Environmental Injustice: An Ohio Case Study

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Abstract

Valuation of environmental regulations and policy changes is usually focused on the achievement of economic efficiency or potential Pareto improvement (PPI): a proposed change or policy is accepted if those who gain from carrying out a specific project or policy could, in principle, compensate those who lose from implementing that policy so no one is worse off. Aggregate measures of value such as aggregate willingness to pay are common measures of economic efficiency. However, in reality, compensations by the gainers to the losers of a policy seldom take place and the disadvantaged must bear most if not all the cost of the adverse effects of the policy change or environmental degradation. Furthermore, willingness to pay is largely dependent on the ability to pay and as such, environmental resources are not shifted to those who only value them the most, but to those who value and can afford them as well. This article focuses on studying the distributional impacts of river contamination and clean up including stated preference evaluation of environmental improvements. In particular, the issue of concern is whether poor and minority households in the study area have been unjustly exposed to contamination in the river; and therefore, whether the use of different weighting schemes for benefits of different demographic groups (especially, minority and low-income) would be justified.

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Valuation of environmental regulations and policy changes is usually focused on the achievement of economic efficiency or potential Pareto improvement (PPI): a proposed change or policy is accepted if those who gain from carrying out a specific project or policy could, in principle, compensate those who lose from implementing that policy so no one is worse off. Aggregate measures of value such as aggregate willingness to pay are common measures of economic efficiency. However, in reality, compensations by the gainers to the losers of a policy seldom take place and the disadvantaged must bear most if not all the cost of the adverse effects of the policy change or the environmental degradation. Most current benefit cost analyses are based on the Kaldor-Hicks criterion of potential compensation to those who lose from a policy change. However, Farrow (1998) argues that actual compensation should be considered in assessing a project's feasibility. He also argues that a project is feasible only if it passes both the Kaldor-Hicks test and the equity test. This means that not only the net present value of a project in aggregate has to be positive but also the net present value of the project for the more sensitive group, especially minorities and low income groups, has to be positive.

Moreover, willingness to pay is largely dependent on the ability to pay and as such environmental resources are not shifted to those who only value them the most, but those who value and can afford them as well (Gauna, 2002). One of the assumptions of neoclassical economic theory is constant marginal utility of money income across all individuals and groups in a society. This assumption has long been debated in the welfare economics literature and some economists (Hitzhusen 2002; Blue and Tweeten 1997) consider it to not be less subjective than other assumptions about marginal utility of money income. Constant marginal utility means that an additional dollar of benefits contributes equally to the well-being of individuals whether they are poor or wealthy. This assumption seems odd especially when considering some governmental policies such as the progressive income tax system which taxes the rich at a higher rate of income than the poor, and thus implicitly assumes a higher marginal utility of money income for the poor than for the rich. As such, several studies (for example, Ahmed 1982) have tried to put different weights on the benefits accrued to different groups of individuals based on income, race, and social status. Blue and Tweeten (1997) went further and estimated marginal utilities for different classes of income by constructing a quality of life (QLI) index, a proxy measure of utility, using factor-weighted and simple-summation weighted aggregation of socio-psychological measures of well being. They found that income, age, and health were the variables having the greatest impact on QLI and that QLI was stable over time.

Previous studies (Timney, 2002) have indicated that environmental deterioration in minority and poor neighborhoods is often a result of social prejudices that existed when the environmental incident was introduced (for example, the construction of a new industry that emits its wastes into nearby rivers and streams.) In another study, Hite (2000) using a hedonic price model to study the effects of proximity to landfills on real estate values in central Ohio found that minorities especially African American households were unjustly exposed to environmental hazardous landfills.

This article focuses on studying the distributional effects of river contamination and clean up including stated preference evaluation of environmental improvements. The study case is the lower Mahoning River in northeast Ohio where contaminated sediments have polluted the river and degraded the ecosystem for almost a century. Contamination in the river is from the steel industry that once boomed in this part of the country during the late nineteenth and most of the twentieth century. An examination of census data by townships shows a potential presence of environmental injustice in the river corridor prior to clean up; minorities and low-income groups are more exposed to the environmental bad (in this case, water pollution) compared to other groups in the population.

Demographic comparisons by census data indicate that, on average, townships inside the river corridor have more African Americans (15% vs. 0.8 %), are less educated (78% vs. 89% of high school completion), and are poorer ($30,526 vs. $47,249 of median household income) compared to townships outside the river corridor. This means that minorities and the disadvantaged might have disproportionately borne the social cost of river pollution that was originally caused by the steel mills a long time ago. However, one might argue that if minorities and poor people had prior knowledge about contamination in the river and chose to live along the river, environmental equity would not be an issue. This is because people would be trading contamination in the river for more housing benefits such as more bed rooms or lower property taxes or rents. A more critical question, as put by Dr. Lauren Schroeder[1], is whether poor people and minorities had equivalent housing opportunities before choosing to live near the river or whether they had few choices. Do poor people live near the polluted Mahoning River because they have little choice or do they live there because the benefits out weight the costs? Schroeder argues, “Poor people and minorities, especially African Americans, have lived along the river despite the environmental degradation, not by choice, but by necessity”.

[1] Lauren Schroeder is an emeritus professor at Youngstown State University and a long-time resident of the Mahoning River area.

He also argues that historical segregation in housing in the area since the steel mills era persists today and results in barriers discouraging movement of poor and minorities from the environmentally impoverished areas along the river.

