

Waste Not or Want Not?

A Contingent Ranking Analysis of Curbside Waste Disposal Options

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Abstract

Recent growth in the municipal solid waste (MSW) stream nationwide has prompted considerable research into alternative waste management programs that would divert a portion of the MSW stream from landfills. Using a sample of 350 individuals from a random digit-dialed telephone survey, a discrete choice contingent ranking approach is used to estimate household's willingness-to-pay for various curbside trash-separation services in Ogden, Utah. Results indicate that Ogden residents are willing to pay approximately 3.7–4.6¢ per gallon of waste diverted for a curbside service that enables separation of green waste and recyclable material from other solid waste. Relative to costly waste diversion experiments conducted by other municipalities, the Ogden experience suggests contingent ranking is a cost-effective means for municipalities to evaluate waste disposal options.

JEL Classifications: C35, D12

1. Introduction

Recent growth in the municipal solid waste (MSW) stream nationwide has prompted considerable research into alternative waste management programs such as curbside recycling and unit-pricing for trash collection services. Economists have generally focused research efforts in two areas: (1) feasibility and effectiveness of unit pricing strategies and/or alternative waste disposal options, such as recycling, in satisfying a community objective of reduced landfilling; and (2) measurements of household benefits of curbside recycling. Choe and Fraser (1998) or Kinnaman and Fullerton (1999) provide excellent overviews of this literature.

Recently, Hong and Adams (1999) found that unit-pricing for waste disposal had limited effects on the amount of waste recycled and the amount of waste landfilled by Portland, Oregon residents. The authors conclude that if communities are interested in diverting large amounts of waste from landfills, a broad range of solid waste management alternatives such as varying container size, expanding the number of materials accepted for recycling, and “other non-price options” should be considered in conjunction with block-pricing. A similar study of unit-pricing effects was conducted in Marietta, Georgia (Nestor, 1998; van Houtven and Morris, 1999). Relative to the Portland experience, this experiment found a somewhat larger impact on waste reduction and recycling activities following the introduction of unit-based pricing.

Communities facing waste disposal constraints may wish to follow the Portland and Marietta examples by conducting large-scale waste disposal experiments. However, these experiments, which entail weighing curbside waste and recyclables for a representative sample of households over a time period that allows for seasonal variation in waste disposal, can be extremely expensive and time-consuming. While many communities face waste disposal constraints similar to Portland and Marietta, few have the resources necessary to evaluate waste management options using this methodology. Alternatively, communities may use techniques that are informative with respect to residents' support for waste disposal options yet are far less expensive relative to the Portland and Marietta experiments. In particular, communities can use referendum-based stated preference techniques to evaluate the range of waste disposal options under consideration. In keeping with the conclusions of Hong and Adams, the referendum survey should present respondents with alternative waste collection options that vary across price and non-price attributes.

This study reports on a contingent ranking study conducted by the city of Ogden, Utah, which at the time of the study faced tightening waste disposal constraints. Despite the presence of unit-based pricing, the city has recently faced the closing of its landfill and has experienced rapidly rising costs as it ships waste out-of-county on rail cars. City planners are therefore aggressively seeking ways to reduce the amount waste sent to the distant landfill. The Ogden City survey

presents respondents with a range of substitute trash collection options, all in the presence of the current unit-pricing program. The options are based on alternatives identified by the city as both fiscally and politically feasible. In addition to evaluating potential support for a curbside recycling program (an option often studied by scientists), the city is also considering options dealing with green waste, an overlooked portion of the waste stream despite its relatively large proportion (17%) of the national waste stream (EPA, 2001a and b). The empirical results suggest that this referendum-survey approach is a promising method for communities to evaluate the support for various MSW disposal options.

2. The Contingent Ranking Method

In contingent ranking (CR), individuals are asked to rank a discrete set of hypothetical alternatives from most to least preferred. Each alternative varies by price and a variety of other choice attributes. CR has been used to value a variety of environmental goods, including the demand for electric cars (Beggs, et al., 1981), improvements in river water quality (Smith and Desvovges, 1986), reductions for diesel odor (Lareau and Rae, 1989), and enhancements in biodiversity in British forests and woodlands (Garrod and Willis, 1997). To our knowledge, the present study is the first to use the CR method to estimate household valuation of curbside waste disposal.

The CR method can offer several advantages over contingent valuation. For example, Smith and Desvougues (1986, p. 145) note that “although rankings of contingent market outcomes convey less information than total values obtained by contingent valuation individuals may be more capable of ordering these hypothetical combinations than revealing directly their WTP for any specific change in these amenities.” Stevens, et al. (2000) echo this sentiment by pointing out that substitutes are made explicit in the CR method, which may encourage respondents to explore their preferences in more detail. In comparing the results from several CR methods, Boyle et al. (2001) find that respondents do not use ties in rankings formats. Boyle et al. (2001) suggest two reasons for this outcome: (1) respondents are making careful distinctions; or (2) respondents feel forced to rank each alternative. As long as respondents are asked to rank only a few familiar options, including the status quo, they are likely able to make careful distinctions. Respondents facing the dilemma of ranking too many options may simply determine the least and most preferred, and then randomly group the others in the middle (Smith and Desvougues, 1986). If, however, a respondent faces only three options, it is a relatively easy task for the individual to determine least and most preferred choices. By default, the remaining choice is the second-most preferred.¹

¹ In various contexts it has been shown that respondents rank inferior alternatives with less care (Hausman and Ruud, 1987; Ben-Akiva, et al. 1992; Layton, 2000). Accordingly, the reliability of ranking information decreases with decreasing rank.

