An Economic Analysis of Localized Pollution: Rendering Emissions in a Residential Setting

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The contingent value method is employed to estimate economic damages to households resulting from rendering plant emissions in a small town. Household willingness to accept (WTA) and willingness to pay (WTP) are estimated individually and in aggregate. The influence of household characteristics on WTP and WTA is examined via regression models. The perception of health risk is an important determinant of household valuation, while income appears insignificant. Both WTA and WTP results indicate that a potential Pareto-improvement is possible with the incorporation of current abatement technology.

La méthode des valeurs contingentes est utilisée pour évaluer les dommages économiques causés aux ménages par les émissions d'une usine d'équarrissage dans une petite localité. Les valeurs WTA et WTP des ménages sont estimées séparément puis sous formes agrégée. L'influence des caractères du ménage sur la WTP et la WTA est examinée au moyen de modèles de régression. La perception du risque pour la santé est un déterminant important de la valeur accordée par le ménage, alors que le niveau de revenu n'aurait qu'une influence négligeable. Les valeurs WTA et WTP obtenues laissent voir qu'un critère Pareto serait possible avec la mise en place des techniques modernes antipollution.

INTRODUCTION

Air pollution problems are most often associated with metropolitan areas having concentrations of industry and vehicles emitting various toxins into the air. An alternative form of air pollution entails the emission of noxious odors. Such emissions are not uncommon to agriculture and related industries, for example, large swine and poultry operations, and abattoirs.

As residential neighborhoods expand and encroach on previously unsettled or sparsely settled areas in the vicinity of such operations, conflicts can arise over noxious odor emissions. Generally, if society deals with such problems, political or legal resolutions are used because profit-conscious firms have little incentive to determine the extent of, reduce, or control such emissions in the absence of costs associated with legal actions, government intervention or public protest. Accurate information pertaining to economic benefits and costs associated with these emissions can be an important factor in contributing to an effective resolution process and to the establishment of more efficient pollution policies.

The primary purpose of this study is to examine and attempt to measure the economic costs incurred by households in a suburban-rural fringe area resulting from noxious odor emissions of a nearby rendering plant. Costs are estimated using a form of the contingent valuation methodology (CVM) to determine annual household economic values associated with the difference between the current level of emissions (odors) and an alternative state of no perceptible ambient rendering odors. Aggregate values are derived and compared with estimated costs of the abatement technology. Regression methods are used to estimate the relationship between household economic values and household characteristics. In addition, some methodological issues concerning the use of CVM in studies of this type are discussed, such as embedding, anchoring, sample size and property rights. The paper offers useful insights into the application of nonmarket valuation to localized public goods problems and provides an illustration of a simple nonparametric confidence interval for median willingness to pay (willingness to accept) — WTP and WTA — when using the payment card elicitation approach.

PROBLEM SETTING

Rendering operations process dead animals and meat by-products into livestock feed additives and other substances. The production process entails "boiling down" animal remains. Vapors produced from the cooking process that escape into the atmosphere usually result in very offensive odors.

In this case, a single rendering plant operates in an industrial zone bordering a residential area in a town of approximately 15,000 residents. The plant has been operating since the mid-1960s, and area residents are acutely aware of the source and extent of the odors being emitted.[1]

Interestingly, since the plant is the only source of persistent noxious odors in the region, it has galvanized community residents to form a citizens committee to lobby specifically for action against the operation. Residents have threatened to withhold payment of property taxes and have pooled resources to hire attorneys for advice on legal possibilities.

THEORETICAL CONSIDERATIONS

Air pollution caused by the production process of a firm is a classic case of externality. Air fouled by the production process results in an external cost to surrounding households. This external cost is in essence a cost of production not internalized by the firm.

Given existing technology, property rights and institutional structure (or lack thereof), the owner(s) of the rendering plant operating to maximize profits produces more emissions than would be the case if the cost of polluting the air were internalized. Depending on transactions costs, such a level of emissions may be socially inefficient.

Conventional microeconomic theory indicates that emissions externalities may be efficiently mitigated through a number of policies. These include Pigouvian taxes or subsidies, standards and penalties, and the assignment of property rights with subsequent development of markets for the external effect (Just et al 1982, 275). Griffin (1991) stresses the importance of recognizing institutional alternatives and of examining externalities on a case-by-case basis.