Methodology:

The analysis in this study proceeds by first classifying the contingent valuation sample into different groups based on demographic characteristics that are expected to be the most important demand shifters in the bid functions especially income, ethnicity and education. The data used in this study was from a 2002 mail survey that was administered randomly in counties within the Mahoning River watershed. A dichotomous choice question as well as a complementary open-ended question was used to elicit households' willingness to pay for two restoration projects: dredging only (D) and dredging and dam removal (D-DR). To study distributional effects, contingent valuation (CV) models were estimated for different groups within each stratum (e.g. black vs. white and rich vs. poor) and then tests were conducted for differences in the log likelihood function and model coefficients. The testable hypothesis is that bid functions are not different between different classes of households. A rejection of this hypothesis means that different classes of people value environmental improvements differently. This alone may not indicate environmental injustice. However, the incidence of these long-term river contamination impacts and the disproportionate distribution of minorities and poor households along the polluted segment of the river may provide this evidence. WTP was estimated using a probit random utility model (McFadden, 1974), in which respondent j agrees to pay the offered price t_j if his true WTP for the proposed scenario exceeds t_j:

$$WTP(Z_j, \eta_j) > t_j$$

where Z_j is a vector of respondent's characteristics, which may include household income, and η_j is a stochastic error term that is distributed with mean zero and constant variance σ^2. This WTP function could be estimated by specifying a functional form for WTP and a distribution for the stochastic error term. Let us assume that WTP is exponential,

$$WTP_j = e^{\Theta Z_j + \eta_j}$$

Where Θ is a vector of coefficients to be estimated that corresponds to the vector of covariates Z. The probability of a yes response by individual j to the offered price t_j is:

$$\Pr(yes_j) = \Pr(WTP_j > t_j)$$

$$= \Pr(e^{\Theta Z_j + \eta_j} > t_j)$$

$$= \Pr(\eta_j > \ln(t_j) - \Theta Z_j)$$

Normalizing the above inequality function by the unknown standard error σ, the probability of yes can be written as follows:

$$\Pr(yes_j) = \Pr(\frac{\eta_j}{\sigma} > \frac{1}{\sigma}\ln(t_j) - \frac{\Theta}{\sigma} Z_j)$$

$$= \Pr(\theta_j > \alpha \ln(t_j) - \beta Z_j)$$

where $\theta_j = \frac{\eta_j}{\sigma}$, $\alpha = \frac{1}{\sigma}, and\ \beta = \frac{\Theta}{\sigma}$. Assuming that η_j is distributed normally then θ_j is distributed as standard normal with mean zero and unit variance and the resulting model is estimated using a probit model. Likewise, if we assume that the error term is distributed logistically, the resulting model is estimable using a logit model. Assuming a normal distribution for the error term, the last inequality can be rewritten as a standard normal cdf function as follows:

$$\Pr(yes_j) = 1 - \Pr(\theta_j < \alpha \ln(t_j) - \beta Z_j)$$

$$= 1 - \Phi_\theta(\alpha \ln(t_j) - \beta Z_j)$$

Where Φ_θ is the cumulative distribution function for the normalized error term θ. Consequently, the probability that respondent j answers no to the offered price is:

$$\Pr(no_j) = \Phi_\theta(\alpha \ln(t_j) - \beta Z_j)$$

Suppose that the sample size is N and let Ij = 1 if respondent j answers yes, parameters α and β are estimated by maximizing the likelihood function:

$$L(\alpha, \beta \mid Z, t) = \prod_{j=1}^{N} \left[1 - \Phi_\theta(\alpha \ln(t_j) - \beta Z_j)\right]^{I_j} \left[\Phi_\theta(\alpha \ln(t_j) - \beta Z_j)\right]^{1-I_j}$$

Second, Willingness to pay (WTP) is calculated (using parameter estimates above) for each group and then compared to WTP of the other group in each classification. It is should be noted that rejecting the null hypothesis of equal bid functions for two groups does not necessarily indicate that central tendency measures of value such as mean or median WTP are significantly different between these groups. This is because mean and median WTP are non linear functions of the estimated coefficients and therefore their distribution functions do not follow the normal form assumed for the error term in the bid function.

Third, the neoclassical assumption of equal marginal utility of money income will be relaxed allowing for different measures of marginal utility to be assigned to different groups of individuals based on income, race, and/or exposure to the environmental disamenity. These measures are calculated using two of the quality of life indices developed by Blue and Tweeten (1997) as well as the inverse of the progressive income tax ratio. The objective of the analysis is not to choose or recommend a specific weight or marginal utility measure for calculating benefits or costs. Rather, the objective is to present decision makers with a sensitivity analysis of the economic viability of the restoration projects under different assumptions of marginal utility of income including the traditional assumption of equal marginal utility of income across all individuals or groups.

Classification Schemes:

Because, the survey frame was counties in northeast Ohio, it was not possible to use township or city data to classify the survey in order to study distribution effects. As such, in all the classification schemes considered in this study county level data will be used. The contaminated segment of the Mahoning River, about 31 miles, is located in Mahoning and Trumbull counties only and thus these counties are more affected by contamination in the river than other counties in the watershed (see Figure 1). Examining census data by county, Table 1 shows that Mahoning and Trumbull counties have lower median household income and higher proportion of African Americans than other counties in the Mahoning River watershed, and than the whole watershed, which includes seven counties in northeast Ohio: Mahoning, Trumbull, Columbiana, Ashtabula, Geauga, Stark, and Portage.

County	Median Household Income	% of African Americans
Mahoning	$ 35,248	15.9
Trumbull	$ 38,298	7.9
Other Counties	$ 42,841	3.4
NE Ohio	$ 40,112	5.6

Table1: Average income and percentage of African Americans by location

In the analysis that follows, the term 'inside MR corridor' is used to indicate counties inside the Lower Mahoning River corridor, namely Mahoning and Trumbull counties, and the term 'outside MR corridor' is used to indicate counties outside the Lower Mahoning River corridor, namely Ashtabula, Geauga, Portage, Columbiana, and Stark counties. This classification is mainly based on closure or exposure to the contaminated segment of the river; i.e., the lower segment located in Mahoning and Trumbull counties. Originally, stratification of the sample was intended to be based on race, education, and income. Education in the sample is positively correlated with income ($\rho = .34$), and negatively correlated with being black ($\rho = -.01$), so education is already represented in the classification of households by location. Furthermore, we could not match the education variable in the sample (a scale of 1 to 6) to the census education variables (for example, percentage of individuals with high school diploma, and percentage of individuals with college degree), which made it difficult to classify the sample based on census data.