The theoretical basis for analysis of preferences using CR data is similar to that of the discrete choice random utility model (RUM). Starting with a binary choice RUM, it is assumed that an individual i selects an alternative j that provides a utility level greater than any other alternative k :

$$U_{ij} > U_{ik} \quad \forall j \neq k. \quad (1)$$

The analyst does not know the individual's utility with certainty, so utility is treated as a random variable. Thus, the utility associated with each alternative is divided into a systematic component, V_{ij} , measurable by the analyst, and a random component, ε_{ij} ,

$$U_{ij} = V_{ij} + \varepsilon_{ij}. \quad (2)$$

V_{ij} may be interpreted as individual i 's indirect utility function resulting from his budget-constrained utility-maximizing choice of option j . This function is commonly specified as linear in parameters:

$$V(q_{ij}, c_{ij}, s_i) = \beta_0 q_{ij} + \beta_1 c_{ij} + \beta_2 s_i \quad (3)$$

where q_{ij} is the environmental attribute of option j that will be experienced by individual i , c_{ij} is the cost of option j to individual i , and s_i is individual i 's vector of demographic attributes. The β coefficients are the parameters to be estimated.

By making the distributional assumption that the random component, ε_{ij} , is independently and identically distributed (iid) with type I extreme value distribution, the probability of a choice can be expressed as logistic:

$$\text{Prob}[U_{ij} > U_{ik} \text{ for } j \neq k] = \frac{\exp(V_{ij})}{\exp(V_{ij}) + \exp(V_{ik})} \quad (4)$$

The binary choice specification in (4) can be extended to ranked data, where the utility level of a given alternative is preferred to all other remaining alternatives. For example, assume that information on the first choice among options $j = 1, 2,$ and 3 of respondent i indicates that i 's utility for the status quo option, U_{i1} , exceeds her utility from the remaining options in the choice set. The data provide a full set of rankings among the $J = 3$ options, so the probability model based on this ordered data yields the probability of the complete ordering,

$$\text{pr}[U_{i1} > U_{i2} > U_{i3}] = \prod_{j=1}^3 \left\{ \frac{\exp(V_{ij})}{\sum_{k=j}^3 \exp(V_{ik})} \right\}. \quad (5)$$

For example, if respondent 1 chooses the ranking $1 > 2 > 3$ and respondent 2 chooses the ranking $1 > 3 > 2$, then the corresponding probabilities of these rankings are,

$$\text{pr}[U_{11} > U_{12} > U_{13}] = \frac{e^{V_{11}}}{(e^{V_{11}} + e^{V_{12}} + e^{V_{13}})} \times \frac{e^{V_{12}}}{(e^{V_{12}} + e^{V_{13}})}, \quad (6a)$$

and

$$\text{pr}[U_{21} > U_{23} > U_{22}] = \frac{e^{V_{21}}}{(e^{V_{21}} + e^{V_{22}} + e^{V_{23}})} \times \frac{e^{V_{23}}}{(e^{V_{22}} + e^{V_{23}})}. \quad (6b)$$

The method of maximum likelihood is then used to find the coefficients of V that maximize the probability that a given respondent ranks the options in the order they were actually selected (e.g., that respondent 1 chose the ranking $1 > 2 > 3$, respondent 2 chose the ranking $1 > 3 > 2$, etc. across all respondents simultaneously). Whereas the estimated coefficients of V are constant across the entire sample, V_{ij} varies across each i and j because s_i varies across each i , and q_{ij} and c_{ij} vary across the ranked choice sets of each respondent.

Let options j be ordered such that $q_{i3} > q_{i2} > q_{i1}$ (i.e., option 3 provides a larger improvement in environmental quality than option 2, which provides a larger improvement than option 1). Further, option 3 costs more than option 2, which costs more than option 1 (i.e., $c_{i3} > c_{i2} > c_{i1}$). Then, individual i 's willingness to pay (WTP) for option $j \geq 1$, c_{ij}^* , is defined as the payment that just makes an individual indifferent between the two options:

$$V(q_{ij}, c_{ij}^*, s_i) - V(q_{i1}, c_{i1}, s_i) = dV_{ij} = \hat{h}_{ij} \quad (7)$$

where $\hat{h}_{ij} = \varepsilon_{i1} - \varepsilon_{ij}^*$; the error term ε_{ij}^* merely signifying that V_{ij} is evaluated at c_{ij}^* rather than at c_{ij} . Given the distribution of ε_{ij} , the distribution of \hat{h}_{ij} also has mean zero and constant variance.

