a substantially higher value on the Mountain Line than the costs they currently incur in order to subsidize the service. The average family currently pays approximately $31.50 in yearly property taxes to support Mountain Line while the study found that the average willingness-to-pay for the bus service among Missoulians is $100.76. As stated above, once aggregated, this average willingness-to-pay leads to a total willingness-to-pay of $3,873,113.64. However, the total local subsidy was only $1,210,000 in 2001, which is a difference of approximately $2,663,113. This has great implications for local policy makers as well as for the Missoula Urban Transportation District. A further study expanding the present research and providing possible scenarios for expanded bus service would be beneficial to both Mountain Line and as well as the city of Missoula.

While a bus has many positive environmental attributes, such as decreasing pollution and congestion and conserving energy, these benefits are only realized if the transportation alternative is utilized. If a bus is empty, or only partially filled, it contributes to road congestion and air pollution instead of abating it. One problem not addressed in this study is that Mountain Line is not yet used enough for Missoula to realize many of these positive benefits. For example, 69 percent of the population sampled never rides the bus and 15 percent rides the bus rarely. With numbers like this, buses operate mostly half-empty or worse. While Mountain Line and the Missoula Urban Transportation District do sponsor several campaigns attempting to increase ridership and decrease private automobile use, it has not been enough to completely fill the empty seats. One possibility for future research on Mountain Line may be to find new ways to advertise and campaign for riding public transportation.

Also, finding the decrease in pollution and congestion resulting from the use of public transportation is a different approach to measuring the benefits. An alternative to the methods used in this study is to physically measure the reduction in pollution, waiting time in traffic, number of cars on the road, and amount of fuel utilized and then assign dollar values to these effects. The results from a study such as this could then be compared to results using the approach in this study and results from any other alternative approach.

Appendix A

Survey Instrument

Hello, my name is _______. I am calling from the Economics Department at the University of Montana. We are doing a research study on the value that people in Missoula place on the Mountain Line bus system. Your telephone number and address were drawn in a random sample of Missoula.

In order for our survey to be most representative, I need to talk to the person living in your household who is over 18 years of age and has had the most recent birthday. May I please speak to that person?

(IF NO: When would be a convenient time to call back? ___________
Thank you for your time.)

(Read if someone else)
Hello, my name is _______. I am calling from the Economics Department at the University of Montana. We are doing a research study on the value that people in Missoula place on the Mountain Line bus system. Your telephone number and address were drawn in a random sample of Missoula.

The questions I would like to ask will take about ten minutes to complete, and all of your answers are completely voluntary and confidential. Would you be willing to help me out by answering a few questions?

(IF NO: When would be a convenient time to call back? _______
Thank you for your time.)

1. Let me start by asking…are you familiar with Missoula's main mode of public transportation, Mountain Line?
   - Yes
   - No
2. Do you live within walking distance of a Mountain Line bus stop?
   - Yes
   - No
   - Not sure
3. Would you say you ride Mountain Line:
   - Never
   - Rarely (if answer is anything other than never skip to question 5)
   - Occasionally
   - Often
4. What is the main reason you do not use Mountain Line?
   - Too far from a bus stop
   - Inconvenient scheduling
   - Freedom of own automobile
   - Discomfort associated with bus environment
   - Other

(skip to question 6)

5. Many people believe that a public bus provides benefits to the community in addition to the transportation provided to the bus riders. For example, the bus system may help conserve energy and reduce traffic congestion and air pollution. In fact, Mountain Line is funded in part through local property taxes.

A typical household in Missoula pays approximately $1360 per year in property taxes. Your household may pay more or less than this amount and if you are not a homeowner, you may pay the taxes indirectly through your rent. Please consider how much of your household's annual property taxes you feel should go towards funding Mountain Line. In doing so, please consider only the benefits to the community and not any personal benefits you may derive from riding the bus. For example, do you feel that Mountain Line is worth $ of your household's annual property taxes?