As for the race variable, African Americans were underrepresented in the sample, 2% in the whole sample and 4% in Mahoning and Trumbull counties compared to 6% and 12%, respectively, in the population. Thus, race could not be used as a basis for classification given the limited number of African Americans in the sample. Alternatively, since income in the sample is negatively correlated with being African American (ρ = -.1) and since the intensity of African Americans is higher inside MR corridor, the classification of individuals based on location will serve as a proxy for the black minority in the analysis of distribution effects.

Classification based on household income is used to study the effect of the environmental change on the low-income group in general regardless of race or education. Studying distributional effects by income groups might provide different or more insights on environmental injustice of river contamination than studying only location-based distributional effects. Median household income in the population ($40,000) is used as a cut off point for classification: households with income levels less than or equal to $40,000 are considered poor or low-income, whereas households with income levels more than $40,000 are considered rich or high-income. Table 2 depicts the two classification schemes used throughout this article.

Classification			
Location		Income	
Inside river corridor	Outside river corridor	Poor	Rich
Lives in Mahoning or Trumbull Counties	Lives in other counties	≤ $40000	> $40000

Table 2: Classification Schemes

Table 3 shows the demographic profiles of different income and location sub-groups in the sample. For the location stratification, it is clear that households in Mahoning and Trumbull counties have lower income levels, have more African Americans, own fewer boats, are slightly less educated, and live closer to the river than households in other counties in the watershed. It should be noted that income levels in the sample are generally higher than income levels in the population. This over representation of high income households in the sample should and will be accounted for in calculating willingness to pay for the different sub-groups. As for the income strata, average income is significantly different between the rich and the poor. In addition, the poor sub-group has more African Americans, owns fewer boats, and is less educated than the rich sub-group. However, the poor in general do not live significantly closer to the river than the rich as indicated by the distance to the river variable. It should be noted that the DISTANCE variable measures the shortest distance to the Mahoning River in general and not specifically to the contaminated segment. Distance to the contaminated segment could not be obtained from the current survey and might have been more useful in demonstrating environmental injustice.

	Classification			
	Location		Income	
Variable	Inside River Corridor	Outside River Corridor	Poor	Rich
INCOME/1000	$44.67	$50.53	$25.43	$71.00
AGE	56.15	56.84	61.49	50.11
WHITE	94%	95%	94%	95%
BLACK	5%	1%	4%	2%
OWN_BOAT	12%	24%	13%	23%
DISTANCE	6.66	43.26	19.66	23.49
EDU	2.87	2.99	2.62	3.32

Table 3: Descriptive statistics by location and income categories

Random Utility Model Results:

A random utility probit model is estimated for each of the sub-groups in order to study structural differences in WTP functions between individuals in each classification, first by location and second by income. Probit regression results are reported in Table 4 for the location stratification and Table 5 for income stratification, for both D and D-DR. A probit model is estimated for the pooled data in each case in order to calculate likelihood ratio statistics for differences between groups in each stratum.

Location Stratification Results:

Inside Mahoning River corridor, the probability of voting yes for dredging (Table 4) is positively and significantly (at the .01 level) correlated with the degree to which the respondent thinks of the potential effect of river restoration on the economy of the MR area (ECONOMY = a scale of 1 to 5), and positively and significantly (at the .1 level) correlated with the respondent's level of education. Income, is positively but not significantly correlated with the probability of a yes response, indicating that education has more impact than income on WTP for dredging in the disadvantaged group inside the MR corridor that is predominantly black and low-income.

Outside MR corridor, the coefficient on ECONOMY is still positive and significant at the .01 level. However, income is positive and significant at the .05 level while education is negative and insignificant at the .1 level in the outside MR corridor group. This suggests that income is more important than education in determining WTP for dredging in the higher-income, more white group living outside MR corridor. VER3 and VER4 are dummy variables for scenarios 3 and 4, respectively, and are included to account for any potential context and/or order effects on WTP in valuation (see Abdul-

Mohsen, 2005 for a detailed treatment of scope, context, and sequence effects in this study). The likelihood ratio (LR) statistic for the difference between the two models is insignificant at the 0.1 level, indicating that WTP behavior is not significantly different between inside and outside MR corridor. However, this result does not necessarily mean that WTP is the same for both groups, given that the LR ratio is significant at the 0.2 level.

Before any calculation of WTP for D or D-DR using coefficient estimates from the bid functions above, it should be noted that the sample at hand is more biased toward the rich and the white, in general. In other words, the sample has higher median income and less percentage of African Americans than the corresponding population. Accordingly, WTP should be adjusted at the calculation stage to be more representative of the true WTP in the population. Since there were not enough observations on African Americans in the sample and since there is positive correlation between being African American and earning low-income as indicated before, income is used as a proxy for both income and race. In order to adjust WTP after estimating bid functions, average household income in the sample was replaced with average household income in the corresponding population for each group and for the whole sample in the calculation stage of WTP. In the analysis that follows, the adjusted estimates of median WTP are used to compare between groups and to extrapolate WTP to the corresponding population(s).

