Curbside Recycling:
Waste Resource or Waste of Resources?

David Aadland
Department of Economics and Finance
P.O. Box 3985
University of Wyoming
Laramie, WY 82071-3985

Arthur J. Caplan
Department of Economics
Utah State University
3530 Old Main Hill
Logan, UT 84322-3530

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Abstract: In this paper, we estimate the social net benefits of curbside recycling. Benefits are estimated using household survey data from over 4,000 households across 40 western U.S. cities. We calibrate household willingness-to-pay for hypothetical bias using an innovative experimental design that contrasts stated and revealed preferences. Cost estimates are compiled from previous studies by the U.S. Environmental Protection Agency and the Institute for Local Self Reliance, and from interviews with recycling coordinators in our sampled cities. Remarkably, we find that the estimated mean social net benefit of curbside recycling is almost exactly zero.*

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1. Introduction

One of society's greatest challenges is determining optimal allocations for environmental goods, such as old-growth forests, wetlands, spotted owls, wolf habitat, clean air, etc. The primary difficulty with this type of problem is measuring the social benefits accruing from the provision of these goods. Unlike private goods, environmental goods have a large public-good component that encourages free-riding behavior. Furthermore, their prices are not determined in well-developed markets. As a consequence, it is often necessary to estimate the benefits from environmental goods through non-market valuation methods, such as contingent valuation.

In this paper, we focus on one such environmental good – curbside recycling. Recycling is typically thought to benefit the environment by diverting solid waste from landfills, which can pollute groundwater, produce airborne pollutants, and compete for open space (U.S. EPA, 1992). At the same time, however, recycling programs are costly. They require households to clean, sort, store and deliver recyclables. Furthermore, curbside recycling programs (CRPs) divert resources from other societal programs and services such as public education, highway maintenance, welfare programs, etc. Our goal in this paper is to provide a comprehensive measure of the social net benefits of curbside recycling, in order to help answer the often contentious question: "Should we be recycling?"

We have witnessed a renewed national debate regarding the efficacy of recycling in the wake of New York City's recent decision to suspend collection of plastics and glass.[1] Mayor Bloomberg's and the city council's decision appears to be based primarily on claims that the recycling of glass and plastics is cost ineffective (Johnson, 2002). Cost effectiveness is an understandable criterion for municipalities under tight fiscal budgets, given the absence of reliable estimates of the social benefits of recycling. However, by failing to assess both the social costs *and* benefits, we are left to wonder whether policymakers (such as New York's mayor and city council) are making socially efficient decisions.

This paper represents a first attempt at establishing an economic basis for making such decisions. On the benefit side, we use contingent valuation methods (CVM) and responses from over 4,000 households located in 40 metropolitan areas throughout the western U.S. to estimate willingness-to-pay (WTP) for CRPs.[2] A common criticism of CVM is that respondents tend to overstate their true WTP due to the hypothetical nature of the good and payment vehicle. Unlike previous CVM studies, we address this problem directly by estimating the magnitude of the potential hypothetical bias in our WTP data. The unique nature of our dataset and experimental design allows us to estimate this magnitude by contrasting stated-preference information (from CVM) with revealed-preference information from actual decisions made by households in communities with voluntary CRPs.[3] Using this estimate of hypothetical bias, we then calibrate the corresponding WTP estimates to the decisions made by households in a real market setting.[4]

On the cost side, we utilize information from a wide array of communities to obtain an estimated per-household economic cost of providing curbside recycling services. In calculating the costs of curbside recycling, we include both explicit variable and fixed costs, as well as the opportunity costs associated with diverting public resources away from their next most productive use.

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[1] New York City is not alone among large cities that are reevaluating the efficacy of their recycling programs. For example, Denver, CO is considering a drastic scaling back its curbside recycling program (Brovsky and Larson, 2003).
[2] Due to budget limitations, our population does not include the eastern U.S.
[3] "Voluntary" CRPs require households to pay only if they have signed up for the program while "mandatory" CRPs require all households to pay, irrespective of whether they have signed up or not.
[4] We use CVM to estimate benefits (rather than derive such measures using market prices and aggregate participation levels) because much of the data from established markets for voluntary curbside recycling are proprietary and also would not generally include information at the household level.

The next section presents a simple theoretical framework that describes the management of solid waste at both the household and community levels. This framework guides our ensuing empirical analysis. In section three, we introduce the data sources used in developing measures of economic costs and benefits. In section four, we present our econometric model for estimating WTP, including the methods used to mitigate hypothetical bias, and discuss our empirical results. In section five, we discuss the policy implications of our empirical findings and suggest some possible avenues for future research.

2. Theoretical Model

Our model involves an equilibrium relationship between households and a community planner, whereby households make utility-maximizing decisions in response to the planner's policies and the planner sets policy to maximize the well-being of the households. We begin with the household's problem.[5]

2.1. Households

Given the policy decisions of the community planner, household *i*, i = 1,…,n, is assumed to maximize utility by choosing recycling effort, e_i, and the composite good, z_i, subject to its budget constraint. Household solid waste, w_i, is generated as a function of consumption according to $w_i = \lambda z_i$, where $0 < \lambda < 1$. Preferences are given by

$$u_i = u(z_i, l_i, g_i, G; \theta_i) \tag{1}$$

where l_i is the fraction of non-market time spent in leisure, $g_i = w_i - r_i$ is the net amount of waste generated by the household, $G = \Sigma_i g_i$ is aggregate net waste generated in the community, and θ_i

is a vector of household-specific characteristics. There is a tradeoff between leisure and the effort required to clean, sort, store and deliver the recyclables (either to the curb or to a centralized dropoff site). We assume the tradeoff is given by $l_i = 1 - e_i$, where maximum leisure is normalized to unity. We also assume that *u* is strictly increasing in z_i and l_i, and weakly decreasing in g_i and G.[6] Similar to Andreoni's (1990) impure-altruism model, household *i* may receive private non-pecuniary (e.g., "warm glow") benefits from recycling due to a sense of ethical fulfillment (measured at the margin by $-u_g$), as well as public benefits associated with contributing to the community's aggregate level of recycling (e.g., helping to increase the landfill's lifespan), measured by $-u_G$. This creates a possible external effect since households have no apparent incentive to fully internalize the effect of their private recycling activity on the welfare of other households. The assumption of impurely altruistic households is based on our survey results showing that the primary motivation behind the decision to recycle for approximately 90% of the sampled households is "an ethical duty to help the environment". We discuss this issue further in Section 5.

