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

by

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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 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, resulting from a new plant technology, of no perceptible ambient rendering odors. Aggregate values are derived and compared to estimated costs of the abatement technology. In addition, regression methods are used to investigate related household characteristics and some methodological issues concerning the use of CVM in studies of this type are discussed. The paper offers useful insights into the application of nonmarket valuation to localized public goods problems.

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 which 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 town of approximately fifteen thousand residents. The plant has been operating since the mid-sixties 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 (Barteaux).

THEORETICAL CONSIDERATIONS

Air pollution caused by the production process of a firm is a classic case of externality. Static economic theory is well developed for such problems (Griffin; Cheung; Just et al.; Randall). In this case, households are affected negatively outside the marketplace by rendering plant emissions. 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 was 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 including Pigouvian taxes or subsidies, standards and penalties, and the assignment of property rights and subsequent development of markets for the external effect (Just et al., p.275). Griffin 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 which may be used to signal a socially desirable change (Cameron and Huppert). In this case aggregate damages to households can be compared with pollution control costs to evaluate alternatives and to determine the existence of more socially efficient pollution levels.

In general, nonmarket methods can be classified as either behavioral or attitudinal approaches to valuation. Behavioral approaches use observed market behavior to infer values for nonmarket goods. Such approaches typically rely on establishing or assuming weak complementarity (Maler, p.183) or substitutability (Randall, p.267) between the nonmarket good and some privately traded commodity. If there is no purchase of the related private good then demand (value) does not exist for the nonmarket good. Examples of popular behavioral valuation techniques include hedonic pricing, travel cost, risk valuation, and aversion expenditure (Adamowicz; Abdalla). Adamowicz concludes that while appealing in some aspects, these approaches are generally limited to consumptive use values. He further concludes that in the case of hedonic pricing, various transactions costs must be negligible and the associated market must be stable. In this study the lack of appropriate housing market conditions precludes the use of hedonic pricing methods.

The use of aversion expenditures is limited to situations where a feasible aversion technology exists. In cases like groundwater contamination, such technology is available, 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 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. Often, as is the case in this study, the description of the good centers on differences in the level of provision or environmental states, e.g., elimination of noxious odors vs. continuation of past levels. Included with a value response question are a number of demographic and other questions which 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, p. 26). In an indirect utility framework, WTP or compensating surplus may be represented for the rendering plant case as, $V_0(Y_0,AQ_0,P_0)=V_0(Y_0-WTP,AQ_1,P_0)$, while WTA or equivalent surplus is $V_1(Y_0+WTA,AQ_0,P_0)=V_1(Y_0,AQ_1,P_0)$, where Y is income, AQ_0 is a state with the current odor level, AQ_1 is a state with no odor level, Y is income, and P is 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. 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. This position has been challenged by Knetsch (1990) wherein he suggests that for certain environmental goods, information on WTA may be more appropriate, particularly in the case of detrimental changes. Because property rights are somewhat disputed in this case, we felt it 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.

CVM has been used to value as environmental improvements (Randall et al.), water quality improvements (Desvousges et al.), aesthetic preferences (Brookshire et al.), air visibility (Rowe et al.), environmental impacts of a power plant (Thayer), external costs of landfill siting (Roberts et al.) and the benefits of controlling nuisance species (Reiling et al.; John et al.).

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

Criticisms of CVM generally focus on the many biases which can result when applying the methodology. Mitchell and Carson 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; Samples; Stevens et al.; and Kahneman and Knetsch. 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 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 problems's dimensions.

EMPIRICAL METHODS

Data

Dillman discusses the merits of mail, telephone, and face-to-face survey techniques and concludes that the question of which is best can only be answered subjectively and on a case-by-case basis. In this case the face-to-face interview approach was chosen as the means for data collection. The literature indicates that this method generally produces higher response rates than mail surveys (Mitchell and Carson). Due to the nature of the good being valued (i.e; air quality differences) it was felt that respondents could answer more meaningfully with an interviewer present to clarify questions. Funding and time constraints were also contributing factors.

A systematic random sample (Cochran) 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 her responses and placing the completed questionnaire among a stack of completed and unlabelled responses thus contributing to the perception of anonymity. The obvious limitations are 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 allows for direct elicitation of Hicksian surplus measures. The payment card falls 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). 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 trades-off reduced sample size with consequent statistical effects for the versatility of obtaining both WTA and WTP measures.