Effective problem examination and possible implementation of corrective policies can be enhanced by identification and estimation of private and social benefits and costs. In the case of producer-consumer externalities, particularly pollution related, determination of marginal costs and benefits associated with different abatement levels based on measurable market information is often impossible.

Valuation Methods

Nonmarket methodologies have evolved as an alternative approach to obtain money-metric estimates of external costs and benefits to households. These estimates can subsequently be aggregated across relevant populations and form the basis of a "crude" compensation test that may be used to signal a socially desirable change (Cameron and Huppert 1989). Damages to households from noxious odor emissions can be aggregated and compared with pollution control costs to evaluate alternatives and determine the existence of more socially efficient pollution levels.

In general, nonmarket methods can be classified as either behavioral or attitudinal approaches to evaluation. Behavioral approaches use observed market behavior to infer values for nonmarket goods. Such approaches typically rely on establishing or assuming weak complementarity or substitutability (Randall 1987, 267) between the nonmarket good and some privately traded commodity. Examples of popular behavioral valuation techniques include hedonic pricing, travel cost, risk evaluation and aversion expenditure (Adamowicz 1991; Abdalla 1990). Adamowicz concludes that, while appealing in some aspects, these approaches are generally limited to consumptive use values. He further concludes that, to use hedonic pricing, various transactions costs must be negligible and the associated market must be stable. The lack of appropriate housing market conditions precludes our use of hedonic pricing methods.

Aversion expenditure methods are limited to situations where a feasible aversion technology exists. Such technology is available for problems like groundwater contamination, e.g., filtration machines and bottled water. Options for households being inundated by ambient noxious odors are far more limited and unrealistic.

The contingent valuation method is an attitudinal approach to nonmarket valuation, relying on direct responses from consumers in hypothetical market situations. Survey techniques are used to elicit values from individuals as to the amount of money they would pay (WTP) for a hypothetical increase or accept as compensation (WTA) for a hypothetical decrease of (or in lieu of) the provision of a public good. Respondents are given a description of the good(s) being valued and the hypothetical market situation in which the good is being provided. In this study, the description of the good centers on differences in the level of provision or environmental states (elimination of noxious odors versus continuation of past levels). Included with a value response question are a number of of demographic and other questions that are used to estimate a valuation function for the good.

Theoretically, the hypothetical values correspond to Hicksian welfare measures and may be represented in a number of ways consistant with the utility maximization problem in microeconomics (Mitchell and Carson 1989, 26). In an indirect utility framework, WTP or compensating surplus may be represented for the rendering plant problem as:

$$V_0(Y_0,\ AQ_0,P_0) = V_0(Y_0 - WTP,AQ_1,P_0) \qquad (1)$$

while WTA or equivalent surplus is:

$$V_1(Y_0\ +\ WTA,\ AQ_0,P_0) = V_1(Y_0,AQ_1,P_0) \qquad (2)$$

where

Y = income,
AQ_0 = a state of annual ambient air with the current odor level,
AQ_1 = a state with no odor level, and
P = a price vector.

Perceived entitlement to the improved air quality is fundamental to WTA.

Literature is inconclusive about the WTP/WTA choice and much has been written about the divergence in their empirical estimation (Mitchell and Carson 1989). A conventional practice is to generally choose WTP, especially when the consumer does not appear to have an inherent right to the good or when the proposed change is a benefit. Bergstrom (1990) surveys 25 recent environmental valuation studies, of which only two use WTA.

Some have advocated dismissing WTA results as being unreasonable while others have criticized the reliability of CVM as a technique that produces empirical results that undermine the conventional presumption of valuation equivalence for quantity changes (Cummings et al 1986; Randall and Stoll 1980; Mitchell and Carson 1989; Knetch and Sinden 1984). Knetsch (1990), however, suggests that, in cases where environmental degradation and preservation are valued, WTP may in fact understate welfare changes. Rolston (1985), from a philosophical standpoint, espouses a similar position. Because property rights to air quality in the vicinity of the plant are disputed, we feel it is appropriate to elicit both measures rather than impose a WTP or WTA judgment.

CVM has become an increasingly popular approach to nonmarket valuation because of a number of factors; foremost among them is flexibility. Such flexibility results from not depending on secondary data sources or relying upon significant complementary or substitute relationships with private goods.