We assume that curbside recycling effort transforms into recyclables according to the function $r_i = r(e_i)$ where $r(0) = 0$. The function *r* is assumed increasing and concave in e_i. Dropoff recycling involves an additional amount of effort, c_i, defined in terms of transportation costs. Therefore, dropoff-recycling effort will result in $r_i = r(e_i - c_i)$, where if $e_i < c_i$ then $r_i = 0$.

The household budget constraint is represented by

$$y_i \geq pz_i + \tau\phi_i \quad (2)$$

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[5] See Fullerton and Wu (1998) and Kinnaman and Fullerton (2000) for alternative general equilibrium models of recycling and other "green policies" at the household level.

[6] We further assume that conditions on *u* are such that sufficient second-order conditions for utility maximization hold, ensuring a well-defined solution.

where y_i is household income, p is z_i's corresponding price index, τ is the recycling fee, and ϕ_i is a binary variable equal to one if household *i* voluntarily signs up for a CRP (or is automatically signed up by virtue of a community mandate) and zero otherwise.[7]

In formulating its WTP for curbside recycling, the household first chooses its recycling effort to maximize (1) subject to (2) and the $r(e_i)$ transformation function. The solution to this problem can be used to derive the household's indirect utility function, $v_i = v(p, \tau, y_i, \theta_i)$.[8] Assuming v is strictly increasing in y_i, one can invert any reference v_i with respect to y_i to produce the household's expenditure function, $m_i = m(\theta_i, v_i)$, where *p* and τ are dropped for convenience. In this case, we set the reference indirect utility, v_i^0, equal to the maximum utility for a household that does not participate in a CRP. WTP for curbside recycling is then derived by subtracting the household's minimum expenditure given that it participates in the CRP from its minimum expenditure given that it does not participate:

$$WTP_i = m(\theta_i, v_i^0 \mid \phi_i = 0) - m(\theta_i, v_i^0 \mid \phi_i = 1). \tag{3}$$

In other words, WTP for household *i* is defined by the amount of income the household would willingly forego so as to participate in a CRP and maintain the original utility level v_i^0. The household's WTP for curbside recycling may be negative if the disutility of foregone leisure is sufficiently large relative to the utility gained from recycling.

[7] To keep the model simple, we abstract from the possibility that households save money by recycling – either by receiving direct revenue from the sale of dropoff recyclables (e.g., selling aluminum cans or newspapers) or by reducing the size of their garbage container. We note, however, that these features could be incorporated into the budget constraint in a straightforward manner.
[8] Details of the household's optimal choice of recycling effort are shown in an appendix, which can be found at www.uwyo.edu/aadland/research/recycle/appendix.pdf.

2.2. Community Planner

The community planner is responsible for managing municipal solid waste G by (a) selecting a type of CRP indexed by $j \in \{N,M,V\}$, where N, M and V refer to no, mandatory and voluntary curbside recycling respectively; and (b) selecting the household curbside recycling fee, τ. The planner is assumed to face a balanced-budget constraint[9]

$$n_j \tau = C(n_j, j) \tag{4}$$

where n_j represents the number of participants for CRP type *j* and C is the total economic cost of providing curbside recycling. The number of participants are $n_N = 0$, $n_M = n$, and $n_V = n^*$, where n is the number of households participating in the mandatory CRP and n* is defined by the number of households that satisfy $WTP_i \geq \tau$ under a voluntary program. C includes both explicit fixed and variable components, as well as the implicit costs associated with the foregone use of resources allocated toward a CRP (further discussion of these costs is provided in the next section). Based on interviews with community recycling coordinators and private contractors (discussed further in Section 3), we also assume that marginal cost (MC) is positive and constant across n_j. Thus, average total cost (ATC) is asymptotically coincident with MC.

The community planner then uses this benefit and cost information, along with budget-balance condition (4), to simultaneously determine whether to establish a CRP, and if so, which type and at what fee level. We begin by stating the condition required for the community planner to offer a CRP of either type M or V.

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[9] We recognize that economic efficiency requires that households be serviced up to the point where price equals marginal, rather than average, costs. We have chosen to focus on balance-budget pricing, however, for two reasons. First, municipal CRPs are commonly expected to be self-sustaining and thus not dip continuously into general tax revenues to cover costs (based on our own personal interviews with community recycling coordinators and private contractors for this study). Note that for mandatory programs, where all households are required to pay for the service, the CRP fee is simply a de facto form of lump-sum taxation and the natural fee is the one causing revenues to just match total costs. Second, we observe communities without mandated recycling goals choosing mandatory

CRP Condition I. Given (3) and (4), the community planner will offer a CRP of either type M or V, if and only if $\sum_{i=1}^{n} WTP_i \geq C(n, M) \Rightarrow \overline{WTP}^M \geq ATC(n, M)$ or

$\sum_{i=1}^{n*} WTP_i \geq C(n^*, V) \Rightarrow \overline{WTP}^V \geq ATC(n^*, V)$, where $\overline{WTP}^M$ and $\overline{WTP}^V$ denote the mean WTP for mandatory and voluntary communities, respectively.

In other words, the community planner will offer a CRP of either type M or V if the mean WTP exceeds the ATC (evaluated at the number of participating households) for that program type. Figure 1 depicts the geometry for CRP Condition I. The aggregate marginal surplus (AMS) curve, drawn linear for simplification, depicts the change in aggregate WTP as the number of households increases, beginning with the household with the largest WTP and ending with the household whose WTP is lowest.

The household fee for the voluntary program, τ_V, is determined by budget balance at the intersection between the AMS and ATC curves, which also determines the number of participating households, n*, and the total net community surplus, area A. In this case, the voluntary program passes CRP Condition I. A mandatory program charges a household fee of τ_M, which by the budget-balance condition is consistent with *n* participating households. The mandatory program also passes CRP Condition I if area A+B+C is larger than area F+G +H. Conversely, both voluntary and mandatory programs would fail CRP Condition I if, for example, the AMS curve lied everywhere beneath the ATC curve. In this case, no τ could be found to satisfy (4), and thus a CRP of neither type would be offered.

