ECONOMIC EFFICIENCY AND INCOME DISTRIBUTION EVALUATION OF TOXICS AND DAM REMOVAL USING CONTINGENT VALUATION

DISSERTATION

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ABSTRACT

Contingent valuation (CV) has been used extensively to value non-marketed environmental resources and public policies. Despite its sound theoretical background as a direct measure of welfare change and its ability to measure nonuse (existence) values, the validity of CV hypothetical estimates of value is still under immense debate. Of equal importance is the issue of equity or income distribution impacts of environmental change and how to incorporate equity into public policy analysis without sacrificing economic efficiency. This dissertation focuses on studying the theoretical validity of dichotomous choice CV as well as the distributional effects of river contamination and clean up including stated preference evaluation of environmental improvements. The study case is restoring the Lower Mahoning River in northeast Ohio through dredging of toxics and/or selected dam removal.

First, theoretical validity, the degree to which results of a CV study are consistent with expectations of economic theory, is examined through the use of split sampling to test for scope, sequence, and context effects. Responses to the dichotomous choice willingness to pay (WTP) questions are estimated using the probit model. Then, comparisons among different treatments are conducted using both the likelihood ratio test and the difference in median WTP test. Results indicate that WTP is insensitive to the

scope of the proposed restoration project in the whole sample. However, scope effects are significant among past users of the river. Additionally, there is mixed evidence of order and context effects. It is concluded that sensitivity to scope in contingent valuation could be dependent on the type of the public good being valued (scope versus scale valuation) and on the characteristics of the individuals being surveyed especially with respect to familiarity of the resource in question.

Second, income distribution impacts of river contamination and clean up are examined through stratification of the sample using income and location of the household as a proxy for race. Results show that poor people and minorities in urban districts along the Mahoning River might have been unjustly exposed to contamination in the river. Traditional BC analysis, in which marginal utility of income is constant 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.

To My Parents

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CHAPTER 1

INTRODUCTION

1.1 Research Rationale

Balancing the costs and benefits of public policies that affect the use of scarce natural and environmental resources has gained increased interest by decision makers in recent years. Demand by the general public in most developed countries and some developing countries for more recreational uses of parks, lakes, and rivers has pressured policy makers to look for analytical tools to quantify or measure the benefits of environmental improvements in order to balance the costs associated with those improvements. Furthermore, when it comes to allocating a scarce natural resource among alternative uses, these tools enable policy makers to put a value on having a clean and sustainable environment along with the value of more job creation, economic competitiveness, and economic growth. Estimating the benefits of environmental improvements can provide valuable information for environmental decision-making (Freeman 1979). However, because services of the environment are not often traded in common markets, it would be difficult to infer the value of environmental quality from market signals; i.e., price and income changes that result from transactions over a traditional private good. This is mainly because most environmental goods and services can be viewed as variations of a public good where the use of the resource by one

individual does not exclude others from using it. This makes it difficult, in practice, to charge a fee for use of the environmental good in question. Mäler (1974) in his pioneer publication, Environmental Economics: A Theoretical Inquiry argued that "*the basic cause of environmental degradation is thus the failure of markets to deal adequately with public goods*". To overcome this market failure problem, policy makers should adapt more active policies that give agents in the economy the right signals so that they consider the environment as a scarce resource. In other words, users of a natural resource, whether they are producers or consumers, should bear the total social cost of depleting or degrading the environment as a result of their improper use of that resource.

Non-market valuation methods of environmental changes can help determine the size of the social costs or benefits of an environmental change, which cannot be captured by free market transactions. In general, there are two approaches to obtaining benefit or demand information for the public good or environmental good. The first approach, the revealed preference technique, relies on the assumption of weak complementarity in consumption between public goods and private marketed goods, and then uses this information to infer demand or value information for the public good. Examples of this approach are the travel cost method and hedonic pricing method. The second approach, the stated preference technique, does not use any market information to infer public goods demand. Instead, this approach relies on asking people directly in a survey setting about their valuations of the public good of interest. Examples of this approach are conjoint analysis[1] and contingent valuation (CV) methods. These non-market valuation

[1] Conjoint analysis is a survey-research methodology that presents each respondent with a number of commodity descriptions, which differ according to the attributes described including the offered price. Then, respondents are asked to rate or rank the desirability of each commodity.

methods are of great value to researchers and decision makers when revealed preference techniques cannot be used because the relationship between the public good and the private good cannot be established or when ex-ante valuation of the public policy is sought.

Contingent valuation is a survey-based approach that asks individuals to reveal their personal valuations of changes (increments or decrements) in non-marketed goods using contingent markets (Randall et al. 1983). One advantage of the contingent valuation method is its ability to measure non-use values of the environment, values not necessarily related to direct use of the good by the individual such as existence and option values. Mitchell and Carson (1989) argue that contingent valuation is "*the most promising approach yet developed for determining the public's willingness to pay for public goods*". This is because contingent valuation is supposed to be as accurate as any other available method and it requires fewer assumptions than other methods. However contingent valuation, like other valuation methods, suffers some pitfalls, which if not attended, could render the value measures obtained using this method unreliable or arbitrary. In particular, the use of surveys to elicit individuals' willingness to pay (WTP) in hypothetical situations makes contingent valuation vulnerable to various types of bias especially when respondents have incentives not to reveal their true preference toward the public good. The question about the validity of value estimates obtained using contingent valuation has been examined frequently in the literature. Three types of validity have been identified by environmental economists as the most prominent: theoretical (construct) validity, content validity, and criterion validity. Theoretical validity is the focus of the Chapter 3 of this dissertation. Particularly, the author examines biases

associated with the presence of context, sequence, and scope effects in contingent valuation mail surveys.

Another important issue in environmental decision making concerns the distribution of benefits and costs associated with environmental improvement and degradation. Freeman (1972) in early work framed the environmental equity problem by posing the following set of questions:

> *What in fact are the actual patterns of distribution and incidence...Does the degradation of environmental quality tend to increase or decrease the degree of inequality of welfare among individuals?...Should distribution play a role in environmental planning and, if so, how?*

The answers to these questions are multi-dimensional and sometimes interrelated in the sense that the decision to include distribution in environmental planning is related to the incidence of environmental inequality. The opposite might also be true if environmental injustice is a result of bad environmental policies that disproportionately benefit the poor or disadvantaged groups in a society. In the current study, the author is trying to answer simpler and more specific questions: how valuation methods, such as contingent valuation, can be adapted to study environmental inequality and, if equity is an issue, how can we develop a weighting mechanism that could be used to incorporate environmental quality into public decision making without equity being the sole criterion? Said another way, how equity consideration can be incorporated in the valuation of environmental programs without sacrificing economic efficiency considerations?