The theoretical constructs of CVM have been well established (Randall and Stoll 1980; Hanemann 1984; Hoehn and Randall 1987). Issues of validity and reliability have been addressed in a number of cases (Bishop and Heberlein 1990; Brookshire et al 1982; Sellar, Stoll and Chavas 1985; Boyle and Bishop 1988; Dickie et al 1987; Kealy et al 1988; Shechter et al 1989; Kealy et al 1990; Loomis 1990). Brookshire et al (1982) use both hedonic pricing and contingent valuation to study air pollution in the greater Los Angeles area and obtain similar results. Nevertheless, validation findings are generally limited to case studies identifying convergent validity.

Criticisms of CVM generally focus on the many biases that can result when applying the methodology. Mitchell and Carson (1989) present a complete typology of these biases. In general, they can be mitigated by careful survey design.

Additional and perhaps more serious questions about CVM related to philosophical constructs as well as individual valuation processes can be found in Rolston (1985), Samples et al (1986), Stevens et al (1991), and Kahneman and Knetsch (1992). Kahneman and Knetsch argue, with some empirical support, that CVM is subject to a problem of embedding. This problem occurs when a respondent includes values for other entities in the value response for the good of interest, often creating an upward bias. For example, if a given air pollutant along with other pollutants were present in an area and individual values for eliminating the given pollutant were elicited via CVM, it would be very possible that responses would include the value of eliminating some or all of the other pollutants. That is, the value elicited when asking about the one pollutant may be quite different from the value elicited when the individual is first asked to value elimination of all pollution in the area before being asked to value the given pollutant. Similarly, embedding can also be considered along time and space dimensions.

While Smith (1992) has uncovered a number of problems with the empirical portion of the Kahneman and Knetsch findings, a cautious approach to the use of CVM remains warranted. The problem of embedding is unlikely in this study. There are no other significant air pollution types or sources in the local area and the local population is acutely aware of the source and extent of the noxious odors and is clearly "experienced" in the problem's dimensions.

EMPIRICAL METHODS

Data

Dillman (1978) discusses the merits of mail, telephone and face-to-face survey techniques and concludes that the "best" must be answered subjectively and on a case-by-case basis. We used the face-to-face interview approach. This method generally produces higher response rates than mail surveys (Mitchell and Carson 1989), an important consideration given our small population. Due to the nature of the good being valued (air quality differences), we felt that respondents could answer more meaningfully with an interviewer present to clarify questions. Funding and time constraints were also contributing factors.

A systematic sample (Cochran 1977, 205) of households in the affected area was conducted in the early evenings over a one-month period.[2] All households were subject to the same experienced interviewer. Each interview was structured so that the respondent (adult household member) had the option of privately recording the responses and placing the completed questionnaire among a stack of completed and unlabeled responses, thus contributing to the perception of anonymity. The obvious limitations were possible interviewer bias and cautious consumer behavior (Mitchell and Carson).

Value responses were elicited using an adaptation of the payment card developed by Mitchell and Carson. This payment vehicle was used because it allowed for direct elicitation of Hicksian surplus measures. The payment card fell between the two extremes of open-ended and dichotomous choice questioning.

Dichotomous choice or take-it-or-leave-it elicitation requires a relatively large sample size for efficient empirical analysis (Cameron and James 1987). The reality of a small sample size precluded the use of the dichotomous choice approach. An open-ended approach was used in the pretest to establish a range for the payment cards.

The sample was split into two groups, one in which WTP was elicited and one in which WTA was elicited. This procedure traded off reduced sample size and consequent reduced estimation precision in each group for the versatility of obtaining both WTA and WTP measures.

Examples of the WTP and WTA payment cards are given in the Appendix. The WTP question was structured in such a way that residents would be responsible for paying into a fund to subsidize installation and upkeep of the necessary abatement technology.[3] For the WTA question, respondents would be eligible to receive payments to tolerate persistance of the odor. While the payer was not identified in the WTA portion (firm or government), a number of respondents linked the idea of WTA to having their property taxes rebated.

The WTP questionnaire had an additional question to deal with zero bids. A respondent giving a WTP of zero was asked why. This question allowed for identification of protest bids (Mitchell and Carson). If the respondent gave a zero WTA value, it was considered to be a protest bid and was excluded from the data.