From Table 4, Median WTP for dredging is \$132.8 for the inside MR corridor group and \$60.1 for the outside MR corridor group, indicating that the disadvantaged group has more WTP for the least cost project (dredging without dam removal) than the rest of the sample. One explanation for this result might be that people living near the contaminated segment of the river in Mahoning and Trumbull counties are more affected by contamination than others are, and thus are willing to pay more for cleaning up the river at the lowest cost possible given their limited budgets. Comparing the 90% confidence interval for WTP of the inside MR corridor group ($37.6 - $550.5) to that of the outside MR corridor group ($32.9 - $148.9), WTP for the dredging only option is not significantly different between the two groups at the 0.1 level.

The lower part of Table 4 shows probit results for the larger scope of the good, dredging with selective dam removal. In the inside corridor group, all variables have the expected signs but only income is significant at the 0.05 level; other variables are insignificant at the 0.1 level including the coefficient on the bid price. This indicates that income becomes more influential in determining WTP of the disadvantaged group for the larger scope and more expensive project. As for the outside MR corridor group, income and education have a positive and significant effect on WTP for Dredging with dam removal while the coefficient on the bid price is negative and significant, as expected by economic theory. Owning a boat has a positive effect on WTP for the D-DR project although it is insignificant in both the inside and outside MR corridor groups.

When comparing both groups, it is obvious that all coefficients (except for VER3 and VER4) increase in magnitude and significance for the outside compared to the inside river corridor group. This again indicates that the higher cost project, dredging with dam removal, is not of significant interest to the disadvantaged group that lives near the contaminated segment of the river in Mahoning and Trumbull counties. This is apparent from median WTP comparison between groups: median WTP outside the river corridor

($105) is higher than median WTP insider the river corridor ($54).

	Dredging Only					
	Inside MR Corridor		Outside MR Corridor		Pooled Data	
Variable	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
Constant	0.171	0.16	0.885	0.57	0.326	0.39
ECONOMY	0.330***	3.03	0.748***	3.70	0.452***	4.95
EDU	0.174*	1.79	-0.019	-0.14	0.111	1.41
INCOME/1000	0.004	0.82	0.018***	2.63	0.008**	2.10
VER3	-0.071	-0.26	0.276	0.70	0.010	0.05
VER4	-0.547**	-1.94	-0.269	-0.66	-0.456**	-2.03
Log (Bid_D)	-0.419**	-1.98	-1.012***	-3.04	-0.573***	-3.33
Log Likelihood	-82.97		-40.39		-128.38	
Sample Size	138		89		227	
LR (d.f.)			10.04 (7)			
MD (WTP_D)	$142.80		$71.20		$100.30	
Adj. MD (WTP_D)	$132.80		$60.10		$90.70	

	Dredging with Dam Removal					
	Inside MR Corridor		Outside MR Corridor		Pooled Data	
Variable	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
Constant	0.617	0.50	2.358	1.36	1.448	1.50
OWN BOAT	0.406	1.18	0.589	1.34	0.469*	1.83
INCOME/1000	0.010**	2.07	0.015**	2.05	0.011***	2.93
EDU	0.103	0.93	0.458***	2.85	0.200**	2.26
VER3	0.367	1.29	0.312	0.74	0.386*	1.69
VER4	0.129	0.40	0.701*	1.73	0.371	1.54
Log (Bid_{D-DR})	-0.334	-1.47	-0.964***	-3.07	-0.582***	-3.30
Log Likelihood	-77.24		-39.18		-121.32	
Sample Size	122		86		208	
LR (d.f.)			9.80 (7)			
MD (WTP_{D-DR})	$67.20		$111.80		$89.40	
Adj. MD (WTP_{D-DR})	$53.70		$105.00		$80.70	

Table 4: Probit model estimation by location

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

However, the difference in WTP is insignificant between the two groups as indicated by the 90% confidence intervals for WTP, \$27.1-\$124.5 inside river corridor versus \$25.8-\$167.3 outside river corridor. The likelihood ratio for the difference between the two bid functions is not significant at the 0.1 level (though significant at 0.2 level), indicating no significant structural differences in WTP responses between the inside and outside river corridor groups with respect to the more inclusive project (D-DR) at the 0.1 level.

Income Stratification Results:

The upper part of Table 5 shows regression results by income class for the dredging only project. As expected, respondents' attitudes toward the goal of protecting the environment in general and their level of education have a positive and significant effect on WTP for dredging in both low and high income groups. Living near the contaminated sediments in Mahoning and Trumbull counties (In-Corridor) has a positive and significant effect at the 0.1 level on WTP for dredging in the low-income group. On the other hand, the In-Corridor coefficient is negative and insignificant in the high-income group. This indicates that low-income people living in Mahoning and Trumbull counties are more supportive of the dredging only project than low-income people living outside those counties. The opposite is also true for the high-income group: high-income people inside Mahoning and Trumbull counties are less supportive of the dredging project than high income people living outside these counties. An explanation for this finding might be that high-income households inside the river corridor can afford alternative recreation opportunities outside the Mahoning River valley, and thus are less supportive of restoring the Mahoning River, than poor households inside river corridor.