The organization of the dissertation is as follows. The remainder of Chapter 1 covers the study objectives and hypothesis and a detailed description of the empirical

study: the economic valuation for various restoration options of the Lower Mahoning River in northeast Ohio. Chapter 2 covers the conceptual framework of environmental valuation with emphasis on the methodology used and investigated in the study; that is, contingent valuation. Chapter 3 covers the economic efficiency dimension in contingent valuation while Chapter 4 covers the equity or distribution dimension and presents cost-benefit analyses by project and by group of individuals. Chapter 5 summarizes research findings and limitations.

1.2 Case Study: The Mahoning River, Ohio

The Mahoning River Drains 1133 square miles in northeastern Ohio and northwestern Pennsylvania. Over the years, sediments in the river have become contaminated with a variety of chemicals. Contaminated sediments in the river are primarily from waste disposal of the steel and related industries, which were developed along the riverbanks, as well as the disposal of adjacent communities into the river. Pollution levels in the river are now lower than before 1970 according to recent measurements by Ohio EPA researchers, due to shut down of most of the steel mills and increased waste water treatment of discharges into the Mahoning River (USACE, 1999). However, some hazardous chemicals such as Polynuclear Aromatic Hydrocarbons (PAHs) and heavy metals are still absorbed in the bottom sediments and prevent recovery of the ecosystem in the river (Testa, 1997).

As a result, the Ohio Department of Health (ODH) has issued an advisory against swimming and wading in the stretch of the Mahoning river from the Northwest Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania border (ODH, 1988).

The advisory affects both Mahoning and Trumbull counties. The ODH recommended also that consumption of fish caught in the advisory area is strongly prohibited, especially bottom-feeding fish such as carp and catfish, which spend much time feeding in the bottom sediments. According to Robert Davic, an OEPA researcher, this lower portion of the Mahoning River is known to the public as the "Mahoning Sewer"; people are afraid of touching the water or coming in contact with the sediments because of the health advisory.

Recently, the Pittsburgh Army Corps of Engineers office has appropriated $ 1,000,000 to initiate a reconnaissance report for the Ohio portion of the Mahoning River. The U.S. Fish and Wildlife Service, Division of Ecological Services conducted part of the study in 1999 to determine the locations of the contaminated sediments along with concentrations of important pollutants. The purpose of the study was to facilitate the dredging and disposal of the contaminated sediments from the river in order to restore water quality and the ecosystem. The reconnaissance study represents the first phase of the Mahoning project and was funded 100 percent by the federal government. The second phase, currently underway, is called the feasibility phase and will be cost shared 50/50 between the federal government and a non-federal local sponsor, Trumbull County. The feasibility study is about technical feasibility of the project in terms of the amount of sediments needed to be dredged, available dredging equipment (technologies) along with their dredging rates, and the risks and uncertainties that might increase project costs such as re-suspension of contaminated sediments during storm events and dredging activities, changes in input prices, and others. The U.S. Army Corps of Engineers has estimated the cost of three remedial alternatives (projects) for Mahoning River sediments (USACE,

1999). These costs (presented in 1999 dollars) ranged from $66.5 million for the minimum cost alternative (hydraulic dredging of sediments with no dam removal) to $101.3 million for the maximum cost alternative (complete dredging- hydraulic and mechanical- of the river sediments, excavation of contaminated bank materials, and the removal of all nine dams in the study area). The third alternative (intermediate cost) costs $91.5 million and entails both hydraulic and mechanical dredging of sediments, excavation of bank materials, and selective removal of five dams. At this time, removal of low-head dams is not being considered by the Army Corps of Engineers as a vital component of restoration. However, it would appear that the removal of low-head dams might have a significant effect on increasing benefits of the clean up, and thereby this study will consider low-head dam removal as well as dredging of contaminated sediments.

Before identifying or measuring the benefits that will result from restoring water quality in the river through dredging or dam removal, it seems reasonable to discuss first the negative impacts of contaminated sediments in surface waters. Hemond and Fechner (1994), in 'Chemical Fate and Transport in the Environment', state that: "*the physical presence of the sediment inhibits turbulent diffusion and thus the transport of dissolved oxygen into the pore waters (water between the solid particles) of the sediment. At the same time, the organic matter that composes a significant fraction of most bottom sediments promotes the growth of oxygen-consuming microorganisms*." This results in lower oxygen levels and thus inhibited animal life in the river bottom except for species that can obtain oxygen from above the sediment, such as some worms and bottom-feeding fish. Moreover, sediments may become a long-term repository for contaminants,

which may then be degraded within the sediment or eventually released to the water during times of high discharge (flow) like storm events. This could also happen during dredging, where a rainfall event could cause the resuspension and transport of sediments or particles in the river, and hence the absorption of contaminants into the bodies of fish and other aquatic species. To summarize, the harmful impacts of bottom sediments, whether settled or suspended, on the aquatic life in surface waters are numerous.

In order to make the survey instrument more accurate and understandable about what is actually being valued; modeling the hydrologic and aquatic effects of dredging, dam removal, or both might be considered. Coupling a hydraulic-ecological model to the economic model is expected to make the valuation experience more reliable. The hydrodynamic-ecological model quantifies the effects of alternative restoration options on ecosystem health and fish habitat in the river while the economic model uses this information to better identify and assess the benefits and risks associated with the different restoration alternatives. This makes the survey instrument more understandable by the respondents in order to make better-informed decisions about valuing the environmental good in question.

Environmental economists have often avoided this type of analysis by making hypothetical predictions about the merits and risks associated with different actions or policy recommendations regarding the allocation of natural resources among alternative uses. However, with the recent advancements in hydrological and ecological modeling of the effects of dam removal on fish habitat and aquatic ecosystems, it is possible to quantify the benefits and risks of available restoration options and incorporate them into the valuation model. In a recent study, Cheng (2001) simulated the effects of removing

the Ballville Dam on Walleye spawning habitat and Walleye population in the Sandusky River (Ohio). A coupled hydrodynamic-ecological model was developed to simulate the effects of two scenarios: with and without dam. The results of this study showed that the removal of the Ballville dam would increase Walleye spawning habitat nine times more than with the dam, and as a result Walleye population would be larger without the dam.

It is possible that this type of ecological modeling could be applied to the Mahoning River case to predict the impacts of low-head dam removal or/ and toxic removal on downstream fisheries and aquatic resources. However, in this case, the ecological model might be more complicated than in the Sandusky case because of the need to consider the physical effects of sediment transport as well as the chemical effects of contaminants on downstream fish habitats and aquatic life. However, given the limited budget for this research, the author used the results of a biological study already done by Schroeder (1998), in which he predicted the effects of river clean-up on restoring benthic habitats in the Lower Mahoning River. The author also benefited from the expertise and research of Tim Granata, a civil/environmental engineer and professor at Ohio State University to approximately predict the hydraulic effects of each restoration project and then use this information along with the biotic information to define the benefits that would be gained from implementing each of these projects.