In total, 84 households were contacted with the final questionnaire. Three respondents initially refused to be interviewed, 13 responses were left incomplete and deemed unusable, and two were identified as protest bids. Problems and possible bias resulting from misclassification of protest bids (Musser et al1990) were not likely with these results, given the very small percentage of protest bids. The problem of outliers or strategic bids was addressed through an *ad hoc* procedure wherein bids of greater than 5% of gross income were identified as questionable. None was found. Of the usable responses, 32 elicited WTP, and 34 elicited WTA (see Appendix for a descriptive summary of the data).

Regression Model

Economic theory suggests that household welfare measures (e.g., WTP and WTA) for changes in the provision of a public good vary with site characteristics and individual household characteristics (Randall 1987). In a study concerning the economics of air visibility, Rowe et al (1980) use such variables as the level of air visibility and the respondents' sex, age, marital status, family size, years in the community, income and education to describe variations in individual value responses. In addition to "standard" household characteristics, Roberts et al (1991) find that respondents' perception of health risk and location are significant variables in describing variations in WTP for ensuring relocation of a proposed landfill site. They also suggest examining the effect of property ownership on WTP.

We hypothesize that household WTP and WTA for alternative states of air quality are stochastic linear functions of years in the community (*YRS*), income (*INC*), perceived health risk (*HLT*) and ownership status (*OWN*):

$$WTP_j = a_{1j} + a_{2j}\, YRS + a_{3j}\, INC + a_{4j}\, HLT + a_{5j}\, OWN + u_j \quad (3)$$

$$WTA_i = b_{1i} + b_{2i}\, YRS + b_{3i}\, INC + b_{4i}\, HLT + b_{5i}\, OWN + v_i \quad (4)$$

where $j = 1{,}32$; $i = 1{,}34$; and the respective errors, u_j and v_i, are assumed independent normal.

Years in the community are thought to affect individual value responses. Two hypotheses are possible: one in which the odors are perceived to be a nuisance suggests a negative relationship between years living in the area and WTP or WTA; the other is that the longer one resides in the area the greater the perceived cumulative damages. Also, those who have been residents of the area since prior to opening of the rendering plant (mid-1960s) may be more inclined to feel that their rights to clean air have been violated. Those who have moved to the area after the rendering plant began operating would have presumably known of the odors and may not have the same perception of rights. Hence, inclusion of this variable is felt to capture possible endowment effects (Knetsch 1989).

Income is chosen to explain WTP because, theoretically, as income increases the demand for a "good" increases (assuming that air quality is a normal good). Most of the CVM literature includes income as an explanatory variable. Regarding WTA, theory is not so clear. Income is included in Eq. 4 primarily by convention (e.g., see Brookshire and Coursey 1987).

A binary variable is included to account for the perception of a health risk from the emissions, i.e., perceived health risk implying higher value responses (Zeiss and Atwater 1987; Roberts et al 1991). Because the affected area is relatively small and in close proximity to the plant (i.e., less than a 3.2-kilometer radius) a distance variable is not included.

Finally, a binary variable for ownership status (owned versus rented) is included because home owners would presumably be concerned about the effects of poor air quality on property values. Thus, one would expect *a priori* that response values for owners would be higher than those for renters.

RESULTS AND DISCUSSION

A relatively large difference between the average WTP and WTA values emerges from the samples, with WTA approximately seven times that of WTP. The sample mean for WTP is $105.31, with a sample standard deviation of $77.1, while the sample mean for WTA is $735, with a sample standard deviation of $382.24. This difference is within the range "typically" experienced in WTP versus WTA results in both controlled and uncontrolled experiments (Cummings et al 1986; Adamowicz 1991; Knetsch 1989). Confidence intervals of 95% for the WTA and WTP means are reported in Table 1.

Median values are $80 and $675 for WTP and WTA, respectively. It is interesting to

Table 1. Mean, median, interval, total and present value estimates of WTA and WTP

	WTA	WTP
Mean	$735	$105.31
Interval[a]	[606.51 – 863.49]	[78.39 – 132.02]
Interval[b]	[622.69 – 847.31]	[81.38 – 129.24]
Total[c]	183,750	26,327
Present value	1,746,016	250,162
Median	$675	$80
Interval[d]	[500.00 – 1000.0]	[25.00 – 100.00]
Total	168,750	20,000
Present value	1,590,795	188,539

[a]95% confidence based on the sample variance.
[b]95% confidence based on the regression residual variance.
[c]based on aggregation over 250 households.
[d]95% confidence based on nonparametric quantile test (Conover 1980).

