2002

Study of willingness to pay for a curbside recycling program in the city of Missoula

Ivan (Jon) Aliri

The University of Montana

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A Study of Willingness to Pay for a Curbside Recycling Program

In the City of Missoula

By

Ivan (Jon) H. Aliri

B.A., California State University, Sacramento, 1994

Presented in partial fulfillment of the requirements

For the degree of

Masters of Arts

The University of Montana

2002

Approved by

Chairperson

Dean, Graduate School

Date

5-30-02
This thesis presents estimates of willingness-to-pay for a curbside recycling program in the city of Missoula. In order to accomplish this estimation, the contingent valuation method was used. For this study, Missoula residents were interviewed regarding their willingness to pay for a curbside recycling service proposed under a hypothetical scenario. The willingness-to-pay estimates allowed for the calculations of the total estimated value of the hypothetical recycling program.

The average willingness-to-pay was $11.10 per month and I estimate that 51 percent of the population would be willing to pay $10 per month for curbside recycling generating approximately $500,000 per month in revenue. Income and education level of the household and whether it is currently recycling aluminum cans are variables found to be statistically significant in determining the probability of accepting the bid amount.

While this study assessed the willingness-to-pay for a curbside recycling program, it did not directly measure the environmental benefits created by the reduction of solid waste going to landfills or due to reduction of alternate disposal procedures that pollute the air.
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Acknowledgements

I would like to thank my committee members Professor Dalenberg, Professor Power, Professor Roy, and Professor Wicks for their individual contributions to this thesis; Professor Dalenberg for guiding me through this project, for his endless patience in explaining the econometric analysis, and for his contagious optimism; Professor Power for sharing his valuable insight; Professor Roy for providing so much well-considered feedback; and Professor Wicks for his guidance and knowledge of contingent valuation and for his endless patience while correcting my careless use of the English language. I will also like to thank Becky Hofstad and Kelsey Keene for their motivation and companionship while administering the survey, without them this project will still be in the making. Also, I will like to thank Dr. Bookwalter, Dr. Photiades and Dr. Unger for their support of me as a graduate student and teaching assistant. Thanks to Ryan Stovall for his courageous editing of my first drafts. Finally, I will like to thank my family and friends for their love and encouragement.
Chapter 1: Introduction

Solid waste is one of the residuals generated by economic activity. Most of the solid waste consists of what the Environmental Protection Agency (EPA) has defined as municipal solid waste. Municipal solid waste includes everyday items such as product packaging, grass clippings, furniture, clothing, glass, food scraps, newspapers, appliances, paint and batteries. In the last fifty years, the amount of municipal solid waste produced in the United States has increased considerably. Cities and counties across the country are facing various problems associated with waste disposal. While the amounts of municipal waste have increased, landfill capacity has decreased. A survey conducted by the American Public Works Association in 1987 revealed that 92 percent of solid waste nationwide is disposed of in landfills (Forrester, 1988). In 1988, the United States produced 160 million tons of municipal waste. This translates to 3.4 pounds of solid waste produced per person per day, as compared to approximately 2.7 pounds per day in 1960 (Forrester, 1988). In 1999, the EPA estimated that U.S. residents, businesses and institutions produced more than 230 million tons of municipal solid waste, or 40 percent more than in 1988.

In 1976 an estimated 10,000 landfills were in operation. Constant concerns about the environmental impact of open dumping reduced the number of operating landfills to 6,584 in 1984. In 1999, the EPA estimated there were 2,300 landfills operating in the U.S., 23 percent less landfill capacity than in 1984 (EPA, 1999). During the 1980's the impact of the disposal crisis was felt by major cities across the eastern part of the nation.
To get rid of their waste, many cities were forced to transport it great distances to other disposal areas. Collection and disposal costs dramatically increased during this period. In 1984, city officials in Philadelphia were told the Kinsley Landfill in New Jersey no longer could accept the 40 percent of Philadelphia’s trash being disposed of there. The costs of municipal solid waste disposal in the city of Philadelphia quadrupled between 1984 and 1988. In 1986, Boston city officials signed collection and disposal contracts totaling $27 million, an increase of more than 100 percent from the previous year. In 1988 the city of Orlando, Florida announced that it was examining the feasibility of transporting all of its solid waste to a resource recovery facility to be constructed on a Caribbean island. The city of Chicago also tripled the amount of money allocated for collection and disposal of its solid waste in 1988. Western cities such as Dallas, Los Angeles and Phoenix have seen a large increase in their solid waste production only recently and have had the luxury of available landfill space to accommodate all of their disposal needs (Forrester, 1988).

Across the nation these latter cases are exceptions. Most often city officials are searching constantly for new waste management plans that would alleviate some of the problems associated with solid waste disposal. Solutions have been hard to find. The creation of new landfills and incinerators has been hampered by residents and protest groups that do not want them in or near their neighborhoods for fear of pollution and depressed property values.

The severity of the problem has required city and county officials to develop comprehensive waste management plans to reduce waste production and waste going to landfills. Several solid waste management practices such as source reduction, recycling
and composting have been successful in diverting materials from the waste stream. In 1999, recycling and composting diverted 64 million tons of waste from landfills and incinerators (EPA, 1999). This constituted 28 percent of municipal solid waste, an amount that has almost doubled during the past 15 years. According to the Environmental Protection Agency, 42 percent of all paper, 40 percent of all plastic soft drink bottles and 55 percent of all aluminum beer and soft drink cans are now recycled.

Twenty years ago only one curbside recycling program was in operation in the U.S. By 1998, 9,000 curbside recycling programs and 12,000 recycling drop-off centers were collecting recyclables to be sent to any of the 480 materials recovery facilities across the country.

The state of Montana has one of the lowest recycling rates in the country. More than 90 percent of the solid waste generated by its residents and businesses is disposed of in landfills. Although Montana has 33 landfills operating with over ten years of remaining landfill life expectancy, the problem of solid waste disposal is a concern that should be addressed. Past and current experiences have proven the effectiveness of recycling in reducing the amount of solid waste going to landfills. Effective and cost efficient recycling programs have sprouted across the nation, and although there is no apparent waste disposal crisis in the state of Montana, the development and implementation of recycling programs may be beneficial to the community.

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1 EPA web site (www.epa.gov)
1.1. Research Purpose

The purpose of this study is to estimate willingness-to-pay for a curbside recycling program in the city of Missoula, Montana. One must note, although the aspects of the good in question are private, in the United States recycling and garbage collection are often provided publicly thus it may be considered a quasi-non-market good. For this reason, this study uses non-market valuation methodology. The contingent valuation method (CVM) is used in this study to obtain residents’ willingness to pay. CVM relies on hypothetical markets presented in a survey to obtain subjects’ responses. For this study, I have personally interviewed 320 randomly chosen Missoula households. Respondents were presented with a survey that elicited their willingness to pay for a hypothetical curbside recycling program in the city of Missoula. It also included questions in the survey regarding socio-economic characteristics of the household. From the analysis of the results I derived Missoula residents’ demand for a curbside recycling program and the willingness to pay for the program. The willingness-to-pay figures should allow companies in the industry to determine whether a curbside recycling program in the city of Missoula could be profitable.

This paper does not investigate the costs of a curbside recycling program. It is acknowledged in the final chapter that a cost-benefit study of a curbside recycling service would provide more valuable information to potential recycling companies. Moreover, this study does not directly measure the externality benefits derived from curbside recycling, except in so far as respondents included these in their acceptance of the bid level.
1.2. Thesis Outline

This thesis contains six chapters. The second chapter is the institutional review that presents the current condition of garbage production, garbage disposal, and landfill condition for the state of Montana and particularly the city of Missoula. It includes a brief description of the waste management plan developed and implemented by the city of Seattle in the state of Washington to illustrate the importance and effectiveness of recycling programs in diminishing the amount of waste going to landfills. The third chapter summarizes the literature regarding non-market value analysis, factors influencing recycling and economic analysis of curbside recycling programs. The fourth chapter contains the mathematical derivation of the logit model used for analysis of referendum data. In the fifth chapter, I discuss the survey instrument used to obtain data for this study and present the descriptive statistics of the data. The sixth chapter discusses the econometric analysis of the data and calculations for marginal effects. This chapter also includes the final estimates for willingness-to-pay for the hypothetical curbside recycling program. The final chapter presents conclusions and policy implications of this study, and several ideas that would improve the economic analysis of curbside recycling programs.
Chapter 2: Institutional Review

This chapter presents facts and information that will help put this study into perspective. In the first section of this chapter I describe some geographic and demographic characteristics of the state of Montana. I also include information about garbage production and disposal in the state. The second section details the collection, disposal and recycling services available in the city of Missoula. In the last section I describe, in general terms, the waste management plan implemented by the city of Seattle, Washington. This plan will serve as a reference of the effectiveness of recycling to reduce solid waste going to landfills.

2.1. Montana

The state of Montana is bordered by Idaho on the west, Wyoming on the south, North Dakota and South Dakota on the east and British Columbia, Alberta, and Saskatchewan on the north. According to the United States Geological Survey phsiographic regions, the state of Montana is part of the Rocky Mountain region on the west and the Great Plains in the east. Montana is the fourth largest state in terms of land area with 145,338 square miles, but it is ranked only 48th in terms of population. The population of Montana in the year 2000 was estimated to be 902,195, and 57.5 percent of the population lived in urban areas. The most populated cities are listed here in descending order: Billings, Great Falls, Missoula, Butte, Helena, Bozeman, Kalispell and
Anaconda. All urban areas mentioned previously have witnessed an increase in their population levels since 1994.

According to the Environmental Protection Agency, Montana, second only to Wyoming, disposes over 90 percent of the solid waste it produces in landfills. There are 33 landfills in operation in the state and, although the number of landfills has decreased since 1990, Montana is the state with the most years of remaining landfill life expectancy. It is thus not surprising that recycling is low. However, it may still be cost effective to recycle. There are only six curbside recycling programs in Montana or one program for every 150,000 individuals, compared to the 1,472 curbside recycling programs in New York or approximately 13,000 people per program and 879 in Pennsylvania or 13,500 people per program.

2.2. Missoula

Missoula is the third largest city in Montana with 61,534 residents. It is located in the Western part of the state, between Glacier and Yellowstone National Parks. In the last six years the population level in Missoula has increased 6.7 percent. Consequently, the amount of waste produced by its residents has also increased. The city does not have a waste management plan or the infrastructure to provide any type of collection, disposal or recycling services. Garbage collection, transportation and disposal services are contracted to BFI Waste Systems by the city of Missoula, and in addition to the recycling services provided by BFI, only two other small companies provide recycling services. In this section, I present land disposal characteristics and the collection, disposal and recycling services currently available to Missoula residents.
2.2.1. Landfills.

There is only one landfill for garbage in the greater Missoula area. The landfill is property of BFI Waste Systems, a private company that operates nationwide. It accommodates all municipal solid waste generated in Missoula and communities up to 125 miles away. It started operating in 1968 with capacity for 18 million cubic yards of garbage. The life expectancy of the landfill is unclear. According to BFI management, in 2001, only 9 million cubic yards of capacity is left, and 775,000 cubic yards are used yearly. In addition, there are no plans for a new landfill.

2.2.2. Collection and Disposal Services.

BFI Waste Systems provides all solid waste collection, transportation, processing and disposal services to both public and private customers. Each customer is allowed to have up to five cans for collection each pick-up service day. City and County ordinances require that the customer use cans with a capacity of 32 gallons or less and that weigh less than 40 pounds. This service is provided for a monthly fee of $16.20, whether or not customers use one or the maximum five cans they are allowed. The first bill, after the service is contracted, will include the charges for the current month and the next three months billing period. Subsequently the customer will be billed every three months after that. If the customer requires larger cans, BFI provides cans with a 90-gallon capacity for an extra charge of $2.35 per month per container. The collection of materials such as wood, brush, appliances, boxes or construction materials is done at an extra cost, which is added to the monthly bill.

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2 There are also two small pits that collect ferrous metals and hazardous materials outside Missoula.
2.2.3. Recycling Services

There are several ways to deposit recycled material in the city of Missoula. BFI Waste Systems, Pacific Recycle and Missoula Valley Recycling are the three private companies that provide recycling services in Missoula. Following is a description of the services provided by each of the companies.

**BFI Waste Systems**: BFI provides waste collection and disposal services and recycling services. They provide a drop off site at 3207 West Broadway which buys back aluminum cans and cardboard, and also accepts newspaper, magazines, pop plastic, car batteries, non-ferrous metals, office paper, milk jugs, radiators and tin cans. Four additional drop off sites for aluminum cans and newspaper are located in commercial lots around Missoula.

BFI also offers a curbside recycling program known as "the blue bag program". Households that have contracted BFI trash collecting services can purchase "handle-tie" Glad bags, fill them with recyclable material and place them on the curb next to their regular garbage cans where they will be picked up on service day. This program is offered at no cost except the bags themselves. Despite the low cost of the service, there are only 4,500 households participating in this program.

Most of the BFI recycled material goes to recovery facilities on the West coast. The cardboard recycled by BFI goes directly to the Frenchtown mill, which produces commercial cardboard.

**Pacific Recycle**: This Company provides a buy-back service offering the market price for recycled materials. Its drop off site, located at 2600 Latimer Rd., accepts scrap

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3 BFI only requires that newspaper and magazines be put in different bags, everything else can go in the same bags.
metal, copper, aluminum cans, office paper, newspaper, cardboard, and plastic milk jugs.

According to the management, the company collected 12,700 tons of recyclables in 2000. Pacific Recycle sells and distributes the recycled materials it collects across the West Coast. According to the management, some of the aluminum material recycled at this facility goes to Portland, Oregon and then they are shipped to a recovering facility in Korea. Pacific Recycle is a for-profit company that operates according to markets for recyclables. Thus, their recycling volumes depend directly on the market price of the recycled material.

**Missoula Valley Recycling:** The other company that provides curbside pick-up of recyclables is MVR. They provide a series of guidelines for sorting materials. Table 2.1 presents all the materials that are recycled by Missoula Valley.

**Table 2.1. MVR’s list of materials recycled at the curb**

<table>
<thead>
<tr>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum cans, food trays, clean aluminum foil</td>
</tr>
<tr>
<td>Glass food and beverage jars and bottles, all colors.</td>
</tr>
<tr>
<td>Plastic: Bottles only, types 1 and type 2 (opaque only) displaying the appropriate label on the bottom</td>
</tr>
<tr>
<td>Batteries from cars trucks, and other vehicles</td>
</tr>
<tr>
<td>Corrugated cardboard boxes</td>
</tr>
<tr>
<td>Steel and tin cans</td>
</tr>
<tr>
<td>Styrofoam packing “peanuts”</td>
</tr>
<tr>
<td>Clothes</td>
</tr>
</tbody>
</table>

This pick-up service is provided once a month and the standard residential rate is $9 per month. Customers are billed every three months for the pick-up service. A “buddy system” is also available. This system is based on the principle that the more
household collections there are in one area, the lower the costs of collection are to Missoula Valley Recycling, and the savings are passed on to the customers. If there are two to three neighbors in one area, the rate is $7 per month per household. If there are more than three neighbors that want to participate in the program in one area, the rate is $15 for the group for each pick-up (once a month). This system is directed towards apartment complexes and multi-family dwellings.