CRPs. Since we know there are households with WTP less than marginal costs, this suggests an objective other than economic efficiency (e.g., a balanced-budget criterion).

If CRP Condition I is satisfied, the community planner then determines which type of program to offer. The following condition gives the condition required for choosing a voluntary or mandatory CRP.

CRP Condition II. Assume CRP Condition I is satisfied. The community planner chooses a voluntary (mandatory) CRP if $\overline{WTP}^{V} - ATC(n^{*}, V)$ is greater (less) than $\overline{WTP}^{M} - ATC(n, M)$ with corresponding household fee τ_V (τ_M) satisfying (4).

In other words, a voluntary program is chosen over a mandatory program whenever the household fees and participation levels for the two programs are such that the net community surplus from the voluntary program is greater than that from the mandatory program.[10]

Figure 1 also depicts the geometry for CRP Condition II. Moving from a voluntary to a mandatory CRP, n* households obtain a net-surplus increase of area B, while n – n* households obtain a net-surplus change of area C – F – G – H. Therefore, if area B + C – F – G – H > 0, a mandatory program is chosen under CRP Condition II with fee τ_M; otherwise a voluntary program is chosen with fee τ_V. As shown in Figure 1, the probability that a voluntary CRP is chosen increases, all else equal, as the ATC curve becomes flatter. Alternatively, mandatory CRPs have a greater probability of being chosen at higher fixed-to-variable cost ratios.

In closing, our joint household-community planner model makes clear predictions about the social efficiency of various recycling options and enables us to predict which types of recycling programs should be observed in the different communities in our sample. Before making these

[10] CRP Condition II is therefore consistent with the Hicks-Kaldor compensation principle.

predictions, however, we first introduce the data sources used to estimate the costs and benefits of the various CRPs sampled from our population.

3. Cost and Benefit Data

3.1. Cost Data

Our CRP cost data was obtained from two sources: (a) interviews with community recycling coordinators and private contractors, and (b) published studies by the Institute for Local Self-Reliance (ILSR) (1991) and Franklin Associates, Ltd (1997). The ILSR study provides detailed cost information for Seattle, WA and West Linn, OR, while the Franklin Associates study provides information for Olathe, KS. From the recycling coordinators and private contractors, we obtained cost information for eight cities – seven communities in our sample and Portland, OR.[11] This information is shown in Table 1.

The costs are based on explicit fixed and variable expenses for collection and processing incurred during the most recent year available. They are reported on a per-household per-month basis in order to be directly comparable with our benefit information.[12] The costs have also been adjusted for cost-of-living differences across communities (MSN, 2003), and in the case of Seattle, West Linn, and Olathe appropriate adjustments for inflation have been made using the consumer price index (Bureau of Labor Statistics, 2003). In addition to the CRP costs, Table 1 also includes information on the number of participating households per year, percentage of the

[11] Cost information was unavailable for many of our sampled communities because it does not exist, cannot be extracted from overall waste-disposal cost information, or is proprietary.

[12] Costs are reported as an average cost over the lifetime of the program. This reflects the fact that recycling coordinators and contractors are generally required to report on an annual basis and that CRPs are generally associated with relatively long planning horizons (e.g., 10-20 years) over which up-front capital costs are spread. As a result, we do not attempt to calculate net present value estimates based on the specific periods in which the costs are incurred. Rather, we presume that the monthly cost estimates provided by the recycling coordinators accurately reflect what a community can expect to incur during any given month of any given year.

community's population participating, as well as indicators for whether the CRP is mandatory and whether household sorting of recyclables is required.

Several observations can be made from the information provided in Table 1. To begin, the estimated mean monthly cost per household across the eleven communities equals $2.93, with a coefficient of variation of 33%, implying a fairly tight distribution of cost estimates around the mean. Second, because each CRP in our sample is different in terms of items collected, collection frequency, whether it is a mandatory or voluntary program, degree of sorting required, etc., we are unable to identify a single underlying ATC curve. As a result, the numbers from Table 1 likely represent distinct points along several different ATC curves, rather than points along a single curve. Lastly, there seems to be a weak relationship between costs and whether the CRP is mandatory or voluntary. Five of the six most cost-efficient CRPs are voluntary.

3.2. Survey Data and Design

Turning to the benefit data, we conducted a random-digit dialed telephone survey regarding recycling behavior during the winter of 2002 to over 4,000 households in 40 western U.S. cities with populations over 50,000.[13] We chose an approximately even three-way split between communities with a voluntary, a mandatory and no CRP. We purposefully over-sampled households in communities with voluntary CRPs to allow for the detection of any hypothetical bias in the data. To supplement the household data, we also conducted a telephone survey of the recycling coordinators in each of the 40 cities in order to provide specific information on the attributes and history of recycling in their respective communities.

4. Econometric Methodology and WTP Estimates

In this section, we discuss (a) the double-bounded dichotomous-choice (DBDC) model used to obtain our welfare estimates, (b) the estimation results for overall WTP, (c) the identification and estimation of hypothetical bias across the different program types (i.e., M, V, and N), and (d) the calibration of the mean WTP estimates for a select group of cities.

4.1. Econometric Model

Our econometric approach follows Cameron and James (1987). WTP questions are set in the DBDC format to elicit a household's WTP through a sequence of dichotomous-choice questions. The first question is: "Would you be willing to pay $\$\nu$ for the service?" The opening bid ν is chosen randomly from a set of predetermined values.[14] Based on her response to the opening bid, the respondent is then asked a similar follow-up question, but with a larger bid value, 2ν, if she answered "yes" (i.e., she is willing to pay at least ν for the service) or a smaller bid, 0.5ν, if she answered "no" (i.e., she is unwilling to pay ν for the service).