Dredging Only						
	Low Income		High Income		Pooled Data	
Variable	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
Constant	0.139	0.11	-0.132	-0.10	0.089	0.10
PROT ENVI	0.473	2.68***	0.340	2.02**	0.382	3.31***
EDU	0.221	1.96**	0.179	1.73*	0.220	3.05***
IN CORRIDOR	0.520	1.86*	-0.011	-0.04	0.134	0.75
VER3	0.088	0.29	0.043	0.14	0.049	0.24
VER4	0.230	0.74	-0.882	-2.73***	-0.373	-1.75*
Log (Bid_D)	-0.760	-3.09***	-0.323	-1.35	-0.524	-3.19***
Log Likelihood	-67.31		-66.56		-141.59	
Sample Size	120		111		231	
LR (d.f.)			15.44** (7)			
MD (WTP_{DR})	$54.70		$187.30		$99.71	

Dredging with Dam Removal						
	Low Income		High Income		Pooled Data	
Variable	Coefficient	t-Value	Coefficient	t-Value	Coefficient	t-Value
Constant	-0.908	-0.55	-0.606	-0.37	-0.803	-0.71
PROT ENVI	0.546***	3.02	0.761***	3.64	0.636***	4.80
EDU	0.130	0.98	0.304**	2.32	0.287***	3.30
DISTANCE	-0.005	-0.88	0.002	0.27	-0.002	-0.63
VER3	0.451	1.31	0.418	1.22	0.383	1.63
VER4	0.448	1.29	0.267	0.72	0.269	1.11
Log (Bid_{DR})	-0.450*	-1.76	-0.696***	-2.59	-0.574***	-3.19
Log Likelihood	-59.28		-51.03		-113.99	
Sample Size	110		95		205	
LR (d.f.)			7.4 (7)			
MD (WTP_{DR})	$30.40		$169.20		$88.40	

Table 5: Probit model estimation by income

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

The likelihood ratio statistics for the difference between bid functions for the two groups is significant at the 0.05 level, indicating a different WTP behavior between low and high income groups. As shown above, the coefficients on protecting the environment, education, and log of the bid price are more significant in the low-income group than in the high-income group. In addition WTP estimates are significantly different between the poor and the rich at the 0.05 level as indicated by confidence intervals for WTP: Median WTP for dredging is $55 with a 95% confidence interval of $7-$78 for the low-income group, and is $187 with a 95% confidence interval of $86-$554 in the high income group. This indicates that the rich in general have a higher WTP for dredging than the poor.

Results for the larger scope of the good, dredging with dam removal, are shown in the lower part of Table 5. In general, most of the coefficients are more significant in the high-income group than in the low-income group. Education has a positive and significant effect on WTP at the 0.01 level in the high-income group whereas it has no significant effect in the low-income group. The coefficient on the bid price is negative and more significant in the high-income group, indicating that the demand for the more inclusive good or project is more responsive to price for high-income categories than for low-income categories. The distance to the river coefficient is insignificant in both income groups, indicating that distance to the river has no significant effect on respondents' valuation of D-DR. It should be noted that DISTANCE is a measure of the distance to the nearest stretch of the Mahoning River and not to the contaminated segment in particular. The negative sign of the distance coefficient in the low-income group suggests that poor individuals who live near the river have higher WTP for D-DR than poor individuals who live far from the river. The opposite is also true for the high-income group: rich individuals living far from the river have higher WTP than rich individuals living near the river. As in the dredging only case above, this result could be explained by the fact that poor households living near the river are less capable of seeking recreation alternatives elsewhere, and thus are supportive of restoring the river than poor households who already live away from the river. In addition, higher WTP of the rich living away from the river than those who live near the river could be attributed to non-use values such as existence value by those who live away from the river.

Comparing bid functions for the two income groups, the likelihood ratio statistic is 7.4 with 7 degrees of freedom and is insignificant at the 0.1 level, which means there is no significance difference between the sets of coefficients in the two models in general. Comparing WTP measures, median WTP for D-DR is higher for the high-income group ($169) than for the low-income group ($30). However, when comparing 90% confidence intervals for WTP, $.24-$114.1 for the low-income group and $68.9-$284.6 for the high-income group, the difference in WTP between the two groups is insignificant at the 0.1 level but significant at the 0.2 level. This shows that the rich as a group have higher WTP for the D-DR project and thus their say could have more effect on the economic viability of the project than the poor in a traditional neoclassical benefit-cost analysis.

The results presented in the foregoing analysis of bid functions by income groups provide some evidence of environmental injustice for minorities and poor people in the Mahoning River Valley in the consumption of the environmental quality (restoring Mahoning River). In particular, the conclusion that poor people inside the Mahoning River corridor are willing to pay more for the dredging only project than poor people outside the MR corridor might indicate that poor people, given the choice, will prefer to live in environmentally healthier areas, and that they are not trading contamination for cheap housing by living along the polluted river.

Benefit-Cost Analysis:

An important outcome of any environmental valuation study, from a policy standpoint, is the comparison of the proposed project's costs and benefits in order to determine its economic viability. Usually, the benefits accrued to all individuals or households in the affected population are added up to estimate the total benefits or economic value of the project or the policy change. This approach of the simple summation of benefits assumes that the marginal utility of money income (MUI) is constant across all individuals or groups in a society. In other words, it implies that a dollar of income contributes to well-being equally regardless of whether dollars are accrued by poor or rich individuals. However, this implicit assumption of constant MUI is in contradiction with the diminishing marginal utility theory, which postulates that as the consumption of a particular good increases, the utility of consuming an incremental unit of that good decreases. If we apply this theory to income, assuming that income is a good or used to buy goods, poor individuals should have higher marginal utility of income than rich individuals should.

Most mainstream economists have emphasized the efficiency criterion in measuring utility and discarded the equity criterion as objectively immeasurable. However, the assumption of equal MUI for all individuals is not less subjective and hypothetical compensation embodied in the Kaldor-Hicks criteria may be even more subjective. Schreiner (1989) argues that benefits and costs of a project should be distributed among members of the society according to their marginal utilities of consumption. In our benefit-cost analysis, we apply different MUIs or weights to different groups of individuals using results of a previous study on measuring preferences as well as our own weights inferred from actual governmental policies, especially the progressive income tax code. Then, these estimates of MUI are used in weighting the benefits accrued to different groups of individuals, especially the disadvantaged, to see how the economic viability of the proposed projects for river restoration varies under different assumptions about MUI.