Yes
No
Not sure
(skip to question 7)

6. Many people believe that a public bus provides benefits to the community in addition to the transportation provided to the bus riders. For example, the bus system may help conserve energy and reduce traffic congestion and air pollution. In fact, Mountain Line is funded in part through local property taxes.

A typical household in Missoula pays approximately $1360 per year in property taxes. Your household may pay more or less than this amount and if you are not a homeowner, you may pay the taxes indirectly through your rent. Please consider how much of your household's annual property taxes you feel should go towards funding Mountain Line. For example, do you feel that Mountain Line is worth $ of your household's annual property taxes?

Yes
No
Not sure
(skip to question 12)

7. Now I'll ask you to only consider the personal benefits you derive from riding the bus. How many times a month would you say you ride the bus? Please consider a round trip as two rides. ______

8. Do you pay to ride the bus?
Yes
No

9. Do you receive a discount?
Yes
No

10. If the fare increased by $, would it affect how often you ride the bus?
Yes

No (if no, skip to question 12)
Not sure

11. Given this increase, how many times a month would you ride the bus? _____

Please indicate your opinion (with strongly agree, agree, not sure, disagree, or strongly disagree) on each of the following statements:

12. Increased bus ridership has a positive environmental impact on the community.
Strongly agree_____ Agree_____ Not sure_____ Disagree_____ Strongly Disagree____

13. It is the local government's responsibility to provide the community with a form of public transportation.
Strongly agree_____ Agree_____ Not sure_____ Disagree_____ Strongly Disagree____

14. Mountain Line should be funded through tax dollars.
Strongly agree_____ Agree_____ Not sure_____ Disagree_____ Strongly Disagree____

15. How many cars in operating condition are in your household? _____

And now here are some questions about you:

16. How long have you lived in Missoula? _____
17. What is your marital status? Single____ Married____
18. Do you own or rent your home? Own____ Rent____
19. What is your age? _____
20. How many years of education do you have? _____
21. What was your household's approximate income last year before taxes?
    - Less than $20,000 ____
    - $20,000 - $50,000 ____
    - $50,000 - $100,000 ____
    - More than $100,000 ____
22. What is your gender? Male____ Female_____

