ESTIMATING EXTERNAL COSTS OF MUNICIPAL LANDFILL SITING THROUGH CONTINGENT VALUATION ANALYSIS: A CASE STUDY

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Abstract

Much of the solid waste stream in the United States is generated by metropolitan areas, while associated landfills are often located in adjacent rural communities. Landfill disposal of municipal solid waste often creates external costs to nearby residents. Contingent valuation was used to estimate external costs of siting a landfill in the Carter community of Knox County, Tennessee. Estimates of annual external costs were $227 per household. Household income, size, years in the community, and distance from the proposed landfill and the respondent's education, sex, and perception of health risks were important in determining a household's willingness to pay to avoid having a landfill in the Carter community. Also, households whose drinking water supplies were at risk of contamination were willing to pay $141 more than those who used piped city water or bottled water.

Key words: landfill siting, solid waste disposal, contingent valuation

Increased perception of health and other risks associated with solid waste disposal facilities has made the siting of new municipal landfills technically difficult and in some cases socially and politically unacceptable. Landfill disposal practices create external costs to nearby residents who perceive risks associated with groundwater contamination, truck traffic, odor, noise, and litter, as well as other nonmarket costs not borne by waste disposal firms and producers of garbage. These external costs result in an inefficient allocation of resources (too much garbage and exposure to it).

By estimating external costs of landfills, economists could help policy makers allocate solid waste disposal resources more efficiently. When external costs are not considered, policymakers may be mistaken if they assume that disposing of all solid waste in landfills is more cost-effective than incorporating incineration and recycling into a solid waste management strategy. Also, external cost estimates could provide insight into alternative incentive and mitigation strategies designed to facilitate landfill siting.

Much of the solid waste stream is generated by metropolitan areas, while associated landfills are often located in adjacent rural communities that are more sparsely populated. The Carter community of Knox County, Tennessee, is an example of such a community where the landfill siting issue has been debated. In 1987, the siting issue emerged when county administrators considered a request by Browning Ferris, Inc. (BFI), to site a new landfill on land in the center of that community for which BFI had purchased an option to buy. The proposed site was located within 1,000 feet of the community recreation facilities and the high school. The BFI request was denied by the Knox County Commission partly because of strong public opposition from Carter community residents. BFI sued for permission to construct the landfill but the court ruled in favor of Knox County and against BFI. Subsequently, an appeals court overturned the decision of the lower court and granted permission for BFI to construct the landfill.

The objectives of this study were (1) to estimate the external costs accruing to nearby residents from siting a municipal landfill in the Carter community and (2) to investigate the relationship between household characteristics and the level of external costs borne by Carter community households. The contingent valuation method was used to accomplish these objectives. This approach has been used to evaluate changes in hazardous waste risks (Smith et al.), but has not been applied previously to the external costs of siting municipal landfills.

THEORETICAL BASIS

Two theoretically appropriate measures for evaluating a decrease in an environmental amenity are Hicksian compensating surplus and Hicksian equivalent surplus. Consumer property rights deter-

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mine which is most appropriate (Mitchell and Carson). In the Carter landfill case, BFI owns an option on the land at the proposed site and has been permitted the right to construct a landfill on that site. Thus, Carter community residents are currently enjoying a higher level of environmental quality than they are actually entitled to. The theoretically appropriate welfare measure for evaluating a decrease in an environmental amenity under these circumstances is Hicksian equivalent surplus, which is measured by a consumer's willingness to pay (WTP) to avoid a decrease in environmental quality (Mitchell and Carson, p. 25). The modeling of this process is based on the microeconomic theory of utility maximization (Varian).

The value a Carter community resident places on environmental quality is reflected in the resident's utility function:

(1) $U' = U'(X, Q'')$,

where U′ is the level of utility from which a change in welfare is measured, X is a vector of quantities of private goods, and Q′ is the level of environmental quality with a landfill nearby. The resident's current level of utility is given by:

(2) $U'' = U''(X, Q'')$,

where U″ is greater than U′, and Q″ is the level of environmental quality without the landfill.