Based on the responses to the opening bid and follow-up questions, the respondent's latent WTP may be placed in one of four regions: $(-\infty, 0.5\nu)$, $(0.5\nu, \nu)$, $(\nu, 2\nu)$ or $(2\nu, \infty)$. Unlike other CVM studies, we follow up with a third valuation question for those who respond "no" to the first two valuation questions: "Would you be willing to use the service if it were free of charge?" Previous experience with household recycling surveys suggests that some households have negative WTP values, or in other words need to be paid to participate in a CRP (Haab and

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[13] The survey was administered by the survey research laboratory at Washington State University. The response and cooperation rates were 27% and 49%, respectively. The survey instrument and a list of the 40 cities in our sample are available at www.uwyo.edu/aadland/research/recycle/datareport.pdf.

[14] The opening bids are chosen with equal probabilities from the set of integers two through 10. This set encompasses the range of household fees charged by the communities in our sample.

McConnell, 1997; Aadland and Caplan, 2003). As a result, our survey generates five rather than four valuation regions with ($-\infty$,0.5ν) being replaced by ($-\infty$, 0) and (0, 0.5ν).[15]

Turning to our econometric model, we specify a reduced-form version of (3) where the dependent variable is WTP_i and the explanatory variables $\mathbf{X}_i$ include the household-specific characteristics (θ_i) and various community-specific effects. A stochastic error term ε_i is added to capture the portion of WTP_i unexplained by $\mathbf{X}_i$, implying

$$WTP_i = \mathbf{X}_i\beta + \varepsilon_i , \qquad (5)$$

where β is a vector of coefficients. The variance of the error terms is assumed to follow

$$\sigma_i^2 = \exp(\mathbf{Z}_i\gamma) , \qquad (6)$$

where $\mathbf{Z}_i$ is a vector of variables (possibly intersecting with $\mathbf{X}_i$) and γ is a vector of parameters.

We further assume that the error terms are mutually independent and normally distributed. Letting $P_{i,j}$ indicate the probability that household *i*'s true WTP falls in the j^{th} region, the (log) likelihood function conditional on (5), (6), and the observed data is

$$\ln(L) = \sum_{i=1}^{n}\sum_{j=1}^{5}\omega_{i,j}\ln(P_{i,j}) , \qquad (7)$$

where $\omega_{i,j} = 1$ if the stated WTP value falls in the j^{th} region and 0 otherwise. The definitions of the explanatory variables used in equations (5) and (6) are provided in Table 2.

[15] Some respondents answered "Don't Know" to one or more of the valuation questions. For these households, their unknown WTP does not fit into one of the five categories, but instead overlaps one or more of the intervals. For example, if a respondent answered "Don't Know" to whether they would be willing to pay \$ν and "Yes" to whether they would be willing to pay \$0.5ν, we assume that their unknown WTP falls in the region (0.5ν, ∞). The likelihood function is adjusted accordingly.

4.2. Econometric Results

In columns two and three of Table 3, we report our DBDC estimates from maximizing (7) across all (N = 4012) households in our sample. First, note that the overall mean estimated WTP is approximately $5.35 per month.[16] This estimate is larger than those reported in Lake et al. (1996); approximately the same as in Caplan and Grijalva (2003); but smaller than those in Aadland and Caplan (2003) and Caplan et al. (2003).

Second, we find several individual- and community-specific characteristics that are significantly related to WTP for curbside recycling. To highlight a few, those willing to pay the most are (a) young; (b) female; (c) highly educated; (d) motivated to recycle because of an ethical duty to help the environment; (e) members of an environmental organization; (f) rated their current CRP as good or excellent; and (g) not needing to sort their recyclables. Many of these effects are similar to those found in Aadland and Caplan (2003). The likelihood ratio statistic used to test for overall goodness of fit is 883.27 with a 1% critical value equal to 156.65. Therefore, we reject the null hypothesis in favor of a significant amount of the variation in WTP being explained by household, community, and program attributes.

Third, we test for heteroscedasticity using (6). By construction of the bid design, BID is systematically related to the variance of the latent WTP errors. Recall that the opening bids are even integers between two and 10, with subsequent bids equal to either half or twice the opening amount. Therefore, the bid design generates larger WTP intervals (and thus more uncertainty regarding the true WTP) for higher opening bids. As expected, the coefficient on BID is positive and statistically significant at the 1% level. Furthermore, the likelihood ratio statistic used to test

[16]We have also tested for possible incentive incompatibility and starting-point bias using an approach originally suggested by Whitehead (2002) and later modified by Aadland and Caplan (2004b). We find evidence of starting-point bias but no incentive incompatibility. The mean WTP estimates for the two models (one controlling for

the null hypothesis that $\gamma = 0$ in (6) is 510.75 with a 1% critical value equal to 6.63. Therefore, we reject the null hypothesis in favor of heteroscedastic errors.

4.3. Calibrating WTP for Hypothetical Bias

The potential for hypothetical bias arises whenever people are asked to provide a maximum amount they are willing to pay for a good or service, even though they will not have to actually pay for it (cf., Arrow et al. 1993; Hanemann, 1994; Diamond and Hausman, 1994). We estimate the magnitude of the bias in each of our community types – voluntary, mandatory and no CRP – and calibrate the mean WTP estimates accordingly. In CVM it is typically not possible to estimate the magnitude of hypothetical bias because the good under question is not typically traded in an established market. Even if the good is traded in an established market, one needs sufficient variation in the price of both the hypothetical and actual goods. With this in mind, our experiment was designed to include two different groups (one making stated decisions and the other making revealed decisions) and price variation across both hypothetical and actual CRPs. This feature of our data enables us to estimate the magnitude of hypothetical bias for each of our community types. We begin with voluntary CRP communities.

4.3.1. Estimating Hypothetical Bias: Communities with Voluntary CRPs

We first extract two non-overlapping subsamples of households from the dataset: (a) households residing in communities with voluntary CRPs that made a *hypothetical* decision about whether to participate in their existing CRP at a randomly assigned initial bid and (b) households residing in communities with voluntary CRPs that have made an *actual* decision

starting-point bias and incentive incompatibility and one not) are very similar. As a result, we report the results from the latter model. The results from the former model are available from the authors upon request.

about whether to participate in their existing CRP. Households in the second subsample (N = 538) have revealed their preferences for curbside recycling, while households in the first subsample (N = 630) are simply stating their preferences for curbside recycling. The subsample of stated-preference households was restricted to those whose initial (cost-of-living adjusted) bids were between \$1.30 and \$4.94 per month in order to be directly comparable with the existing fees faced by the revealed-preference households.