2.3. Waste Management for the City of Seattle

From 1988 to 1999, the total amount of waste generated (disposed in landfills or recycled) by residents in Seattle, Washington rose 30 percent, from 650,000 tons per year to 843,000 tons annually. In early 1989, Seattle city officials anticipated this increase in waste and they implemented one of the most ambitious waste management plans ever developed. This program was named “On the Road to Recovery” and attained world recognition for its achievements (www.seattle.gov). This early plan combined aggressive waste reduction campaigns with intensive recycling programs. In 1988, Seattle implemented two distinct curbside recycling programs. One program consisted of a weekly three-bin source-separated system in the north end and another one was a monthly co-mingled system in the south part of the city. Recycling collection was not on the same day as garbage collection. At the start of the program the materials collected were newspaper, mixed paper, glass, aluminum and tin cans. Polyethylene terephthalate bottles were added in 1989, high-density polyethelene plastic bottles were added in 1991 and ferrous metals were added in 1993. Participation in the program was voluntary, although it was motivated by the high trash collection rates, and the service was provided
at no cost to the resident. There were several drop-off sites throughout the city to collect recycled materials from those residents who were not participating in the curbside recycling program. The overall recycling rate rose sharply from 18 percent in 1988 to just over 40 percent in 1991. Since then, it has risen slowly to 43 percent in 1998. In addition to recycling programs, the city of Seattle conducted an aggressive waste reduction campaign aimed at single and multi-family dwellings. Television, radio and newspaper ads were heavily used to instill concerns over environmental and health problems associated with garbage. The single most important incentive to reduce household waste was a garbage collecting rate system based on the amount of garbage collected. Table 3.1 shows Seattle’s monthly garbage collection rates for the year 1999.

<table>
<thead>
<tr>
<th></th>
<th>Seattle</th>
<th>Missoula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro Can (12 gal)</td>
<td>$10.05</td>
<td></td>
</tr>
<tr>
<td>Mini Can (19 gal)</td>
<td>$12.35</td>
<td></td>
</tr>
<tr>
<td>One Can (32 gal)</td>
<td>$16.10</td>
<td>Up to Five (32 gal)</td>
</tr>
<tr>
<td>Two Cans (64 gal)</td>
<td>$32.20</td>
<td></td>
</tr>
<tr>
<td>Each Additional Can</td>
<td>$16.10</td>
<td>Each Additional Can</td>
</tr>
<tr>
<td>Extra Garbage (per bag)</td>
<td>$3.00</td>
<td></td>
</tr>
<tr>
<td>Yard Waste</td>
<td>$4.25</td>
<td>Yard Waste</td>
</tr>
<tr>
<td>Extra Yard Waste</td>
<td>$1.50</td>
<td>(per cubic yard)</td>
</tr>
</tbody>
</table>

Since the implementation of this waste management plan in 1988, Seattle has become an example of aggressive waste management policy. In August 1998, the City adopted a new solid waste plan named “On the Path to Sustainability”. This new waste management plan for the 21st century builds itself on the achievements of the previous
plan. It includes improvements to existing programs plus new initiatives. In order to take advantages of efficiencies, to foster competition among collection companies and to have same-day collection of recyclables, garbage and yard waste, Seattle chose to split the city in two and award two contracts for all collection services, including single family and multi-family dwellings. One firm, Waste Management, Inc., provides collection of garbage, recycling and yard waste to the north half of the city. A second firm, U.S. Disposal⁴, provides all collection services to the south half of the city. There are two different recycling programs offered by the former firm. Customers who receive garbage can service (primarily single family through four-plexes, but some larger structures are included) also receive the new co-mingle curbside recycling service. Larger structures which receive garbage dumpster service (primarily apartment buildings with five or more units) are part of the centralized recycling collection program. These buildings receive a dumpster and/or several large containers for their recyclables. However, this system is flexible and the intent is to customize the container choice to the needs of the building. Each household receives all collection services on the same day of the week. This represents a reduction in the number of separate collection contracts from nine down to two. Payments to recycling contractors have been affected by the market value of the recycled material. In 199, the average payment per ton paid by the city to recycling contractors increased to a high of almost $100. In 1999, Seattle paid an average of $86.39 per ton for collection and processing of recycled material.

⁴ U.S. Disposal is a subsidiary of Allied Waste
Chapter 3: Review of the Literature

3.1. Introduction

This chapter describes the literature that was useful for the completion of this project. I have divided the chapter into three sections. In the first section, I present the literature concerning the characteristics of non-market goods and the methods used to measure the value of these goods. In the second section, I present the methodology and results of two studies that are directly relevant to this thesis. In the final section, I describe the literature regarding the variables that influence household recycling behavior and willingness to pay for recycling services.

3.2. Valuing Non-market Goods

Most of the research regarding non-market benefit estimation has been done in the field of environmental economics. The most important approaches to valuation of use and non-use value of goods fall into three categories: (1) market based, (2) hypothetical markets and, (3) revealed preferences (Zerbe & Dively, 1994, Ward & Duffield, 1992). Market based approaches, such as market price or appraisal methodology, lack applicability in most non-market benefit assessments. In the following section, I present the literature regarding the methods based on hypothetical markets, known as contingent valuation (CV) and the literature regarding methods based on revealed preferences (Hedonic Pricing and Travel Cost Method).
3.2.1. Hedonic Pricing

One approach to value non-market goods is the hedonic pricing method. In hedonic pricing, implicit prices are estimated for individual characteristics of property and housing (Ward and Duffield, 1992). The market price of the property is regressed on both, housing and property attributes such as proximity, number of rooms, lot size, and environmental qualities such as crime rate, pollution, noise, etc. The results yield valuations of the component attributes. This method may be useful in estimating the local value of environmental damages with long-term consequences (Ward and Duffield, 1992).

3.2.2. Travel Cost Method

The travel cost method is used primarily to evaluate outdoor recreation sites. The basic assumption underlying this approach is that there is a relationship between the use of the outdoor site and the travel costs associated with visiting the site (Ward and Duffield, 1992). The premise of this method is to use the amount of money people spend to travel to a site as a lower bound on their willingness to pay to enjoy the site. A demand curve can be derived by relating the differences in travel costs with differences in consumption of the resource.

3.2.3. Contingent Valuation Method (CVM)

The contingent valuation method (CVM) uses survey techniques to ask people the values they would place on non-market commodities. The CVM relies on hypothetical markets or possible vehicle payments presented in a survey to elicit subjects’ responses.
Randall et al. (1983) described CVM as follows:

"Contingent valuation devices involve asking individuals, in survey or experimental settings, to reveal their personal valuations of increments (or decrements) in unpriced goods by using contingent markets. These markets defined the good or amenity of interest, the status quo level of provision and the offered increment or decrement therein, the institutional structure under which the good is to be provided, the method of payment, and (implicitly or explicitly) the decision rule which determines whether to implement the offered program. Contingent markets are highly structured to confront respondents with a well-defined situation and to elicit a circumstantial choice contingent upon the occurrence of the posited situation. Contingent markets elicit contingent choices" (p. 637).

To estimate non-market benefits, CVM relies on surveys where people are asked how much they are willing to pay for a commodity or how much they are willing to accept to bear a loss. There are several approaches to elicit willingness to pay. The most widely used are: (1) bidding games, (2) open-ended questions, (3) payment-card formats and, (4) the dichotomous choice format. Following is a brief explanation of each approach.

**Bidding Games**

Until recently, bidding games were the most widely applied CVM approach. In a standard bidding game, the respondent is asked whether he or she is willing to pay a specific amount, known as the starting point. If the response is affirmative, a successive higher amount is presented to the respondent until a maximum willingness to pay is reached. Likewise, if the starting point elicits a negative response, the amount is decreased in predetermined increments until the respondent indicates an acceptable amount. Despite wide acceptance of the bidding game, there are some concerns associated with it. The bidding game technique requires personal or telephone interviews.
in order to conduct the bidding game process. Critics of this approach assert a need for better and less costly interviewing techniques (Ward & Duffield, 1992). Much criticism also focuses on the possible "starting point bias" (Boyle, Bishop and Welsh, 1985). The starting point refers to the initial bid offered in the bidding game. The starting point bias in the bidding game exists when the initial bid affects the final bid stated by the respondent (Ward & Duffield, 1992). Mitchell and Carson (1989) and Boyle et al. (1985) have presented evidence of starting point bias.

Open-ended

Another approach to CVM questions is the open-ended format. After the commodity has been defined and the payment vehicle described, the respondent is free to state any amount he or she is willing to pay for the good. Most CVM research has been reluctant to use open-ended questions because it does not provide the respondent with sufficient information about the product to make a reliable decision about its value (Cummings et al., 1986, Ward and Duffield, 1992). Participants in the study may not be familiar with the product and they may never have considered what its economic value might be. Cummings et al. (1986), have found that open-ended responses are consistently lower than bidding game answers (Ward and Duffield, 1992).

Payment Card Method

Another alternative to CVM questions is the payment card method. This format was proposed by Mitchell and Carson in an attempt to avoid starting point bias yet still provides the respondent with enough information about the product (Ward and Duffield, 1992). After the product is clearly defined, a pre-established (anchored) payment card, with an initial dollar amount to pay for the good, is handed to the respondent. The
anchored payment card shows amounts spent by people, in the same tax bracket as the respondent, for some publicly provided goods such as education or national defense, which serve as a reference for the respondent. After the respondent examines the payment card, he or she is asked the maximum amount they would be willing to pay for the good in question (Ward and Duffield, 1992). More research needs to be done to determine whether a bias is introduced with the anchored payment card.

**Dichotomous Choice**

Currently the most widely used approach to CVM questions is the dichotomous choice format. This technique gives respondents a specific amount called the bid level and respondents are asked if they would be willing to pay that amount. The bid levels are chosen to cover the range of possible payments for the good. Some research has used open-ended pilot surveys to determine the bid levels. Only one bid level is offered to the respondent and the bid levels vary across the sample. Analysis of the dichotomous choice data and the estimation of maximum willingness-to-pay are more difficult than for the other techniques. Although there is disagreement among the various studies as to what method provides the most accurate estimation of willingness-to-pay, the research community generally favors the dichotomous choice format because it most closely resembles the choice faced with private goods. The National Oceanic and Atmospheric Administration (Arrow et al., 1993) panel on contingent valuation recommended the dichotomous choice method.
3.3. Relevant studies

*Household Valuation of Curbside Recycling*, by Aadland and Caplan (1999), and *A Kerbside Recycling Scheme* by Lake, Bateman and Parfitt (1993) are the two studies that have served as references for this project. Both studies used contingent valuation methodology to measure willingness to pay for a curbside recycling program in their respective communities. Each presented unique approaches to the same question. Aadland and Caplan measured the community’s willingness to pay as well as its willingness to participate in a curbside recycling program. Bateman et al. analyze the garbage flow for each household that was interviewed.

3.3.1. Aadland & Caplan

David Aadland and Arthur J. Caplan (1999) used contingent valuation (CV) to estimate a general demand and willingness to participate for a curbside recycling program in the city of Odgen, Utah. A contracted professional research firm administered a telephone survey to 401 residents. The survey was comprised of 85 questions, that were intended to measure the general attributes of each household. These included age, gender, and education of the respondent; income, recycling habits and general attitude of the household toward recycling; and travel, sorting and storage costs. They presented the willingness to pay question in an ordered interval format, whereby the respondents were offered a series of bid intervals and asked to choose one of the intervals. The researchers compared their survey instrument to the National Oceanic and Atmospheric Administration (Arrow et. al., 1993) set of guidelines. They found that their survey met all of the guidelines except in one main respect: their willingness to pay question was
presented in an order interval rather than the dichotomous choice format preferred by the National Oceanic and Atmospheric Administration.

Using a simultaneous equation model that linked willingness to pay and participate in a curbside recycling program, Aadland and Caplan estimated that the mean willingness to pay for curbside recycling was $2.05 per month and that 72 percent of the residents would be willing to participate in such a program. Furthermore, they found that females, young people, college educated, high income households, people currently recycling and those who regard recycling as beneficial to the community were willing to pay the most for a curbside recycling program (Aadland & Caplan, 1999). Aadland and Caplan also concluded that the most important factor in determining household participation in curbside recycling was its estimated willingness to pay.

The importance of this study rests, first, on the method of estimation and, second, on the specific findings regarding the value of curbside recycling. The CVM survey was designed following the NOAA's set of guidelines, which have become general practice in CV studies. Moreover, Aadland and Caplan present the willingness-to-pay question in an ordered interval format rather than a referendum format. They modified Cameron and James' (1987) econometric model to fit the ordered interval data, and they estimated willingness to pay for and willingness to participate in a curbside recycling program. The ordered interval format is not commonly used in CVM surveys and this study offered an alternate econometric analysis. The specific results of this study reflected the community's assessment of curbside recycling programs and sought to provide policy makers with specific community information that should help them in their decision as to
whether they should implement or can implement such a program in the city of Ogden, Utah.

3.3.2. Lake, Bateman and Parfitt

Lake et al. (1995) used contingent valuation to estimate willingness to pay for a curbside recycling program in the village of Hethersett, South Norfolk, U.K. In addition, they included a waste stream assessment and related the household’s level of recyclables and refuse to the socio-economic characteristics of households. The study was conducted under unique conditions. The village of Hethersett was currently offering a temporary curbside recycling scheme, so respondents had a high level of information about the service in question.

Data for the waste stream assessment and willingness to pay estimation was gathered as follows. First, a random sample of 300 households was chosen from the 1,400 households that were currently participating in the South Norfolk Council recycling scheme. For each selected household their regular garbage and recyclable materials were weighed separately each week. Second, a CVM survey was administered face-to-face to the selected households. The survey instrument elicited information on the socio-economic characteristics of the household, their recycling behavior and an evaluation of the recycling program in question. The willingness-to-pay question was presented in a dichotomous choice format, whereby the respondent chooses to accept or reject a payment level (bid level). The payment level was varied across the sample. The eight bid levels chosen for this study were determined by a pilot survey administered to 48 households. The pilot survey presented the WTP question in an open-ended format,
where the respondent was free to choose any sum. The unique setting in which this study was conducted and the nature of the service that was being valued diminished many of the problems facing contingent valuation surveys.