Now consider the policy option to restrict the landfill given that the resident has the right only to Q′, the level of environmental quality with a landfill nearby. To value this change, one could look at the associated dual minimization problem. The objective of the dual problem is to minimize total consumer expenditures needed to maintain a given level of utility. Minimum expenditures with the landfill can be obtained by solving the problem in (3), while minimum expenditures without the landfill can be obtained from (4):

(3) Minimize $\sum P_j X_j$ subject to $U' = U'(X, Q')$, and

(4) Minimize $\sum P_j X_j$ subject to $U' = U'(X, Q'')$,

where P_j is the price of private good j and X_j is the quantity of private good j. The solutions to these problems define the expenditure functions presented in equations (5) and (6), which by duality also define the consumer's income levels:

(5) $E' = E'(P_j, Q', U') = M'$, and

(6) $E'' = E''(P_j, Q'', U') = M''$,

where M′ and M″ are the consumer's income levels before and after the policy decision to restrict the landfill, holding U at U′ (Varian).

Thus, the decrease in income required to maintain the resident's level of utility at U′ when Q changes from Q′ to Q″ can be defined as:

(7) $V_i = M' - M''$.

The difference, V_i, represents the maximum WTP by a resident to avoid the landfill (Mitchell and Carson). This amount can be viewed as the external cost to a resident of having the landfill located nearby.

The aggregate value, V(t), of the community's annual WTP at time t is the sum of all household WTP values, as expressed in equation (8):

(8) $V(t) = \sum V_i, \quad i = 1, 2, ..., n$,

where n is the number of households in the community.

The present value of the stream of annual external costs of locating the landfill in the community is

(9) $P = \int_0^\infty -V(t)e^{-rt}dt$,

where P is the present value of current, t = 0, and future external costs generated by the landfill and r is the discount rate.

METHODS

External costs of landfill siting are not directly valued in the marketplace, making their estimation difficult. Several approaches available for estimating external costs in similar situations include the damage-avoidance approach (Raucher), hedonic price analysis (Fisher and Raucher; Havlicek, et al.), and the contingent valuation method (Mitchell and Carson; Davis; Randall et al.).

The basic premise of the damage-avoidance approach is that the value of reducing expected human suffering from environmental contamination is at least as great as the expected costs of restoration, containment, or avoidance if contamination were allowed to occur. These costs are considered to be a lower bound on the value of reducing environmental contamination because they estimate the use value of protecting the environment (e.g., the value of protecting drinking water) while omitting nonuse values such as option and existence values (Raucher; Bishop; Krutilla).

Hedonic pricing methods use changes in property values as a proxy for the external cost of pollution. However, Maler argued that the underlying assumptions of property-value models are unrealistic (e.g., the assumption of full information), and Lave argued that property values merely offer a substitute method for the damage avoidance approach.

Randall et al. argued that the more emphasis on measuring total values in general, and nonuse values in particular, the more dependent the researcher is on contingent valuation. In this study, the total value of avoiding a landfill was of primary concern. Hence, external costs were evaluated using the contingent valuation method (CVM). This method allowed external costs to be estimated using a survey to set up a hypothetical market and asking respondents to indicate the maximum amount of money they would be willing to pay to avoid a landfill (Freeman; Mitchell and Carson; Randall).[1]

The Carter population was defined as encompassing four Knox County tax maps (numbers 62, 63, 73, 74). The total number of households in the population (798) was estimated by counting the number of improved property lots in each of the four tax map areas. The geographical size of the area was approximately eight square miles. All households fell within a four-mile radius of the proposed landfill site.

No consensus existed in the literature as to whether personal interview CVM surveys were more effective than CVM mail surveys. Two pretests were performed on the Carter population to determine the most effective method of eliciting WTP responses. In the first pretest, ten randomly selected households were given questionnaires and asked to complete and return the forms by mail in a pre-addressed, stamped envelope. An additional ten randomly selected households were personally interviewed in the second pretest. The results of the pretests indicated that respondents were able to understand and reasonably respond to the questionnaire when administered personally, while in the mail pretest, 50 percent did not respond and 20 percent responded incorrectly. Thus, the respondents in the Carter landfill study were personally interviewed.