Appendix B

Logit Model Output

```
set noscan
delete/all
sample 1 300
read(a:kksample.xls) id busstop rider rideoc rideof bid wtp eatt1sa
eatt1a eatt1i eatt1d eatt2sa eatt2a eatt2i eatt2d eatt3sa eatt3a eatt3i
eatt3d cars yrsres marstat rntown age edu incml incmh inch gender
skipif(incml.eq.-999)
skipif(incmh.eq.-999)
skipif(inch.eq.-999)
stat/all

****BIVARIATE MODEL****

gen lbid=log(bid)

logit wtp lbid/coef=d


**median**
gen1 med=exp(-d:2/d:1)
print med

**truncated mean with bootstrapping**
sample 1 1
gen1 upper=200
gen1 lower=.00001
integ am1 lower upper tmean=1-(1/(1+exp(d:2+d:1*(log(am1)))))
print tmean

sample 1 300
copy wtp lbid z
dim tmean2 1000
set nodoecho
do #=1,1000
matrix m=samp(z,300)
matrix yes=m(0,1)
matrix bid=m(0,2)
?logit yes bid/coef=c
?integ am1 lower upper tmean2:#=1-(1/(1+exp(c:2+c:1*(log(am1)))))

endo
stat tmean2
sample 1 1000
sort tmean2
stat tmean2
sample 1 25
print tmean2
sample 976 1000
print tmean2

**marginal effects of BID (at the means)**
sample 1 300
logit wtp lbid/coef=d
stat wtp lbid bid/means=m1
gen1
margbid=((exp(d:1*m1:2+d:2)*d:1)/((1+exp(d:1*m1:2+d:2))**2))*(1/m1:3)
print margbid
```

```
genl
marg5=((exp(d:1*log(5)+d:2)*d:1)/((1+exp(d:1*log(5)+d:2))**2))*(1/5)
genl
marg10=((exp(d:1*log(10)+d:2)*d:1)/((1+exp(d:1*log(10)+d:2))**2))*(1/10
)
genl
marg20=((exp(d:1*log(20)+d:2)*d:1)/((1+exp(d:1*log(20)+d:2))**2))*(1/20
)
genl
marg30=((exp(d:1*log(30)+d:2)*d:1)/((1+exp(d:1*log(30)+d:2))**2))*(1/30
)
genl
marg60=((exp(d:1*log(60)+d:2)*d:1)/((1+exp(d:1*log(60)+d:2))**2))*(1/60
)
genl
marg100=((exp(d:1*log(100)+d:2)*d:1)/((1+exp(d:1*log(100)+d:2))**2))*(1
/100)
genl
marg200=((exp(d:1*log(200)+d:2)*d:1)/((1+exp(d:1*log(200)+d:2))**2))*(1
/200)
print marg5 marg10 marg20 marg30 marg60 marg100 marg200

**probabilities**
genl prob5=((exp(d:1*log(5)+d:2))/(1+exp(d:1*log(5)+d:2)))
genl prob10=((exp(d:1*log(10)+d:2))/(1+exp(d:1*log(10)+d:2)))
genl prob20=((exp(d:1*log(20)+d:2))/(1+exp(d:1*log(20)+d:2)))
genl prob30=((exp(d:1*log(30)+d:2))/(1+exp(d:1*log(30)+d:2)))
genl prob60=((exp(d:1*log(60)+d:2))/(1+exp(d:1*log(60)+d:2)))
genl prob100=((exp(d:1*log(100)+d:2))/(1+exp(d:1*log(100)+d:2)))
genl prob200=((exp(d:1*log(200)+d:2))/(1+exp(d:1*log(200)+d:2)))
print prob5 prob10 prob20 prob30 prob60 prob100 prob200



****MULTIVARIATE MODEL****

sample 1 300
gen lyrsres=log(yrsres)
gen lage=log(age)
gen ledu=log(edu)
logit wtp lbid busstop rider rideoc rideof eatt1sa eatt1a eatt1i eatt1d
eatt2sa eatt2a eatt2i eatt2d eatt3sa eatt3a eatt3i eatt3d cars lyrsres
marstat rntown lage ledu incml incmh inch gender/coef=b

**marginal effects for multivariate model**
stat lbid busstop rider rideoc rideof eatt1sa eatt1a eatt1i eatt1d