1.3 Study Objectives and Hypotheses

The main objectives of the study are to:

1) Construct a contingent valuation model to estimate willingness to pay for a cleaner Mahoning River with and without selective removal of some of the low-head dams.
2) Separate the environmental goods of dam and dam plus toxics removal, and test for the presence of sequence, scope and context effects in the contingent valuation mail survey.
3) Estimate bid functions for willingness to pay to study the different economic and demographic variables that affect respondent's valuation of water quality improvement.
4) Examine possible distribution effects of river contamination and clean-up. More specifically, the objective is to test for incidence of environmental equity by race and income groups, and then develop mechanisms to help decision makers incorporate equity objectives into public goods policies.
5) Calculate an aggregate willingness to pay dollar value that would represent an upper bound estimate of the economic benefits for each of the restoration projects

Theoretical validity is the extent to which the measure of a theoretical construct (such as willingness to pay) behaves according to theoretical predictions. One way to perform the theoretical validity test is to use split-sampling to determine if individuals respond to the contingent market questions in theoretically predictable ways (this includes testing for scope, sequence and context effects). Another way to test for theoretical validity is to

examine the internal consistency of CV responses. The later test looks at whether the sign and magnitude of the estimated coefficients on different demographic and behavioral variables in the bid function are consistent with theoretical predictions.

With regard to scope effects, theory would predict that respondents should be willing to pay more for a larger amount of a desired good. The null hypothesis therefore is that respondents are insensitive to the scope of good in their answers to WTP questions. A rejection of the null hypothesis would indicate that WTP is significantly increasing in the scope of the good and that WTP estimates obtained using contingent valuation are theoretically valid for the scope test.

With regard to sequence and context tests, the null hypothesis is that the value of a public good is invariant to the serial position of that good in a sequence of other similar or different goods (sequence effect), and to whether the good is valued independently or as part of a larger package (context effect). A rejection of the null hypothesis has been considered by critics of the CV method (for example, Kahneman and Knetsch 1992; Hausman 1993; and Payne et al 2000) as inconsistent with theoretical expectations because a good is expected to have only one true value. Other economists (for example, Hoehn and Randall 1989, 1996; and Carson et al 2001),on the other hand, argue that a rejection of the null hypothesis is expected by economic theory and that the value of a particular good will vary depending on what additional goods are offered prior to or simultaneously with it. The economic explanation for these effects is that each new public good the individual obtains reduces his available income to spend on other public goods and that substitutability among public goods makes each new good added to the package less desirable than when valued independently. Having said that, a rejection of

the null hypothesis that WTP responses are invariant to context or sequence effects would indicate that WTP estimates are theoretically valid. On the other hand, failure to reject the null hypothesis does not prove that WTP estimates are theoretically invalid. This is because sequence and context effects, if present, might be consistent with theoretical predictions due to substitution effects and the budget constraint, but are not necessary conditions for the theoretical validation of estimated WTP.

With regard to internal consistency of CV responses as a test for theoretical validity, standard economic theory predicts that the coefficient on the bid price in the bid function should be negative and significant indicating that the quantity demanded of the public good decreases as its price increases. It is also expected that the coefficient on income is positive and significant indicating that WTP for a public good is increasing in household income. The signs and magnitudes on other demographic variables such as age and education and on behavioral variables such as past use of the resource and recreation patterns of the respondent cannot be predicted by economic theory. A discussion on hypotheses regarding the expected effects of these various variables on willingness to pay for restoration of the Mahoning River is presented later in the section on "determinants of willingness to pay for Mahoning River restoration projects".

In order to study the income distribution impacts of river contamination and clean up, the sample is stratified into groups based on household income, race, or exposure to contamination in the river. The null hypothesis is that key demographic characteristics (such as income, race, and education) are not significantly different between groups. A rejection of the null hypothesis might be an indication that disadvantaged groups are unjustly exposed to contamination in the river or can only afford to buy or rent property

in more contaminated areas. The researcher then estimates bid functions and calculates WTP for different demographic groups in the population. The null hypothesis is that the estimated coefficients and/or estimated mean or median WTP are not significantly different between groups in each stratum (for example, between whites and blacks or rich and poor). A rejection of the null hypothesis means that different classes of people in the watershed value environmental improvements differently, but does not necessarily mean that there is environmental injustice. However, the incidence of these long term contamination impacts may provide evidence of environmental injustice. This is particularly true if minorities and poor people did not know about contamination in the river before they chose to live along the river, or they knew about contamination but did not have much choice due to ethnic discrimination in the market for housing in the area.

The policy objective of this research is to estimate benefits of the removal and disposal of contaminated sediments from the lowest 30 miles of the river in the State of Ohio, extending from Pennsylvania/Ohio line up to and including the vicinity of Warren. These benefits will be estimated for two projects: with and without the removal of low-head dams. This is expected to restore the aquatic ecosystem within the study area to the biotic integrity in a model reach on the Mahoning River just upstream of the study area and help eliminate the DOH human health advisories. The upper portions of the river, upstream of Warren, are cleaner and known as monitoring sites. This is because OEPA officials monitor water quality in these sites and their water quality levels meet EPA standards. These monitoring sites host many recreational activities such as fishing and boating and hence can be considered a benchmark for targeted water quality in the study area.

The expected total benefits of restoring the Mahoning River must exceed, or at least match total costs, if the objective is to increase the social welfare of residents in the study area subject to budget and technology constraints. According to a 1981 study by Richard Thorn at the University of Pittsburgh, the net economic benefit from restoring a healthy ecosystem in the river is rather substantial. The study concluded that potential water quality improvement resulting from going from Best Practical Control Technology Currently Available (BPT) to Best Available Control Technology Economically Achievable (BAT) would yield significant economic benefits. Those benefits ranged from $70.8 million for the gross upper bound estimate obtained by making assumptions that would maximize the benefits resulting from the implementation of (BAT) to $28.3 million for the most likely benefit estimate calculated taking into consideration the effects of site specific constraints and more realistic assumptions about the utilization of the potential opportunities created by the new water quality standards (Thorn, 1981). Thus, the second estimate is more constrained and hence more conservative than the first estimate of benefits.