A sample of 150 households was chosen by personally interviewing an adult member of every fifth household in the Carter community during the last two weeks of July, 1988. Interviews were conducted from Monday through Saturday between 1:00 p.m. and 6:30 p.m. If no respondent was available, the interviewer returned three times before substituting the adjacent household on the right for the unavailable respondent. Only one potential respondent refused to complete the interview.

Because the objective of the survey was to obtain household WTP, the contingent market in the questionnaire was explained to the respondent with the request that the head of the household or both spouses jointly determine the WTP value. As Smith et al. suggested, careful consideration was given to ensure that respondents were able to understand and evaluate the hypothetical environmental amenity in the contingent market. Respondents were asked to imagine a hypothetical situation where Knox County residents could make annual payments in the form of taxes or higher garbage collection fees into a fund that would enable landfills to be located away from residential areas. Respondents were then asked to indicate the absolute maximum amount of money they would be willing to pay each year to ensure that a landfill would not be located in their community. To aid respondents in understanding and relating to the contingent market, they were given payment cards (Mitchell and Carson) indicating average amounts paid annually by households in each income class for similar public services such as police and fire protection. For their respective levels of household income, respondents circled a value from zero to a predetermined number indicating their WTP to avoid a landfill being sited near their residence.[2]

Respondents were also asked to indicate the number of persons in their household, their age, their sex, their income class, their education level, whether they owned or rented their home, the number of years of residence in the Carter community, whether their drinking water was from a well, spring, or

[1] The authors recognize the potential problems with CVM for estimating risk-related damages. Mitchell and Carson (p. 305) note that some progress in this difficult research area has been made, citing, among others, the study by Desvousges and Freeman (1985) of the reduced risks from hazardous waste sites. However, they go on to say that issues-related risk characteristics, as well as the uncertainty that often surrounds the initial risk level and risk reduction, pose challenges for researchers in this area.

[2] The exact formulation of the contingent market in the questionaire was as follows:

Everyone knows that garbage has to go somewhere. Imagine a hypothetical situation where county residents could make annual payment (in the form of taxes or higher prices) into a fund that would enable governments to locate landfills away from residential areas, or to use more environmentally suited methods (e.g. recycling programs) for disposing of garbage. In this section, we would like to know how much it is worth to you to ensure that a landfill is not located in your area.

In order to do this, please look at the payment cards attached to the questionnaire. Find the card that corresponds to your before-tax household income, and circle the maximum amount that your household would be willing to pay to ensure that a landfill is not located near your residence. Because this is not something we usually think about, we have included on the payment cards what the average household like yours pays in taxes or higher prices each year for some other types of public programs. Once again, I would like to remind you that this interview is completely confidential and that your name will never be associated with your answers.

While relating public service payments to income on the payment card does pose a possible source of anchoring bias, Mitchell and Carson (p. 100) argue that within this approach the "context is enhanced," and that the payment card method in general reduces the likelihood of starting-point bias as compared to the bidding-game method.

piped city water, and the number of miles they lived from the proposed landfill site. In an effort to increase response rates and to conserve interviewer resources, respondents were given a list of categories for each household characteristic and asked to identify the category in which their household fell.[3] Respondents were asked to indicate whether they were very concerned, somewhat concerned, or unconcerned about health risks from the proposed landfill. Finally, respondents who gave a zero WTP bid were asked to indicate their reason for the zero bid. Possible responses included: (1) I can't afford to pay anything, (2) I object in principle to paying anything, (3) I do not believe there are any dangers from landfills, (4) I plan to leave the area regardless of whether the landfill is built, and (5) other. Ten questionnaires were eliminated from the sample as irrelevant (one was moving away) or protest bids (nine objected in principle to paying), leaving 140 usable questionnaires.

EXTERNAL COST ESTIMATES

The first objective of this study was addressed by presenting the estimated external costs of siting the landfill. First the distribution of WTP bids is discussed and then the estimated external costs are presented. Both are important in drawing policy implications from the results.

Table 1. Frequency Distribution of Household Willingness to Pay to Avoid a Landfill in the Carter Community, 1988

Range of annual household WTP	Number reporting	Percent
0	19	13.6
1-25	5	3.6
26-50	13	9.3
51-75	34	24.3
76-100	14	10.0
101-200	19	13.6
201-500	24	17.1
501-1,000	5	3.6
1,001-1,500	4	2.9
1,5001-2,000	3	2.1
	140[a]	100.0

[a] Ten responses rejecting the payment vehicle were removed from the analysis.