note that median WTP is approximately the same as the lower bound on the confidence interval for mean WTP. Acknowledging the potential limitations of the mean as the measure of central tendency when dealing with small samples, a nonparametric procedure is used to calculate confidence intervals for median WTA and WTP. The results are reported in Table 1.[4]

The data for WTP responses do not appear to be unusual; however, this is not the case for the WTA responses (Appendix Table A.3). Nearly one half of the WTA responses (44%) are $1000 while 23.5% respond $500. This is an interesting phenomenon since $1000 is the highest specified value on the payment card. In the face-to-face procedure, all potential respondents were informed of the option to fill in a value in the "other" category above or between any of the listed values. Only one respondent chose that option and reported a WTA of $2000. Such data may suggest either that a censored analysis is called for or that respondents are simply anchoring on common values like $500 and $1000. If the former is the case, the median may be the more reliable measure of WTA. If the latter is the case, then censoring would result in discarding a valid WTA observation of $2000.

Total aggregate annual valuation figures are estimated by multiplying the average WTP and WTA values by the estimated number of households affected by odors from the rendering plant. This procedure is used by Roberts et al (1991) and is advocated by Loomis (1987) in cases of "select populations." The estimated number of households (250) was determined with two county property maps and by personal survey. The boundaries for the affected population were determined from the survey (i.e., the households who revealed that they were unaffected by the odors). Using sample means, the estimated aggregate annual WTA is $183,750 while that of WTP is $26,327. Aggregates based on medians are $168,750 and $20,000 for WTA and WTP, respectively.[5]

Total discounted benefits to households of air pollution control may be estimated using the following equation:

$$PV = \int V(t)e^{-rt}dt \qquad (5)$$

where

PV = the present value of the stream of annual benefits from pollution control, and

V = aggregate annual WTP (WTA) for the entire population affected by the rendering odors.

A discount rate of 10% and a planning horizon of 30 years results in aggregate WTA benefits of $1,746,016 and WTP benefits of $250,162 based on means. Substituting medians for means leads to present values of $1,590,795 for WTA and $188,539 for WTP. A sensitivity analysis for years and discount rates is contained in Table 2.

Unfortunately, plant officials could not make available exact costs or economic life of the equipment. However, they estimated state-of-the-art odor emission control equipment would include a scrubber ($35,000), duster ($50,000) and a gas incinerator ($50,000). Installation and annual maintenance would bring the total to approximately $150,000. Resulting emissions reduction was estimated

Table 2. Sensitivity of discounted aggregated benefits of air pollution control

		Discounted benefits[a]	
		WTA	WTP
$r=5\%$	$t=50$	$3,373,337	483,318
$r=10\%$	$t=50$	1,825,119	261,496
$r=15\%$	$t=50$	1,224,322	175,416
$r=5\%$	$t=40$	3,177,642	455,280
$r=10\%$	$t=40$	1,803,845	258,488
$r=15\%$	$t=40$	1,221,963	175,078
$r=5\%$	$t=30$	2,854,996	409,053
$r=10\%$	$t=30$	1,746,016	250,162
$r=15\%$	$t=30$	1,211,391	173,563
$r=5\%$	$t=20$	2,289,931	328,093
$r=10\%$	$t=20$	1,564,367	224,137
$r=15\%$	$t=20$	1,150,152	164,789

[a]means aggregated over 250 households, r = discount rate, t = time.

to be "roughly" 90%. Comparing the approximate costs of $150,000 with either WTA or WTP estimates from Table 2 leads to positive net benefits results, even if benefits are reduced to 90% of estimated levels.[6]

The valuation functions (Eqs. 3 and 4) for average annual household WTP and WTA are estimated using ordinary least squares (OLS). Results of the regressions are summarized in Table 3.[7]

Cameron and Huppert (1989) compare the use of maximum likelihood estimation (MLE) versus OLS on payment card data. They find that in "well-designed" surveys the differences between estimation procedures are "very close" when using interval midpoints but, as intervals between card values became "coarser," OLS results become more suspect. In this study, we allowed the respondent to fill in any value should the represented values be felt to be insufficient; hence we feel that modeling interval midpoints and MLE is unnecessary. Aside from possible differences in regression coefficients, modeling midpoints would lead to larger median and mean values for WTA and WTP.