Use value in Thorn's study was mainly attributed to increasing recreational fishing opportunities in the Mahoning Valley (Ochs and Thorn, 1984). The upper bound estimate of recreation benefits (warm water fishing) resulting from the implementation of BAT was $40.76 million (in 1981 dollars). The method used to derive this value was a single-site travel cost model, where the derived benefits reflect the decreased costs (travel and time) on fishing at the Mahoning River versus fishing at other substitute sites farther away (such as Mosquito creek Lake and Olentangy River). The upper bound estimate of non-use benefits was estimated as 50 percent (Freeman, 1979) of the upper bound

recreation benefits, approximately $23.4 million. This study did not model factors that determine nonuse values (such as existence and option values), which we intend to account for in our model.

It is worth noting that the study performed by Ochs and Thorn (1984) does not include any primary data collection of WTP to estimate benefits of increased recreational fishing. The method adopted is the use of an upper bound approach to measure recreation benefits using available data on maximum supply capacity of the Mahoning River for fishing days (from the Ohio Statewide Comprehensive Outdoor recreation Plan); this was estimated at 96.6 activity days per acre per year on the Mahoning in 1980. Then, travel cost savings (automobile operating cost savings + value of saved travel time) were calculated assuming an average round trip travel time savings of four hours, and assuming that there would be zero travel cost for users of the Mahoning River. One disadvantage of this methodology, as described by the authors, is that it provides an ambiguous result if cost and benefit estimates are close, in which case the use of more precise methods of estimation should be sought. However, the major problem with this study is that it is not based on estimating WTP or the demand side, but rather on the supply side for increased recreational fishing after restoration of the river. In other words, this method does not provide any prediction of how many people will fish at the river or how much their WTP would be. Instead, it predicts how much fishing days will the river be able to supply after clean up and what would be the value of the maximum supply capacity of the river if it is restored.

CHAPTER 2

MEASURING WELFARE CHANGE: CONCEPTS AND METHODS

2.1 A Theoretical Concept of Welfare Change

Benefits or positive welfare changes of, for example, environmental improvements are defined by the area under the demand or inverse demand curve for the good or service (Freeman 1979). This measure of welfare change, depending on the type of demand or inverse demand curve used to estimate benefits, has been known as the consumer's surplus or compensating or equivalent variation. Consumer's surplus is measured by the area under the ordinary or Marshallian demand curve, which is derived by solving the problem of the individual's utility maximization subject to the budget constraint. On the other hand, the "theoretically correct" (Randall and Stoll 1980) Hicksian compensating and Equivalent variations are measured by the area under the Hicks-compensated demand curve, which is derived by solving the dual problem of utility maximization, that is, by minimizing the cost of achieving a specified level of utility given market prices for goods and services. Compensating variation (CV) is the compensating payment of the change in income required to make the individual indifferent between the original situation and the alternative change. For a welfare improvement, CV can be interpreted as the maximum amount that the individual would be willing to pay for the improvement to take place.

Equivalent variation (EV), on the other hand, is the change in income that is equivalent to the change in welfare associated with the proposed policy. For a welfare improvement EV can be interpreted as the minimum amount that the individual would be willing to accept to voluntarily forego the improvement. The difference between compensating and equivalent variation is the reference level of utility. The reference level for CV is the original situation or the status quo utility, whereas the reference level for EV is the individual's utility after the change.

Comparing Marshallian and Hicksian measures of welfare change, Consumer's surplus is readily observable from market transactions; however, it is not consistent with any theoretical definition of welfare change. On the contrary, Hicksian compensating and equivalent variations are consistent with a theoretical definition of welfare change using the expenditure function approach. However, neither CV nor EV is readily obtainable from observable market data. In the case of public or environmental goods and services, market observations on prices and quantities are typically not available. Furthermore, many environmental policies or programs involve changes in quantities of an environmental good or service rather than changes in prices: most environmental goods and service are unpriced (non-marketed). In this case, CV and EV measures of welfare change are applicable in principal to unpriced environmental goods such as improvements in water quality or saving a sound river ecosystem for future generations. The problem, however, is how to infer public goods demands, in practice, when private markets do not provide price and quantity data on the public good being evaluated. In order to solve this problem, resource economists have resorted to indirect market and

non-market valuation techniques to infer demand functions for environmental goods and consequently to obtain CV or EV measures of changes in the provision of these goods.

2.2 Valuing Environmental Change

Since markets do not exist for environmental goods and services, the demand for these services is not revealed in the same way the demand for private goods is revealed. As such, indirect market techniques and non-market valuation methods are used to estimate demand prices or values for environmental goods and services. Valuation methods, in general, can be classified into three broad categories, stated preference methods, revealed preference methods, and benefit transfer.

2.2.1 Revealed Preference Methods

These methods rely on the relationship between marketed private goods and public goods in consumption (or production) and use this relationship to infer information about public goods demands from revealed preferences toward related private goods. More specifically, this indirect market approach to estimate demand prices for environmental services relies on the assumption of weak complementarity between an environmental quality and a private good. Weak complementarity, as defined by Mäler (1974), states that if the demand for the private good is zero, then the demand for the related environmental quality will also be zero. For example, consider the case where the private good is fishing on a river and the environmental service is water quality in that river. If an individual does not fish on this river, then he is indifferent to its water quality and thus his demand price for water quality would be zero. Revealed preference data about fishing

activities in that river can be used to estimate welfare effects of various changes to the river's environment such as increasing fish habitat or reducing pollution.

As indicated by Freeman, weak complementarity involves two conditions:

(1) that there is a price $\overline{p}_1$ for the private good x_1 such that the demand for x_1 is zero, given the level of environmental quality (Q), prices of other goods and services (P) and the individual's income (M)

$$x_1(\overline{p}_1, P, Q, M) = 0, \text{ and}$$

(2) that, at $\overline{p}_1$, the marginal demand price for Q is zero

$$\partial E(\overline{p}_1, P, Q, M) / \partial Q = 0$$

where E (.) is the expenditure function. Weak complementarity is a simplifying assumption to establish the initial position for an individual that would be used to estimate the change in utility associated with the change in the environmental quality (Q). Two of the most frequently used indirect market techniques to value non-marketed resources are the travel cost method and the hedonic pricing method. Travel cost (TC) uses visitation data to a recreational site to infer demand or marginal WTP for changes in the environmental quality of that site. The method, which was introduced first by Harold Hotelling (1947), relies on the proposition that people need to travel to a site and in doing so incur some cost to enjoy the recreational services provided by that site. These consumption costs, which are used as a proxy for the price of the environmental service, include travel costs (including the value of travel time), entry fees, on-site expenditures, and use fees of equipment necessary for the enjoyment of the site services. In order to derive a demand curve for visits to a particular site, the key assumption is that as the travel costs increase the number of visits decreases (Hanley and Spash 1993).