The frequency distribution of WTP bids is shown in Table 1. Nineteen zero bids were retained in the sample. These zero bids included 12 respondents who indicated that they could not afford to pay anything and seven who indicated that they did not believe there was a danger from landfills. The distribution of WTP bids is positively skewed toward higher bids. At first glance this skewed distribution of bids might seem to suggest strategic bidding (Mitchell and Carson). However, the distribution of bids tends to be highly correlated with the distributions of income and education. All respondents who gave bids of $500 or more had household incomes of $30,000 or more and had attended at least some college, with 79 percent being college graduates. Similarly, 76 percent of respondents who gave bids of $50 or less had household incomes of less than $20,000 and 68 percent had attended no college. Given this high correlation of bids with income and education, and the meager evidence for strategic behavior in previous studies (Mitchell and Carson), it appears reasonable to conclude that no substantial bias was introduced by strategic behavior.[4]

The WTP estimates for the Carter community to avoid a landfill are shown in Table 2. Average WTP per household, as estimated by the sample mean, was $227 annually with 95 percent confidence limits of $165 and $289. Total WTP of $181,264 for the entire Carter population was estimated by multiplying the estimate of average annual household WTP ($227) by the approximate number of households in the community at the time of the survey (798).[5] The

Table 2. Average, Total, and Present Value Estimates of Willingness to Pay to Avoid a Landfill in the Carter Community

	Value (dollars)	95% Confidence Interval (dollars)
Average annual household WTP[a]	227	165 to 289
Total annual WTP	181,264	131,664 to 230,864
Present value of total annual WTP	2,167,872	1,574,668 to 2,761,075

[a] Estimated by the sample mean.

[3] Dillman (pp. 105-108) discussed the effects of objectionable questions, such as on income and on response rates, and recommended using broad categories to make sensitive questions less of a problem for telephone and mail surveys. Wallis and Roberts (152-153) emphasized the negative relationship between personal interview response rates and sensitive questions.

[4] Alternatively, as a reviewer aptly noted, it could be argued that respondents with higher income and education are generally more aware of public debates and therefore more likely to engage in strategic bidding.

[5] Aggregation of individual WTP bids in this manner requires the assumptions that (a) "... the current distribution of income is acceptable from a social welfare standpoint," and (b) "... a suitable payment structure ... could be designed to collect all the revenues the respondents in a CV survey indicate they are willing to pay" (Mitchell and Carson, p. 44).

95 percent confidence limits for total annual WTP were estimated to be $131,644 and $230,864.

Also shown in Table 2 is the estimated present value of external costs of $2,167,872 as estimated by equation (9), assuming a discount rate of 7.875 percent and a planning horizon of 50 years. A planning horizon of 50 years and discount rate of 7.875 percent were selected to conform with federal procedures used to estimate benefits and costs of public projects (Hansen; U. S. Water Resources Council).

EFFECTS OF HOUSEHOLD CHARACTERISTICS ON EXTERNAL COSTS

The second objective of this study was addressed by estimating, through regression analysis, the relationship between household characteristics and external costs from the landfill. A household's WTP was hypothesized to be a function of household characteristics and a random error term, stated as:

(10) $V_i = f(NIH_i, AGE_i, SEX_i, INC_i, EDU_i, HOM_i, YIC_i, DWS_i, MFL_i, POR_i) + e_i,$
$i = 1...n,$

where i is a subscript representing an individual household, V is annual WTP to avoid a landfill, NIH is number in household, AGE is age of respondent, SEX is sex of respondent, INC is annual household income, EDU is education of respondent, HOM is home ownership by resident, YIC is number of years of residence in the Carter community, DWS is dependence on a well or spring for drinking water, MFL is miles from the proposed landfill site, POR is perception of health risk from the proposed landfill and e is an error term assumed to be normally and independently distributed with zero mean and constant variance.