MUI Based on the Quality of Life Indices:

Blue and Tweeten (1989) in a study published in the Agricultural Economics Journal constructed a quality of life index (QLI) to approximately measure utility from socio-economic measures of well-being. These quality of life indices were then regressed on selected socio-demographic variables using different functional forms including quadratic, Cobb-Douglas, square root, and semilog forms. Among the independent variables used in the regressions, income, education, and health had the most effect on well-being. QLI was not influenced much by the year of measurement, sector, or region of residence; and that makes it more suitable to use in the current analysis. Furthermore, much of the variability in the QLI was unique to individuals, which makes it more useful in predicting group rather than individual well-being. Taking the first order condition of the utility function with respect to income, Blue and Tweeten were able to derive an estimator of the marginal utility of income for a specific group as a function of mean income in that group expressed as a proportion of mean income in the whole population. We apply two QLI functional forms from Blue and Tweeten's, the quadratic and the square root forms, to our analysis of the benefits of Mahoning River restoration projects. The marginal utility curve for the quadratic utility function is:

$$MUI = 1.5065 - 0.5065PI$$

Where, PI is average income of the interest group as a proportion of average income in the respective population. MUI of the square root utility function is:

$$MUI = -0.4242 + 1.4242PI^{-0.5}$$

The quadratic form has the best fit in explaining the variability of the QLI in Blue and Tweeten's study, but implies theoretically implausible results at higher income levels. In particular, the quadratic form implies that MUI approaches zero at some higher income level. On the other hand, the square root, semilog and Cobb-Douglass functional forms imply that MUI decreases as income increases but never approaches zero, which is more plausible. The square root function is preferred to the quadratic function at higher income levels, and is preferred to the semilog and Cobb-Douglass functions on the grounds of goodness-of-fit. In summary, the quadratic form was chosen because it has the best fit and also because it gives the most conservative estimate of MUI, and the square root form was chosen because it has the second best fit and is more plausible at higher income levels.

In the benefit-cost analyses of the MR restoration projects, two assumptions are made. First, we assume that MUI for the advantaged group (either the outside river corridor group or the high-income group) is unity and thus the average income of that group is used as the average income in the population. This is assumed for purposes of normalization and relative comparisons between groups in each stratum. The second assumption is that the cost of any approved project is to be borne equally by each individual in the study area. This is consistent with hypotheses of the discrete choice contingent valuation survey that the cost amount of a project is to be shared by everyone if is approved by the majority of respondents, and that the payment mechanism is a one-time payment and not a percentage increase in income taxes or utility fees. However, one might argue that if payment was a percentage of the household income, rich people would pay more for the public or environmental good than poor people and the proposed project would be more economically attractive. A problem with this payment vehicle is that it may induce strategic behavior on the part of rich people in contingent valuation surveys, meaning that rich people may protest the payment mechanism and understate their true WTP for the good in question.

Substituting average incomes in the corresponding populations for inside and outside MR corridor groups from the 2000 census data, $36,773 and $42,841 respectively, into the quadratic form MUI equation above, PI is 0.86 and MUI for the disadvantaged group is 1.07. Similarly, substituting average incomes for the poor and rich from census data, $20,145 and $73,111 respectively, into the MUI equation above yields a PI ratio of 0.28 and MUI of 1.36 for the poor and 1 for the rich. Substituting the same PI ratios into the square root function above yields an MUI of 1.11 for the inside MR corridor group and 2.27 for the poor group. Then, multiplying the total benefits accrued to each group by MUI for that group, one can obtain an estimate of the weighted benefits for each group and for the project as a whole and then compare it to the project's estimated cost as shown in Tables 4.7 and 4.8. It should be noted that the cost figures used in these tables were obtained from the Army Corps of Engineers 1999 reconnaissance report on the restoration options for the Mahoning River, in which the estimated cost were $66 million and $91 million for the dredging only and dredging with partial dam removal projects, respectively. It should be noted that the costs of restoration are in 1999 dollars and the benefits are in 2002 dollars. Thus, inflating the cost figures to 2002 values may have a slight effect on lowering benefit-cost ratios for both projects.

MUI Based on the Progressive Income Tax Code:

Despite the assertions of social welfare theorists that utility is not measurable per se and that interpersonal comparisons of utility are not objectively possible, the use of a progressive income tax system by policy makers belies these assertions. By taxing high-income brackets at a higher rate than low income brackets, decision makers appear to have implicitly made the assumption that a dollar of money is worth more to the poor than to the rich. This progressivity in the tax code could be considered a political rejection of the constant marginal utility of income assumption (Farrow 1998). In this method of weighting benefits using the progressive income tax code, marginal rates of income tax are used to derive a proxy measure for the marginal utility of income function. In this function different weights are placed on increments of income accrued to different groups from a particular project based on the effective income tax[2] rate applicable to each group.

As mentioned above, it is assumed that MUI for the advantaged group is unity, and thus MUI for the disadvantaged group is estimated relative to that of the advantaged group. To illustrate, based on the average household income for the inside and outside Mahoning River corridor groups, the effective income tax rates for these

[2] Effective income tax equals total tax liabilities (individual income, corporate income, payroll, and excise) as a percentage of total income.

groups are 15% and 25%, respectively. If we assume that MUI for the outside MR group is unity, then MUI for the inside MR group is 1.67. The same result is obtained for groups in the income stratum since average household incomes of both the inside MR group and the poor group fall within the same income bracket, and those of the outside MR group and the rich group fall within the same income bracket for tax purposes. Table 6 shows how the marginal utility of income is obtained for each income bracket.