The hedonic pricing (HP) method is another revealed preference technique that builds on the characteristics theory of value (Lancaster 1966 and Rosen 1974). The theory postulates that the value of a marketed commodity, such as a house, can be identified as a function of its characteristics including environmental service flows around the house. Differentiating the price of a house with respect to the quantity of the environmental service gives the implicit price associated with the environmental service. HP uses either time or cross-sectional variations in the price of goods that can be attributed to the environmental characteristic to impute willingness to pay for that characteristic. For hedonic pricing to work as described above, two assumptions are needed. One is week complementarity as is the case with all revealed preference methods. The other assumption is that utility of the representative individual is weekly separable in housing (Freeman 1979), meaning that the demand price for the environmental good can be estimated ignoring the prices of all other goods.

Hedonic pricing methods have been used to value a variety of environmental amenities such as air quality (Brookshire et al 1982) and disamenities such as exposure to landfills (Hite et al 2001). There are some limits, however, for using revealed preference techniques to value different aspects of the environment. First, these techniques target only use-values, that is, values that stem from direct use of the environmental resource such as recreation and housing. Second, there are some circumstances in which benefits of the public cannot be derived from market transactions of the private good because weak complementarity does not exist or because required time-series or cross-sectional data are not available. In such cases, non-market techniques such as contingent valuation

methods are the only choice available to the researcher. These methods are discussed in the next section.

2.2.2 Stated Preference Methods

The essence behind the stated preference approaches is to induce people, in survey or experimental settings, to reveal directly or indirectly their preferences for the provision of some public good. Different approaches can be used to get people to reveal their preferences toward the provision of public goods. One approach is to ask individuals to state their total willingness to pay (WTP) or willingness to accept (WTA) for a specified level or change in the level of the public good. The second approach is to ask individuals to choose the quantity of the public good they would demand at a given price in a way similar to choosing the quantity to buy of a private good at a given price in a traditional market. The third approach is to ask people to vote on the provision of a specified level of the public good in a specified price in a referendum, in which individuals may vote yes or no. The choice of the appropriate preference revelation method depends on the practicality of the method and on whether it creates incentives for strategic behavior on the part of respondents. Strategic behavior happens when an individual is not revealing his true WTP for the public good in question; rather, he may overstate or understate his stated WTP in order to influence the outcome of the public policy and his repayment obligation to his benefit.

The first two approaches─ asking about WTP values and asking about quantities─ may suffer from an incentive-compatibility problem. This is because the respondent knows that his choice or the price to pay or the quantity to demand would have direct effect on the decision to provide the public good and therefore he has an incentive not to

reveal his true preference toward the public good or policy. Moreover, the second approach is not empirically visible since it would be difficult, if not impossible, to vary the amount supplied of a public good, such as air or water quality improvements, in the same way that private goods are varied in private goods markets. The third approach, the dichotomous choice model, is more incentive-compatible than the first two approaches because of the diminished ability of the respondents to directly influence the public policy outcome through voting (Haab and McConnell 2002). The referendum format is also recommended by the Blue Ribbon Panel of the National Oceanic and Atmospheric Administration (NOAA) on contingent valuation as the valuation question of choice because it is incentive-compatible. However, the method might still suffer from another incentive problem: even though respondents to the dichotomous choice valuation question may have no incentive to provide biased responses, they have no incentives to provide accurate responses either (see Freeman 1978). Freeman argues that this problem of the accuracy of individual responses should be treated as a measurement error, which could be alleviated through the proper design of questions in experimental settings.

2.2.2.1 Contingent Valuation

Contingent valuation, a stated preference method, is defined by Randall (1987) as follows:

"contingent valuation methods (CVM) attempt to determine the amount of compensation paid (WTP) or received (WTA), that will restore the initial utility level of an individual who experiences an increment or decrement in the level of Q [some nonmarketed good]".

Data required for a contingent valuation study may be collected through surveys or

economic experiments. In any case, a properly designed CV instrument must accomplish the following tasks:

1) Establish the baseline conditions or the status quo (Q) regarding the availability of the environmental resource and distribution of property rights over that resource.
2) Describe the change in Q that would result from the proposed change in policy.
3) Establish a contingent market, in which participants may, hypothetically, obtain the change in Q by paying a specified amount of money through a specified payment vehicle that is both relevant and familiar to respondents (for example, increases in taxes, good prices, and utility fees)
4) Elicit participants maximum WTP for the proposed change in Q either directly through open-ended, bidding, or payment card formats, or indirectly through referenda.

The hypothetical nature of contingent valuation might affect the accuracy of stated WTP if individuals treat the whole experiment as hypothetical or inconsequential. This, in turn, leads individuals to satisfice or not to devote the effort required to discover their true valuation of the public good in question. The difference between satisficing and strategic behavior is that people who satisfice do not intend to influence the outcome of the policy through their actions whereas people who behave strategically do. However, Carson and Mitchell (1989) postulate that the possibility of respondents giving meaningless (hypothetical) values is much more serious a problem than the possibility of them giving untruthful (strategic) values because of the effect of the former on the validity of WTP as a measure of value. They concluded that laboratory and field experiments on predicting behavior did not find difference between the results obtained

by treatments that used a hypothetical payment structure and those that used a real-dollar payment structure. Unfamiliarity with the public good in question or with how it will be provided and paid for characterizes most of the difficulties posed by the hypothetical nature of CV; that is, the more familiar the public good and the contingent market to the respondent, the more realistic the valuation task (and thus the less the hypothetical error) will be. Randall (1987) argues that the difference between contingent (hypothetical) markets and real markets is a matter of degree and that this kind of error or bias, if present in public good valuation, tends to have a conservative effect on benefit cost analysis. That is, it results in understatement of WTP and overstatement of WTA.

The validity of stated willingness to pay (WTP) as a measure of value has been examined extensively in the literature (for example, Mitchell and Carson 1989; Smith 1992; Kahneman and Knetsch 1992; Hoehn and Randall 1989). The validity of a measure, as defined by Mitchell and Carson (1989), is "*the degree to which it measures the theoretical construct under investigation*". Three types of validity are distinguished in contingent valuation method (CVM) studies ─ content validity, criterion validity, and theoretical (construct) validity. Content validity is concerned with how a CVM questionnaire presents the market structure and defines the amenity in a way that accords with well defined preferences. Content validity is typically assessed through subjective examination of the instrument typically for wording and question ordering. Criterion validity is concerned with whether the measure of interest could be related to other measures considered to be criteria for the construct in question. A criterion is a measure of value, which is closer to the construct than the measure being validated. Theoretical validity is concerned with the degree to which the outcomes of a CVM study─ for

example, the sign and magnitude of the estimated coefficients in the bid functions and the relative magnitude of willingness to pay under different split-sample conditions ─ are consistent with expectations of economic theory.