The relationships between WTP and household characteristics were hypothesized as follows. NIH was expected to be negatively related to WTP because as household size increases, holding household income constant, per capita income declines, thereby reducing a household's ability to pay. The demographic characteristics of AGE and SEX were hypothesized to influence a respondent's WTP but signs were not hypothesized *a priori*. INC was expected to be positively related to WTP through ability to pay. Respondents with more education (EDU) were hypothesized to have higher WTP bids than less educated respondents because they are more likely to be aware of and interested in the environmental implications of landfills. Homeowners were expected to give higher WTP bids than renters because of their vested interest in maintaining property values. WTP was expected to be positively related to YIC because residents who had lived in the Carter community longer would more likely be involved in community affairs and would be less mobile than those who had lived there for shorter periods of time. Respondents who obtained their drinking water from wells or springs (DWS) were expected to be willing to pay more to avoid possible contamination of their water supplies from landfill leachate than those who received water from a municipal source. MFL was hypothesized to be negatively related to WTP because the prospect of being adversely affected by a landfill diminishes with distance. Finally, those respondents with the greatest perception of health risk (POR) were expected to be willing to pay more than those with less concern for their health.[6]

Ordinary least squares was used to estimate the relationship between WTP and the hypothesized explanatory variables in equation (10). Explanatory variables were expressed as 0,1 dummy variables as described in Table 3.[7]

To avoid perfect multicollinearity, the variable representing the last category of each household characteristic was deleted from the regression. Consequently, regression coefficients represent deviations from the deleted categories. A joint F-statistic was used to test whether all categories of a particular household characteristic collectively affected WTP.

Preliminary ordinary least squares regression combined with multicollinearity diagnostics and Spearman correlation coefficients (Belsley et al.; SAS Institute, Inc.) indicated a high degree of collinearity between income, education, and several other variables. One source of collinearity resulted from the fact that there were only four respondents in the highest income and household size categories and only three in the highest education category. This problem was reduced by combining those observations with the next highest income, household size, and education categories. Further problems associated with multicollinearity were practically eliminated by creating 0,1 dummy variables for 16

[6] All respondents indicated that they were either very concerned or unconcerned about health risks from the landfill. No respondents indicated that they were somewhat concerned about health risks.

[7] Dummy variables are especially appropriate when using a model with qualitative data, though many of the explanatory variables in equation 10 are cardinal variables. Johnston (p. 228) suggests that one may use groupings or categories of a cardinal variable to define a qualitative variable. Similarly, Kooyman discusses the appropriateness of using dummy variables in regression analysis.

Table 3. Ordinary Least-Square Estimates of the Willingness to Pay Function to Avoid a Landfill in the Carter Community, Knox County, Tennessee

Explanatory variable[a]	Category definition	Regression coefficient	Significance level
Number in Household (NIH)			
NIH1	one to two	198.06	.0031
NIH2	three to four	169.37	.0127
NIH3[b]	more than four		
Age of Respondent (AGE)			
AGE1	less than 35	-16.58	.8544
AGE2	36 to 45	58.75	.4601
AGE3	46 to 55	145.31	.1238
AGE4	56 to 65	70.01	.3850
AGE5[b]	more than 65		
Sex of Respondent (SEX)			
SEX1	female	-157.11	.0045
SEX2[b]	male		
Income and Education (IE)			
IE11	less than $10,000 no high school diploma	-825.25	.0001
IE12	less than $10,000 high school graduate	-827.56	.0001
IE13	less than $10,000 some college	-709.92	.0028
IE21	$10,000 to $19,000 no high school diploma	-647.62	.0001
IE22	$10,000 to $19,000 high school graduate	-594.57	.0001
IE23	$10,000 to $19,000 some college	-742.03	.0001
IE32	$20,000 to $29,999 high school graduate	-583.35	.0001
IE33	$20,000 to $29,999 some college	-646.98	.0001
IE34	$20,000 to $29,999 college graduate	-380.54	.0012
IE43	$30,000 or more some college	-762.21	.0001
IE44[b]	$30,000 or more college graduate		
Homeownership (HOM)			
HOM1	homeowner	-77.74	.5018
HOME2[b]	renter		
Years in Community (YIC)			
YIC1	less than one year	-130.52	.2699
YIC2	one to five years	89.72	.2077
YIC3	six to 15 years	165.89	.0033
YIC4[b]	more than 15 years		
Drinking Water Source (DWS)			
DWS1	district water	-141.36	.0109
DWS2[b]	well or spring water		
Miles from Landfill (MFL)			
MFL1	less than one	127.69	.1172
MFL2	between one and two	-79.61	.4264
MFL3	between two and three	-159.08	.0072
MFL4[b]	more than three		
Perception of Risk (POR)			
POR1	unconcerned	-332.34	.0001
POR2[b]	very concerned		
Intercept		821.06	.0001
F-NIH[c]		5.12	.0115
F-YIC[c]		4.60	.0044
F-AGE[c]		0.97	.4276
F-MFL[c]		3.44	.0023
R^2		0.7397	
Number of observations		140	