The hypothesized explanatory variables *YRS*, *INC*, *HLT* and *OWN* accounts for 46% of the variation in WTP and 47% of the variation in WTA. *R*-square values of these magnitudes are relatively high compared with an average for CVM studies listed by Adamowicz (1991).

The coefficient for years in the community is positive in both regression equations. Although not highly significant, the WTP *YRS* coefficient could reflect the fact that residents do not get used to the odor nuisance as they

Table 3. OLS regressions of WTP and WTA[a]

Variable	WTP (1)	WTP (2)	WTA (1)	WTA (2)
YRS	3.4943	4.0965	17.084	19.533
	(1.57)	(1.94)	(2.15)*	(2.62)
INC	−0.90282	−0.461	−6.7791	−4.9745
	(−0.84)	(−0.48)	(−1.58)	(−1.35)
HLT[b]	119.42	102.18	459.93	422.73
	(3.06)**	(3.01)	(3.23)**	(3.11)
OWN[c]	39.386		158.04	
	(0.91)		(0.91)	
Constant	38.75	48.88	517.51	545.90
	(1.12)	(1.48)	(3.46)**	(3.74)
R^2	0.4616	0.4453	0.4708	0.4556
R^2ADJ	0.3819	0.3859	0.3978	0.4012
F-Value	5.787**	7.49	6.499**	8.37
OBS	32	32	34	34
AVE	105.3	105.5	735	735

[a]*t*-statistics in parentheses.
[b]0,1 dummy variable to denote whether respondent felt the rendering emissions were a health risk: YES=1, NO=0.
[c]0,1 dummy variable to denote whether respondent owned or rented their household: OWN=1, RENT=0.
*significant at the .05 level.
**significant at the .01 level.

might with other types of nuisances, for example, black flies (Reiling et al 1989). Indeed those who have lived in the area for many years have witnessed the unsuccessful attempts by citizens who have lobbied local and provincial government for stricter pollution control regulations. The WTA *YRS* coefficient is highly significant, suggesting the possibility that an endowment effect identified by years of residence significantly influences WTA.

The coefficients on household income are negative and insignificant in both equations. Theory suggests that WTP should increase with income; however, these results suggest odor-free air to be income-inelastic in this population. This finding is consistent with a number of previous studies that find little impact or significance of income of WTP/WTA.

A speculative explanation for negative signs in both cases might be that households with higher incomes have greater means of averting the effects of the odors with such things as air conditioners in the summer and the ability to spend more time away from the area (e.g., vacations, summer cottages etc.). Indeed, survey results revealed that 10% of the WTP respondents and 20% of WTA respondents spent more than one month away from the area (Appendix). We feel the best explanation is that income is simply not a factor in explaining certain necessary environmental goods.

The health risk variable is significant at the 1% significance level in both equations. Respondents who believed the rendering emissions to be a health hazard had predicted WTP and predicted WTA of $119.42 and $459.93 more, respectively, than those who felt the emissions were not a risk. This result has interesting ramifications. If the emissions are not a health hazard, then better information for consumers could result in a significant drop in the estimated benefits associated with abatement.

The coefficients on ownership in both equations are insignificant. This result is somewhat confounding in that one would expect homeowners to be more concerned about the adverse effects of poor air quality on property values than nonowners. However, if one considers ownership a proxy for wealth, the results are like those for the income variable. Alternatively, given the small number of nonowners in the sample, there may not be much variation. Roberts et al (1991) find a similar insignificance of ownership in their landfill location study.

CONCLUSION AND IMPLICATIONS

The results of this study indicate that the estimated discounted benefits of improved air quality to households affected by rendering plant emissions are likely more than the costs to the plant of installing pollution control equipment. It appears that installation of new emissions control equipment would effect a potential Pareto-improvement and efficiency gains from a social perspective. Whether the taxpayer or the firm ultimately pays is for legal and political determination.

The above conclusion stands whether WTP or WTA, means or medians, are used to capture the household values for the difference in air quality with and without complete abatement. However, establishing a nonparametric confidence interval around median WTP indicates the results may not be as robust as they initially appear. Also, higher discount rates and shorter time spans coupled with unforseen operation costs might reverse the conclusion if only WTP is used to obtain household values.