Income Group	Tax Rate*	MUI
$10000 - $38050	15%	1.67
$38051 - $98250	25%	1

Table 6: Deriving MUI from Income Tax Rates

* Federal personal income tax rates for 2003 (head of household)

Benefit-Cost Analysis by Location:

Table 7 shows the analyses of benefits and costs for the inside and outside MR corridor groups under the different assumptions of marginal utility of income presented above. In the traditional B-C analysis by location groups, in which MUI is assumed one for all groups, the benefit cost (BC) ratio is 0.68 for the dredging only project and 0.48 for the dredging with dam removal project. Additionally, BC ratio for Dredging only is higher for the disadvantaged group inside MR corridor than for the outside group. The opposite is true for the more inclusive project (D-DR). This indicates that the less expensive dredging only project is preferred more by the disadvantaged group than by the other group. However, with the constant marginal utility of income assumption, both projects are not economically viable.

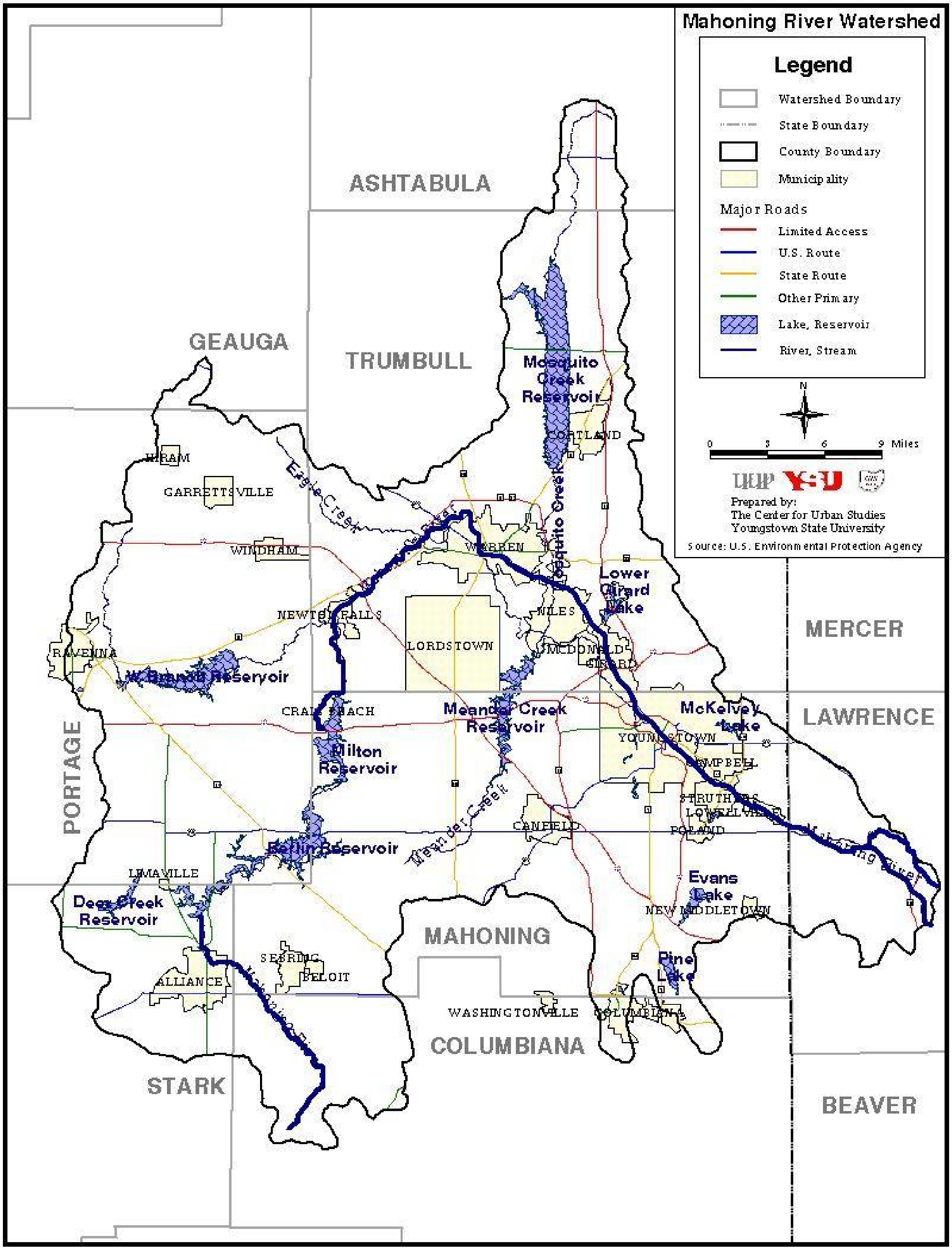
When we apply MUI values obtained from the quality of life index quadratic function by Blue and Tweeten (1.07 for the inside group and 1 for the outside group) to the total benefits estimated for each group, both projects become more economically appealing. BC ratio of the disadvantaged group is now 0.98 for dredging only and 0.29 for dredging with dam removal. BC ratio of the outside group is still as before for both projects since we assumed that MUI for the advantaged is unity under any weighting scheme. The economic viability of any project is influenced by the weight placed on the benefits accrued to the targeted group in the population affected by the project or the environmental change. As such, the income distribution or equity criterion of utility could be embedded into the efficiency criterion in a more inclusive benefit-cost analysis, which includes the traditional efficiency-based analysis as one policy option. When applying the weights obtained from the square root QLI function (1.11 for the inside MR group and 1 for the outside MR group), BC ratio for the targeted group is slightly higher (1.01 for the dredging only project and 0.30 for the dredging with dam removal project), however, both projects are still not economically viable in aggregate.