Examples of the WTP and WTA payment cards are located in Appendix A. In the case of WTP, the question was structured in such a way that the residents would be responsible for paying into a fund to subsidize installation and upkeep of the necessary abatement technology.[3] In the case of WTA, the 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. If a respondent gave a WTP of zero, she was asked why she gave a zero bid. 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 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 2 were identified as protest bids. Problems and possible bias resulting from misclassification of protest bids (Musser et al.) are not likely with these results. 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 A 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. used 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. found that respondents' perception of health risk and location were significant variables in describing variations in willingness to pay for ensuring relocation of a proposed landfill site. They also suggested examining the effect of property ownership on WTP.

For this study, household WTP and WTA were hypothesized to be stochastic linear functions of years in the community (YRS), income (INC), perceived health risk (HLT), and ownership status (OWN):

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

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

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

Income was 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 Equation 2 primarily by convention (e.g., see Brookshire and Coursey).

A binary variable was 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; Roberts et al.). Because the affected area is relatively small and in close proximity to the plant (i.e.; less than a 3.2 km radius) a distance variable was not included.

Finally, a binary variable for ownership status (owned vs. rented) was 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 renters.

RESULTS AND DISCUSSION

There is a relatively large difference between the average WTP and WTA values with WTA approximately seven times that of WTP. The sample mean for WTP was $105.31 with a standard deviation of $77.1 while the sample mean for WTA was $735 with a standard deviation of $382.24. This difference is within the range "typically" experienced in WTP vs. WTA results in both controlled and uncontrolled experiments (Cummings et al.; Adamowicz; Knetsch). Median values were $80 and $675 for WTP and WTA respectively. Parametric confidence intervals at the 95% level for means as well as nonparametric confidence intervals for the medians are reported in Table 1.

Some have advocated dismissing WTA results as being unreasonable while others have criticized the reliability of CVM as a technique that produces empirical results which undermine the conventional presumption of valuation equivalence for quantity changes (Cummings et al.; Randall and Stoll; Mitchell and Carson; Ketsch and Sinden). Knetsch (1990) however, suggests that in cases where environmental degradation and preservation are valued, WTP may in fact understate welfare changes. Rolston, from a philosophical standpoint, espouses a similar position.

The data for WTP responses do not appear to be unusual however, this is not the case for the WTA responses (Appendix A, Table A.3). Nearly one half of the WTA responses (44%) were at $1000 while 23.5% responded $500. This is an interesting phenomenon since $1000 was 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 that either 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 disgarding a valid WTA observation of $2000.

Total aggregate annual valuation figures were estimated by multiplying the average WTP and WTA values by the estimated number of households affected by odors from the rendering plant. This procedure was used by Roberts et al. and 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 was $183,750 while that of WTP was $26,327 while with medians the WTA and WTP aggregates are $168,750 and $20,000 respectively.

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

$$PV=\int V(t)\,e^{-rt}dt \tag{3}$$

where PV is the present value of the stream of annual benefits from pollution control and V is aggregate annual WTP(WTA) for the entire population affected by the rendering odors. Using a discount rate of 10 percent and a planning horizon of 30 years resulted in aggregate WTA benefits of $1,746,016 and WTP benefits of $250,162 based on means. Substituting medians for means led 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 were estimated to be "roughly" 90 percent. Comparing the approximate costs of 150,000 to either WTA or WTP estimates from Table 2 leads to positive net benefits results, even if benefits are reduced to 90 percent of estimated levels.

The valuation functions (equations 1 and 2) for average annual household WTP and WTA were estimated using ordinary least squares. Results of the regressions are summarized in Table 3.[4]

Cameron and Huppert compared the use of MLE vs. OLS on payment card data. They found that in "well-designed" surveys the differences between estimation procedures to be "very close" when using interval midpoints. However 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 she feel the represented values insufficient, hence we feel that modelling interval midpoints and MLE are unnecessary. Aside from possible differences in regression coefficients, modelling midpoints would lead to larger median and mean values for WTA and WTP.

The hypothesized explanatory variables YRS, INC, HLT and OWN accounted for 46 percent of the variation in WTP and 47 percent of the variation in WTA. R-square values of these magnitudes are relatively high compared to an average for CVM studies listed by Adamowicz.