Following Garrod and Willis (1997) and Lareau and Rae (1989), we assume a linear specification of utility with various interaction terms.

Specifically, we assume that:

$$V_{ij} = \beta_0 q_{ij} + \beta_1 c_{ij} + \sum_m \beta_m (q_{ij} s_{im}) + \sum_n \beta_n (c_{ij} s_{in}) + \varepsilon_{ij} \quad (8)$$

where β_0 and β_1 are constant parameters; β_m and β_n are mutually-exclusive sets (each of any size) of constant parameters that are keyed to corresponding, possibly non-mutually exclusive sets of household demographic attributes s_{im} and s_{in} . Thus, the terms $(q_{ij} s_{im})$ and $(c_{ij} s_{in})$ in (8) form sets of interaction terms between various demographic attributes of the respondents and the environmental attributes and costs of the options, respectively.

Totally differentiating (8), defining dc_{ij}^* as the difference between c_{ij}^* and c_{ij} (WTP net of current waste disposal costs) and using the fact that $E(\eta_{ij}) = 0$, we derive the following welfare measure for this study:

$$E\left(\frac{dc_{ij}^*}{dq_{ij}}\right) = -\frac{\beta_0 + \sum_m \beta_m s_{im}}{\beta_1 + \sum_n \beta_n s_{in}}. \quad (9)$$

Expression (9) is used to directly estimate the marginal WTP for individual i with respect to a change in the environmental attribute away from option 1 (status quo), or the mean marginal WTP for a unit of MSW directed away from the landfill. Note that interactions between cost of program j (c_{ij}) and demographic characteristics for person i (s_{in}) affect the denominator of the WTP expression in equation (9). The denominator can be interpreted as the marginal utility of income, so that the demographic interactions allow the marginal utility of income to vary across respondents. Similarly, the numerator can be interpreted as the

marginal utility of environmental quality (waste diverted). The quality-demographic interactions (s_{im}) in the numerator thus allow the marginal utility of environmental quality to differ across respondents.

3. Survey Methods and Data

Over the past five years, Ogden City has aggressively researched waste management alternatives. The motivation for its research is tied to the city's rapid population growth, the recent closure of its landfill, and increasing shipping and tipping fees.² In early 1997 Ogden City's Public Works Department (OPWD) began developing alternative waste management options for consideration by the city council. As part of these efforts, residents' WTP for a hypothetical curbside recycling program were elicited in a telephone survey. As reported in Aadland and Caplan (1999), mean WTP for curbside recycling was estimated to be \$2.05 per household per month.

In July 2000, under the direction of a newly elected city council and mayor, OPWD conducted another random-digit-dialed telephone survey of Ogden

² Until its closure, the Weber County Landfill serviced 165,000 county residents, accepting approximately 180,000 tons per year of solid waste; this tonnage represented an average annual increase in the quantity of disposed solid waste since 1991 of approximately 4.4% (SCS Engineers, 1996). From 1990 to 1996, the county tipping fee had risen an average of approximately 21% per year (Ogden City Public Works Department, 1998). The city currently ships all waste by railway approximately 150 miles to a landfill in Central Utah.

residents. The survey, administered to 401 randomly selected households in July 2000, asked respondents to rank-order their preferences over a discrete set of three curbside waste pickup options.³ Each option differed by cost and the level of curbside services. Option 1 was the status quo: continued weekly pickup of garbage without curbside recycling at a unit cost of \$10.65 per 90-gallon cart per month with no additional curbside services. Option 2 added green waste pickup for nine months of the year, at a maximum additional cost of \$2.00 per month. Under this option households would not be required to place green waste at the curb; if approved, however, the fee would be mandatory for all households. Finally, Option 3 included curbside garbage and green waste, and added a curbside recyclables pickup option. Relative to the status quo, Option 3 would cost households a maximum additional \$3 per month. Similar to Option 2, the fee would be mandatory for all households but participation would be voluntary. The exact text of the program descriptions can be found in Table 1.

[INSERT TABLE 1 HERE]

It is important to emphasize that the options presented to survey respondents were *exactly* those options under consideration by OPWD and the

³ The survey was sponsored by Ogden City and designed with the help of a private survey firm. Unfortunately the survey research firm did not maintain call disposition records thus making it impossible to calculate a response rate. The authors were asked by OPWD to estimate willingness to pay, with the results later used in a final assessment of the waste disposal options.

Ogden City Council. The elements of each option—the number and type of waste receptacles, the necessary waste separation actions by Ogden residents, program cost, and quantities of green waste and/or recyclables diverted—were based on OPWD research. The three options selected for the survey were regarded by OPWD as the most fiscally and politically feasible waste management alternatives among a broad range of possibilities. Further, respondents were told the survey was sponsored by Ogden City and OPWD and that the results would be formally presented to the Mayor and the City Council. Finally, Ogden area media had in the past reported extensively on the landfill closure and the rapid increase in tipping fees. Thus, it is likely that respondents perceived a degree of “realism” in the Ogden City survey that most stated preference studies are unable to achieve.