One way to examine the theoretical validity of a CVM study is to compare WTP estimates of different scenarios for which theory suggests statistically different or similar values. For example, economic theory would predict that the greater the amount of the public good being offered, the more an individual would be willing to pay for that amount. This has been known in the literature as scope or scale effect or the absence of part-whole bias (Whitehead et al. 1998) in CV surveys. Theory would also suggest that the value of an environmental good is independent of the serial position of the good in a sequence of other environmental goods (sequence or order effects) and independent of the context in which the good is presented or what is known as context effects (Carson et al. 2002). The last two effects (order and context) constitute what has been known in the literature as embedding effect: the value of a particular good depends upon whether it is valued alone or as part of a more inclusive agenda or package (Loomis et al. 1993). Split-sampling is usually used to test for the presence of these effects and hence for the theoretical validity of contingent valuation as a measure of value.

2.2.2.2 Contingent Valuation and Nonuse Value

An advantage of the contingent valuation method over other methods of environmental valuation is its ability to directly measure nonuse (passive or existence) benefits. Nonuse values are important when an individual obtains utility from an amenity without having to use or expect to use that amenity. Existence values have been

categorized by Carson and Mitchell (1989) into two groups: vicarious consumption such the consumption of the environmental resource by significant others and the general public, and stewardship such as inherent and bequest values. The problem with estimating nonuse values using contingent valuation is that there are no means to scientifically disprove these methods using, for example, behavioral studies. CV estimated use values of a river or lake such as recreational benefits can be disproved using behavioral valuation methods such as travel cost; whereas, nonuse values such as preserving some wilderness areas in Australia cannot be disproved in the same way. Despite the lack of disproof for nonuse values, it has been argued in the literature that contingent valuation, if designed and implemented carefully, could be used with confidence to estimate total benefits of an environmental change which include nonuse components. However, obtaining meaningful estimates of separate value components using contingent valuation is unwarranted.

2.2.2.3 A parametric Model for Contingent Valuation

Specifying and estimating a parametric model for dichotomous choice contingent valuation responses serves two objects: first, to calculate willingness to pay for the prescribed amenity, and second, to study the effects of respondents' characteristics (demographic or behavioral) on WTP. This, in turn, allows the generalization of value estimates to the affected populations and testing for reliability and validity of contingent valuation. The basic model for analyzing dichotomous CV responses is the random utility model first developed by McFadden (1974). The following presentation of the model follows that of Haab and McConnell (2002):

Suppose that an individual j is confronted with a choice between a program to provide an environmental amenity, for example restoring a contaminated river to improve recreation experience and other services provided by the river, and the status quo which is doing nothing about contamination in that river. The indirect utility function for respondent j is

$$u_{ij} = u_i(y_j, X_j, \varepsilon_{ij})$$

where i=1 if the proposed program is implemented (the alternative state), and i=0 for the current state; y_j is household j's discretionary income; X_j is a vector of household-specific and choice-specific characteristics; and is a random preference component that is know to the respondent but not observable by the researcher.

Respondent j would be willing to pay a specified sum (t_j) for the proposed program if his utility with program net of the payment (t_j) exceeds his utility without the program; that is, if

$$\Pr(yes_j) = \Pr(u_1(y_j - t_j, X_j, \varepsilon_{1j}) > u_0(y_j, X_j, \varepsilon_{0j}))$$

Assuming that the indirect utility function is additively separable in the deterministic and stochastic components, the probability of a yes response by respondent j can be written as:

$$\Pr(yes_j) = \Pr(v_1(y_j - t_j, X_j) + \varepsilon_{1j} > v_0(y_j, X_j) + \varepsilon_{0j})$$

$$= \Pr(\varepsilon_j > -(v_1(y_j - t_j, X_j) + v_0(y_j, X_j)))$$

$$= 1 - F_\varepsilon[-(v_1(y_j - t_j, X_j) + v_0(y_j, X_j))]$$

where $\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$, the difference between the two random preference components,

which is also random. Writing the probability function in this fashion allows specifying it as a cumulative distribution function (cdf) in terms of the random error term; the shape of this cdf function depends on the functional form assumed for the deterministic part of utility and on the distribution assumed for the stochastic preference term. Basically, WTP is the amount of t_j that makes the respondent indifferent between the proposed CV change and the current situation.

Another, and more direct, way to model dichotomous CV responses is to specify a model for the random willingness to pay function. The question imposed by the dichotomous valuation question then is whether WTP for respondent j exceeds the offered price t_j ; that is, the respondent answers yes to the CV valuation question 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. Again, the 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, the functional form chosen in the current CV study:

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

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:

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

This model can be estimated using any of the packaged econometric software programs such as Limdep and SAS. The estimated coefficients are then used to calculate WTP for the mean or median individual in the survey as illustrated in Chapter 3.

2.3 Estimating Benefits of the Mahoning River Restoration Projects

A contingent valuation model (CVM) will be used to determine people's willingness to pay for different levels of improvements in water quality and river ecosystem. The major advantage the CVM has when compared to other evaluation methods of environmental amenities is that it is the only method that accounts for both use and non-use values. The CVM has been used extensively in the environmental economic literature to value non-marketed resources and public goods when market-based methods such the travel cost and the hedonic pricing are inappropriate or cannot be applied. Contingent valuation devices are hypothetical and involve asking individuals to reveal their personal valuations for increments (or decrements) in unpriced goods by using contingent markets (Randall et al., 1983).

The major limitation of contingent valuation lies in the self-reported nature of the data (Randall, 2002), which leads to different types of biases (e.g., strategic bias and payment vehicle bias) that raise some doubts about the validity of CV in the legislation-policy arena. Fortunately, most of these problems can be overcome through the correct choice of survey design and modeling. However, the legitimacy of aggregating this range of subjective (hypothetical) use and non-use values into a single measure over the various

interdependent good characteristics as is done in CV studies remains a controversial issue (Brouwer, 1999). It is not the focus of this study to compare the pros and cons of CV and associated research; although every effort will be made to make sure that the CV results are valid and comparable to those of revealed preference methods such as travel cost and hedonic pricing.

One methodological problem of this study is how to incorporate dam removal into the valuation context for dredging. Three environmental proposals (producing possibly different sets of environmental amenities) could be considered at least from a theoretical point of view. These proposals are dredging only, dredging plus removal of low-head dams, and dam removal only. Technically, the third alternative cannot be solely considered since taking out the dams without dredging of the contaminated sediments is not likely to do much for water quality. Furthermore, it could make the situation worse because removing the dams may release some of the sediments that were originally trapped behind them causing pollution problems downstream. Hence, this study considers only the first two alternatives with dredging being the only solution considered feasible by the Corps of Engineers at this time.