The coefficient for years in the community was 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 might with other types of nuisances, for example black flies (Reiling et al.). 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 (Barteaux). The WTA YRS coefficient was highly significant suggesting the possibility of an endowment effect identified by years of residence significantly influences WTA.

The coefficients on household income were 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 finding little impact or significance of income on 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 A). We feel the best explanation is that income is simply not a factor in explaining certain necessary environmental goods.

The health risk variable was significant at the .01 significance level in both equations. Respondents who believed the rendering emissions to be a health hazard were found to have E(WTP) and E(WTA) of $119.42 and $459.93 more respectively than those who felt the emissions were simply a were not a risk. This result has interesting ramifications if in fact the emissions are not a health hazard.

The coefficients on ownership in both equations were 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. found a similar insignificance of ownership in their landfill location study.

CONCLUSIONS 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.[5] Such a 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. 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. 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 conclusion of positive social gains however should 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 were estimated in the WTP case under the assumption that odors would be completely eliminated. If not, the question of additional costs for "complete" control of odors vs. the relevant WTP or WTA benefit measure is raised. Certainly, linearly extrapolated benefit or cost estimates should be viewed cautiously. In a larger area researchers would be advised to attempt to estimate a total benefits curve based on varying levels of abatement.

The use of the payment card in this study raises some questions. It appears to be the most propitious elicition technique when samples are small and it is gaining in popularity of late. However, as this study shows in the WTA responses, ambiguities and possible censoring problems in the top end can arise. Whether respondents are anchoring to a familiar value or not having a fully adequate response range cannot be determined in this study. We choose to believe that since we did receive a response above $1000 and had an interviewer explain the optional fill-in, that the data is not censored. However, 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 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 mean 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.

Regression results are often tenuous when derived from small samples. In this case, 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.

Mitchell and Carson (p. 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 for local applications, sample size and property rights issues will likely be unavoidable. In such cases economists should make as much use of sample information as possible, e.g., report means and 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. 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.

3. Our sampling plan 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.

4. Both models were re-estimated after dropping the OWN variable. 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.). However three of the four estimated WTA coefficients and two of four estimated WTP coefficients became "significant" at the .05 level. Signs were unchanged and magnitudes are changed only marginally indicating a certain amount of "robustness". Debertin and Freund 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 were not found to be present based on simple correlations and the coefficient stability reported above.

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. Our WTP and WTA results were derived strictly from households, therefore we feel that total benefits to all consumers of air in the area may be at worst understated somewhat.

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	183,750	26,327
Present Value	1,746,016	250,162
Median	$675	$80
Interval[c]	[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] 95% confidence based on a nonparametric quantile test (Conover)

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] based on aggregated means

Table 3. OLS Regressions of WTP and WTA

Variable	Description	WTP	WTA
YRS	Years in Community	3.4943 (1.57)[c]	17.084 (2.15)*
INC	Total household income	-.90282 (-0.84)	-6.7791 (-1.58)
HLT[a]	Whether respondent feels air quality is a health hazard	119.42 (3.06)**	459.93 (3.23)**
OWN[b]	Whether respondent owns or rents	39.386 (0.91)	158.04 (0.91)
CONSTANT		38.75 (1.12)	517.51 (3.46)**
	R^2	.4616	.4708
	F-Value	5.787**	6.499**
	Observations	32	34
	Sample Mean	105.3	735

[a] 0,1 dummy variable to denote whether respondent felt the rendering emissions were a health risk: YES=1, NO=0.

[b] 0,1 dummy variable to denote whether respondent owned or rented their household: OWN=1, RENT=0.

[c] t-statistics in parentheses

* significant at the .05 level

** significant at the .01 level

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APPENDIX A

Table A.1. 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 odours emitted from _______ over the past year.

(WTP Version)
Assume the new equipment _______ is installing fails to reduce odor emissions from the plant but meets goverment 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 was set up to ensure that _______ would install such equipment, what is the maximum amount you would be willing to contribute anually 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 was implemented that would make households affected by the odors eligible for annual compensation payments.

If your household was 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$_______

Table A.2. Results of Survey - Summary Statistics

WTP QUESTIONAIRES

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	14.6	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

Table A.3. Distribution of household WTA and WTP values.

Payment Card Values	WTA Number Reporting	WTA Percent	WTP Number Reporting	WTP 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.