This “realism,” while useful from a sampling and cognitive perspective, comes at an econometric cost. First, the program price is fixed for each option and thus fails to establish price variation across respondents as usually obtained in a standard stated preference survey. We can, however, take advantage of Ogden City’s current unit-pricing structure (\$10.65 per 90-gallon cart) to introduce additional variation in the cost of Options 2 and 3. Some 17% of survey respondents put out two or more 90-gallon garbage carts each week. A survey question asked these respondents if they would place fewer garbage carts at the curb should they be provided with a second cart to be used for green waste and/or recycling. Some 24% of these individuals (about 4.2% of our final sample) said

that they would be able to use one less garbage cart. The net cost of the proposed options for these respondents is negative because the added cost of the Green Waste and Green Waste/Recycling programs is less than the savings from averted garbage disposal. Thus, program prices for these households were $-\$8.65$ ($\$2$ minus $\$10.65$) and $-\$7.65$ ($\$3$ minus $\$10.65$) for Options 2 and 3, respectively.

A second place in which the “realism” of the survey has an econometric cost is in the environmental quality variable. OPWD determined that approximately 26% of Ogden’s total residential solid waste stream could be reduced under Option 2 (green waste only), with an additional 13% potentially diverted under the green waste and recyclables Option 3 (OPWD, 2000). Similar to the lack of variation in the price attribute, the environmental quality indicator (i.e., percentage of waste diverted) is not randomized across respondents. Additional data collected by the survey, however, allow us to characterize respondents according to the size of the desired cart if the current garbage-only collection program were continued.⁴ The selected cart size (60 gallons, 90 gallons, 110 gallons, or two 90-gallon carts) approximates the current amount of waste generated by each household; the potential amount of waste diverted for each household can then be calculated. For example, under the green waste only

⁴ Respondents were told that if the current curbside “garbage-only” program were continued, they may be permitted to select different cart sizes. The cart size indicated by the respondent is used to approximate current household waste generation.

program (Option 2), a household currently needing a 60-gallon cart could divert up to 15.6 gallons of green waste per week (0.26×60), whereas a household needing a 90-gallon cart could divert up to 23.4 gallons per week (0.26×90). A description of the explanatory variables ultimately used to estimate the empirical models, along with their corresponding sample means and standard deviations, are provided in Table 2.⁵

[INSERT TABLE 2 HERE]

4. Empirical Results

A total of 350 respondents provided useful ranking data.⁶ The frequency of ranking alternatives is presented in Table 3. Option 1 (garbage-only pickup) is most preferred by 33% of respondents, Option 2 (garbage and green waste pickup) is most preferred by 17% of respondents, and Option 3 (garbage, green waste, and recyclables pickup) is most preferred by 50% of respondents. The data

⁵ The sample is reasonably representative of the Ogden population with respect to gender, although we have slightly greater percentages of persons more than 45 years old (46% sample vs. 28% census), college graduates (36% sample vs. 23% census), and high income households (33% sample vs. 22% census), where the census figures are based on the 2000 Census of Population.

⁶ Of these 350, some 58 did not report income. Income for these respondents is estimated using an ordered probit model that related income to demographics for the remainder of the sample. This model is reported in Appendix A.

also reveal that a significant proportion of the population would prefer alternative waste disposal options relative to the status quo in that 52% identified Option 1 as their least preferred option. In contrast, some 38% stated that Option 3 was least preferred.

[INSERT TABLE 3 HERE]

Results for four alternative specifications of the CR model are presented in Table 4. The models differ according to the way in which the demographic variables are interacted with the cost or environmental quality variables. Model I—our benchmark—does not include any interaction terms, Model II includes interactions between cost and demographics (thus allowing the marginal utility of income to vary), and Model III includes interactions between the amount of waste diverted and demographic characteristics (allowing the marginal utility of waste diversion to vary). Model IV includes all interactions, and allows both marginal utilities to vary across respondents.

[INSERT TABLE 4 HERE]

Model I is the simplest specification, including only the *Program Cost* and *Waste Diverted* variables. The coefficient on *Program Cost* is negative and statistically significant at the 0.05 level, indicating that as the price of a given option rises (all else equal), the probability that the status quo option will be most-preferred increases. The coefficient on *Waste Diverted* is positive and significant at the 0.01 level, indicating that (all else equal) as potential waste diversion by

households rises, the probability that the Green Waste/Recycling option will be most-preferred increases. Both of these signs conform to expectations derived from economic theory. Overall the equation is statistically significant, with the Wald test statistic (66.01) indicating that the hypothesis that all coefficients equal zero can be rejected at the $\alpha = 0.01$ critical value (9.21, 2 degrees of freedom).