The conclusion of positive social gains should also be tempered by a number of important practical factors upon which future research should focus. First is the assumption that a 90% reduction in emissions would place the odors under an accepted tolerance threshold. Benefits based on WTP are estimated under the assumption that odors would be completely eliminated. If not, the question of additional costs for "complete" control of odors versus the relevant WTP or WTA benefit measure is raised. Linearly extrapolated benefit or cost estimates should be viewed cautiously. In a larger area with greater population, researchers would be advised to attempt to estimate a total benefits curve based on varying levels of abatement.

The use of the payment card raises some questions. It appears to be a propitious elicitation technique when samples are small, and respondents have little difficulty arriving at values. However, as this study shows with the WTA responses, ambiguities and possible censoring problems in the top end can arise. Whether respondents are anchoring to a familiar value or do not have a fully adequate response range cannot be determined in this study. We choose to believe that because we did receive a response above $1000 and had an interviewer present to explain the optional fill-in; the data are not censored, but could nevertheless be somewhat biased. For future use of the payment card, we suggest using an unfamiliar number as the top value on the card, varying ranges on the cards, and having an interviewer present to explain the use of a fill-in option. The latter suggestion is difficult and expensive in large samples, while card payment range treatments require large samples. The importance of establishing a reasonable value range from a pretest should not be diminished.

Another question needing to be addressed is the value associated with the payment card response. Cameron and Huppert (1989) argue that respondents report the lower bound of an interval in which their WTA/WTP lies. As such, modeling interval midpoints either by OLS or MLE is appropriate. However, if respondents report values closest to their WTA/WTP, then modeling interval midpoints may bias means and medians upward. If intervals are small enough, this may not be much of a problem. It would appear that structured laboratory experiments could contribute to this debate.

Extrapolating regression results from one study to another in social science is often tenuous (Desvouges et al 1992). Problems are exacerbated when the results are derived from small samples. In this study, the regression results are secondary to the fundamental charge of the analysis. Nevertheless, a particularly interesting and potentially consequential finding pertains to the magnitude and significance of the perception of health risk variable (*HLT*). If there is little or no real health risk, yet a very strong perception thereof, greatly influencing household value, then a firm and or the government might consider "investing" in information to modify this perception. Such an "investment" could be cheaper than emissions equipment, yet lead to an outcome yielding a relative increase in net social benefits. This would be predicated on a certain amount of trust between residents and the information provider, which may not be easy to establish.

Mitchell and Carson (1989, 303) call for greater use of CVM in valuing "local public goods." We agree, particularly in cases where conditions preclude the use of indirect valuation procedures. While the technique holds promise in local applications, sample size and property rights issues will likely be unavoidable in many applications. In such cases, researchers should make as much use of sample information as possible, e.g., reporting means and associated confidence intervals as well as medians and associated confidence intervals, while being cautious to generalize regression findings. Moreover, where rights are not clearly understood or defined, the objectivity of obtaining WTP and WTA information could well be worth the sacrifice in sample size.

NOTES

[1]Because there is only one rendering plant in the immediate area, the location and name of the plant are not disclosed. In addition, local residents are well aware that the only known source of identifiable and persistent odors in the study area is this plant.

[2]Our sampling plant could introduce a possible bias if our timing led to omitting values from a segment of our population, which would systematically change the results. We have no reason to believe that those omitted should have values explainably different from those sampled.

[3]At the time of the study, the plant was installing a new cooker. The cooker is not abatement technology *per se*; however, minor impacts on emissions could be expected. Locals were aware of the installation but not sure of the effect, and our payment cards are worded accordingly.

[4]Following Conover (1980, 112), a nonparametric confidence interval may be calculated for any quantile in a distribution as:

$$c_l = np + z_{a/2}\,(np\,(1 - p))^{.5}$$

$$c_u = np + z_{1-a/2}\,(np\,(1 - p))^{.5}$$

where

c_l and c_u = lower and upper bounds (observation numbers), which are rounded to integers,
n = sample size,
$1-a$ = the desired confidence coefficient,
z's = quantiles from the normal distribution, and
p = the quantile to be bounded.

This method provides a simple and convenient alternative to a bootstrap.

[5]It should be noted that there are two shopping malls, a number of commercial facilities and a golf course within the zone affected by the emissions. Also, as one Journal reviewer has pointed out, we may have overlooked households in the community at large, outside the "affected area," which have measurable WTP or WTA. Because our WTP and WTA results are derived strictly from households in the affected area, we feel that total benefits to all consumers of air in the area may be, at worst, understated somewhat. To expand the sample increases the possibility of embedding and purchase of moral satisfaction problems.