Applying the weights obtained from the marginal income tax rates to the benefits accrued by different groups, the dredging only project is almost economically viable (BC=0.93) in aggregate but the larger more expensive project (D-DR) is still not viable. When considering benefit cost analysis for the disadvantaged group, expected benefits are approximately one and half times the costs for the dredging only project, and are only half the costs for the dredging with dam removal project. As more weight is placed on the benefits accrued to the inside MR corridor group, the dredging only project becomes more economically viable to policy makers while the more inclusive project is not viable under any assumption about marginal utility of income. This shows that low-income, households inside the Mahoning River corridor, that are predominantly poor and African American, are more supportive of the dredging only project than households outside the river corridor. One reason could be the lower cost of the dredging only project compared to dredging with dam removal. Another possible reason might be that people inside the river corridor are not in favor of removing the dams because some of the dams are used for recreation, or by the remaining steel mills to store water for cooling purposes, which may translate into local jobs.

	D		D-DR	
	Inside Corridor	Outside Corridor	Inside Corridor	Outside Corridor
Med WTP	$133	$60	$54	$105
# of Households	191610	318782	191610	318782
Total Cost	$27,859,487	$38,140,513	$38,412,323	$52,587,677
<u>Aggregate B-C Analysis</u>				
Med WTP	$91		$81	
∑WTP	$46,445,672		$41,341,752	
Aggregate B/C	0.70		0.45	
<u>B-C Analysis by Location Groups</u>				
∑WTP	$25,445,808	$19,158,798	$10,289,457	$33,472,110
B/C	0.91	0.50	0.27	0.64
Aggregate B/C	0.68		0.48	
<u>Weighted B-C Analysis (Quadratic QLI)</u>				
MUI	1.07	1	1.07	1
Weighted ∑WTP	$27,227,015	$19,158,798	$11,009,719	$33,472,110
B/C	0.98	0.50	0.29	0.64
Aggregate B/C	0.70		0.49	
<u>Weighted B-C Analysis (Square root QLI)</u>				
MUI	1.11	1	1.11	1
Weighted ∑WTP	$28,244,847	$19,158,798	$11,421,297	$33,472,110
B/C	1.01	0.50	0.30	0.64
Aggregate B/C	0.72		0.49	
<u>Weighted B-C Analysis (Progressive Income Tax Code)</u>				
MUI	1.67	1	1.67	1
Weighted ∑WTP	$42,494,499	$19,158,798	$17,183,393	$33,472,110
B/C	1.53	0.50	0.45	0.64
Aggregate B/C	0.93		0.56	

Table 7: Benefit cost analysis by location

Figure1: Mahoning River Watershed



Source: The Center for Urban Studies at Youngstown State University

Summary and Conclusions

In conclusion, there is evidence of environmental injustice with respect to contamination in the Mahoning River; poor people and minorities inside the Mahoning River corridor (especially in Mahoning and Trumbull Counties) might have been unjustly exposed to contamination in the river. The incidence of these long-term contamination impacts and the fact that poor and African Americans are more concentrated along the polluted river than other groups in the valley provide this evidence. On the other hand, one might argue that if minorities and poor people had prior knowledge about contamination in the river and chose to live along the river, they would be trading contamination in the river for more housing benefits such as more bedrooms or lower property taxes, and environmental equity would not be an issue. Thus, finding out what people knew about contamination in the river could be one way to investigate environmental injustice. Unfortunately, this kind of information is not readily available and could only be obtained by interviewing poor and minority households along the Lower Mahoning River. Another way is to investigate whether poor and minorities along the river had equivalent housing opportunities outside the river corridor and chose to live along the river because the gains out-weighted the costs of exposure to contamination. However, If low-income and minorities have little choice of moving out of the environmentally impoverished areas due to possible ethnic discrimination in the housing market, as historically evident in this area, then environmental justice is an issue.

Traditional BC analysis, in which marginal utility of income is the same across all groups in the society, would in turn underestimate the value of Mahoning River restoration projects to the disadvantaged, and thus render the project(s) less economically appealing to decision makers. Conducting benefit-cost analyses for different demographic groups in the affected population should help the analyst gain information on the income distribution effects of policy changes regarding the provision of public goods and environmental resources. This should not be a surrogate to the economic efficiency analysis of public programs or policies. Instead, the distribution analysis should be considered complimentary to the efficiency analysis so that efficiency is not sacrificed for equity or vise versa. This study does not recommend a specific weighting scheme, but rather presents a sensitivity analysis of the value of environmental improvements under different assumptions about marginal utility of income including the traditional assumption of constant MUI across all groups in a society. This kind of analysis could help policy makers make more informed decisions on issues that affect the use of scarce environmental resources if the welfare of a target group(s) in the society, especially minorities and the poor, will be significantly affected by the public policy or regulation.

In practical terms, this means that decision makers need to consider the effects of the proposed policy or program on different groups in a society, especially minorities and low-income groups, as a second (complementary) step after considering the overall economic effect of the policy (i.e., the traditional benefit cost analysis). If the proposed policy or program has significantly different income distribution impacts on different groups in the population, the decision to adopt a specific weighting scheme or other approaches to incorporate equity considerations into public policy analysis is left to judgment of the decision maker. This decision could be dependent on several factors including the relative size of the disadvantaged group(s) in the population, and whether there is historical evidence of unjustly exposure to environmental bads such as landfills by those groups.

Neoclassical welfare theory assumes constant marginal utility of money income, costless transfers, and hypothetical compensation. The question is should all these assumptions be relaxed to accommodate equity? Only the assumption of equal MUI is relaxed in the current study because of its direct effect on benefit-cost analysis. The hypothetical compensation assumption was criticized by Farrow (1998) who argued that actual compensations should be used in assessing changes to the environment instead of hypothetical compensation. This raises important questions about benefit capture and actual versus hypothetical compensation. Future research should be directed to examine the other two assumptions of applied welfare economics, namely hypothetical compensation and costless transfers and their implications for studying environmental equity.

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