eatt2sa eatt2a eatt2i eatt2d eatt3sa eatt3a eatt3i eatt3d cars lyrsres
marstat rntown lage ledu incml incmh inch gender bid yrsres age
edu/mean=m2
genl
z2=b:1*m2:1+b:2*m2:2+b:3*m2:3+b:4*m2:4+b:5*m2:5+b:6*m2:6+b:7*m2:7+b:8*m
2:8+b:9*m2:9+b:10*m2:10+b:11*m2:11+b:12*m2:12+b:13*m2:13+b:14*m2:14+b:1
5*m2:15+b:16*m2:16+b:17*m2:17+b:18*m2:18+b:19*m2:19+b:20*m2:20+b:21*m2:
21+b:22&
*m2:22+b:23*m2:23+b:24*m2:24+b:25*m2:25+b:26*m2:26+b:27*m2:27+b:28

*me LBID*
```

```
genl margbidm=((exp(z2)*b:1)/((1+exp(z2))**2))*(1/m2:28)
print margbidm

*me BUSSTOP*
genl zbs1=z2-(b:2*m2:2)+b:2
genl prob11=((exp(zbs1))/((1+exp(zbs1))))
genl zbs0=z2-(b:2*m2:2)
genl prob01=((exp(zbs0))/((1+exp(zbs0))))
genl margbs=prob11-prob01
print margbs

*me RIDER*
genl zrr1=z2-(b:3*m2:3)+b:3
genl prob12=((exp(zrr1))/((1+exp(zrr1))))
genl zrr0=z2-(b:3*m2:3)
genl prob02=((exp(zrr0))/((1+exp(zrr0))))
genl margrr=prob12-prob02
print margrr

*me RIDEOC*
genl zrc1=z2-(b:4*m2:4)+b:4
genl prob13=((exp(zrc1))/((1+exp(zrc1))))
genl zrc0=z2-(b:4*m2:4)
genl prob03=((exp(zrc0))/((1+exp(zrc0))))
genl margrc=prob13-prob03
print margrc

*me RIDEOF*
genl zrf1=z2-(b:5*m2:5)+b:5
genl prob14=((exp(zrf1))/((1+exp(zrf1))))
genl zrf0=z2-(b:5*m2:5)
genl prob04=((exp(zrf0))/((1+exp(zrf0))))
genl margrf=prob14-prob04
print margrf

*me EATT1SA*
genl z1sa1=z2-(b:6*m2:6)+b:6
genl prob15=((exp(z1sa1))/((1+exp(z1sa1))))
genl z1sa0=z2-(b:6*m2:6)
genl prob05=((exp(z1sa0))/((1+exp(z1sa0))))
genl marg1sa=prob15-prob05
print marg1sa

*me EATT1A*
genl z1a1=z2-(b:7*m2:7)+b:7
genl prob16=((exp(z1a1))/((1+exp(z1a1))))
genl z1a0=z2-(b:7*m2:7)
genl prob06=((exp(z1a0))/((1+exp(z1a0))))
genl marg1a=prob16-prob06
print marg1a

*me EATT1I*
genl z1i1=z2-(b:8*m2:8)+b:8
genl prob17=((exp(z1i1))/((1+exp(z1i1))))
genl z1i0=z2-(b:8*m2:8)
genl prob07=((exp(z1i0))/((1+exp(z1i0))))
genl marg1i=prob17-prob07
```

```
print marg1i

*me EATT1D*
genl z1d1=z2-(b:9*m2:9)+b:9
genl prob18=((exp(z1d1))/((1+exp(z1d1))))
genl z1d0=z2-(b:9*m2:9)
genl prob08=((exp(z1d0))/((1+exp(z1d0))))
genl marg1d=prob18-prob08
print marg1d

*me EATT2SA*
genl z2sa1=z2-(b:10*m2:10)+b:10
genl prob19=((exp(z2sa1))/((1+exp(z2sa1))))
genl z2sa0=z2-(b:10*m2:10)
genl prob09=((exp(z2sa0))/((1+exp(z2sa0))))
genl marg2sa=prob19-prob09
print marg2sa

*me EATT2A*
genl z2a1=z2-(b:11*m2:11)+b:11
genl prob110=((exp(z2a1))/((1+exp(z2a1))))
genl z2a0=z2-(b:11*m2:11)
genl prob010=((exp(z2a0))/((1+exp(z2a0))))
genl marg2a=prob110-prob010
print marg2a

*me EATT2I*
genl z2i1=z2-(b:12*m2:12)+b:12
genl prob111=((exp(z2i1))/((1+exp(z2i1))))
genl z2i0=z2-(b:12*m2:12)
genl prob011=((exp(z2i0))/((1+exp(z2i0))))