[a]All explanatory variables are 0,1 dummy variables. They take the value of one if the respondent falls in the corresponding category and zero otherwise.

[b]To avoid perfect collinearity, one dummy variable is deleted from the regression for each household characteristic. The coefficients for the remaining dummy variables estimate the difference in WTP from respondents in the deleted category, other things constant.

[c]Joint F-statistics for explanatory variable groups.

combinations of four income and four education levels as described in Table 3. Combining income and education in this manner prevented any pretest bias problems that might have arisen if either the income variables or the education variables were eliminated from the equation. Dummy variables were not included for IE14, IE24, IE31, IE41, and IE42, because no respondents fell into those categories. Also, IE44 was deleted from the regression to avoid perfect collinearity. After these adjustments had been made, collinearity was still evident between HOM and the intercept, probably because only nine respondents rented their homes. Little evidence existed to indicate that multicollinearity was a problem with any other linear combination of explanatory variables in Table 3.

Regression results (Table 3) indicate that 74 percent of the variation in WTP was explained by the hypothesized household characteristics ($R^2 = 0.74$). Only AGE and HOM were not significant in explaining household WTP, the latter variable perhaps due to multicollinearity.

All coefficients for the income and education variables (IE) were highly significant and negative as expected, suggesting that respondents who were college graduates with household incomes of $30,000 or more were willing to pay significantly more than those in other income and education categories. Differences between estimated coefficients for IE are presented in Table 4. Hypothesis testing indicates that respondents who were college graduates with household incomes between $20,000 and $29,999 (IE34) were also willing to pay significantly more than most respondents with less education and equal or less income. This finding, in conjunction with the lack of significance of most other differences in Table 4, suggests that income and education may not significantly influence WTP unless a respondent has a college degree. The significance of the coefficient for IE34 (Table 3) suggests that college graduates who were in the highest income class were willing to pay about $380 more than college graduates with household incomes between $20,000 and $29,999. Hence, for college graduates, the level of income appears to be important.

Coefficients for SEX, DWS, POR, and NIH had their hypothesized signs and were highly significant. Female respondents (SEX) were willing to pay about $157 less than male respondents, while respondents who depended on piped city water or bottled water for drinking (DWS) were willing to pay about $141 less than those who relied on well or spring water, *ceteris paribus*. Those who said they were very concerned about health risks from the proposed landfill (POR) were willing to pay $332 more than those who said they were unconcerned. Results presented in Tables 3 and 5 suggest that household size (NIH) significantly reduced WTP only for households with more than four members. It seems possible that the lack of difference in WTP between the one-to-two person and three-to-four

Table 4. Estimated Differences in Willingness to Pay by Income and Education Categories