Next, we pool these two groups together and estimate a probit model for the decision of whether to participate in a voluntary CRP, controlling for a host of household, program, and community attributes. We also allow the error variances to differ according to whether households are stating or revealing their preferences (Adamowicz et al., 1994). Our null hypothesis of no hypothetical bias is tested by observing the statistical significance of the coefficient on the dummy variable for whether the participation decision is hypothetical or real. If this coefficient is positive and statistically significant, we conclude that the typical household in a community with a voluntary CRP will, all else equal, tend to overstate their WTP for curbside recycling by the value of the coefficient. The estimation results for this model, shown in columns four and five of Table 3, indicate that hypothetical bias for households in voluntary CRP communities is nearly \$2 per month.[17]

4.3.2. Estimating Hypothetical Bias: Communities with a Mandatory or No CRP

Next, we estimate hypothetical bias for households residing in communities with either a mandatory or no CRP, using methods similar to those described above. In this case, the revealed-preference group includes all households residing in voluntary CRP communities with

[17] For more details about this method of detecting and estimating the magnitude of hypothetical bias see Aadland and Caplan (2004a).

existing (cost-of-living-adjusted) fees between $1.30 and $4.94 per month and that are aware of the program's existence, irrespective of the initial bid that they received (N = 994).[18]

There are two stated-preference groups in this case – those making hypothetical decisions about their mandatory CRP (N = 332) and those in communities without a CRP who are deciding about a hypothetical CRP described in the survey (N = 788). We then pool all three groups – the revealed-preference voluntary CRP group, the mandatory CRP group, and the hypothetical CRP group – and estimate a probit model to predict whether a household participates in a CRP. As before, we control for a wide variety of household, program and community attributes, and we allow error variances to differ by CRP type and whether the households are stating or revealing their preferences. Two variables of most interest are the binary ones for whether the stated-preference households are located in a community with either a mandatory or no CRP. If the coefficients on these dummy variables are positive and statistically significant, we interpret this as evidence of positive hypothetical bias. In other words, when faced with the decision of whether to sign up for a CRP, all else equal, households located in a mandatory or no CRP community that are making a hypothetical decision are more likely to do so (and consequently have a higher latent WTP) than those making an actual decision.

The results from this experiment, shown in columns six and seven of Table 3, indicate that hypothetical bias among households in mandatory and no CRP communities is $2.65 and $2.77 per month, respectively. As anticipated, the bias estimate for the typical household in a mandatory CRP community is lower (albeit slightly) than that for the no-CRP community, and both of these estimates are higher than that for the typical household in a voluntary CRP

[18] We estimate hypothetical bias for the mandatory and no CRP households separately from the bias in the voluntary CRP households because the revealed-preference group in this section is larger than that in Section 4.3.1.

community. This ordering suggests that the experience associated with voluntarily signing up for and/or using a CRP enables households to more accurately determine their true WTP.

4.3.3. Calibrated WTP

Using the hypothetical bias estimates from the previous two sections, we can adjust the mean WTP estimates, conditional on whether the household resides in a voluntary, mandatory, or no CRP community. Also, using city-level U.S. Census Bureau data (2000) we are able to adjust the estimates to better represent population demographics. Making adjustments for hypothetical bias and sampling error, we find that the average calibrated WTP value across the 40 communities in our sample is $2.92 (see bottom of Table 3). Table 4 provides additional details on the calibration process for the nine cities in our sample with available cost data and three randomly selected non-CRP cities. In terms of estimated WTP, these 12 cities are representative of our sample of 40 cities and highlight the diversity across communities. It is interesting to note that the estimated average monthly benefits per household from curbside recycling range from a high of nearly $5 in Tempe, AZ to a low of slightly more than $1 in Palo Alto, CA.

5. Policy Analysis and Conclusions

Remarkably, by comparing our mean calibrated WTP and cost estimates, we conclude that the social net benefits of curbside recycling are almost exactly zero. As a result, to determine whether it is an efficient use of society's resources, we need to evaluate curbside recycling on a city-by-city basis.

In Table 5, we take a closer look at the 12 communities included in Table 4. Calibrated WTP values from Table 4 and per-household costs from Table 1 are provided in columns 2 and 3.

Column 4 presents the corresponding social net benefits of curbside recycling, which vary greatly across the 12 communities. For example, monthly net benefits in Tempe, AZ are $3.27 per household, while in Palo Alto, CA they are -$3.08. At their current populations and rates of CRP participation, this amounts to annualized net benefits of $1.5 million in Tempe and nearly -$1.0 million in Palo Alto.

The last two columns of Table 5 compare the observed recycling programs with our theoretical/empirical predictions. The column titled "CRP Predictions" shows that five of the 12 communities satisfy CRP Condition I (i.e., social net benefits of curbside recycling are positive). Of these five, two communities have mandatory CRPs (Tempe, AZ and Longmont, CO), while the remaining three have voluntary CRPs. CRP Condition II predicts that Tempe and Longmont may have mandatory CRPs because of high fixed-to-variable cost ratios (relative to Orem, Wichita and Fargo). Unfortunately, we cannot test this hypothesis since we were unable to attain reliable fixed and variable cost information for Tempe and Longmont.

Of the seven communities that we predict should not have a CRP, three (Abilene, Peoria and Inglewood) represent correct predictions and four (Escondido, Olathe, Newport Beach and Palo Alto) do not. The most probable explanation for why Escondido, Newport Beach, and Palo Alto have chosen mandatory CRPs (when our estimates suggest that their social net benefits are clearly negative) is that California has implemented a state-mandated recycling goal. Recall that we have not incorporated mandatory recycling goals into our theoretical model.

In sum, using our theoretical model and estimates of net social benefits, we have correctly predicted the choice of whether or not to implement a CRP for 8 of the 12 selected communities. Furthermore, if Escondido, Newport Beach, and Palo Alto have in fact chosen mandatory CRPs in order to meet a state-mandated recycling goal, then we can explain all but one community's (Olathe, KS) choice of whether or not to provide a CRP.