genl marg2i=prob111-prob011
print marg2i

*me EATT2D*
genl z2d1=z2-(b:13*m2:13)+b:13
genl prob112=((exp(z2d1))/((1+exp(z2d1))))
genl z2d0=z2-(b:13*m2:13)
genl prob012=((exp(z2d0))/((1+exp(z2d0))))
genl marg2d=prob112-prob012
print marg2d

*me EATT3SA*
genl z3sa1=z2-(b:14*m2:14)+b:14
genl prob113=((exp(z3sa1))/((1+exp(z3sa1))))
genl z3sa0=z2-(b:14*m2:14)
genl prob013=((exp(z3sa0))/((1+exp(z3sa0))))
genl marg3sa=prob113-prob013
print marg3sa

*me EATT3A*
genl z3a1=z2-(b:15*m2:15)+b:15
genl prob114=((exp(z3a1))/((1+exp(z3a1))))
genl z3a0=z2-(b:15*m2:15)
genl prob014=((exp(z3a0))/((1+exp(z3a0))))
genl marg3a=prob114-prob014
print marg3a
```

```
*me EATT3I*
genl z3i1=z2-(b:16*m2:16)+b:16
genl prob115=((exp(z3i1))/((1+exp(z3i1))))
genl z3i0=z2-(b:16*m2:16)
genl prob015=((exp(z3i0))/((1+exp(z3i0))))
genl marg3i=prob115-prob015
print marg3i

*me EATT3D*
genl z3d1=z2-(b:17*m2:17)+b:17
genl prob116=((exp(z3d1))/((1+exp(z3d1))))
genl z3d0=z2-(b:17*m2:17)
genl prob016=((exp(z3d0))/((1+exp(z3d0))))
genl marg3d=prob116-prob016
print marg3d

*me CARS*
genl mcars=(((exp(z2)*b:18)/((1+exp(z2))**2)))
print mcars

*me LYRSRES*
genl myrsres=(((exp(z2)*b:29)/((1+exp(z2))**2)))*(1/m2:29)
print myrsres

*me MARSTAT*
genl zms1=z2-(b:20*m2:20)+b:20
genl prob119=((exp(zms1))/((1+exp(zms1))))
genl zms0=z2-(b:20*m2:20)
genl prob019=((exp(zms0))/((1+exp(zms0))))
genl margms=prob119-prob019
print margms

*me RNTOWN*
genl zro1=z2-(b:21*m2:21)+b:21
genl prob120=((exp(zro1))/((1+exp(zro1))))
genl zro0=z2-(b:21*m2:21)
genl prob020=((exp(zro0))/((1+exp(zro0))))
genl margro=prob120-prob020
print margro

*me LAGE*
genl mage=(((exp(z2)*b:22)/((1+exp(z2))**2)))*(1/m2:30)
print mage

*me LEDU*
genl medu=(((exp(z2)*b:23)/((1+exp(z2))**2)))*(1/m2:31)
print medu

*me INCML*
genl ziml1=z2-(b:24*m2:24)+b:24
genl prob123=((exp(ziml1))/((1+exp(ziml1))))
genl ziml0=z2-(b:24*m2:24)
genl prob023=((exp(ziml0))/((1+exp(ziml0))))
genl margiml=prob123-prob023
print margiml
```

```
*me INCMH*
genl zimh1=z2-(b:25*m2:25)+b:25
genl prob124=((exp(zimh1))/((1+exp(zimh1))))
genl zimh0=z2-(b:25*m2:25)
genl prob024=((exp(zimh0))/((1+exp(zimh0))))
genl margimh=prob124-prob024
print margimh

*me INCH*
genl zih1=z2-(b:26*m2:26)+b:26
genl prob125=((exp(zih1))/((1+exp(zih1))))
genl zih0=z2-(b:26*m2:26)
genl prob025=((exp(zih0))/((1+exp(zih0))))
genl margih=prob125-prob025
print margih

*me GENDER*
genl zg1=z2-(b:27*m2:27)+b:27
genl prob126=((exp(zg1))/((1+exp(zg1))))
genl zg0=z2-(b:27*m2:27)
genl prob026=((exp(zg0))/((1+exp(zg0))))
genl margg=prob126-prob026
print margg


****TESTING THE MULTIVARIATE MODEL (see LR tests below)****

sample 1 300
gen lbid=log(bid)

logit wtp lbid