The results from the waste stream assessment showed that there was a positive relationship between the amount of garbage and the amount of recyclables produced by the household. Also, households that were recycling previous to the curbside program produced more recyclables than those who were not. This result suggested that, instead of encouraging households which already recycle to increase their efforts, the city council should concentrate their efforts on persuading non-recycling households to do so. Lake et al. also estimated the overall rate of regular garbage diverted into recyclable material was 22.9 percent by weight.

From the CVM survey the authors estimated the households' truncated mean willingness to pay for a curbside recycling program in the village of Hethersett to be £39.69 ($58 approximately) per month. Although each of the socio-economic and recycling behavior variables showed the theoretically expected relationship with the dependent variable, only the bid level was statistically significant in explaining households' willingness-to-pay responses. This is a conclusion found in many contingent valuation studies that use dichotomous choice surveys (Duffield et al., 1991).

Lastly, Lake et al. provided a cost benefit analysis of the three possible scenarios that the curbside recycling scheme in the village of Hethersett may encounter. Table 3.1. presents the results of this analysis.
Table 3.1. Cost benefit of various recycling scenarios

<table>
<thead>
<tr>
<th></th>
<th>Hethersett Pilot Scheme (£/tonne)¹</th>
<th>Hethersett: Best estimate of costs (£/tonne) for the extended scheme ²</th>
<th>Best case scenario (£)³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net cost of Scheme</td>
<td>248</td>
<td>124</td>
<td>65</td>
</tr>
<tr>
<td>Benefit estimated through CVM</td>
<td>260</td>
<td>260</td>
<td>260</td>
</tr>
<tr>
<td>Net benefit of Recycling program</td>
<td>12</td>
<td>136</td>
<td>195</td>
</tr>
</tbody>
</table>

¹ SNC cost estimates of Hethersett scheme
² SNC cost estimates of extended Hethersett scheme
³ Cost of cheapest UK recycling scheme (Atkinson & New, 1993)

Lake et al. reported the diversion rates (for recycled material diverted from garbage) and costs associated with other recycling programs across England and compared these to the Hethersett figures (Table 2.2). They concluded that the CVM estimation of benefit value of 260 £/tonne of recyclables exceeds the cost of providing the program in all three scenarios. Also, the curbside recycling program in the village of Hethersett achieved a diversion rate above most other recycling programs, although at a significantly higher cost (Lake et al., 1993). The relatively high cost of the Hethersett scheme was associated with the remote geographical location of the village and the transportation cost the South Norfolk Council incurred taking the recyclable materials to recycling facilities located outside the area.
Table 3.2: Diversion rates and costs of UK kerbside recycling schemes

<table>
<thead>
<tr>
<th>Area and type of scheme</th>
<th>Diversion Rate (%)</th>
<th>Net Cost (£/Tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Separate wheeled bins (bi-weekly)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leeds</td>
<td>50.1</td>
<td>68</td>
</tr>
<tr>
<td>Blue Box (weekly)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stocksbridge</td>
<td>6.6</td>
<td>130</td>
</tr>
<tr>
<td>SE Sheffield</td>
<td>15.3</td>
<td>110</td>
</tr>
<tr>
<td>Milton Keynes</td>
<td>18.7</td>
<td>65</td>
</tr>
<tr>
<td>Adur</td>
<td>27.0</td>
<td>130</td>
</tr>
<tr>
<td><strong>No Container (bi-weekly)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chudleigh (Devon)</td>
<td>6.9</td>
<td>59</td>
</tr>
<tr>
<td><strong>Green Bag (bi-weekly)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiff</td>
<td>17.7</td>
<td>63-82</td>
</tr>
<tr>
<td>Hethersett</td>
<td>22.9</td>
<td>248</td>
</tr>
</tbody>
</table>

1 Diversion rates for Leeds and Adur are approximate due to difficulties encountered during monitoring.
2 As reported by scheme operator.
Source: All figures except for Hethersett are from Arkinson and New (1993). Costs from Hethersett scheme are from SNC.

This study raises a theoretical issue. The answers to the willingness-to-pay question were based on the prevention of welfare loss, which may differ from those based on whether to begin a new scheme (Lake et al. 1993). Lake et al. conclude that the willingness-to-pay to maintain an existing scheme may be significantly higher than the willingness-to-pay for new programs in areas that have not previously experienced the benefits of curbside recycling. This may be because households currently participating in the recycle program are aware of the positive externalities produced by the program, while households that have never participated may not be aware of these externalities.

The estimated results in the waste stream flow, the contingent valuation survey and the cost benefit analysis for this study provided a comprehensive picture of the valuation of a curbside recycling program. Although the characteristics of the community of Hethersset may be different than those of other communities, Lake et al. provide a general model to follow for other contingent valuation studies regarding...
3.3 Kinnaman and Fullerton (NBER Working Paper, 1997)

This study estimates the impact of a user fee garbage collecting program (per bag of garbage disposed) and a curbside recycling program on garbage and recycling amounts. The user fee involved charging a price for collection and disposal of waste proportional to the amount of waste generated. In addition, Kinnaman and Fullerton allowed for the possibility of endogenous policies.

First, the authors collected data on socioeconomic characteristics, prices and characteristics of the recycling services from 100 communities that had implemented a curbside recycling program and also charged a price per bag of garbage collected. They combined this original data with a similar data set for over 800 communities with and without curbside recycling and user fee garbage services. Second, they estimated the demand for garbage and recycling collection. Also, they estimated the effect of these prices and curbside recycling programs on garbage and recycling collections. Third and most important they accounted for the possibility of endogeneity in the two local policies. To account for the possible endogeneity, the authors specified a sequence of government decisions about curbside recycling, characteristics of the program, whether to charge a price and what price to charge. These choices were estimated as functions of observable variables such as the tipping fee (a charge that cities pay for the disposal of waste), population density and demographic characteristics. They then used predicted values for these policy variables in the garbage and recycling demand equations. They found that, when considering endogeneity, the effect of the garbage price in the recycling equation...
became insignificant. In other words, their estimate of the positive effect of the garbage price on the recycling quantity under the exogenous approach disappear. Hence user fee for garbage collecting did not increase recycling quantity under the endogenous model.


The following section summarizes the National Oceanic and Atmospheric Association panel’s concerns associated with CVM and their set of guidelines to follow when designing a CVM survey. The NOAA panel has reported that the most important problems with CVM are: (1) results that are inconsistent with rational choice, (2) implausibility of responses, (3) absence of a defined budget constraint, (4) lack of information about the goods in question, (5) questions about the extent of market and, (6) the warm glow effect (Arrow et. al., 1993). I discuss each of these briefly.

Arrow et al. concluded that CVM responses might be inconsistent with rational choice. For example, the NOAA referred to a study by Kahneman (1986) where he found that the willingness-to-pay for the cleanup of all lakes in Ontario was only slightly higher than willingness-to-pay for cleanup lakes in only one region (Arrow et al., 1993). Other studies mentioned by the NOAA where the results appear to be inconsistent with rational choice are Kahneman and Knetch (1992), Desvousges et al. (1992), and Diamond et al. Desvousges et al. found that the average willingness to pay (WTP) to prevent 2,000 birds (not endangered species) from dying in an oil-filled pond was as much as the average WTP to save 20,000 to 200,000 birds from dying.

A further concern with CVM is the implausibility of responses. Although
individual households in the sample may give zero or very low WTP, the average WTP for the sample is usually a few dollars. With over 100,000,000 households in the United States, the total amount estimated is often very large.

Another problem that is of concern to the NOAA panel is the absence of a meaningful budget (Arrow et al., 1993). Most respondents do not take into consideration how much disposable income they have when deciding their WTP, unless reminded by the interviewer. If the budget constraint is not specified, respondents may consider a wishful amount rather than their true WTP.

Additionally, CV surveys often lack the necessary information about the commodity that is being valued. Respondents must understand precisely what it is they are being asked to value in order to make an accurate assessment (Arrow et al., 1993). Even if detailed information about the good is provided, one must question the respondent's ability to accept the information and hypothetical scenarios presented to them and proceed to assess the economic value of the good based on the information provided.

Another problem with contingent valuation is how to establish the extent of the market or population that is relevant to determine the value of the good (Arrow et al., 1993). Research often excludes populations assuming the population has values too low to examine. The exclusion of relevant populations may cause underestimation of the true value of the program.

An additional problem associated with CVM is known as the "warm glow" effect. Critics of the CVM have observed that individuals may use contingent valuation responses as altruistic donations, not only to support the environmental cause but also to
feel the warm glow associated with donating to worthy causes (Arrow et al., 1993). The warm glow effect will result in an over-estimation of the true WTP.

In addition to the criticism presented in the NOAA report, current literature in the field suggests that strategic bias and hypothetical bias may influence the validity of contingent valuation results (Mitchell, 1989). Strategically biased answers are those that are intended to mislead the researcher. Respondents may overestimate their true WTP for the preservation of environmental quality in a specific area if they believe it will influence the decision to preserve the environment in general. On the other hand, respondents may underestimate their true WTP if they believe that others will pay enough to provide the good. Hypothetical bias is the difference between WTP responses in a hypothetical scenario and actual payments when the same individuals are presented with the opportunity to purchase the good in real life. Hypothetical bias is difficult to estimate. However, research has found that inconsistent of individual responses with economic theory may be a sign of hypothetical bias.

3.4.1. Survey Guidelines (Arrow et al. 1993)

The NOAA panel on contingent valuation presented a series of guidelines to design and to administer a CVM survey to best ensure the reliability of the information elicited. The panel favored face-to-face interviews rather than mail or telephone surveys. The panel found that in-person interviews had higher rates of coverage and response than the other methods. Also, in-person interviews offered the advantage of maintaining the respondent’s interest on the interview (Arrow et al., 1993 p.47). The design of the survey should be conservative in order to minimize the possibility of overestimation. That is, the
survey should elicit the more conservative option of willingness to pay instead of willingness to accept. Also, the valuation question should be presented in a dichotomous choice format. In addition to the “yes” or “no” options a “no answer” option should also be included in the survey. To help the researcher interpret the WTP response, it should be followed by an open-ended question asking why they answered yes/no/no-answer. The survey should also give an accurate description of the program or policy that is being valued. Prior testing of the survey will allow the researcher to determine if the information presented about the good is adequate and well presented.

3.5. Review of the General Recycling Literature

The literature concerning household waste production and disposal is very extensive. Most research in this field concentrates on the production side of waste. Richardson and Havlicek (1974 and 1978) analyzed household generation and composition of waste. Saleh and Havlicek (1975) examined households' production of waste associated with food consumption. K.L. Wertz (1975) published a study which measured the economic factors influencing household production of solid waste. Bonus and Hastings (1982) developed a theory of solid wastes accompanied by a perspective on the production side. In the following years, concerns over the disposal of increasing amounts of solid waste led to new research in this field. Research in solid waste combined the production and disposal side of waste and focused its attention on evaluating alternative methods of waste disposal and waste reduction.

Recycling has become the most important method for reducing the amount of waste going into landfills. Early research in recycling was dedicated to determining the
factors influencing household recycling behavior (Oskamp, Harrington, Edwards, Aberwood, Okuda & Swanson, 1991; Vining & Ebreo, 1990; Reid, Luyben, Rawers, & Bailey, 1976; Webster, 1975). Oskamp et al. analyzed the influence of attitudinal factors on recycling participation and found that the most important ones are those focusing directly on recycling rather than on broader environmental concerns. They found that although most demographic variables were not significant in predicting household recycling participation the variable of owning one's home and living in a single-family house were significant predictors of recycling participation (Oskamp et al., 1991). In addition, respondents' acknowledgement, rather than denial, of environmental problems and intrinsic motives to recycle were also good predictors of household recycling participation (Oskamp et al., 1991).

Vining and Ebreo (1990) examined differences in knowledge, motives and demographic characteristics of people who had the opportunity to recycle voluntarily. They found that people who recycled had more knowledge about local recycling programs than those who did not. Both recyclers and non-recyclers were motivated by concerns for the environment, but their results showed that non-recyclers were more concerned with financial incentives to recycle, rewards for recycling and the inconvenience associated with recycling (Vining and Ebreo, 1990). In addition, the study showed that the only demographic differences between recyclers and non-recyclers were age and level of income. People who recycle had higher incomes and higher levels of education.

Reid et al. (1976) estimated factors influencing newspaper recycling and measured the effect of the proximity of newspaper recycling containers on recycling.
behavior in a Southeastern community. They found that informing people of recycling locations, and distributing newspaper recycling containers in places of close physical proximity to common activities increased the amount of newspaper recycled (Reid et al., 1976). Hong, Adams and Love (1992) estimated the effect of households’ and respondent characteristics on the rate of participation in recycling in Portland, Oregon. They also estimated the demand for solid waste collection in the Portland metropolitan area. Their results indicate that education level, perceived value of time, number of people in the household and whether the property was rented or owned were statistically significant factors influencing recycling participation. Income and race were not statistically significant at the 5 percent level of confidence (Hong et al., 1992). In summary, the results of estimation of the demand for solid waste collection reveal that renters, non-white, and large households demand more garbage collection services.

In recent years, the literature regarding recycling has focused on the valuation and economic feasibility of waste recycling options. Several studies have been published regarding the valuation of recycling programs. As detailed earlier, Aadland and Caplan (1999) and Lake, Bateman and Parfitt (1995) estimated willingness to pay for a curbside recycling program in Odgen, Utah and Hethersset, England respectively. Atkinson and New (1993) give a detailed cost benefit analysis and diversion analysis of different recycling programs in the United Kingdom. Furthermore, communities are developing waste management plans that include extensive research in recycling.
Chapter 4: Modeling Methods

This chapter is divided into three sections. In the first section, I give a general overview of the logit model used for the analysis of dichotomous-choice responses. In the second section, I present the econometric model derived by Hanemann (1984) and briefly discuss Cameron (1988), and Duffield and Patterson's (1990, 1991) contributions regarding the analysis of referendum data. These studies provide the proper econometric methodology to obtain a measure of the money value of the non-market commodity using a contingent value dichotomous choice model. In the final section, I derive the specific model used for the economic valuation of the curbside recycling program.

4.1. Introduction

In the dichotomous-choice format, individuals respond "yes" or "no" to a specific cash amount presented in the survey for a specified commodity or service. If it is assumed that each individual has a true willingness to pay (WTP), then the person will respond positively to any bid that is lower than their true WTP (Duffield et al., 1990). The econometric analysis of referendum data is complicated by the fact that we do not know the exact magnitude of the individual’s valuation; we only know whether it is greater or less than some specified amount. For this reason, logit analysis is used to analyze referendum data. Logit analysis transforms the dichotomous-choice response into a logistic probability distribution. Thus, the interpretation of the results are based on
the probability that a given bid level is accepted or rejected. Hanemann (1984), Cameron (1988) and Duffield and Patterson (1990, 1991) have developed the formulation of appropriate econometric methodologies for analyzing dichotomous data.