Next, we highlight the main shortcomings of our approach. On the one hand, our mean WTP estimates may understate the social benefit of recycling if survey respondents are not fully internalizing the public benefits associated with recycling. As mentioned in Section 2, we have assumed that households are "impurely altruistic", in the sense that although they are motivated to recycle out of an "ethical responsibility to help the environment," they may not be fully internalizing the effects of their recycling effort on the welfare of other households located in their community. To the extent that each household values increased aggregate recycling, this may cause us to understate the social net benefit of recycling.

On the other hand, it is possible that we may be overstating the net benefits of curbside recycling. The issue of how to account for implicit opportunity costs through discounting is hotly debated (Hanley and Spash, 1993). We have tacitly assumed that the opportunity cost associated with diverting resources toward curbside recycling is the foregone interest income at the market interest rate, which in turn is assumed to equal the social discount rate. As a result, discounting completely offsets any accumulated opportunity costs. To the degree that the market interest rate exceeds the social discount rate, the social net benefit of recycling will diminish, possibly becoming negative. In other words, the explicit costs reported in Table 1 are assumed to be the full economic costs associated with curbside recycling.

In sum, despite the shortcomings mentioned above, this is the most comprehensive study to-date of the social efficiency of curbside recycling. The study covers approximately 20 western U.S. states, surveying over 4,000 households and recycling coordinators in 40 different communities. The benefit measure generated from the household survey is carefully calibrated for hypothetical bias by contrasting with the actual decisions of households residing in communities with voluntary CRPs. The economic cost of providing curbside recycling services is estimated from direct interviews with the recycling coordinators from cities within our sample and from previous research compiled by the U.S. EPA and ISLR. Remarkably, we find that, on average, the benefits and costs per household are almost exactly identical.

Although this finding lends scientific credibility to an often contentious national recycling debate, it does little to guide national opinion regarding the efficiency of municipal recycling programs. At a local level, however, our research suggests that the public policy choices are often much more clear. Cities with significantly positive net social benefits should be supporting curbside recycling programs while cities with significantly negative net social benefits should consider other waste management options. Toward that end, our research provides local policymakers within our population of western U.S. states the additional tools necessary to decide whether to implement or maintain a CRP. A natural next step would be to extend our research to the eastern U.S. where the constraints on landfill space are more binding, and to obtain more precise CRP cost data across a wider variety of communities. To accomplish this, more case studies of existing CRPs are required (along the lines of ILSR, 1991; U.S. EPA, 1994; Franklin Associates, Ltd., 1997; and Kinnaman, 2000). This would enable us to more accurately estimate the marginal and average costs of providing curbside recycling and to identify programs that are the most cost effective.

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Figure 1. CRP Conditions I and II.

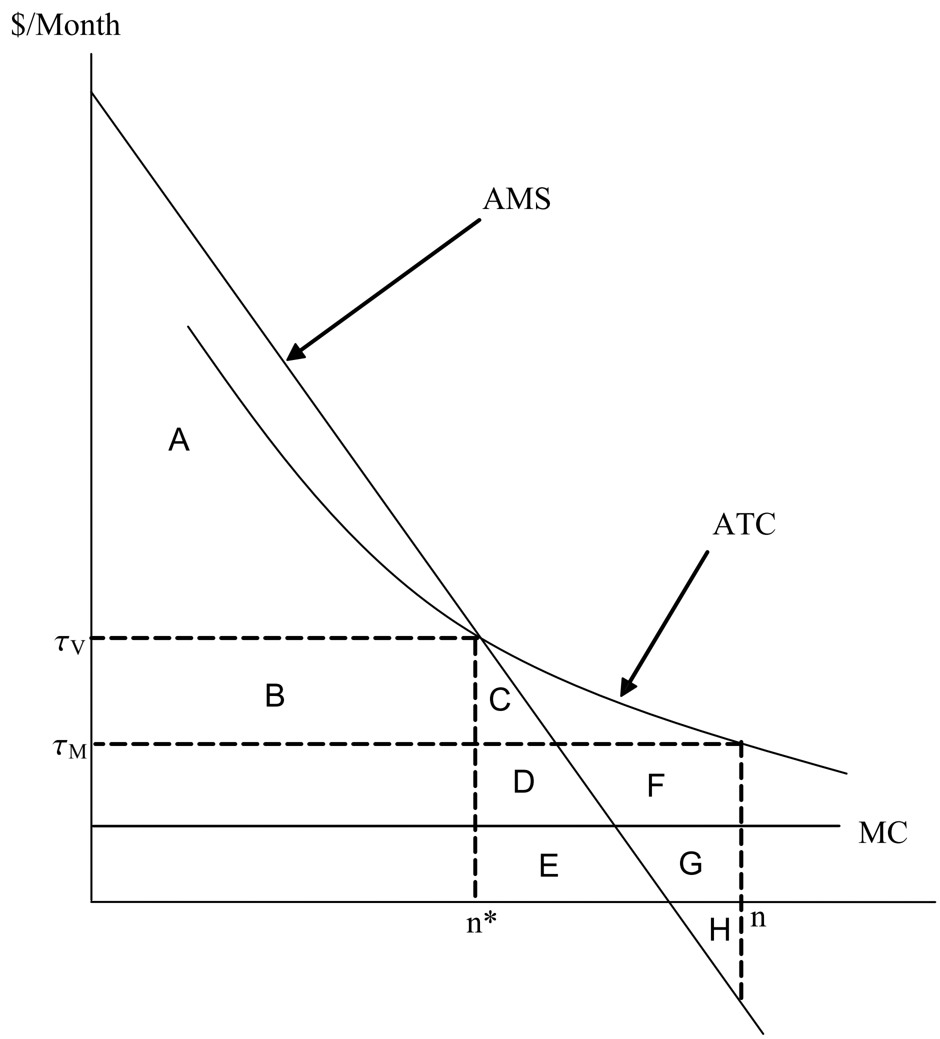

Table 1. Costs per Household and Other Characteristics for CRPs

City	Cost ($) per Household per Month	Number of Households Participating	Percent of Households Participating	Mandatory Program?	Household Sorting Required?
Tempe, AZ	1.62	38,000	60	Yes	Yes
Seattle, WA[e]	1.71	113,484	44	No	No[f]
West Linn, OR[e]	2.21	4,956	61	No	Yes
Fargo, ND	2.68	1,452	4	No	Yes
Orem, UT	2.78[b]	5,400	23	No	No
Portland, OR[c]	2.89	139,431	62	Yes	Yes
Longmont, CO	3.03[g]	22,950	86	Yes	Yes
Escondido, CA	3.16[b]	NA	NA	Yes	Yes
Newport Beach, CA	3.42	27,700	84	Yes	Yes
Olathe, KS[a]	3.58[b]	30,000	93	No	Yes
Palo Alto, CA	5.10[d]	25,216	100	Yes	No
Mean	2.93	40,859	61.7	---	---
Coefficient of Var.	0.33	1.15	0.50	---	---