In Model II, individual demographic characteristics are interacted with *Program Cost*. In general, a negative sign indicates that, for any given program cost, a respondent with the given characteristic is more likely to rank the status quo program as most-preferred than a respondent not sharing the characteristic. A positive sign indicates the respondent with this characteristic is more likely to rank the Green Waste/Recycling option as most preferred relative to those who do not share the characteristic. For the program cost-income interaction variables appearing in Model II, economic theory suggests that the sign of the coefficients on these variables be positive and that the sign for high-income respondents be greater than that for medium-income respondents, and that both be greater than that of low-income respondents. This coefficient pattern would indicate a diminishing marginal utility of income and, all else equal, greater WTP as income rises.⁷

⁷ For other demographic variables, economic theory does not provide testable hypotheses. Past research, however, has indicated that such factors influence participation in waste

The Model II results generally conform to theoretical expectations. Individually, the *Program Cost* and *Waste Diverted* variables are negative and positive, respectively, but only *Waste Diverted* is statistically significant ($P < 0.01$). The income variables that are interacted with *Program Cost* are positive; the coefficients demonstrate that mid-income respondents have lower marginal utility of income relative to low- and high-income respondents. With respect to other demographic characteristics, the *Program Cost* interactions with gender (*Male*), age (*>45 Years Old*) and community tenure (*Live >10 Years in Ogden*) show that respondents with any of these characteristics are more likely to rank the status quo as the most-preferred option, all else equal, relative to those who do not share the given characteristic. Respondents living in the north sector of the city are also more likely to rank the status quo as most preferred.⁸ Conversely, those who feel that *GW/Recycling is Beneficial* were more likely to rank the Green Waste/Recycling program as most preferred. Overall, the equation is highly

management programs and hence, willingness-to-pay. See, for example, Granzin and Olsen (1991); Oskamp et al. (1991); Jakus, et al. (1997); and Aadland and Caplan (1999).

⁸ The city was divided into quadrants using two major thoroughfares as axes, with a representative number of households were drawn from each quadrant. Demographic and socio-economic census information was not used to determine quadrant boundaries, thus making the interpretation of this result difficult.

significant, with the Wald test statistic (396.39) exceeding the $\alpha=0.01$ critical value (23.21, with 10 degrees of freedom)

The interaction effects of Model III are between the environmental quality variable, *Waste Diverted*, and the demographic characteristics. Coefficients are interpreted in a manner similar to the interactions terms of Model II. For any given amount of *Waste Diverted*, a negative coefficient for an interaction term indicates that a respondent with the given characteristic is more likely to rank the status quo option as most preferred relative to a respondent not sharing that characteristic. A positive sign indicates a greater probability of ranking the Green Waste/Recycling program as most preferred. Economic theory suggests that we should observe a negative sign on *Program Cost*, a positive sign on *Waste Diverted*, and positive signs on the income-*Waste Diverted* interactions.

The empirical results for Model III suggest that Ogden residents conform to theoretical expectations. The income-*Waste Diverted* interaction terms are both positive and highly significant. *Program Cost* is negative and significant. With respect to other demographic characteristics, again gender (*Male*), age (*>45 Years Old*) and community tenure (*Live >10 Years in Ogden*) are negative and statistically significant. The interaction with higher education (*College*) is also negative and significant. As in Model II, respondents living in the north sector of the city are also more likely to rank the status quo as most preferred, while those who believe *GW/Recycling is Beneficial* are more likely to rank the Green

Waste/Recycling program as most preferred. Overall the equation is statistically significant, with the Wald test statistic (310.55) exceeding the $\alpha = 0.01$ critical value (23.21, 10 degrees of freedom).

The final specification (Model IV) includes all interaction effects. Once again, *Program Cost* is negative and highly significant whereas *Waste Diverted* is positive and significant. It is difficult to interpret the effect on program ranking of any given demographic characteristic because the characteristic appears twice in the specification. As indicated in Equation (8) the overall effect on the utility of any option is a combination of the impacts of the characteristic on the marginal utilities of income and environmental quality. Overall, the equation is statistically significant, with the Wald test statistic (512.67) exceeding the $\alpha = 0.01$ critical value (34.81, 18 degrees of freedom).

A major concern with the contingent ranking model under the logit specification used in the empirical models is the assumption of independent and identically distributed (iid) errors and the independence of irrelevant alternatives (IIA) restriction that flows from the logistic specification. These assumptions were tested, with the detailed results reported in Appendix B. The first hypothesis test supported the pooling of the rank ordered data into a single model, i.e., the iid assumption is tenable. The second test failed to reject the hypothesis that IIA holds for the full choice set.