4.2. Major Literature

Hanemann’s study addresses the issues of how the logit model should be formulated to be consistent with the theory of utility maximization and how welfare measures should be derived from the model. Cameron (1988) and Duffield and Patterson (1990, 1991) make important contributions in the analysis of referendum data.


Hanemann (1984) presented a method for deriving Hicksian compensating and equivalent welfare measures from referendum data recognizing the theoretical framework of utility maximization. To illustrate Hanemann’s method using this study, one may represent the dependent variable as \( y \), where \( y = 1 \) if the household says “yes” to the bid level and is willing to participate, and \( y = 0 \) if the household is not willing to pay for the bid. Income is denoted by \( I \), and the vector \( s \) includes other observable attributes of the household which may affect its preferences. For example, if a household is willing to pay for the curbside recycling program, the household utility is \( u_1 = u (1, I, s) \), if it is not willing to pay, then the household’s utility function is represented as \( u_0 = u (0, I, s) \).

Although it is assumed the household knows its utility function with certainty, the author suggests that it contains components which are unobservable to the econometric investigator and should thus be treated as stochastic components. These unobservable
characteristics generate the stochastic structure of the statistical binary response model (Hanemann, 1984).

Thus, for purposes of econometric analysis $u_1$ and $u_0$ are random variables with a given parametric probability distribution and with means, $v(0, I; s)$ and $v(1, I, s)$. Thus:

$$u(j, I; s) = v(j, I; s) + \varepsilon_j,$$

where $\varepsilon_0$ and $\varepsilon_1$ are random variables with zero means.

When the individual is asked his or her willingness-to-pay the individual will accept the bid presented, BID, if

$$v(1, I - BID; s) + \varepsilon_1 \geq v(0, I, s) + \varepsilon_0$$

and refuse it otherwise. As mentioned before, it is assumed the individual knows which choice maximizes his utility; but for the econometrician, the individual's response is a random variable whose probability distribution is given by

$$P_1 = \Pr \{ \text{individual is willing to pay} \}$$

$$= \Pr \{ v(1, I - BID; s) + \varepsilon_1 \geq v(0, I, s) + \varepsilon_0 \}$$

$$P_0 = \Pr \{ \text{individual unwilling to pay} \}$$

$$= 1 - P_1$$

If we define the stochastic components of the model ($\varepsilon_j, j = 0,1$) as $\eta = \varepsilon_0 - \varepsilon_1$

$$P_1 = \Pr \{ v(1, I - BID; s) - v(0, I, s) \geq \varepsilon_0 - \varepsilon_1 \}$$

then the willingness-to-pay probability may be written as
\[ P_1 = F_\eta(\Delta v) \]

According to Hanemann (1984), if we interpret the outcome of the binary model as the outcome of a utility maximizing choice, then the cumulative distribution function must take the form of a utility difference

\[ \Delta v = v(1, I-BID, s) - v(0, I, s) \]

Hanemann notes that this condition is the analogue of the integrability condition\(^5\) in conventional demand theory. It provides a framework to test whether a statistical model is consistent with the economic theory of utility maximization. Since \( F_\eta(\Delta v) \) is the cumulative distribution function of a standard logistic variate, the probability of an individual responding positively to the dichotomous choice question, equation (1) may be written as

\[ P_1 = F_\eta(\Delta v) = (1 + e^{-\Delta v})^{-1} \]

The issue now is to derive the proper functional form of the statistical model that is consistent with utility theory. The analogue of the integrability condition (equation 1a) also offers a mathematical framework. To illustrate, we must first define \( v(j, I, s) \), \( j = 0, 1 \), in some functional form and then compute the difference.

---

\(^5\) Samuelson (1947) calls the symmetry condition of consumer demand theory the reciprocal integrability condition.
where \( \lambda_j \) and \( \beta \) are functions of the vector \( s \). If we assume there is no variability in \( s \) i.e., we assume a homogeneous sample except for income differences the change is

\[
\Delta v = (\alpha_1 + \beta(BID)) - (\alpha_0 + \beta I)
\]

\[
= (\alpha_1 - \alpha_0) + \beta BID
\]

Thus, the statistical bivariate model in the linear form becomes

\[
P_1 = F_\eta(\alpha + \beta BID) \quad \text{where } \alpha = (\alpha_1 - \alpha_0)^6
\]

or

\[
P_1 = (1 + e^{-(\alpha + \beta BID)})^{-1}
\]

Hanemann's derivation is consistent with the economic theory of utility maximization. However, he observes that the linear functional form of the cumulative distribution function does not fit referendum data very well. This is because the logistic distribution is symmetric and allows for negative values, while willingness-to-pay responses are often positive and skewed to the right. (Duffield et al., 1990, Bishop and Heberlein, 1979). This problem can be corrected by selecting the logarithmic functional form of the statistical model. The statistical model becomes:

\[
P_1 = (1 + e^{-(\alpha + \beta \ln BID)})^{-1}
\]

\(^6\) Hanemann notes that \( \alpha_1 \) and \( \alpha_0 \) cannot be observed from the data; we can only observe the difference.
However, Hannemann has shown that the logarithmic functional form of the model is inconsistent with utility maximization theory. In fact, he notes that no utility model \( v(j, I; s), j = 0, 1 \) can generate a logarithmic functional form for \( \Delta v \).

Although in models (3) and (4) the only covariate Hannemann allows to influence the probability outcome is the actual BID level presented to the individual, one could estimate the impact of other explanatory variables. They can be introduced in the logit model by rewriting equation (3) and (4) as

\[
P_1 = (1 + e^{-(\beta X)})^{-1}
\]

and

\[
P_1 = (1 + e^{-(\ln X)\beta})^{-1}
\]

where \( \beta \) is a vector of the parameters and \( X \) is a vector of explanatory variables, in the logarithmic functional form, including BID amount and socioeconomic characteristics of the household. This model implies that the distribution of the WTP values, given the value of the explanatory variables, is logistic with a constant variance and a mean, which depends linearly on the covariates. Again, using the logarithmic functional form of the independent variables gives WTP distributions that are more consistent with what has been observed in real life.

Maximum likelihood is the preferred method for estimating logit models. Maximum likelihood estimation allows for the estimation of the parameters for almost all analytical specification of the probability function (Cramer 1991). Once we obtain the estimated distribution of WTP values, we can calculate a measure of willingness to pay.
for an “average” or “typical” individual. Hanemann proposes the mean and the median of the WTP distribution as the proper welfare measures.

The mean is the measure of choice if one wishes to be consistent with the theoretical framework of utility. It is the only measure that allows us to aggregate the values. To calculate the mean, we compute $C = E(C)$, where $C$ makes the utility function $u(0, I + C; s)$ exactly equal to $u(1, I; s)$. If we use a cumulative distribution function that is standard logistic, $C$ can be written as:

$$\text{Mean} = C = \frac{\alpha}{\beta}$$

$$\text{Mean in log model} = C = \int_{-\infty}^{\infty} (1 - F(x))dx$$

As an alternative measure of value, Hanemann suggests the median of the distribution of $C$, calling it $C^*$. The median is probably the best measure of an “average” individual’s WTP, but it cannot be aggregated over the population to give an estimated total willingness to pay for the non-market commodity. The corresponding formulas for models (5) and (6) are:

$$\text{Median} = C^* = \frac{\alpha}{\beta}$$

$$\text{Median in log model} = C^* = \exp \left[ \frac{\alpha}{\beta} \right]$$

Hanemann concludes his study by noting that choosing among the mean or the median as welfare estimates entails a value judgment. Moreover, it is crucial to
formulate the statistical model in the proper functional form that is consistent with the underlying utility function.

4.2.2. Cameron (1988) and Duffield and Patterson (1990, 1991)

Cameron (1988) and Duffield and Patterson (1990, 1991) also provide important contributions to the literature regarding the analysis of dichotomous data. Cameron proposes an improved method for the estimation of welfare values for non-market commodities, while Duffield and Patterson’s 1990 publication is a commentary regarding Cameron’s findings. A second publication by Duffield and Patterson (1991) presents the methodology for a third welfare measure. The truncated mean, according to Duffield and Patterson, has desirable properties including the ability to be aggregated and its consistency with theoretical constraints.

Cameron suggests taking a mathematical approach when deriving the statistical model for dichotomous data. The model should be simply viewed as a statistical model that allows us to derive an approximation to an unidentified and complex utility maximizing model. Her model assumes that each individual has a true willingness-to-pay and the individual will respond positively to a bid only if his WTP or “his threshold” is greater than the bid. The WTP values have a logistic distribution and mean conditional to the value of the independent variables in her model. Cameron provides the threshold motivation in dichotomous-choice contingent valuation surveys as an alternative to the utility theory approach.
Cameron proposes that referendum data is different from usual discrete choice data. Thus we can extract additional information, and the estimated demand relationships and the effects of the independent variables on willingness to pay are simpler to derive. The conventional logit model can be fit using a traditional logistic regression program to obtain the maximum likelihood estimate of the parameters of the model and its estimated covariance matrix.

While Cameron's approach provides a useful method for the analysis of referendum data, the interpretations she suggests were recognized previously by Hanemann and other researchers. Thus, her analysis of the logit model does not replace the conventional analysis.

In a 1991 publication, "Inference and Optimal Design for a Welfare Measure in Dichotomous-Choice Contingent Valuation", Duffield and Patterson offer the truncated mean as an alternative measure of welfare surplus for referendum data. The distribution of the WTP responses in dichotomous-choice data is skewed to the right. Thus, the estimate of the mean can be far out in the tail of the distribution. Since the tail of the distribution is unobservable beyond the maximum bid, it is extrapolated and the mean can be very large in some cases. The truncated mean reduces the influence of the tail of the distribution on the estimate of the mean. It is computed by first establishing a truncation point T, then integrating up to the truncation point. Thus the influence of the values in the tail is reduced. Duffield and Patterson's formula for the truncated mean is:

\[
\text{Truncated Mean} = \int_0^T (1 - F(x))dx
\]

Where:
\[ F(x) = \frac{1}{1 + \exp(-\alpha + \beta BID)} \]

\[ T = \text{truncation point} \]

In addition, the truncated mean can be aggregated over the population simply by multiplying the estimate by the population size. The result is an estimate of the average WTP after the truncation procedure has been performed.

Exact formulas for the standard errors of the truncated mean are not available from the logit model. Duffield and Patterson suggest the use of the bootstrapping technique to derive the standard errors for the truncated means. Once the standard errors are obtained from the bootstrapping technique, it is possible to calculate confidence intervals for the truncated means. The formula to calculate the confidence intervals is

\[ \text{TRUE MEAN} = \bar{X} \pm \text{SE}_M \cdot t_{0.05/2, n-k} \]

where \( t \) is the \( t \)-statistic at the 95% confidence level.

4.3. Model Specification

This section of the chapter derives the logit models used for the estimation of the willingness-to-pay for a curbside recycling program in Missoula, and the monthly total market value of the program. The first model has the bid amount (BID) as the only independent variable. Research has indicated that the bid amount is the most important factor that determines the WTP response (Hanemann 1984; Duffield and Patterson,
The second model included other variables thought to influence recycling behavior.

For the first model, the probability that an individual will respond positively to a given bid amount \(x\) is

\[
P = Pr(WTP > \text{BID}) = 1 - F(\text{BID})
\]

where \(F(\text{BID})\) is the cumulative distribution function of WTP values in the population of the study. The standard analysis of referendum data assumes that the distribution of the WTP values is logistic and similar in shape to the normal distribution. This leads to the logit model

\[
L = \log\left(\frac{P}{1-P}\right) = a + b\text{BID}
\]

where \(L\) is the logit or log of the odds of paying the bid amount \(\text{BID}\), and \(a\) and \(b\) are the parameters of the model (\(a\) is the constant). Equation (2) can be rewritten in terms of the probability of paying the bid amount (\(\text{BID}\)):

\[
P = \left(1 + e^{-a - b\text{BID}}\right)^{-1}
\]

As the literature shows, the model in (9), although consistent with utility theory, does not fit referendum data very well. It has been found that the logarithmic functional

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form fits the dichotomous data much better. If the bid value is replaced by \( \ln (BID) \), then the model becomes

\[
(10) \quad P = \left(1 + e^{a - b \ln (BID)}\right)^{-1}
\]

This model implies that the distribution of WTP values is log-logistic. In this simple model, the amount of the bid (BID) presented to the individual is the only variable included. The bid level should play an important role in determining whether the individual will respond positively or negatively to the WTP question. As the amount of the bid increases, the probability that an individual will respond “yes” decreases.

The logit model can be fit by maximum likelihood estimation to yield maximum likelihood estimates of \( a \) and \( b \). There are several statistical programs that perform maximum likelihood operations; Shazam v 8.0 is used here.

The second model I formulate includes all variables thought to influence WTP for a curbside-recycling program. Thus, model (4) becomes

\[
(11) \quad P = (1 + e^{-(\ln X)\beta})
\]

where \( \beta \) is a vector of parameters (including the constant term) and \( \ln X \) is a vector containing bid and the socioeconomic characteristics of the household. The multivariate model becomes
(12) \[ \log \left( \frac{P_i}{1-P_i} \right) = \]

\[ b_0 + b_1 \log (\text{BID}_i) + b_2 \log (\text{INCMED}_i) + b_3 \log (\text{INCMEHI}_i) + b_4 \log (\text{INCHIGH}_i) + b_5 \log (\text{YRSRES}_i) + b_6 \log (\text{PEOPLE}_i) + b_7 \log (\text{CHILD}_i) + b_8 \log (\text{MARRIED}_i) + b_9 \log (\text{ROOMATE}_i) + b_{10} \log (\text{RENTOWN}_i) + b_{11} \log (\text{EDU}_i) + b_{12} \log (\text{GENDER}_i) + b_{13} \log (\text{PLASTIC}_i) + b_{14} \log (\text{ALCANS}_i) + b_{15} \log (\text{GLASS}_i) + b_{16} \log (\text{NEWSP}_i) + b_{17} \log (\text{PAYREC}_i) + b_{18} \log (\text{BLUE}_i) + b_{19} \log (\text{DROPOFF}_i) + b_{20} \log (\text{ENVATT1}_i) + b_{21} \log (\text{RECATT}_i) + b_{22} \log (\text{ENVATT2}_i) \]

where:

\( P \) = Probability of a yes response.

\( \text{BID} \) = Hypothetical random dollar amount the respondent is asked to pay \{\$1, \$3, \$5, \$8, \$12, \$15, \$20\}.

\( \text{INCMED} \) = Dummy variable equal to 1, if income level between $20,000 and $50,000; and equal to 0, otherwise. The omitted base case is income less than $20,000.