Notes. [a]Based on figures provided by Franklin Associates, Ltd., "Solid Waste Management at the Crossroads," December 1997. [b]Since the revenues from the sale of recyclable materials were unavailable, we used the average revenue (adjusted for location) across communities that reported revenue sales. This amounted to $0.44 per household per month. [c]Based on figures provided by Neal Johnson, Recycling Coordinator, December 2002. [d]Includes once-a-month curbside collection of household hazardous waste and green waste. [e]Based on figures provided by ILSR (1991). [f]Approximately 56 percent of households (those located in the "north section" of the city) participate a commingled program, while the remaining 44 percent (located in the "south section") participate in a non-sorting program. [g]Processing costs are inferred using Franklin Associates, Ltd. (1997) at $1.53 per household per month (after adjusting for location and inflation). NA means "not available".

Table 2. Variable Definitions

Variables	Description
Ethical Duty	Do you feel an ethical duty to recycle to help the environment? 1 = yes, 0 = no.
Monetary	Are you motivated to recycle in order to save money? 1= yes, 0 = no.
Primarily Ethics	Which most encourages your household to recycle? 1 = ethical duty, 0 = save money.
Dropoff Distance	Distance in miles to the nearest dropoff site.
Dropoff User	In the past 12 months has your household used dropoff recycling? 1 = yes, 0 = no.
Young	1 if 18<Age<35, 0 otherwise.
Old	1 if 65<Age, 0 otherwise.
Male	1 = male, 0 = female.
High School	Highest level of education in household? 1 = high school graduate, 0 = otherwise
Associates	1 = associates degree, 0 = otherwise
Bachelors	1 = bachelors degree, 0 = otherwise
Masters	1 = masters degree, 0 = otherwise
Ph.D.	1 = Ph.D. or equivalent professional degree, 0 = otherwise
Household Size	Number of adults in household, other than the respondent.
Environmental Org.	Anyone in your household belong to an environmental organization? 1 = yes, 0 = no.
Med Income	1 if \$35K/yr<Household Income<\$75K/yr, 0 otherwise
High Income	1 if \$75K/yr<Household Income, 0 otherwise
Employed	Adult with the highest income currently employed? 1 = yes, 0 = no.
Retired	Adult with the highest income currently retired? 1 = yes, 0 = no.
Short Cheap Talk	1 = received short cheap-talk statement, 0 otherwise.
Longer Cheap Talk	1 = received longer cheap-talk statement, 0 otherwise.
Sorting Required	1 = CRP requires some sorting of recyclable materials, 0 otherwise.
Polite	1 if polite refusal for first call attempt, 0 otherwise.
Angry	1 if angry refusal for first call attempt, 0 otherwise.
Landfill Visit	Has anyone in your household visited your community's landfill? 1 = yes, 0 = no.
Landfill Distance	Distance to nearest landfill in miles.
Landfill Distance > 2 mi.	Distance above and beyond 2 miles to nearest landfill, 0 otherwise.
Hypothetical	1 = respondent valued a hypothetical CRP, 0 = otherwise.
Precision	On a scale of 0-100, how certain are you of the answers to your WTP questions?
English	Is English your first language? 1 = yes, 0 = no
Employer Recycle	Do you recycle at work? 1 = yes, 0 = no
Caucasian	What racial group best describes you? 1 = White or Caucasian, 0 otherwise
Hispanic	What racial group best describes you? 1 = Hispanic, 0 otherwise
African American	What racial group best describes you? 1 = Black or African American, 0 otherwise
Generation Link	Were you (or other adults in your house) raised in recycling households? 1 =yes, 0 = no
Neighbor Recycle	Do most of your neighbors currently recycle?
Years in Community	How many years have you lived in your community?
Number of Children	How many children under the age of 18 currently live in your home?
Attempt 1	Respondent available for survey after first dialing attempt.
Attempt 2	Respondent available for survey after second dialing attempt.
Fee Known	Respondent offer answer to how much household pays for current CRP? 1 = yes, 0 = no
Fee Difference	Stated CRP fee minus actual CRP fee.
CRP Performance	Job performance of your current CRP? 1 = excellent or good, 0 = fair or poor
Bid	Opening Bid υ

Notes. The description does not always exactly match the wording in the survey instrument. To see the exact wording, please refer to www.uwyo.edu/aadland/research/recycle/datareport.pdf.