	IE11	IE12	IE13	IE21	IE22	IE23	IE32	IE33	IE34
IE12	2.31[a] (.98)[b]								
IE13	-115.33 (.63)	-117.64 (.62)							
IE21	-177.63 (.14)	-179.94 (.14)	-62.3 (.80)						
IE22	-230.68 (.02)	-232.99 (.01)	-115.35 (.62)	-53.05 (.57)					
IE23	-83.22 (.50)	-85.53 (.47)	32.11 (.89)	94.41 (.43)	147.46 (.13)				
IE32	-241.91 (.13)	-244.21 (.10)	-126.57 (.62)	-64.27 (.68)	-11.22 (.93)	-158.68 (.29)			
IE33	-178.27 (.08)	-180.58 (.09)	-62.94 (.79)	-0.64 (.99)	52.41 (.51)	-95.05 (.37)	63.63 (.66)		
IE34	-444.71 (.00)	-447.02 (.00)	329.38 (.19)	-267.08 (.07)	-214.03 (.06)	-361.49 (.01)	-202.81 (.22)	-266.44 (.03)	
IE43	-63.04 (.61)	-95.35 (.60)	-52.29 (.83)	114.59 (.36)	167.64 (.12)	20.18 (.87)	178.86 (.26)	115.23 (.28)	381.67 (.01)

[a] The difference between the regression coefficients for the variable in the column minus the variable in the row.

[b] Significance levels using a two-tailed test for the difference between the coefficients.

Table 5. Estimated Differences in Willingness to Pay by Category for Miles from Landfill, Age, Years in Community, and Number in Household

	MFL1	MFL2	AGE1	AGE2	AGE3	YIC1	YIC2	NIH1
MFL2	207.30[a] (.06)[b]							
MFL3	286.77 (.00)	79.47 (.40)						
AGE2			-75.34 (.33)					
AGE3			-161.90 (.09)	-86.56 (.28)				
AGE4			-86.60 (.32)	-11.26 (.87)	75.30 (.42)			
YIC2						-220.24 (.05)		
YIC3						-296.41 (.01)	-76.17 (.28)	
NIH2								28.69 (.54)

[a] The difference between the regression coefficients for the variable in the column minus the variable in the row.

[b] Significance levels using a two-tailed test for the difference between the coefficients.

person households may be due to the likely presence of children in the latter offsetting the effect of the lower per capita income on ability to pay.

The number of years of residence in the Carter community (YIC) was also determined to be significant in explaining WTP. However, certain anomalies existed in its parameter estimates. Because of community loyalty, one might expect respondents who had lived in the Carter community longer to be willing to pay more than those who had moved in more recently. This pattern seems to hold for those who had been in the Carter community less than 15 years. Results in Table 5 indicate that residents of less than one year were willing to pay between $200 and $300 less than residents of one to 15 years. Interestingly, however, residents of more than 15 years were willing to pay significantly less than residents of six to 15 years (Table 3). This phenomenon may be explained by the fact that newer residents were typically households with school-age children who had moved into relatively new subdivisions. Their higher WTP may reflect concern over the proposal to locate the landfill near community recreation facilities and the high school.

Another household characteristic that exhibited an unusual pattern in its coefficients was the household's distance from the proposed landfill site (MFL). Respondents who lived closer to the proposed site were expected to be willing to pay more than those who lived farther away. This pattern holds for distances of up to three miles, with households who lived within one mile of the proposed landfill site being willing to pay between $200 and $300 more than those who lived between one and three miles away (Table 5). However, those who lived more than three miles from the proposed site were not willing to pay significantly less than those who lived within one mile of the proposed site. They were, in fact, willing to pay significantly more than those households located between two and three miles away. Again, respondents who lived more than three miles from the proposed landfill site lived in relatively new subdivisions and were very concerned about the exposure of their school-age children to risks from the landfill.

POLICY IMPLICATIONS

These findings are valuable to policymakers for several reasons. First, communities developing comprehensive waste management plans could use a similar approach in evaluating the external costs or benefits of all waste disposal alternatives including landfill disposal, incineration and recycling. As much as $20 billion may be invested in new solid waste disposal facilities in the United States over the next several years (Selman and Perkins). If such expenditures are to be made in a cost-effective manner, more complete analyses are needed to compare the total costs (realized plus external) of all solid waste disposal alternatives.

Second, if minimizing overall costs were the only objective and if similar results were found to hold for other areas, one might conclude that landfills should be sited in areas with fewer college graduates in higher income classes. However, equity considerations would likely limit acknowledgement of such a strategy, at least explicitly or officially. In the case of Knox County, Tennessee, proposals have been made by some legislators to require waste disposal facilities in all four quadrants of Knox County, which would require some distribution of the associated external costs among education and income classes.