\( \text{INCMEHI} \) = Dummy variable equal to 1, if income level between $50,000 and $100,000; and equal to 0, otherwise. The omitted base case is income less than $20,000.

\( \text{INCHIGH} \) = Dummy variable equal to 1, if income level over $100,000; and equal to 0, otherwise. The omitted base case is income less than $20,000.

\( \text{YRSRES} \) = Number of years living in Missoula.
PEOPLE = Number of people living in the household.
CHILD = Dummy variable equal to 1, if there are children in the household; and
Equal to 0, otherwise.
MARRIED = Dummy variable equal to 1, if the household is a married
household, and equal to 0, otherwise.
ROOMATE = Dummy variable equal to 1, if the household is a roommate
household, and equal to 0, otherwise.
RENTOWN = Dummy variable equal to 1 if the residence is owned; and equal to
0, otherwise.
EDU = Years of formal education.
GENDER = Dummy variable equal to 1 if the respondent is male; and equal to 0,
otherwise.
PLASTIC = Dummy variable equal to 1 if the household recycles plastic; and
equal to 0, otherwise.
ALUM = Dummy variable equal to 1 if the household recycles aluminum cans;
and equal to 0, otherwise.
GLASS = Dummy variable equal to 1 if the household recycles glass; and equal
to 0, otherwise.
NEWSP = Dummy variable equal to 1 if the household recycles newspaper; and
equal to 0, otherwise.
PAYREC = Dummy variable equal to 1 if the household pays for a recycling
service; and equal to 0, otherwise.
BLUE = Dummy variable equal to 1 if the household participates in the blue bag service provided by BFI waste systems, and equal to 0, otherwise.

DROP OFF = dummy variable equal to 1 if the household uses a drop-off location; and equal to 0, otherwise.

ENVATT1 = First environmental attitude scale presented to the respondent.

RECATT = Attitude scale regarding recycling.

ENVATT2 = Second environmental attitude scale presented to the respondent.

i = 1 to 320 observations.

The base case is a low-income single household with no children who rents and does not recycle.
4.4. Calculation of Benefits

Once the estimated distribution of WTP values is obtained from model (12), the total monthly value of the recycling program is calculated. The median and the truncated mean will be used for this purpose. The median may be calculated from the bivariate model using this equation:

\[
\text{Median} = \exp\left(-\frac{b_0}{b_1}\right)
\]

(13)

The equation for calculating the truncated mean is:

\[
\text{Truncated mean} = \int_{0}^{T} (1 - F(x)) \, dx
\]

(14)

where

\[
F(x) = \frac{1}{1 + \exp\left(-b_0 - b_1x\right)}
\]

and

\[
T = \text{truncation point}
\]
Chapter 5: The Data

This chapter discusses the design of the survey instrument used in this study, how it was administered, and the descriptive statistics of the data collected through the surveys. The questionnaire was designed following the suggestions of the NOAA panel on contingent valuation (Arrow et al., 1993). The final survey was administered between December 2, 2001 and February 28, 2002 in Missoula, Montana. During this time I gathered a total of 320 observations. All but 26 surveys were completed, yielding a response rate of 92 percent. Appendix A contains the final version of the questionnaire.

5.1. Survey Instrument

A pilot survey was conducted to establish the range of random bids and to improve interviewing skills. The willingness-to-pay question in the pilot survey was presented in an open-ended format where the respondent was free to state any amount he was willing to pay for the recycling program. Based upon this pilot survey, eight bid levels were set between $1 and $20.

The final survey consisted of an introduction, twelve questions and three attitude scales. First there were four questions regarding the socioeconomic characteristics of the household (length of residency in Missoula, how many people in the household, the number of children under the age of sixteen and whether the household head was married, single or roommate). The next question asked if the household recycled plastic, aluminum cans, glass and newspaper; if they paid for a recycling service; if they
participated in the BFI waste systems blue-bag program; or if they used a drop-off site to
discard their recyclables. The purpose of this section of the questionnaire was to induce
respondents to examine their recycling behavior and prepare them for the dichotomous-
choice question.

Before proceeding to the willingness-to-pay question, the respondent was
presented with a brief statement describing the curbside recycling program that they were
asked to value. It read as follows:

"Imagine that you could have a service that collects newspaper,
plastic, glass and aluminum cans twice a month. Your household
would have to take the time to sort your recyclables into groups
of similar materials. You would also have to place the containers
with the recyclables on the curb. This service will be provided for
a monthly fee, separate from your garbage bill."

According to Arrow et al. (1993), respondents to contingent valuation
questionnaires seldom take into consideration their budget constraint, thus, they tend to
give an overestimate of their true willingness-to-pay. For this reason, a brief statement
reminding respondents of their budget limitations was presented following the description
of the curbside recycling program. It read as follows:

"Now, remembering that any money which you spend on the
recycling service cannot be spent anywhere else, please
consider the next question carefully."
Respondents were asked to value the hypothetical curbside recycling program. The question was asked in a dichotomous-choice format. The random bids presented were $1, $3, $5, $8, $10, $12, $15, and $20. The question stated,

"Would you be willing to pay bid $ amount for a curbside recycling program in your community?"

The next section of the survey consisted of three attitude scales and two more questions regarding the education level of the respondent and the yearly household income before taxes. The purpose of the two attitude scales,

"Environmental laws in the United States need to be stronger”,

and

"Economic development in a community is more important than the protection of its environment”,

was to measure the environmental stand of the individual. The purpose of the third attitude scale, "sorting recyclables makes recycling undesirable”, was to measure the opportunity cost of recycling.

All three scales ranged from 10 if the respondent strongly agreed with the statement, to −10 for strong disagreement. The survey also contained a section with information on location of the interview, gender of the respondent, date, time, and an identification number.
5.2. Site and Data Collection

The interviewing process was conducted door-to-door in the city of Missoula between December 1, 2001 and February 28, 2002. Most interviewing days were Friday, Saturday and Sunday between the hours of 1 p.m. and 6 p.m. in order to increase the probability of a household response. The city was divided into 11 areas; each one was assigned a number of surveys according to 1990 census population density. Appendix B contains a brief description of the areas. To begin, the interviewer would start on the right side of the street closest to the Clark Fork River and nearest to the University. If the household was willing to participate in the survey, at the conclusion of the interviewing process the interviewer would then choose the house in front on the opposite side of the street. If the interviewer reached an absent residence or a household not willing to participate in the survey, he would try the following residence on the same side of the street until he arrived at a household willing to participate in the survey. The interviewing process ended for a given area once all surveys assign to that area were obtained. I note that this interviewing pattern did not give each household the same probability of participating in the survey. Thus, it was not optimal and it may have jeopardized randomness in the sample.

5.3. Descriptive Data

The following section discusses the descriptive statistics of the socio-economic characteristics, recycling behavior and environmental stand of the sample. The sample population consisted of 320 households. Although every respondent answered the dichotomous choice question, 23 individuals opted for not revealing the total household
income for last year, three of them did not respond to the first attitude scale, and one individual did not respond to the third attitude scale. Table 5.1 presents the descriptive statistics for the sample. For dummy variables their mean indicates the percentage of respondents that answer yes to the question.

After estimation of the results, the models were re-estimated with non-responses to find if they deviated from the average individual. It was found that non-respondents did not influence the results of the statistical analysis.
Table 5.1. Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Number</th>
<th>Mean</th>
<th>Stand. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of Residency</td>
<td>320</td>
<td>17.040</td>
<td>15.563</td>
<td>.25</td>
<td>68</td>
</tr>
<tr>
<td>Number of People</td>
<td>320</td>
<td>2.7906</td>
<td>1.2950</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Children</td>
<td>320</td>
<td>.29688</td>
<td>.45760</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Married Household</td>
<td>320</td>
<td>.58125</td>
<td>.49413</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Single Household</td>
<td>320</td>
<td>.18750</td>
<td>.39092</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Roommate Household</td>
<td>320</td>
<td>.23125</td>
<td>.42229</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>House Owned</td>
<td>320</td>
<td>.74375</td>
<td>.44436</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Years of Education</td>
<td>319</td>
<td>12.470</td>
<td>56.775</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Respondent Male</td>
<td>320</td>
<td>.50625</td>
<td>.50074</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Recycles Plastic</td>
<td>320</td>
<td>.66563</td>
<td>.47251</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Recycles Aluminum Cans</td>
<td>320</td>
<td>.85938</td>
<td>.34818</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Recycles Glass</td>
<td>320</td>
<td>.46563</td>
<td>.49960</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Recycles Newspaper</td>
<td>320</td>
<td>.65938</td>
<td>.47466</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pays for a Recycling Service</td>
<td>320</td>
<td>.04062</td>
<td>.19773</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Participates in the BFI Blue Bag Service</td>
<td>320</td>
<td>.25312</td>
<td>.43548</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Uses a Drop-Off Site</td>
<td>320</td>
<td>.59375</td>
<td>.49190</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Attitude Scale (1)</td>
<td>317</td>
<td>6.1325</td>
<td>4.1850</td>
<td>-10</td>
<td>10</td>
</tr>
<tr>
<td>Recycling Attitude Scale</td>
<td>320</td>
<td>-4.5844</td>
<td>5.5414</td>
<td>-10</td>
<td>10</td>
</tr>
<tr>
<td>Environmental Attitude Scale (2)</td>
<td>319</td>
<td>-4.2696</td>
<td>5.3924</td>
<td>-10</td>
<td>10</td>
</tr>
<tr>
<td>Income Less than $20,000</td>
<td>297</td>
<td>.21549</td>
<td>.41185</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Income between $20,000 - $50,000</td>
<td>297</td>
<td>.43908</td>
<td>.49605</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Income between $50,000 - $100,000</td>
<td>297</td>
<td>.33670</td>
<td>.47338</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Income more than $100,000</td>
<td>297</td>
<td>.016835</td>
<td>.12887</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

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

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Table 5.2. shows the income (INC) distribution in the sample. The income bracket for households with less than $20,000 is represented by the number “1”. The bracket for households with incomes between $20,000 and $50,000 is represented by the number “2”. For households with incomes between $50,000 and $100,000 the bracket is represented by the number “3”. Households with incomes above $100,000 are represented by the number “4”. Lastly, -999 represents households that declined to answer the income question.

![Table 5.2. Income Distribution](image)

Table 5.3. presents the distribution of the number of years of residency (YRSRES) of respondents. Almost 30 per cent of respondents have lived over 25 years in Missoula. Vinning and Ebreo (1988) found that individuals that owned their home and individuals that have resided in a community for a long period of time feel a deeper concern for the
welfare of their community. Thus, one would expect for these households to engage in activities which they perceive to improve the community’s welfare, such as recycling.

Table 5.3. Distribution of Number of Years Residing in Missoula

<table>
<thead>
<tr>
<th>YRSRES</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>4.0</td>
<td>10.0</td>
</tr>
<tr>
<td>5.0</td>
<td>15.0</td>
</tr>
<tr>
<td>6.0</td>
<td>20.0</td>
</tr>
<tr>
<td>7.0</td>
<td>25.0</td>
</tr>
<tr>
<td>8.0</td>
<td>30.0</td>
</tr>
<tr>
<td>9.0</td>
<td>35.0</td>
</tr>
<tr>
<td>10.0</td>
<td>40.0</td>
</tr>
<tr>
<td>11.0</td>
<td>45.0</td>
</tr>
<tr>
<td>12.0</td>
<td>50.0</td>
</tr>
<tr>
<td>13.0</td>
<td>55.0</td>
</tr>
<tr>
<td>14.0</td>
<td>60.0</td>
</tr>
<tr>
<td>15.0</td>
<td>65.0</td>
</tr>
<tr>
<td>16.0</td>
<td>70.0</td>
</tr>
<tr>
<td>17.0</td>
<td>75.0</td>
</tr>
<tr>
<td>18.0</td>
<td>80.0</td>
</tr>
<tr>
<td>19.0</td>
<td>85.0</td>
</tr>
<tr>
<td>20.0</td>
<td>90.0</td>
</tr>
<tr>
<td>21.0</td>
<td>95.0</td>
</tr>
<tr>
<td>22.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Most households engaged in some recycling activity. More than 85 per cent of households recycle aluminum cans and an average of 66 per cent recycle plastic materials and newspapers. The private recycling companies’ inability to accept and recycle glass accounts for the low percentage of household that recycles glass material. Almost 60 per cent of households use a drop-off site to discard their recyclables, while only 4 percent of them paid for a curbside recycling program. In addition, 25 percent of respondents participate in the free curbside bluebag program offered by BFI Waste Systems Inc. This figure is inconsistent with BFI estimate of 4,500 participants or 4.5 percent of the population.
The three attitude scales ranged from –10 strongly disagreed, to +10 strongly agreed. For the first attitude scale (Environmental laws in the United States need to be stronger), the average individual agreed with the statement. For the second attitude scale (Sorting recyclables makes recycling undesirable), the average individual disagreed with the statement, which may indicate that the opportunity cost of recycling is not very high. For the third attitude scale (Economic development in a community is more important than the protection of its environment), the average individual disagreed with the statement.

The average number of years of education was 12.5, the equivalent of a high school degree. One may expect households with high levels of education and higher incomes to engage in recycling activities more often than those with lower levels. Table 5.4 compares education level (EDU) and recycling behavior of the individual (ALCANS, 1 if they recycle aluminum cans, 0 otherwise).
Table 5.4. Comparison of education level and recycling behavior

Table 5.5. shows the distribution of the number of years of education (EDU) for individuals in the sample. Although the average level of education is 12.5 years (high school degree), over 50 per cent of respondents have the equivalent to a bachelor degree or post-graduate degree. Only five individuals had education levels below high school diploma or equivalent.
5.5. Comparison of Descriptive Census Data and Study Data

This section compares the descriptive statistics of the socio-economic characteristics of the sample with the 1997 Census Bureau statistics for the city of Missoula and the state of Montana. Table 5.6 presents some demographic characteristics of the population in the city of Missoula and the state of Montana and the sample used in this study.
Table 5.6. Demographic characteristics for the city of Missoula, the state of Montana and the sample population

<table>
<thead>
<tr>
<th>Census Characteristics</th>
<th>Missoula County</th>
<th>Montana</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 2000</td>
<td>95,802</td>
<td>902,195</td>
<td>320</td>
</tr>
<tr>
<td>Female Persons Percent, 2000</td>
<td>50.0%</td>
<td>50.2%</td>
<td>50%</td>
</tr>
<tr>
<td>College Graduates 25 and Over, 1990</td>
<td>14%</td>
<td>11.2%</td>
<td>53%1</td>
</tr>
<tr>
<td>Homeownership Rate</td>
<td>61.9%</td>
<td>69.1%</td>
<td>74%</td>
</tr>
<tr>
<td>Persons per Household, 2000</td>
<td>2.40</td>
<td>2.45</td>
<td>2.79</td>
</tr>
<tr>
<td>Households with Persons under 18, percent, 2000</td>
<td>31.0%</td>
<td>33.3%</td>
<td>30%</td>
</tr>
<tr>
<td>Median Household Money income, 1997</td>
<td>$33,248</td>
<td>$29,672</td>
<td>Occurs in the $20,000 - $50,000 range</td>
</tr>
</tbody>
</table>

1 This figure represents the total percentage of college graduates.

The number of female respondents in the sample used for this study seems to be consistent with the number of female residents in Missoula and the state of Montana in general. According to the 1997 Census Bureau, the number of college graduates 25 years of age and over residing in the city of Missoula is much lower than the number of college graduates in the sample population. The difference may be attributed in part to the fact that the Census Bureau did not include college graduates between the ages of 22 and 24 years old. The rate of homeownership for the sample population differs from the one provided by the Census for the population of Missoula by a few percentage points. The average number of individuals per household for the sample is 2.8 while the average provided by the Census for Missoula and Montana is 2.40 and 2.45 respectively. The percentage of households with persons under the age of 18 for the sample population is similar to that of Missoula’s population, and almost four percentage points lower than the rate for the state of Montana.
Since the measurement of income level in the sample was done with four categories, the median income falls between $20,000 and $50,000. This is consistent with the Missoula census figure of $33,248.