genl rlr=$llf

gen lyrsres=log(yrsres)
gen lage=log(age)
gen ledu=log(edu)

logit wtp lbid busstop rider rideoc rideof eatt1sa eatt1a eatt1i eatt1d
eatt2sa eatt2a eatt2i eatt2d eatt3sa eatt3a eatt3i eatt3d cars lyrsres
marstat rntown lage ledu incml incmh inch gender/coef=f
genl urlr=$llf
genl a=.05
distrib a/type=t df=270 inverse


****REDUCED MODEL****
logit wtp lbid eatt3sa eatt3a eatt3i eatt3d ledu incml incmh inch
gender/coef=b
genl a2=.05
distrib a2/type=t df=287 inverse
genl ur2lr=$llf

**MARGINAL EFFECTS**
stat lbid eatt3sa eatt3a eatt3i eatt3d ledu incml incmh inch gender bid
edu/mean=m2
```

```
genl
z2=b:1*m2:1+b:2*m2:2+b:3*m2:3+b:4*m2:4+b:5*m2:5+b:6*m2:6+b:7*m2:7+b:8*m
2:8+b:9*m2:9+b:10*m2:10+b:11


*me LBID*
genl margbidm=((exp(z2)*b:1)/((1+exp(z2))**2))*(1/m2:11)
print margbidm

*me EATT3SA*
genl zsa1=z2-(b:2*m2:2)+b:2
genl prob11=((exp(zsa1))/((1+exp(zsa1))))
genl zsa0=z2-(b:2*m2:2)
genl prob01=((exp(zsa0))/((1+exp(zsa0))))
genl margsa=prob11-prob01
print margsa

*me EATT3A*
genl za1=z2-(b:3*m2:3)+b:3
genl prob12=((exp(za1))/((1+exp(za1))))
genl za0=z2-(b:3*m2:3)
genl prob02=((exp(za0))/((1+exp(za0))))
genl marga=prob12-prob02
print marga

*me EATT3I*
genl zi1=z2-(b:4*m2:4)+b:4
genl prob13=((exp(zi1))/((1+exp(zi1))))
genl zi0=z2-(b:4*m2:4)
genl prob03=((exp(zi0))/((1+exp(zi0))))
genl margi=prob13-prob03
print margi

*me EATT3D*
genl zd1=z2-(b:5*m2:5)+b:5
genl prob14=((exp(zd1))/((1+exp(zd1))))
genl zd0=z2-(b:5*m2:5)
genl prob04=((exp(zd0))/((1+exp(zd0))))
genl margd=prob14-prob04
print margd

*me LEDU*
genl medu=(((exp(z2)*b:6)/((1+exp(z2))**2)))*(1/m2:12)
print medu

*me INCML*
genl ziml1=z2-(b:7*m2:7)+b:7
genl prob15=((exp(ziml1))/((1+exp(ziml1))))
genl ziml0=z2-(b:7*m2:7)
genl prob05=((exp(ziml0))/((1+exp(ziml0))))
genl margiml=prob15-prob05
print margiml

*me INCMH*
genl zimh1=z2-(b:8*m2:8)+b:8
genl prob16=((exp(zimh1))/((1+exp(zimh1))))
genl zimh0=z2-(b:8*m2:8)
```

```
genl prob06=((exp(zimh0))/((1+exp(zimh0))))
genl margimh=prob16-prob06
print margimh

*me INCH*
genl zih1=z2-(b:9*m2:9)+b:9
genl prob17=((exp(zih1))/((1+exp(zih1))))
genl zih0=z2-(b:9*m2:9)
genl prob07=((exp(zih0))/((1+exp(zih0))))
genl margih=prob17-prob07
print margih

*me GENDER*
genl zg1=z2-(b:10*m2:10)+b:10
genl prob18=((exp(zg1))/((1+exp(zg1))))
genl zg0=z2-(b:10*m2:10)
genl prob08=((exp(zg0))/((1+exp(zg0))))
genl margg=prob18-prob08
print margg

***LR tests***

*full model*
genl lrtest=2*(urlr-rlr)
print lrtest
genl a3=.05
distrib a3/type=chi df=26 inverse

*reduced model*
genl lrtest2=2*(ur2lr-rlr)
print lrtest2
genl a4=.05
distrib a4/type=chi df=9 inverse
```

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