Third, if WTP is viewed as a lower bound on willingness to accept (WTA) compensation for a reduction in environmental quality, these findings can provide insight into what types of mitigation techniques might be effective in gaining acceptance of a landfill site.[8] The significance of the drinking-water-source variable suggests that a mitigation strategy designed to protect drinking water supplies may be effective in the Carter case. However, the effectiveness of a similar strategy designed to protect property values is uncertain because of the insignificance of the homeownership variable. Further research quantifying the effects of homeownership on WTP could reveal information on the effectiveness of mitigation strategies designed to protect property values.

Finally, suppose for the sake of discussion that WTA is approximated by the WTP estimates in this case. Findings such as these then can provide insight into the potential use of incentives in strategies to site landfills or other waste disposal facilities (Park). Considering the bid distribution presented in Table 1, the level of compensation that would win community approval for a site deserves further consideration (Mitchell and Carson, pp. 47-50). The Carter community as a whole would be indifferent between (1) not having the landfill nearby and (2) receiving $227 per year to compensate for the external costs of having the landfill nearby. Suppose that to avoid delay in landfill siting, the Knox County Commission adopted a strategy of compensating each household for external costs at the mean of $227 per year. This strategy would elevate the utility levels of 74 percent of all Carter community households above levels currently enjoyed without the landfill. Such a strategy would likely win support from the majority of households because of their improved utility positions, reducing the likelihood of protest and delay. An alternative strategy might be to compensate households at the median of external costs, which is substantially less ($75 per year) than the mean. This strategy would leave about 50 percent better off and 50 percent worse off, and would be less readily accepted by the community than compensation at the mean. The Carter community as a whole would be worse off because all external costs would not be covered. Nevertheless, compensation at the median would require all Knox County residents to pay lower taxes and garbage collection fees compared with compensation at the mean. The optimal strategy from the Knox County Commission's point of view might be to compensate Carter community residents at some level above the median and below the mean so as to win sufficient community support for siting the proposed landfill, while keeping taxes and collection fees at a minimum. Such a strategy would still leave the Carter community with a higher cost burden than other Knox County residents.

CONCLUSION

This study provides an initial attempt at estimating external costs associated with municipal landfill siting using the Carter community of Knox County, Tennessee as a case study. While the willingness to pay estimates seem plausible, the authors are unaware of any other CVM studies of municipal landfill siting that would allow comparison. The most similar study would appear to be Smith and Desvousges' analysis of suburban Boston households' willingness to pay to be further away from a hazardous waste landfill, in which consumer surplus estimates ranging from $330 to $495 per year per mile were generated. While our WTP estimates are certainly in the same range as are estimates of residential property value impacts from nearby municipal landfills (Baker; Havlicek et al.), careful comparisons are difficult due to differences in method and period of analysis. Our hope is that other researchers might view this study as a point of departure, rather than a definitive work, in their efforts to address landfill siting issues using contingent valuation

[8] Although WTP is the appropriate welfare measure for estimating external costs to the Carter community from siting the landfill, it is not necessarily the correct measure for use in designing mitigation and incentive strategies to gain community approval for the landfill. Hicksian compensating surplus, measured by minimum willingness to accept (WTA) compensation for allowing a decrease in environmental quality, may be more useful for analyzing such strategies. However, Randall and Stoll demonstrate that WTP defines a lower bound on WTA, and that WTA may not significantly exceed WTP for indivisible or lumpy goods with typical price flexibilities of income and budget shares. On the other hand, Hanemann shows (Mitchell and Carson) that WTA can be substantially higher than WTP when the public good has few close substitutes. Finally, Mitchell and Carson (p. 37) imply that approximating WTA from WTP is difficult since the price flexibility of income is not readily available from contingent valuation surveys. Nevertheless, WTP estimates can still give insight into mitigation and incentive strategies if they are recognized as less than perfect lowerbound estimates of WTA.

methodology. Future research is needed on the following topics in particular: (1) the effects of homeownership on WTP bids, (2) the separate effects of income and education, (3) methods for measuring willingness-to-accept compensation, as would be appropriate with an alternative property rights endowment, and (4) implications of CVM study findings for development of mitigation and incentive strategies to facilitate landfill siting.

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