The sample used for this study seems fairly representative of the population except that it is skewed a bit away from the poorest population. One may expect low-income households to recycle less.
Chapter 6: Model Estimation and Calculation of Benefits Associated with a Curbside Recycling Program

The first section of this chapter focuses on the bivariate and multivariate models of willingness to pay. A third multivariate model of willingness to pay includes the most statistically significant variables from the full model. This section also presents the marginal effects and elasticities of the variables from both multivariate models. The second section illustrates the benefit estimates derived from the bivariate model. Lastly, once the median and the truncated mean have been estimated, they are aggregated to find the total willingness to pay for the hypothetical curbside recycling program.

6.1. Model Estimation

In this section I estimate the three models discussed in chapter four. The bivariate model given by equation 15 is used to derive the mean willingness-to-pay for the curbside recycling program. The variables used in the multivariate model were chosen based on statistical significance and economic theory. The marginal effects are the marginal effects at the means and were calculated by taking the derivatives of equation 16.

\[
P_t = 1 + \exp \left( (b_1 + b_2 \ln BID_t) \right)^{-1}
\]
\( P_i = (1 + e^{z_i})^{-1} \)

Where \( z_i = X_b \) and \( X \) includes the variables listed in chapter four.

The marginal effects measure the effect of a unit change in the independent variable on the probability of a "yes" response to the mean bid amount. The method to calculate the marginal effects for each of the dummy variables differs from the one used for continuous variables. The probability was calculated when the dummy equaled 1 and 0. The probability with the dummy variable equaled to 0 was then subtracted from the equation with the dummy equaled to 1. This difference was the marginal effect. The bivariate model has only the log of the bid as the independent variable. The following tables present the estimated coefficients, standard errors, t-ratios, marginal effects and elasticities at the means of all variables in the bivariate, multivariate and the reduced multivariate models. The multivariate model includes variables that have been found in the literature to influence willingness-to-pay and to participate in curbside recycling.

From the econometric analysis of the multivariate model one derives the second multivariate model with the intention to derive an improved model, which includes variables with mathematical signs consistent with economic theory or found to have a T-ratio of greater than \( |1.75| \). I have called this second multivariate model the reduced model.

### Table 6.1. Bivariate Model

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>T Ratio</th>
<th>Marginal Effect</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>4.3318</td>
<td>.60426</td>
<td>7.1687</td>
<td>1.3650</td>
<td></td>
</tr>
<tr>
<td>Log (BID)</td>
<td>-1.8704</td>
<td>.25987</td>
<td>-7.1975</td>
<td>-.04410253</td>
<td>-1.1204</td>
</tr>
</tbody>
</table>

LR (0) = -198.03  LR (1) = -150.49  \( \chi^2 = 5.02 \)
Table 6.2. shows the marginal effects of the (BID) in the bivariate model at each bid level with their respective probabilities of an individual accepting the bid.

Table 6.2. Marginal Effects and Probabilities at the Bid Level

<table>
<thead>
<tr>
<th>Bid</th>
<th>Marginal Effect at BID</th>
<th>Probability Accepting BID</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1</td>
<td>-0.023952</td>
<td>.987026</td>
</tr>
<tr>
<td>$3</td>
<td>-0.157860</td>
<td>.906943</td>
</tr>
<tr>
<td>$5</td>
<td>-0.310940</td>
<td>.789415</td>
</tr>
<tr>
<td>$8</td>
<td>-0.445470</td>
<td>.608804</td>
</tr>
<tr>
<td>$10</td>
<td>-0.467540</td>
<td>.506228</td>
</tr>
<tr>
<td>$12</td>
<td>-0.456120</td>
<td>.421624</td>
</tr>
<tr>
<td>$15</td>
<td>-0.409954</td>
<td>.324430</td>
</tr>
<tr>
<td>$20</td>
<td>-0.319901</td>
<td>.218988</td>
</tr>
</tbody>
</table>

The marginal effect at the $10 bid level is the largest. This seems to be consistent with our estimated median of $10.13. We would expect the marginal effect of the bid level closer to the estimated truncated mean and median to be the largest, because a small change in the bid amount will motivate people to reject it. Most people accept lower bid levels and reject higher bid amounts.

The probabilities at each of the bid levels are also consistent with economic theory. The large marginal effects and probabilities at the $15 and $20 bid level may be a product of the few respondents who accepted these bids.
Table 6.3. Multivariate Model

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>T Ratio</th>
<th>Marginal Effect</th>
<th>Elasticity at means</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-1.2778</td>
<td>3.3859</td>
<td>.37738</td>
<td>-.31935</td>
<td></td>
</tr>
<tr>
<td>Log (BID)</td>
<td>-2.8258</td>
<td>.38947</td>
<td>-7.2553</td>
<td>-1.3424</td>
<td></td>
</tr>
<tr>
<td>INCMED</td>
<td>.91610</td>
<td>.59624</td>
<td>1.5365</td>
<td>.1657940</td>
<td>.098902</td>
</tr>
<tr>
<td>INCMHI</td>
<td>2.3017</td>
<td>.75162</td>
<td>3.0623</td>
<td>.3507853</td>
<td>.19175</td>
</tr>
<tr>
<td>INCHIGH</td>
<td>1.0650</td>
<td>1.6232</td>
<td>.65611</td>
<td>.1486208</td>
<td>0.045267</td>
</tr>
<tr>
<td>Log (YRSRES)</td>
<td>-2.6570</td>
<td>.21237</td>
<td>-1.2411</td>
<td>-.0029558</td>
<td>-.15412</td>
</tr>
<tr>
<td>Log (PEOPLE)</td>
<td>.42251</td>
<td>.67423</td>
<td>62.666</td>
<td>.02812343</td>
<td>.098832</td>
</tr>
<tr>
<td>CHILDREN</td>
<td>-0.081719</td>
<td>.3225</td>
<td>-.14797</td>
<td>-.01543978</td>
<td>-.0062521</td>
</tr>
<tr>
<td>MARRIED</td>
<td>56157</td>
<td>66610</td>
<td>84307</td>
<td>1073583</td>
<td>.081153</td>
</tr>
<tr>
<td>ROOMMATE</td>
<td>79439</td>
<td>82899</td>
<td>95826</td>
<td>1331155</td>
<td>.04727</td>
</tr>
<tr>
<td>RENTOWN</td>
<td>-4.3061</td>
<td>64174</td>
<td>-.67100</td>
<td>-.07661825</td>
<td>-.078701</td>
</tr>
<tr>
<td>Log (EDU)</td>
<td>2.1162</td>
<td>1.2786</td>
<td>1.6551</td>
<td>.0253163</td>
<td>1.4487</td>
</tr>
<tr>
<td>ENDER</td>
<td>.50048</td>
<td>37455</td>
<td>-1.3362</td>
<td>-.09346063</td>
<td>.06382</td>
</tr>
<tr>
<td>PLASTIC</td>
<td>.64024</td>
<td>45887</td>
<td>1.3952</td>
<td>.1261722</td>
<td>.10776</td>
</tr>
<tr>
<td>ALCANS</td>
<td>2.6800</td>
<td>1.2514</td>
<td>2.1416</td>
<td>.5832868</td>
<td>.57638</td>
</tr>
<tr>
<td>GLASS</td>
<td>-0.034037</td>
<td>39749</td>
<td>-.08563</td>
<td>-.006383862</td>
<td>-.003993</td>
</tr>
<tr>
<td>NEWSP</td>
<td>-.76000</td>
<td>45560</td>
<td>-1.6323</td>
<td>-.1335165</td>
<td>-.12534</td>
</tr>
<tr>
<td>PAYRECY</td>
<td>-1.1360</td>
<td>1.8495</td>
<td>-1.6142</td>
<td>-.2563265</td>
<td>-.011588</td>
</tr>
<tr>
<td>BLUEBAG</td>
<td>-2.3003</td>
<td>1.3735</td>
<td>-1.6747</td>
<td>-.4911040</td>
<td>-.15056</td>
</tr>
<tr>
<td>DROPOFF</td>
<td>-2.7506</td>
<td>1.3765</td>
<td>-1.9982</td>
<td>-.4481048</td>
<td>-.40218</td>
</tr>
<tr>
<td>ENVATT1</td>
<td>.13572</td>
<td>.05676</td>
<td>2.3911</td>
<td>.02544241</td>
<td>.21009</td>
</tr>
<tr>
<td>RECYATT</td>
<td>-.01054</td>
<td>.038749</td>
<td>-2.7204</td>
<td>-.0019761</td>
<td>.012626</td>
</tr>
<tr>
<td>ENVATT2</td>
<td>-.049648</td>
<td>.037628</td>
<td>-1.3194</td>
<td>-.009307</td>
<td>.055034</td>
</tr>
</tbody>
</table>

LR (0) = -198.03
LR (1) = -107.89
\( \chi^2 = 36.78 \)
### Table 6.4. Reduced Multivariate Model

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Estimated Coefficient</th>
<th>Standard Error</th>
<th>t Ratio</th>
<th>Marginal Effect</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-.41119</td>
<td>3.1950</td>
<td>-.12870</td>
<td>-.10755</td>
<td></td>
</tr>
<tr>
<td>Log (BID)</td>
<td>-2.6376</td>
<td>.35343</td>
<td>-7.4629</td>
<td>-1.3114</td>
<td></td>
</tr>
<tr>
<td>INCMED</td>
<td>60955</td>
<td>.47138</td>
<td>1.2931</td>
<td>1020901</td>
<td></td>
</tr>
<tr>
<td>INCMEDII</td>
<td>1.9632</td>
<td>.57173</td>
<td>3.4338</td>
<td>.3080603</td>
<td></td>
</tr>
<tr>
<td>INCHIGH</td>
<td>95557</td>
<td>1.5905</td>
<td>6.0081</td>
<td>.1377454</td>
<td></td>
</tr>
<tr>
<td>Log (YRSRES)</td>
<td>-.32169</td>
<td>.18313</td>
<td>-1.7567</td>
<td>-.00414222</td>
<td></td>
</tr>
<tr>
<td>Log (PEOPLE)</td>
<td>.65372</td>
<td>.39458</td>
<td>1.6567</td>
<td>.00789138</td>
<td></td>
</tr>
<tr>
<td>CHILDREN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARRIED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROOMATE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RENTOWN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (EDU)</td>
<td>1.5641</td>
<td>1.1930</td>
<td>1.3110</td>
<td>.1777015</td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td>-.35678</td>
<td>.35142</td>
<td>-1.0153</td>
<td>-.06671729</td>
<td></td>
</tr>
<tr>
<td>PLASTIC</td>
<td>.56470</td>
<td>.42519</td>
<td>1.3281</td>
<td>.1107057</td>
<td></td>
</tr>
<tr>
<td>ALCANS</td>
<td>1.1891</td>
<td>.66240</td>
<td>1.7952</td>
<td>260936</td>
<td></td>
</tr>
<tr>
<td>GLASS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEWSP</td>
<td>-.84087</td>
<td>.42501</td>
<td>-1.9785</td>
<td>-1466635</td>
<td></td>
</tr>
<tr>
<td>PAYRECY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLUEBAG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DROPOFF</td>
<td>-.62779</td>
<td>.41259</td>
<td>-1.5216</td>
<td>-.1143432</td>
<td></td>
</tr>
<tr>
<td>ENVATT1</td>
<td>.17439</td>
<td>.050523</td>
<td>3.4517</td>
<td>.0336824</td>
<td></td>
</tr>
<tr>
<td>RECYATT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENVATT2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR (0) = -198.03</td>
<td>LR (1) = -112.35</td>
<td>$\chi^2$ = 24.7356</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The likelihood ratio test for all three models reveal that we can reject the null hypothesis of all betas being equal to zero.
The following section presents the prediction success tables for each of the models. These tables illustrate the predicting power of each of the models.

### Table 6.5. Prediction Success Table for the Bivariate Model

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>72</td>
<td>36</td>
</tr>
<tr>
<td>1</td>
<td>46</td>
<td>140</td>
</tr>
</tbody>
</table>

Percent Correct = 72%

### Table 6.6. Prediction Success Table for the Multivariate Model

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>95</td>
<td>21</td>
</tr>
<tr>
<td>1</td>
<td>23</td>
<td>155</td>
</tr>
</tbody>
</table>

Percent Correct = 85%

### Table 6.7. Prediction Success Table for the Isotope Multivariate Model

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>91</td>
<td>24</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
<td>152</td>
</tr>
</tbody>
</table>

Percent Correct = 83%
6.3. Benefit Estimation

The bivariate model was used for benefit estimation. Duffield et al. (1990) suggest that if the bivariate model fits the data well, then the willingness-to-pay distribution may be well approximated without covariates. The absence of covariates simplifies the computations and interpretation of benefit estimates.

In order to tell whether the bivariate model fits the hypothetical logistic model a likelihood ratio test was performed.

The benefit measures used for this study are the median and truncated mean. For the latter, the truncation point was $20.00. The measures were calculated using the equations found in chapter 4. The standard errors for the truncated mean were calculated using the bootstrapping technique with 1000 iterations. Table 6.8. provides the median and truncated means derived from the bivariate model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Median</th>
<th>Truncated Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bivariate</td>
<td>10.13408</td>
<td>11.10</td>
</tr>
</tbody>
</table>

6.3.1. Confidence Intervals for Truncated Means

Using the standard errors derived from the bootstrapping technique and the equation presented in section 4.4., one can calculate the confidence intervals for the truncated mean. Table 6.9. presents the confidence intervals for the bivariate model.
Table 6.9. Confidence Intervals

<table>
<thead>
<tr>
<th>Model</th>
<th>Truncated Mean at 95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bivariate</td>
<td>10.16 – 12.04</td>
</tr>
</tbody>
</table>

6.4. Total Valuation at Different Price Levels

The total population for the county of Missoula is 95,802 residents, thus the total value of the hypothetical curbside recycling program can be calculated at various price levels.