The reason to include dam removal is that toxic removal might restore the aquatic resources in the river but for a short period of time. Eventually, sediments will rebuild behind dams and cause problems again. Although these sediments will not be as toxic as the current deposits, dam removal per se has some advantages like improving the water flow along the river, which leads to improvements in fish habitat and better navigation for some kinds of boats. As Schroeder (1998) suggests; "*removal of low head dams would improve habitat quality by increasing stream velocity, increasing exposure of*

substrate with high habitat quality, prevent deposition from covering restored substrate habitat, and provide easy access for fish to colonize the river." It is apparent now that we have two different goods for respondents to value and indirectly decide if dam removal should be considered in addition to dredging. Each good produces multiple benefits – for dredging only, these benefits include a healthier ecosystem, recreational activities (fishing, boating, hiking… etc), lifting the human health advisory, and economic return to businesses and residents of the river valley. For dredging plus dam removal, the benefits include all of the above for the long run in addition to enhancing fish habitat and allowing more navigation along the river. However, it should be noted that the removal of some dams will probably lower the water level in some reaches of the river, and as a result some types of navigation may not be available. Also, the removal of some dams might lower water supply levels for some of the steel mills that are still operating on the river and draw water for cooling and other operations from behind the dams.

To solve this methodological problem, one could send out two scenarios of the questionnaire to different groups of respondents, one for each group. One of the scenarios is asking a respondent to value the benefits resulting from dredging only. The other scenario is asking another respondent to value the benefits resulting from dredging and dam removal. Then, statistical tests (such as, the likelihood ratio test) will be used to test the null hypothesis that the two scenarios are no different. A more comprehensive approach is to send out four scenarios randomly to four groups of respondents. The first scenario asks a respondent to value dredging only. The second scenario asks another respondent to value dredging plus dam removal. The third will ask a third respondent to value dredging only and dredging plus dam removal with the dredging only option

offered first. The fourth scenario asks a fourth respondent to value dredging plus dam removal first, and then asks him again to value dredging only. The purpose of using the last two scenarios is to test for sequence effects; the maintained hypothesis is that an environmental good is less valued by a respondent, the later it is offered to him/her in a sequence of goods (Carson et al, 2002).

Payne et al (2000) found a strong sequence effect when respondents were asked to value five environmental goods using WTP and other evaluative attitude ratings. They also found that the total WTP for the bundle of the five environmental goods depended on the identity of the good evaluated first in a sequence. They argued that the total (sum) WTP for a set of goods varies systematically across valuation sequences due to an anchoring effect of the monetary value assigned to the first good on subsequent WTP amounts. This result contradicts with the theoretical prediction by Carson and Mitchell (1995) that the sum of WTP for a bundle of goods should be invariant to the serial position of goods in a sequence.

One of the study objectives is to test for the presence of sequence, scope, and context effects in CV surveys containing nested environmental goods. By comparing the third and forth scenarios of the survey, it is possible to test for sequence effects. Comparing the first and second scenarios allows testing for scope effects since one good (dredging only) is nested within the other good (dredging + dam removal). The testable hypothesis here is that respondents are insensitive to the scope (quantity) of the good being valued. Carson and Mitchell (1995) developed a 'component sensitivity test', which rejected the hypothesis that respondents are insensitive to scope effects. This means that respondents in their study were able to perceive different levels of provision

of the environmental good and took this difference into account when asked to state a value for that good.

Comparing scenarios one and three, and two and four respectively allow testing for context effects. This test looks at how CV responses are affected by the context in which the valuation question is asked. The question here is: does WTP for a particular public good depend upon whether it is being valued on its own or within an agenda? Hoehn and Randall (1989) have argued that conventional benefit cost methods in which public goods are valued independently will overstate the measure of benefits for each good. According to this argument, scenarios one and two are expected to overstate the values of (dredging only) and (dredging plus dam removal) proposals respectively compared to scenarios three and four. We test for this proposition by comparing scenarios one and two (in which dredging and dredging plus dam removal are valued independently) with scenarios three and four (in which each proposal is evaluated first in a sequence containing both proposals), respectively.

In order to make better value judgments, respondents need to be well informed about the constructed market situation for the environmental good before being confronted with the valuation question. The questionnaire will first inform respondents about the status quo of the Mahoning River and then describe the process that will take place to complete the project and the benefits people will gain when the project is accomplished. The respondents will be also informed that the sediments can only be dredged if extra funds are generated to give them an incentive to participate and be involved in the policy decision rule.

The second part of the questionnaire will elicit values that the respondents are willing to pay for different levels of increases in water quality. Different values will be assigned to different respondents in order to estimate a demand function for the hypothetical good. It is worth noting that the use of standard (objective) water quality measures, such as the index of biotic integrity (IBI), invertebrate community index (ICI)…etc, to represent different quantities of the hypothetical good may not be comprehended by a majority of the respondents. In this case, the use of more understandable (quantitative and qualitative) measures to represent different levels of the good supplied is recommended. These measures might include different amounts of fish catch and fish species, different levels for lifting the DOH human health advisory (example: catch but don't eat fish, eat some species of caught fish…etc), and/or different levels of public access (such as public parks and trails) to the river.

The third part of the survey will ask questions about several demographic and behavioral characteristics of the respondents. These variables are used in the bid functions to study factors that affect respondents' valuation of water quality improvements. Demographic variables that affect willingness to pay usually include household income, level of education, age, gender, etc. Behavioral variables may include participation in environmental groups or organizations, awareness of major environmental problems like global warming and extinction of some rare species, etc.

2.3.1 Determinants of Willingness to Pay for MR Restoration Projects

Covariates are chosen in the model based on the results of previous studies done on the Mahoning River as well as contacts with Ohio EPA officials and some members of

the Mahoning River Consortium - an environmental organization whose objective is to increase public knowledge and support for river restoration. These variables include demographic characteristics (household income, age, level of education) behavioral characteristics of the respondents (participation in environmental entities, preference for outdoor recreation), and site-specific and location characteristics (access to the river, proximity to the river, and upstream vs. downstream residence). In a recent work, Schroeder et al (2000) study factors that affect people's support for the Mahoning River restoration projects by analyzing correlation between willingness to support restoration and various behavioral, knowledge, and demographic variables. Their conclusion is that increasing public support for restoration requires educating people about the river, promoting increased use of the river, allowing more public access to the river, and fostering local responsibility and control.

It is expected that the coefficient on the respondent's income (INCOME) would be positive in the bid function meaning that respondents with higher incomes would be more willing to pay for the Mahoning River restoration project than low-income respondents. However, when computed as a fraction of the respondent's income, Schroeder et al (2000) found that higher-income respondents are willing to pay smaller fractions of their incomes for restoration than lower-income respondents. They argued that people with lower incomes may be unable to seek recreational opportunities outside of the river valley and thus are more committed to local recreational resources than people with higher incomes. Nevertheless, this contention was not supported by visitation patterns to Mill Creek Park (one of the most visited parks in the Mahoning Valley); there

was no significant difference in the number of visits per year to the park based on income categories (Schroeder et al, 2000).