Table 3. Estimation Results for WTP and Participation Models

Explanatory Variables[†]	DBDC WTP Estimates		Voluntary CRP Participation Probit Estimates		Mandatory/No CRP Participation Probit Estimates	
	Coefficient	P –Value	Coefficient	P –Value	Coefficient	P –Value
Ethical Duty	2.839***	0.000	3.299***	0.001	4.725***	0.000
Monetary	0.289	0.244	0.797	0.200	-0.626	0.264
Primarily Ethics	1.167***	0.000	0.924**	0.023	1.414***	0.003
Dropoff Distance	0.022	0.194	0.049	0.114	0.067	0.101
Dropoff User	-0.056	0.398	-0.203	0.289	-0.422	0.178
Young	1.507***	0.000	-0.681**	0.032	0.266	0.271
Old	-0.246	0.194	-0.464	0.184	-0.822*	0.096
Male	-0.557***	0.000	-0.238	0.171	-0.002	0.497
High School	0.512	0.138	0.044	0.484	1.150	0.160
Some College	0.643*	0.087	-0.254	0.407	1.196	0.150
Associates	0.276	0.291	0.243	0.413	1.542*	0.100
Bachelors	0.822**	0.039	0.522	0.313	1.803*	0.060
Masters	0.858**	0.039	0.969	0.193	2.199**	0.034
Ph.D.	1.518***	0.002	0.431	0.353	2.039*	0.053
Household Size	0.093	0.127	-0.026	0.424	0.026	0.438
Environmental Organization	1.319***	0.000	0.802**	0.039	1.567***	0.003
Med Income	-0.011	0.478	0.043	0.454	0.139	0.377
High Income	0.165	0.241	-0.060	0.440	0.484	0.159
Employed	3.732**	0.024	1.273**	0.041	0.246	0.364
Retired	0.161	0.331	1.381**	0.039	1.334*	0.054
English	0.777*	0.079	-1.111	0.230	-1.711	0.118
Caucasian	0.681***	0.005	-0.135	0.376	-0.645	0.116
Hispanic	0.215	0.278	-0.379	0.279	-0.919	0.124
African American	0.071	0.442	1.129	0.117	-0.071	0.473
Generational Link	0.181	0.120	0.238	0.186	0.547**	0.050
Neighbors Recycle	-0.220	0.155	---	---	---	---
Number of Children	-0.049	0.200	0.106	0.119	-0.048	0.327
Call Attempt #1	-0.182	0.183	0.492*	0.070	0.810**	0.024
Call Attempt #2	-0.477**	0.028	0.350	0.193	0.706*	0.080
Years in Community	-0.020***	0.000	-0.008	0.199	-0.007	0.267
Employer Recycle	0.005	0.490	0.186	0.281	0.884**	0.018
Polite	-0.698***	0.002	-0.487*	0.086	-0.895**	0.026
Angry	-0.394	0.323	-0.075	0.481	1.270	0.233
Precision	-0.013***	0.000	-0.003	0.301	-0.009	0.104

Table 3. Estimation Results for WTP and Participation Models (continued)

	Fee Known	-0.455**	0.015	1.094***	0.003	---	---
	Fee Overstated	0.069***	0.000	-0.013	0.235	---	---
	CRP Performance	2.027***	0.000	---	---	---	---
	Sorting Required	-0.261*	0.076	---	---	-1.140***	0.004
	Landfill Visit	0.029	0.435	0.132	0.325	0.089	0.402
	Landfill Distance	-1.731	0.117	0.211	0.147	0.570***	0.010
	Landfill Distance > 2 mi.	1.747	0.115	-0.234	0.136	-0.674***	0.005
	Short Cheap Talk	0.351**	0.021	1.301*	0.075	1.362**	0.031
	Longer Cheap Talk	0.694***	0.000	1.839**	0.024	2.307***	0.002
	CRP Community	-1.021***	0.000				
	Voluntary CRP Hypothetical Bias			1.967***	0.003		
	Mandatory CRP Hypothetical Bias					2.645**	0.017
	No CRP Hypothetical Bias					2.765***	0.000
Hetero.	Constant	1.798***	0.000	2.359***	0.000	2.828***	0.000
	Bid	0.190***	0.000	0.220*	0.058	0.158*	0.073
	Voluntary SP			2.428***	0.000		
	Mandatory SP					1.277**	0.013
	No CRP SP					1.050***	0.005
	Sample Size	4012		1168		2114	
	Mean WTP	5.368		---		---	
	Calibrated Mean WTP	2.922		---		---	

Notes. (***), (**), and (*) refer to statistical significance at the 1, 5 and 10 percent levels respectively. The estimates for the constant terms, community dummy variables, as well as the dummy variables for "don't know" and "missing responses" are not shown. †Although not explicitly listed as an explanatory variable, we control for BID in creating the probabilities that enter the likelihood function. See Cameron and James (1987) for further details.

Table 4. Calibrated WTP for Select Cities

City	CRP Type	Raw WTP Estimate	Hypothetical bias correction	Sample vs. population correction	Calibrated WTP Estimate
Tempe, AZ	M	7.57	-2.65	-0.03	4.89
Longmont, CO	M	7.21	-2.65	-0.02	4.54
Orem, UT	V	5.75	-1.97	+0.05	3.83
Wichita, KS	V	5.16	-1.97	+0.15	3.34
Fargo, ND	V	4.86	-1.97	+0.07	2.96
Abilene, TX	N	4.97	-2.77	+0.06	2.26
Palo Alto, CA	M	5.03	-2.65	-0.36	2.02
Olathe, KS	V	4.06	-1.97	-0.07	2.02
Peoria, AZ	N	4.81	-2.77	-0.02	2.02
Escondido, CA	M	4.58	-2.65	+0.04	1.97
Inglewood, CA	N	4.06	-2.77	+0.36	1.65
Newport Beach, CA	M	4.09	-2.65	-0.30	1.14

Notes: Mandatory and voluntary CRP cities were selected due to the availability of cost data. Three representative non-CRP cities were chosen at random. The correction for differences between the sample and population demographics includes the variables: gender, age, education, household size, income, primary language and race.

Table 5. City Comparisons of Net Benefits and Theoretical CRP Predictions

City	WTP	Cost	Net Benefit (WTP-Cost)	CRP Type	CRP Predictions
Tempe, AZ	4.89	1.62	3.27	M	CRP
Longmont, CO	4.54	3.03	1.51	M	CRP
Orem, UT	3.83	2.78	1.05	V	CRP
Wichita, KS	3.34	2.93[a]	0.41	V	CRP
Fargo, ND	2.96	2.68	0.28	V	CRP
Abilene, TX	2.26	2.93[a]	-0.67	N	No CRP
Peoria, AZ	2.02	2.93[a]	-0.91	N	No CRP
Escondido, CA	1.97	3.16	-1.19	M[b]	No CRP
Inglewood, CA	1.65	2.93[a]	-1.28	N	No CRP
Olathe, KS	2.02	3.58	-1.56	V	No CRP
Newport Beach, CA	1.14	3.42	-2.28	M[b]	No CRP
Palo Alto, CA	2.02	5.10	-3.08	M[b]	No CRP

Notes: (a) The overall mean cost estimate from Table 1. (b) Theoretical prediction does not account for state-mandated recycling goals.