Table 6.10 presents the percentage of individuals in the sample that accepted each of the bid amounts, and the potential payout at each of the bid levels. The potential payout was calculated by multiplying the percentage of bid level acceptance times the total population of Missoula County and times the bid amount.

Table 6.10. Percentage of acceptance and total payout at each bid level

<table>
<thead>
<tr>
<th>Bid Amount</th>
<th>Percentage of Acceptance</th>
<th>Total Payout</th>
<th>Duffield &amp; Ward's Estimate (28%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1</td>
<td>98.7026 %</td>
<td>$94,557</td>
<td>$26,476</td>
</tr>
<tr>
<td>$3</td>
<td>90.6943 %</td>
<td>$260,661</td>
<td>$72,985</td>
</tr>
<tr>
<td>$5</td>
<td>78.9415 %</td>
<td>$378,138</td>
<td>$105,879</td>
</tr>
<tr>
<td>$8</td>
<td>60.8804 %</td>
<td>$466,597</td>
<td>$130,647</td>
</tr>
<tr>
<td>$10</td>
<td>50.6228 %</td>
<td>$484,977</td>
<td>$135,793</td>
</tr>
<tr>
<td>$12</td>
<td>42.1624 %</td>
<td>$484,709</td>
<td>$135,718</td>
</tr>
<tr>
<td>$15</td>
<td>32.4430 %</td>
<td>$466,216</td>
<td>$130,540</td>
</tr>
<tr>
<td>$20</td>
<td>21.8988 %</td>
<td>$419,589</td>
<td>$117,485</td>
</tr>
</tbody>
</table>

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At a bid level of $10 per month, 51 percent of the population is willing to pay the $10 fee generating almost $500,000 per month in revenue. A firm could generate the same revenue at a price of $12 per month, but would have less participation.

One important concern with hypothetical surveys is that responses may not reflect actual behavior. In this sample, the population of people who claim to recycle is far higher than the national average. Duffield and Ward (1994) addressed this issue and estimated that people would actually pay only 28 percent of their estimated willingness-to-pay for the reintroduction of wolves in certain areas. Applying this percentage to the current study yields the last column of table 6.10. In this case, a fee of $10 per month would generate approximately $135,000 in revenue. However, one should note the link between the hypothetical and a real curbside recycling program is stronger than the link between the hypothetical and real introduction of wolves under Duffield et al. study. In addition the low willingness-to-pay figures for a curbside recycling program reduces implausibility of responses.
Chapter 7: Conclusions and Future Research

This chapter summarizes the results of this study, provides policy alternatives and makes suggestions for further research in the valuation of curbside recycling programs.

7.1. Summary

In the past decades, recycling has become an important alternative to landfill disposal of waste. A variety of recycling programs have sprung out in many communities. A widely accepted recycling program is the curbside recycling program. Under this service, participants must separate recyclables into groups of similar materials and place them on the curb for pick-up. Since, garbage collection and recycling services in the United States are often provided by local governments, hence they are public goods, this study treats curbside recycling as a quasi-non-market good and uses a non-market valuation method.

Using contingent valuation, and survey techniques, this study estimated the demand for a curbside recycling program in the city of Missoula by calculating the probability that a resident will answer yes to a given dollar amount. Using logit analysis three probability models were calculated. The first one included only the bid presented to the respondent. The second model was based on a set of economic and sociological factors. These factors included household's total income (INC), number of years residing in Missoula, number of people in the household (PEOPLE), if the household had children (CHILD), if the household was a married, single or roommate household, education level...
of the individual, if the residence was owned or rented and finally the gender of the respondent. Current recycling behavior of the household was taken into consideration. The household was asked if they recycle plastic, glass, aluminum cans, and newspaper. Furthermore, the household was asked if it participated in the blue-bag recycling service provided by BFI Waste Systems or contracted the services of Missoula Valley Recycling which provides the current curbside recycling program for the city of Missoula, or used one of the drop-off sites in the city. In addition, attitude scales were used to measure the individual's stand for the environment, and opportunity cost of recycling. The third model included only those variables found to be statistically significant in the second model.

In the analysis, the median willingness-to-pay per month derived from the first model was $10.13 and the average willingness-to-pay per month was $11.10. The confidence intervals for the truncated average were $10.16 - $12.04. The only economic characteristic found to be significant was the income level of the household, implying its impact on accepting the bid is of importance. In specific, the income level between $50,000 and $100,000 was the most statistically significant. If the household recycled aluminum cans was also found to be significant in the model. In addition, only one environmental attitude scale was significant which may indicate the poor measuring quality of the attitude scales in this study.

There are concerns over specific bias in this study. First, the sample may not be representative of the population. Low-income households are somewhat excluded from the sample. Also, the average level of education is not consistent with census estimates.
For a fee of $10 per month, the recycling program was estimated to generate approximately $500,000 per month in revenue. This measure will be the basis for the following policy alternatives.

7.2. Policy Alternatives

The first alternative is for a private firm to provide the curbside recycling program. The firm will find this venture economically feasible only if the costs of providing the monthly service are lower than the estimated monthly total value of the program. A cost-benefit analysis of the curbside recycling program may provide a clearer picture for the economic feasibility of the program, however we have calculated the potential payouts. It is important to note that the current curbside recycling program in Missoula provides a single pick-up monthly service for $9. A price that is higher than the estimated average willingness to pay\(^7\). It may be that Missoula Valley Recycling can not offer this service at a lower price and they are only servicing those households with higher willingness-to-pay than the estimated WTP in this study.

On the other hand, there are important externalities that have not been directly measured in this study but need to be mentioned. Recycling produces positive externalities that affect the environment and social aspects of the community such as reduction of litter, reduction of solid waste going to landfills and reduction of alternate disposal procedures that pollute the air and water. To the extend that response to bid do not capture these externalities, these must also be valued to derive a more accurate approximation of the total value of the recycling program to society. Private firms often

\(^7\) The estimated average willingness to pay was $11.10 for two service days a month. Thus, it is divided by two ($5.55) to estimate single pick-up WTP.
exclude these externalities from their valuation, to set prices which ignore these externalities.

Public agencies are more prone to consider and value externalities. The local government of Missoula may capture some of the externalities produced by recycling more efficiently than the private sector can. The city government may institute subsidies for the private sector or tax breaks or tax incentives for households to promote the provision and participation in the recycling program.

7.3. Future Research

There have been various studies regarding curbside recycling programs. A study that aggregates a stream flow analysis, willingness-to-pay and willingness-to-participate in a curbside recycling program may provide a better understanding of the economic valuation of the program. Also, because different vehicle payments have different impact on the individual's willingness-to-pay, studies using different payment vehicles may add greatly to the research of implementation of recycling programs.

Another area for future research could be in studies of before and after a proposed program has been implemented. The future of recycling lies behind its effectiveness to improve the current state of waste disposal and more research is necessary to evaluate recycling as a viable alternative to landfill disposal of waste.

In addition, future research could determine the externalities produced by recycling activity. The spillovers from curbside recycling mask the value of the non-market externalities that spillover from this activity. A direct valuation of these spillover characteristics will provide a better estimate of the value of curbside recycling.
While this research revealed the total willingness to pay for a curbside recycling program in the city of Missoula to be approximately $500,000 per month at a fee of $10 per month, research regarding the costs of providing recycling services may provide more useful information to help policy makers in the decision making process.
Appendix A

Survey Instrument
QUESTIONNAIRE

Hello, my name is Jon Aliri and I am a graduate student in Economics at The University of Montana. I am doing a study on curbside recycling in the city of Missoula for my master’s thesis. It will really help me if you would answer a few questions about recycling. Participation is voluntary and responses will be kept confidential.

1. How long have you lived in the city of Missoula? ________

2. How many people live in the household? ________
   Are there any children? ________

3. What is the type of household? Please choose from the following
   Married _____ Single _____ Roommate _____

4. Do you own or rent your house? Owned _____ Rent _____

5. Do you recycle any of the following?
   Plastic ____ Aluminum Cans ____ Glass ____ Newspaper ______

   If they answer no to all of them, go to paragraph

6. Do you pay for a recycling service? Yes ____ No ____

7. Do you participate in the BFI blue-bag service? Yes ____ No ____

8. Do you use a drop-off site to discard your recyclables? Yes ____ No ____

Imagine you could have a service that collects newspaper, plastic, glass and aluminum cans twice a month. Your household would have to take the time to sort your recyclables into groups of similar materials. You would also have to place the containers with the recyclables on the curb. This service will be provided for a monthly fee, separate from your garbage bill. Remembering that any money you spend on the recycling service cannot be spent anywhere else. Please carefully consider the next question.

9. Would you be willing to pay ($amount) for a curbside recycling program in your community? ________
Please read each of the following statements and place a vertical line on the scale where best reflects your opinion about each statement.

Environmental protection laws in the United States need to be stronger

<table>
<thead>
<tr>
<th>STRONGLY DISAGREE</th>
<th>STRONGLY AGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10 -8 -6 -4 -2 0 2 4 6 8 10</td>
<td></td>
</tr>
</tbody>
</table>

Sorting recyclables makes recycling undesirable

<table>
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Economic development in a community is more important than the protection of its environment

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</tr>
</tbody>
</table>

11 How many years of formal education have you completed? __________

12 Approximately what was your household's income before taxes last year?

- Less than $20,000
- $20,000 - $50,000
- $50,000 - $100,000
- More than $100,000
Appendix B

Missoula Map\textsuperscript{8} and Specification of Surveying Zones

\textsuperscript{8} Map is located on side pocket.
<table>
<thead>
<tr>
<th>Zone</th>
<th>Number of Surveys Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>36</td>
</tr>
<tr>
<td>Zone 2</td>
<td>25</td>
</tr>
<tr>
<td>Zone 3</td>
<td>24</td>
</tr>
<tr>
<td>Zone 4</td>
<td>24</td>
</tr>
<tr>
<td>Zone 5</td>
<td>37</td>
</tr>
<tr>
<td>Zone 6</td>
<td>32</td>
</tr>
<tr>
<td>Zone 7*</td>
<td>41</td>
</tr>
<tr>
<td>Zone 8</td>
<td>27</td>
</tr>
<tr>
<td>Zone 9</td>
<td>9</td>
</tr>
<tr>
<td>Zone 10</td>
<td>37</td>
</tr>
<tr>
<td>Zone 11</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>320</strong></td>
</tr>
</tbody>
</table>

* Note that in the sample Zone 7 was included in Zone 6
Appendix C

Variable Definitions
<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCMED</td>
<td>dummy variable with 1 = income level medium; base case at 0 = low income level.</td>
</tr>
<tr>
<td>INCMEDHI</td>
<td>dummy variable with 1 = income level medium high; base case at 0 = low income level.</td>
</tr>
<tr>
<td>INCHIGH</td>
<td>dummy variable with 1 = income level high; base case at 0 = low income level.</td>
</tr>
<tr>
<td>LYRSRESID</td>
<td>the log of the number of years residing in Missoula.</td>
</tr>
<tr>
<td>LPEOPLE</td>
<td>the log of the number of people in the household.</td>
</tr>
<tr>
<td>CHILDREN</td>
<td>dummy variable with 1 = if there are children in the household; base case at 0 = no children.</td>
</tr>
<tr>
<td>MARRIED</td>
<td>dummy variable with 1 = married household; base case at 0 = single.</td>
</tr>
<tr>
<td>ROOMATE</td>
<td>dummy variable with 1 = roommate household; base case at 0 = single.</td>
</tr>
<tr>
<td>RENTOWN</td>
<td>dummy variable with 1 = household owned; base case at 0 = rented.</td>
</tr>
<tr>
<td>LEDU</td>
<td>the log of the number of years of formal education.</td>
</tr>
<tr>
<td>GENDER</td>
<td>dummy variable with 1 = male; base case at 0 = Female.</td>
</tr>
<tr>
<td>PLASTIC</td>
<td>dummy variable with 1 = household recycles plastic; base case at 0 = it does not.</td>
</tr>
<tr>
<td>ALCANS</td>
<td>dummy variable with 1 = household recycles aluminum cans; base case at 0 = it does not.</td>
</tr>
<tr>
<td>GLASS</td>
<td>dummy variable with 1 = household recycles glass; base case at 0 = it does not.</td>
</tr>
<tr>
<td>NEWSP</td>
<td>dummy variable with 1 = household recycles newspaper; base case at 0 = it does not.</td>
</tr>
<tr>
<td>PAYRECY</td>
<td>dummy variable with 1 = household pays for a recycling service; base case at 0 = it does not.</td>
</tr>
<tr>
<td>BLUEBAG</td>
<td>dummy variable with 1 = household participates in the blue-bag program; base case at 0 = it does not.</td>
</tr>
<tr>
<td>DROPOFF</td>
<td>dummy variable with 1 = household uses a drop-off site; base case at 0 = it does not.</td>
</tr>
<tr>
<td>ENVATT1</td>
<td>Likert scale to measure environmental attitude.</td>
</tr>
<tr>
<td>RECYATT</td>
<td>Likert scale to measure attitude towards recycling.</td>
</tr>
<tr>
<td>ENVATT2</td>
<td>Likert scale to measure environmental attitude.</td>
</tr>
</tbody>
</table>
Appendix D

Shazam program
set noscan
delete / all
read (a:onsbook.xls) id bid wtp r inc yrsres people children thouse
renown edu gender plastic alcans glass newsp payrecy &
bluebag dropoff envatt1 recyatt envatt2 zone
stat/all
*type of House*
if (thouse.eq.l) married=l
if (thouse.eq.2) single=l
if (thouse.eq.3) roommate=l
stat married single roommate
*Income*
skipif (inc.eq.-999)
if (inc.eq.l) inclow=l
if (inc.eq.2) incmed=l
if (inc.eq.3) incmehi=l
if (inc.eq.4) inchigh=l
stat inclow incmed incmehi inchigh:
delete skip$
skipif (edu.=q.-999)
stat edu
delete skip$
skipif (envatt1.eq.-999)
stat envatt1
delete skip$
skipif (envatt2.eq.-999)
stat envatt2
delete skip$