Equation (9) can now be used to calculate estimates of marginal WTP for each gallon of MSW diverted from the landfill. Marginal WTP estimates are presented in Table 5, where the point estimates range from 3.7¢ per gallon (Model II) to 8.5¢ per gallon (Model III). Models I and III provide the highest per gallon estimates of marginal WTP (7.9¢ and 8.5¢ per gallon, respectively). Models I, II, and III are less desirable than Model IV, however. Model I fails to include demographic interactions that the other model specifications suggest are important, and Model II has a statistically insignificant price effect. A likelihood ratio test of Model IV against each of its nested alternative specifications suggests that this model explains a greater proportion of the variation in the data. This model generated a marginal WTP estimate (4.6¢ per gallon) with a relatively narrow confidence interval of 3.1¢–6.1¢ per gallon. If this marginal WTP measure can be extrapolated to the maximum household waste diversion under each program, monthly household WTP is estimated to be \$3.27 to \$4.91 for the Green Waste program and \$6.44 to \$9.66 for the Green Waste/Recycling program evaluated at the mean.

[INSERT TABLE 5 HERE]

5. Conclusions

The contingent ranking survey conducted by Ogden City aided city planners in evaluating potential waste management options. At its most basic level, the city was able to gauge the overall level of community support for its two

most fiscally and politically viable alternatives to the status quo. Approximately 67% of respondents supported some degree of expansion in curbside disposal services, with 17% favoring the Green Waste only program and 50% favoring the combined Green Waste/Recycling program.

The contingent ranking models also identified how respondent characteristics influence support for waste management alternatives. Males, those more than 45 years old, and residents who had resided in the city for more than 10 years were more likely to state that the status quo “garbage-only” option was most preferred. Females, those less than 45 years old, and residents relatively new to the community were more likely to support the combined Green Waste/Recycling option. Those with mid- to high-incomes (greater than \$30,000 annually) were more likely to state that the combined Green Waste/Recycling option was most preferred, whereas low-income respondents (less than \$30,000 annually) were more likely to state that the garbage-only option was most preferred. Finally, the contingent ranking models were used to estimate the marginal WTP for a unit of waste diverted from the landfill. The model explaining most of the variation in the data resulted in a marginal WTP estimate of 4.6¢ per gallon of waste diverted.

Other communities may follow the Ogden example by conducting a similar survey of residents. Surveys such as that conducted by Ogden City can, relatively cheaply, generate a wealth of information regarding community support for and willingness to pay for alternative MSW programs. The approach is not

without its disadvantages, however. A key component of the Portland and Marietta household waste studies was the measurement of the actual quantity of waste diverted by the unit-pricing structure. In contrast to these actual diversion measurements, the contingent ranking approach presented here measures only *potential* waste diversion. Thus, communities seeking to evaluate waste management alternatives must think carefully about the type of information needed to make a decision among the alternatives.

For the city of Ogden, the information derived from the contingent ranking survey was sufficient to make a decision among the proposed waste disposal services. City officials interpreted the results as providing strong evidence in support of some alternative to the garbage-only status quo, yet the 50% preference for the combined Green Waste/Recycling option did not provide a mandate for the combined program. The city ultimately decided to provide curbside recycling in combination with an expanded drop-off green waste program. Households may co-mingle recyclables in a single 96-gallon cart and place the cart at their curb. The monthly fee per household for curbside recycling has been set at \$1.85. However, the city is also offering a smaller 64-gallon garbage cart that effectively reduces the monthly cost of recycling to \$0.25 for those households that are able to switch from the current 90-gallon cart.

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Table 1. Text of Waste Management Options Described in Telephone Survey

Ogden City is interested in having residents evaluate the existing garbage collection program and the possibility of adding recyclable and green waste collection services. Residential solid waste includes green waste, recyclable, and other garbage.

As you may know, Green Waste makes up about 26% of Ogden's total residential solid waste. It includes grass clippings, leaves, branches, and other yard trimmings. Green waste could be hauled to the Weber County Compost Facility and reused instead of being taken to the landfill and buried, as we do now.

Recyclables make up about 12-14% of the total residential solid waste collected by Ogden City. Ogden City is considering collecting the following types of recyclables: aluminum/tin cans, types 1 and 2 plastics, newspaper, magazines, and cardboard. Recyclables would then be re-used instead of being taken to the landfill and buried.

Ogden City is considering changing its curbside garbage collection program by asking residents to separate recyclables and green waste from other garbage.

Both would be collected curbside. The curbside green waste service would be provided nine months of the year, from March through November.

I would like to read you the three options and have you rank these options from your most favorite to your least favorite:

Option 1:

- Continue with our current waste collection system, where all residential solid waste is placed in one cart without any separation of recyclables or green waste from other garbage.
- All material would be taken to the landfill
- Only one cart would be used
- Cost would remain at \$10.65 per month

Option 2:

- Residents would separate Green Waste ONLY.
- Recyclables and garbage would both be taken to the landfill.
- Two carts would be used.
- Cost would increase to approximately \$12.15 to \$12.65 per month

Option 3:

- Residents would separate Green Waste and recyclables from other garbage.