[6]An alternative context for comparing costs with benefits was suggested by one Journal reviewer. Annualized abatement costs are disaggregated to a per-household basis, facilitating comparison to annual household WTP and WTA. Amortizing $150,000 over 30 years at 10% interest, spread over 250 households, yields an annual cost of $63.65 per household. Increasing the number of households to 300 decreases per household costs to $53.04, while decreasing households to 200 increases costs to $79.56.

[7]Both models were reestimated after dropping the *OWN* variable and are reported in Table 3. In both cases R-squares dropped marginally ($<.02$) while adjusted R-squares improved marginally ($<.01$). These "new" models have unknown statistical properties and hence t-statistics are invalid (Judge et al 1988). However, three of the four estimated WTA coefficients and two of four estimated WTP coefficients become "significant" at the .05 level. Signs are unchanged and magnitudes are changed only marginally, indicating a certain amount of "robustness." Debertin and Freund (1975) provide a relevant discussion about the morality of variable seeking. In the case of small data sets, use of "preliminary regressions" as mentioned by Cameron and Huppert is not an option. The possibility of some collinearity between income and ownership is acknowledged; however, high multicollinearity between income and ownership is not found to be present based on simple correlations and the coefficient stability reported above.

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APPENDIX

Survey Payment Card Questions

The main objective of this study is to estimate the value of air quality in the area. The following question was designed to provide us with a means of obtaining this value. Please consider your answer carefully. It is important to the success of this study that your answer reflect your true opinions. Note that this is a hypothetical situation and *does not* represent any government proposals or policy plans.

Recall the odors emitted from _____ over the past year.

WTP Version

Assume the new equipment _____ is installing fails to reduce odor emissions from the plant but meets government standards. Under these circumstances, _____ would have little incentive to take further pollution control measures. Suppose the odors could be eliminated by further pollution control measures. The only incentive for _____ to adopt such equipment is if the costs of installing and maintaining the equipment were to be subsidized.

If a special pollution control fund were set up to ensure that _____ would install such equipment, what is the *maximum* amount you would be willing to contribute *annually* to such a fund to ensure odor-free air? (Please circle *one*)

$ 0	100	300	600
20	150	350	750
40	200	400	1000
80	250	500	other $ _____

WTA Version

Assume the new equipment _____ is installing fails to reduce odor emissions from the plant. Suppose a plan were implemented that would make households affected by the odors eligible for annual compensation payments.

If your household were eligible to receive such payments, what is the *minimum* annual payment you would *accept* as compensation for the reduced air quality? (Please circle *one*)

$ 0	100	300	600
20	150	350	750
40	200	400	1000
80	250	500	other $ _____

Results of Survey: Summary Statistics

WTP Questionnaires

N=32	Mean	St. dev.	Minimum	Maximum
WTP	105.31	77.1	0	300
YEARS	14.0	6.7	2	28
EDU	13.1	2.2567	9	20
INCOME	43.3	17.2	15	90
AGE	43.5	24.6	25	75

Qualitative statistics:
- 19% of respondents felt air quality was a health risk
- 10% spent more than one month away from community
- 18% were members of environmental organization
- 15% were retired
- 87% owned their residence.

WTA Questionnaires

N=34	Mean	St. dev.	Minimum	Maximum
WTA	735	382.24	40	2000
YEARS	15	8.4	1	38
EDU	13.4	1.9	10	16
INCOME	40.9	16.4	5	75
AGE	47.4	14.9	25	75

Qualitative statistics:
- 24% felt air quality was a health risk
- 20% spent more than one month away from community

- 20% were members of environmental organizations
- 24% were retired
- 82% owned their own residence.

Distribution of Household WTA and WTP Values

	WTA		WTP	
Payment card values ($)	Number reporting	Percent	Number reporting	Percent
0	0	0	1	3.1
20	0	0	5	15.6
40	1	2.9	2	6.3
80	0	0	8	25
100	1	2.9	7	21.8
150	0	0	4	12.5
200	0	0	2	6.3
250	1	2.9	1	3.1
300	3	8.8	2	6.3
350	0	0	0	0
400	0	0	0	0
500	8	23.5	0	0
600	2	6	0	0
750	2	6	0	0
1000	15	44.1	0	0
Other*	1	2.9	0	0
Total	34	100	32	100

*One respondent reported a WTA value of $2000.