*Bivariate logit Model*
skipif (inc.eq.-999)
skipif (edu.eq.-999)
skipif (envatt1.eq.-999)
skipif (envatt2.eq.-999)
gen lbid=log(bid)
gen lylrsres=log(yrsres)
gen lpeople=log(people)
gen ledu=log(edu)
logit wtp r lbid/coef=d
*median*
gen1 med=exp(-d:2/d:1)
print med
***MARGINAL EFFECTS of BID at MEANS****
stat wtp r lbid bid/ means=ml
\[
\text{margbid} = \frac{\exp(d:l*ml:2+d:2)\cdot d:1}{(1+\exp(d:l*ml:2+d:2))^2} \cdot \frac{1}{ml:3}
\]
\[
\text{print margbid}
\]
\[
\text{margl} = \frac{\exp(d:l*log(1)+d:2)\cdot d:1}{(1+\exp(d:l*log(1)+d:2))^2} \cdot \frac{1}{l}
\]
\[
\text{marg3} = \frac{\exp(d:l*log(3)+d:2)\cdot d:1}{(1+\exp(d:l*log(3)+d:2))^2} \cdot \frac{1}{3}
\]
\[
\text{marg5} = \frac{\exp(d:l*log(5)+d:2)\cdot d:1}{(1+\exp(d:l*log(5)+d:2))^2} \cdot \frac{1}{5}
\]
\[
\text{marg8} = \frac{\exp(d:l*log(8)+d:2)\cdot d:1}{(1+\exp(d:l*log(8)+d:2))^2} \cdot \frac{1}{8}
\]
\[
\text{marg10} = \frac{\exp(d:l*log(10)+d:2)\cdot d:1}{(1+\exp(d:l*log(10)+d:2))^2} \cdot \frac{1}{10}
\]
\[
\text{marg12} = \frac{\exp(d:l*log(12)+d:2)\cdot d:1}{(1+\exp(d:l*log(12)+d:2))^2} \cdot \frac{1}{12}
\]
\[
\text{marg15} = \frac{\exp(d:l*log(15)+d:2)\cdot d:1}{(1+\exp(d:l*log(15)+d:2))^2} \cdot \frac{1}{15}
\]
\[
\text{marg20} = \frac{\exp(d:l*log(20)+d:2)\cdot d:1}{(1+\exp(d:l*log(20)+d:2))^2} \cdot \frac{1}{20}
\]
\[
\text{print marg1 marg3 marg5 marg8 marg10 marg12 marg15 marg20}
\]

**PROBABILITIES**
\[
\text{prob1} = \frac{\exp(d:l*log(1)+d:2)}{1+\exp(d:l*log(1)+d:2)}
\]
\[
\text{print prob1}
\]
\[
\text{prob3} = \frac{\exp(d:l*log(3)+d:2)}{1+\exp(d:l*log(3)+d:2)}
\]
\[
\text{print prob3}
\]
\[
\text{prob5} = \frac{\exp(d:l*log(5)+d:2)}{1+\exp(d:l*log(5)+d:2)}
\]
\[
\text{print prob5}
\]
\[
\text{prob8} = \frac{\exp(d:l*log(8)+d:2)}{1+\exp(d:l*log(8)+d:2)}
\]
\[
\text{print prob8}
\]
\[
\text{prob10} = \frac{\exp(d:l*log(10)+d:2)}{1+\exp(d:l*log(10)+d:2)}
\]
\[
\text{print prob10}
\]
\[
\text{prob12} = \frac{\exp(d:l*log(12)+d:2)}{1-\exp(d:l*log(12)+d:2)}
\]
\[
\text{print prob12}
\]
\[
\text{prob15} = \frac{\exp(d:l*log(15)+d:2)}{1+\exp(d:l*log(15)+d:2)}
\]
\[
\text{print prob15}
\]
\[
\text{prob20} = \frac{\exp(d:l*log(20)+d:2)}{1+\exp(d:l*log(20)+d:2)}
\]
\[
\text{print prob20}
\]

**Multivariate Logit Model**
\[
\text{logit wtpr lbid incmed incmehi inchigh lysres lpeople children married roomate rentown \& ledu gender plastic alcans glass newsp payrecy bluebag \& dropoff envattl recyatt envattl bid yrsres people edu/means=m}
\]
\[
\text{***Marginal effects for multivariate model***}
\]
\[
\text{stat lbid incmed incmehi inchigh lysres lpeople children married roomate rentown \& ledu gender plastic alcans glass newsp payrecy bluebag \& dropoff envattl recyatt envattl bid yrsres people edu/means=m}
\]
\[
\text{genl z=b:1*m:1+b:2*m:2+b:3*m:3+b:4*m:4+b:5*m:5+b:6*m:6+b:7*m:7&}
\]
**ME LBDI**
\[
\text{genl margbidm} = \frac{(\exp(z) \cdot b:1)}{(1 + \exp(z))^{2}} \cdot \frac{1}{m:23}
\]
print margbidm

**ME INCMED**
\[
\text{genl ziml = } z - (b:2 \cdot m:2) + b:2
\]
\[
\text{genl probl} = \frac{(\exp(ziml))}{(1 + \exp(ziml))}
\]
\[
\text{genl zim0 = } z - (b:2 \cdot m:2)
\]
\[
\text{genl prob0} = \frac{(\exp(zim0))}{(1 + \exp(zim0))}
\]
\[
\text{genl margincmed} = \text{probl} - \text{prob0}
\]
print margincmed

**ME INCMEDHIGH**
\[
\text{genl zimhl = } z - (b:3 \cdot m:3) + b:3
\]
\[
\text{genl probl} = \frac{(\exp(zimhl))}{(1 + \exp(zimhl))}
\]
\[
\text{genl zimh0 = } z - (b:3 \cdot m:3)
\]
\[
\text{genl prob0} = \frac{(\exp(zimh0))}{(1 + \exp(zimh0))}
\]
\[
\text{genl meimedhigh} = \text{probl} - \text{prob0}
\]
print meimedhigh

**ME INCHIGH**
\[
\text{genl zihl = } z - (b:4 \cdot m:4) + b:4
\]
\[
\text{genl probl} = \frac{(\exp(zihl))}{(1 + \exp(zihl))}
\]
\[
\text{genl zih0 = } z - (b:4 \cdot m:4)
\]
\[
\text{genl prob0} = \frac{(\exp(zih0))}{(1 + \exp(zih0))}
\]
\[
\text{genl meinchigh} = \text{probl} - \text{prob0}
\]
print meinchigh

**ME YRSRES**
\[
\text{genl meyrsre} = \frac{(\exp(z) \cdot b:5)}{(1 + \exp(z))^{2}} \cdot \frac{1}{m:24}
\]
print meyrsre

**ME PEOPLE**
\[
\text{genl mepeople} = \frac{(\exp(z) \cdot b:6)}{(1 + \exp(z))^{2}} \cdot \frac{1}{m:25}
\]
print mepeople

**ME CHILDREN**
\[
\text{genl zchl = } z - (b:7 \cdot m:7) + b:7
\]
\[
\text{genl probl} = \frac{(\exp(zchl))}{(1 + \exp(zchl))}
\]
\[
\text{genl zch0 = } z - (b:7 \cdot m:7)
\]
\[
\text{genl prob0} = \frac{(\exp(zch0))}{(1 + \exp(zch0))}
\]
\[
\text{genl mechildren} = \text{probl} - \text{prob0}
\]
print mechildren

**ME MARRIED**
\[
\text{genl zmarl = } z - (b:8 \cdot m:8) + b:8
\]
\[
\text{genl probl} = \frac{(\exp(zmarl))}{(1 + \exp(zmarl))}
\]
\[
\text{genl zmar0 = } z - (b:8 \cdot m:8)
\]
\[
\text{genl prob0} = \frac{(\exp(zmar0))}{(1 + \exp(zmar0))}
\]
\[
\text{genl memarried} = \text{probl} - \text{prob0}
\]
print memarried

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**ME ROOMATE**
genl zroom=z-(b:9*m:9)+b:9
genl prob1=((exp(zroom))/((1+exp(zroom))))
genl zroom0=z-(b:9*m:9)
genl prob0=((exp(zroom0))/((1+exp(zroom0))))
genl meroomate=prob1-prob0
print meroomate

**ME RENTOWN**
genl zrel=z-(b:10*m:10)+b:10
genl prob1=((exp(zrel))/((1+exp(zrel))))
genl zrel0=z-(b:10*m:10)
genl prob0=((exp(zrel0))/((1+exp(zrel0))))
genl merentown=prob1-prob0
print merentown

**ME EDU**
genl meedu=(((exp(z)*b:11)/((1+exp(z))**2))*(l/m:26))
print meedu

**ME GENDER**
genl zgel=z-(b:12*m:12)+b:12
genl prob1=((exp(zgel))/((1+exp(zgel))))
genl zgel0=z-(b:12*m:12)
genl prob0=((exp(zgel0))/((1+exp(zgel0))))
genl megender=prob1-prob0
print megender

**ME PLASTIC**
genl zzpl=z-(b:13*m:13)+b:13
genl prob1=((exp(zzpl))/((1+exp(zzpl))))
genl zzpl0=z-(b:13*m:13)
genl prob0=((exp(zzpl0))/((1+exp(zzpl0))))
genl meplastic=prob1-prob0
print meplastic

**ME ALCANS**
genl zacl=z-(b:14*m:14)+b:14
genl prob1=((exp(zacl))/((1+exp(zacl))))
genl zacl0=z-(b:14*m:14)
genl prob0=((exp(zacl0))/((1+exp(zacl0))))
genl mealcans=prob1-prob0
print mealcans

**ME GLASS**
genl zgsl=z-(b:15*m:15)+b:15
genl prob1=((exp(zgsl))/((1+exp(zgsl))))
genl zgsl0=z-(b:15*m:15)
genl prob0=((exp(zgsl0))/((1+exp(zgsl0))))
genl meglass=prob1-prob0
print meglass

**ME NEWSP**
genl znewl=z-(b:16*m:16)+b:16
genl prob1=((exp(znewl))/((1+exp(znewl))))
genl znew0=z-(b:16*m:16)
genl probO={{exp(znewO)}/(1+exp(znewO))}
genl menewsp=prob1-probO
print menewsp

**ME PAYRECY**
genl zpayl=z-(b:17*m:17)+B:17
genl probl={{exp(zpayl)}/(1+exp(zpayl))}
genl zpayO=z-(b:17*m:17)
genl probO={{exp(zpayO)}/(1+exp(zpayO))}
genl mepayrecy=prob1-probO
print mepayrecy

**ME BLUEBAG**
genl zbbl=z-(b:18*m:18)+b:18
genl probl={{exp(zbbl)}/(1+exp(zbbl))}
genl zbbO=z-(b:18*m:18)
genl probO={{exp(zbbO)}/(1+exp(zbbO))}
genl mebluebag=prob1-probO
print mebluebag

**ME DROPOFF**
genl zdol=z-(b:19*m:19)+b:19
genl probl={{exp(zdol)}/(1+exp(zdol))}
genl zdoO=z-(b:19*m:19)
genl probO={{exp(zdoO)}/(1+exp(zdoO))}
genl medropoff=prob1-probO
print medropoff

**ME ENVATT1**
genl meenvatt1={{exp(z)*b:20}/(1+exp(z))^2}
print meenvatt1

**ME RECYATT**
genl merecyatt={{exp(z)*b:21}/(1+exp(z))^2}
print merecyatt

**ME ENVATT2**
genl meenvatt2={{exp(z)*b:22}/(1+exp(z))^2}
print meenvatt2

** Isotope Multivariate **
logit wtpr bid incmed incmehi inchigh lyrsres lpeople ledu gender plastic alcans newsp &
dropoff envatt1 /coef=a
stat bid incmed incmehi inchigh lyrsres lpeople ledu gender plastic alcans newsp &
dropoff envatt1 bid yrsres people edu/means=m2

**MARGINAL EFFECTS**
genl
zi=a:1*m2:1+a:2*m2:2+a:3*m2:3+a:4*m2:4+a:5*m2:5+a:6*m2:6+a:7*m2:7+a:8*m2:8 &
a:9*m2:9+a:10*m2:10+a:11*m2:11+a:12*m2:12+a:13*m2:13+a:14

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**ME BID**
genl mebid=(((exp(z)*a:1)/(1+exp(z))**2))*(1/m:14)

**ME INCMEDE**
genl ziiiml=zi-({a:2*m2:2}+a:2
genl probl=(((exp(ziiim1))/((l+exp(ziiim1))

**ME INCMEHII**
genl ziimhl=z-(a:3*m2:3)+a:3

**ME INCHIGH**
genl ziihl=z-(a:4*m2:4)+a:4

**ME LYRSRES**
genl melyrsres={{exp(z)*a:5}/((l+exp(z))}**2)}

**ME LPEOPLE**
genl melpeople=(((exp(z)*a:6}/((l+exp(z))}**2)}

**ME LEDU**
genl meledu=(((exp(z)*a:7}/((l+exp(z))}**2)}

**ME GENDER**
genl zigel=z-(a:8*m2:8)+a:8

**ME PLASTIC**
genl zipl1=z-(a:9*m2:9)+a:9

**ME ALCANS**
genl ziacl=z-(a:10*m2:10)+a:10
genl probl=((exp(ziacl))/((1+exp(ziacl))))
genl ziac0=z-(a:10*m2:10)
genl prob0=((exp(ziac0))/((1+exp(ziac0))))
genl mealcans=prob1-prob0
print mealcans

**ME NEWSP**
genl zinpl=z-(a:11*m2:11)+a:11
genl probl=((exp(zinpl))/((1+exp(zinpl))))
genl zinp0=z-(a:11*m2:11)
genl prob0=((exp(zinp0))/((1+exp(zinp0))))
genl menewsp=prob1-prob0
print menewsp

**ME DROPOFF**
genl zidol=z-(a:12*m2:12)+a:12
genl probl=((exp(zidol))/((1+exp(zidol))))
genl zido0=z-(a:12*m2:12)
genl prob0=((exp(zido0))/((1+exp(zido0))))
genl medropoff=prob1-prob0
print medropoff

**ME ENVATT1**
genl meenvatt1=((exp(zi)*a:13)/((1+exp(zi))**2))
print meenvatt1

**bootstrap??***
sample 1 1
genl upper=20
genl lower=.0001
?integ aml lower upper answer=1-(1/(1+(exp(b:2+b:1*(log(aml))))))
print answer

sample 1 320
copy wtpr lbid zz
dim answer2 1000
set nodoecho
do #=1,1000
matrix m=samp(zz,320)
matrix yes=m(0,1)
matrix bid=m(0,2)
?logit yes bid / coef=d
?integ aml lower upper answer2:#=1-(1/(1+(exp(d:2+d:1*(log(aml))))))
endo
stat answer2
sample 1 1000
sort answer2
stat answer2
sample 1 25

print answer2
sample 976 1000
print answer2
stop

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Bibliography


Hickman, Lanier. 1999. "Garbage: Bin there, done that," *American City and..."