- Only garbage would be taken to the landfill.
 - Two carts would be used.
 - Cost would increase to approximately \$13.15 to \$13.65 per month.
-

Table 2. Variable Names and Descriptions

Variable	Description	Mean (standard deviation) ^a
<i>Choice specific attributes</i>		
<i>Program Cost</i>	The difference between the price of option 1 and prices of options 2 and 3 for household <i>i</i> .	\$1.362 (2.050)
<i>Waste Diverted</i>	The amount (in gallons per month) of solid waste directed away from the landfill by household <i>i</i> .	87.979 (76.863)
<i>Individual characteristics</i>		
<i>Mid-Income</i>	Dummy Variable—1 indicates that a respondent's income level is \$30,000–\$49,999.	0.394 (0.489)
<i>High-Income</i>	Dummy Variable—1 indicates that a respondent's income level is above \$49,999.	0.329 (0.470)
<i>Male</i>	Dummy Variable—1 indicates that the respondent is	0.489

	male.	(0.500)
<i>>45 Years Old</i>	Dummy Variable—1 indicates that the respondent is 45 years and above.	0.463 (0.499)
<i>Live >10 Years in Ogden</i>	Dummy Variable—1 indicates that the respondent has lived in Ogden for 10 or more years.	0.694 (0.461)
<i>College</i>	Dummy Variable—1 indicates that the respondent has a college degree.	0.357 (0.479)
<i>GW/Recycling is Beneficial</i>	Dummy Variable—1 indicates that a respondent believes that recycling and separating green waste from other solid waste material is very beneficial to the community.	0.600 (0.490)
<i>North</i>	Dummy Variable—1 indicates that a respondent resides north of 20 th Street in Ogden, Utah	0.486 (0.500)

^a Number of observations = 350.

Table 3. Frequency of Ranked Options

Ranking by Option Number ^a	Frequency	Percent
1 > 2 > 3	102	29
1 > 3 > 2	12	4
2 > 1 > 3	32	9
2 > 3 > 1	28	8
3 > 1 > 2	21	6
3 > 2 > 1	155	44

^a Refer to Table 1 for a description of each option number.

Table 4. Empirical Results from Ranked-Ordered Logit Models (350

observations)

Variable	Model I	Model II	Model III	Model IV
<i>Choice specific attributes</i>				
<i>Program Cost</i>	-0.051**	-0.098	-0.052*	-0.277**
	(-2.048) ^a	(-1.294)	(-1.874)	(-1.953)
<i>Waste Diverted</i>	0.004**	0.007***	0.005***	0.011***
	(7.619)	(11.729)	(3.175)	(3.997)
<i>Attributes interacted with demographic characteristics</i>				
<i>Program Cost × Mid-Income</i>		0.117**		-0.139
		(2.015)		(-1.563)
<i>Program Cost × High-Income</i>		0.084		-0.367***
		(1.370)		(-4.007)
<i>Program Cost × Male</i>		-0.206***		0.126*
		(-4.440)		(1.726)
<i>Program Cost × >45 Years Old</i>		-0.244***		-0.524***
		(-5.197)		(-6.936)
<i>Program Cost × Live >10 Years in Ogden</i>		-0.129***		0.208**
		(-2.515)		(2.009)

<i>Program Cost</i> × <i>College</i>	0.028	0.672***
	(0.561)	(7.012)
<i>Program Cost</i> × <i>GW/Recycling is</i>	0.539***	0.529***
<i>Beneficial</i>	(11.905)	(7.687)
<i>Program Cost</i> × <i>North</i>	-0.395***	-0.454***
	(-8.727)	(-7.181)
<i>Waste Diverted</i> × <i>Mid-Income</i>	0.004***	0.006***
	(3.039)	(3.159)
<i>Waste Diverted</i> × <i>High-Income</i>	0.006***	0.013***
	(4.895)	(6.767)
<i>Waste Diverted</i> × <i>Male</i>	-0.005***	-0.007***
	(-4.638)	(-4.823)
<i>Waste Diverted</i> × <i>>45 Years Old</i>	-0.005***	0.005***
	(-5.030)	(2.944)
<i>Waste Diverted</i> × <i>Live >10Years</i>	-0.002**	-0.008***
<i>in Ogden</i>	(-2.305)	(-3.773)
<i>Waste Diverted</i> × <i>College</i>	-0.003***	-0.015***
	(-2.988)	(-7.996)
<i>Waste Diverted</i> × <i>GW/Recycling</i>	0.011***	0.002
<i>is Beneficial</i>	(11.344)	(1.612)

<i>Waste Diverted</i> × <i>North</i>			−0.006***	0.001
			(−6.660)	(0.492)
<hr/>				
Total Log Likelihood	−611.75	−554.22	−555.30	−534.66
Wald Test (all $\beta = 0$)	66.01	396.39	310.55	512.67
<hr/>				

^a T-statistics in parentheses. *, **, *** indicate coefficient significant at 0.10, 0.05, and 0.01 levels, respectively.

Table 5. WTP per Gallon of Waste Diversion

Model	\$/gallon (standard error) ^a	95% Confidence Interval lower, upper
I	\$0.079 (0.034)	\$0.012, \$0.147
II	\$0.037 (0.004)	\$0.028, \$0.046
III	\$0.085 (0.039)	\$0.006, \$0.164
IV	\$0.046 (0.007)	\$0.031, \$0.061

^a Standard errors calculated using the Delta Method Approximation (Greene, 1997).

Appendix A

Income Model (Ordered Probit)

Variable	Coefficient
<i>Intercept</i>	-1.330*** (-4.885)
<i>Male</i>	0.247*** (3.334)
<i>College</i>	0.613*** (8.049)
<i>Age</i>	0.123*** (10.077)
<i>Age Squared</i>	-0.001*** (-10.852)
μ_1	0.787*** (13.727)
μ_2	1.455*** (21.814)
μ_3	1.892*** (26.562)

μ_4	2.470***
	(31.470)
μ_5	3.157***
	(33.544)

Log-likelihood	-1555.2
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χ^2	228.4
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Dependent Variable: Income category.

Number of observations is 294.

t-statistics in parentheses.

***significant at $\alpha=0.01$.

Income Categories: 1 = Less than \$20,000
 2 = \$20,000 – \$29,999
 3 = \$30,000 – \$39,999
 4 = \$40,000 – \$49,999
 5 = \$50,000 – \$74,999
 6 = \$75,000 – 125,000
 7 = Greater than \$125,000

Appendix B

The ranked-ordered logit model is based on the assumption that the errors of the indirect utility function are independent and identically distributed (iid) according to a type I extreme-value distribution. This assumption implies that a conditional logit model for the most preferred choice can be extended to a complete or partial ranking (Beggs, et al., 1981). Rank-ordered logit models also exhibit the independence of irrelevant alternatives (IIA) property, which means that the conditional distribution of the utility from a given choice is independent of the ranking of the other choices. We examine these assumptions using two separate hypothesis tests. The null hypotheses for the iid and IIA assumptions, respectively, are stated as:

H1: Stated preference data can be consistently pooled in a contingent ranking logit model.

H2: The IIA property holds for the full choice set.

Rejection of H1 means that the data should not be pooled to estimate a partial or complete rank-ordered logit model, and therefore the errors associated with the rank-ordered model are not iid. Following Hausman and Ruud (1987), Ben-Akiva, et al. (1992), and Layton (2000), the data were divided into two separate data sets where: (1) the most preferred (first) choice is chosen from the three waste disposal options; and (2) the second most preferred choice is chosen from the remaining two. A standard logit model is estimated for each of the

restricted datasets. A likelihood ratio test is then used to test for equality of parameter estimates across the full model and the restricted models using the test statistic:

$$\chi^2 = -2[L(\beta_{CR}) - L_1(\beta_1) - L_2(\beta_2)], \quad (10)$$

where $L(\beta_{CR})$ is the log-likelihood value of the full ranked-logit model, $L_1(\beta_1)$ is the log-likelihood value from the model estimated with the first rank data, and $L_2(\beta_2)$ is the log-likelihood value from the model estimated with the second rank data. The test statistic is distributed as chi-squared with degrees of freedom equal to $K_1 + K_2 - K_{CR}$ degrees of freedom where K represents the number of parameter estimates in each respective model. As indicated in Table B.1, we fail to reject H1 for each specification.

[INSERT TABLE B.1 HERE]

Following Hausman and McFadden (1984) (see also Ben-Akiva and Lerman, 1985, p. 184), testing H2 requires a comparison of estimates from a conditional logit model estimated with the full choice set to estimates from a restricted choice set (or a subset of a full choice set). In this study, Option 2 is dropped in estimating the restricted model. The following test statistic is then calculated:

$$\chi^2 = (\hat{\beta}_r - \hat{\beta}_f)' (\hat{V}_r - \hat{V}_f)^{-1} (\hat{\beta}_r - \hat{\beta}_f), \quad (11)$$

where the subscript r represents estimators from the restricted model and f represents estimators from the full model; and $\hat{\beta}$ and \hat{V} are the parameter estimates and asymptotic covariance matrices for the restricted or full models, as denoted. The statistic is distributed as chi-squared with K parameter degrees of freedom. As indicated in Table B.1, across all model specifications (I-IV), we fail to reject H2. The two test results therefore suggest that the iid and IIA assumptions are acceptable for the rank-ordered logit model used in this study.

Table B.1. iid and IIA Hypotheses Test Statistics (χ^2) and Results

Model	H1 ^a	H2 ^b
	[degrees of freedom]	[degrees of freedom]
I	1.482 [2] \Rightarrow fail to reject	0.107 [2] \Rightarrow fail to reject
II	8.464 [10] \Rightarrow fail to reject	1.675 [10] \Rightarrow fail to reject
III	5.594 [10] \Rightarrow fail to reject	1.334 [10] \Rightarrow fail to reject
IV	10.77 [18] \Rightarrow fail to reject	1.558 [18] \Rightarrow fail to reject

^a H1: Stated preference data can be consistently pooled in a contingent ranking logit model.

^b H2: The IIA property holds for the full choice set.