It is also expected that respondents who prefer outdoor recreation to indoor activities would be more willing to pay for restoring the river. This is because people seeking outdoor recreational activities (e.g., hiking, camping, fishing, bird watching…. etc) are usually more aware about the environment and environmental problems in their area than those who prefer indoor activities. Variables, such as visiting area parks (PARKS) and participation in recreational activities on the Mahoning River and on other lakes and streams in the area, are used in the bid function to represent these behavioral characteristics.

Education level of the respondent is expected to be positively related to WTP since more educated people are more likely to know about their local environmental resources, and thus would be more willing to preserve those resources than less educated respondents. The number of years that a respondent spent in education (EDU) is used to represent this demographic characteristic in the bid functions. Another demographic that might have an effect on responses to the valuation question is age of the respondent. This effect cannot be easily predicted and may be case-specific. Sometimes, older people are more knowledgeable about the history of environmental assets in their area and hence are more committed to restoring them than younger residents. On the other hand, it may be the case that the young are better educated, participate more in recreational activities, and thus are more willing to protect these resources than the old. A third case could be that age has no effect on respondents' WTP for restoration as Schroeder et al (2000) found in their study. Another variable that may have more effect on WTP than age is how long the

individual has lived in the Mahoning River Valley (YEARSIN). It is hypothesized that residents who have lived long times in the area would be willing to pay for river restoration than relatively new residents.

Access to the Mahoning River is considered by most residents (67%) of the Mahoning Valley as an important determinant of their use of the river. It is possible that if the Mahoning River were more accessible in the impacted area, more residents would have visited the river for recreation. Thus, it is expected that more access to the river will be positively correlated with WTP for restoration. We incorporate this effect in the model by using a dummy variable (ACCESS) that is set equal to one if respondents indicate that more access is needed, and is set to zero otherwise. The intuition behind this is that if people say that more access is needed, they would be more willing to use the river had it been cleaned.

Location of the respondent is another important covariate that is expected to influence WTP for the restoration project in different ways. First, proximity to the river is expected to be positively related to WTP (or the probability of saying yes to the dichotomous choice question). Since the Mahoning River is not a popular destination for recreation in northeast Ohio, people residing closer to the river (e.g., in Warren and Youngstown) are more likely to visit the river after restoration, and hence would be more willing to pay for the project than respondents living away from the river. This information is obtained by asking respondents to state how close to the river they live (DISTANCE).

Another dimension for the location effect would be the distinction between upstream and downstream respondents. If there is uncertainty regarding the effect of

dredging and/or dam-removal on the downstream portion of the river in Pennsylvania, then downstream respondents might hold negative WTP for the restoration projects. The Army Corps of Engineers assures that hydraulic dredging is fairly clean and will not cause a pollution problem downstream. Furthermore, Ohio EPA will be monitoring pollutants levels in the ambient water to make sure that water quality is not being worsened downstream. Nevertheless, the possibility that downstream respondents might have less WTP or more protest bids for the project than upstream respondents should be considered.

Parallel with the restoration project of the Ohio portion of the Mahoning River, the downstream portion in Pennsylvania (12 miles) has its own restoration project, which is expected to take place after the Ohio portion is cleaned. The 'Environmental Dredging Reconnaissance Study for the Lower Mahoning River in Pennsylvania' (2001) states "the success of the Lower Mahoning River, Pennsylvania, Environmental Dredging Project is linked to the restoration of the upstream Ohio portion of the Lower Mahoning River and the elimination of the Department of Health Public Health Advisory." It also states that if action is taken in Ohio, the potential benefits of compatible actions in Pennsylvania may be maximized. This means that downstream residents in Pennsylvania may benefit from restoring the Ohio reach of the Mahoning River given that the Pennsylvania dredging project is to be started after the Ohio project is concluded. It is possible also, however, that dredging, excavation, and dam removal operations in Ohio could result in release of contaminants and sediments to Pennsylvania that may change the conditions in Pennsylvania. Therefore, actions in Ohio and Pennsylvania should be coordinated (USACE, 2001). In summary, the Ohio restoration project(s) might have external impact

on increasing the cost of dredging in Pennsylvania but, on the other hand, the Pennsylvania project may not be beneficial unless the Ohio project is undertaken first. Therefore, the potential costs and benefits of the Ohio actions on the Pennsylvania options should be accounted for in this study.

2.3.2 Choosing the Sample

Choice of the population to survey is a very important factor in CV experiments since the estimated value of mean/median WTP and the aggregate WTP are both affected by the choice of survey population and the size of the population. In general, people who benefit or will benefit from the project in the future should be included, regardless of the type of benefits enjoyed (use or non-use values). In the case of the Mahoning River, direct use benefits are classified by Schroeder (1998) into recreational (e.g., canoeing, bird watching, hiking…etc), ecological functional (e.g., flood mitigation, pollution abatement, and biodiversity), social (e.g., aesthetic and psychological benefits), in addition to economic development and lifting the DOH public health advisory. These benefits will be enjoyed by most if not all the residents of the Mahoning valley from the city of Warren to the Ohio/ Pennsylvania state line, and may be some residents in the unimpacted area upstream. Besides, residents of the Mahoning Valley in Pennsylvania could benefit indirectly (indirect use value) from the restoration efforts in Ohio since the actions taken in Ohio are expected to increase potential benefits of the subsequent actions in Pennsylvania, as shown before. Originally, Lawrence County in Pennsylvania was included in the survey but was excluded later from the sample used in model estimation because responses from this county were not enough to estimate WTP in Pennsylvania.

Non-use values, such as knowing that the Mahoning River is restored or continues to be restored for future generations, are likely to be enjoyed by all the residents of the valley along the river. The geographic zone for non-use values might be extended to a wider area like the state of Ohio and some parts of Pennsylvania). However, we chose to limit the sample population to only residents of the river valley in Ohio in order to obtain conservative and more defensible estimates of willingness to pay.

Survey participants were picked randomly from phonebook-generated mail lists for Mahoning, Trumbull, Columbiana, Ashtabula, Geauga, Portage, and Stark counties in northeast Ohio, and Lawrence County in northwest Pennsylvania. This sample population is different from that of Schroeder (2000) in two aspects. First, it covers all of the counties in the Mahoning River Valley and not just the watershed boundaries (as in Schroeder's). This is because use of the Mahoning River by visitors from the surrounding counties is expected not to be limited by the watershed boundaries; though it is still a conservative use zone for the river. Second, the proposed population for the current study includes parts of Pennsylvania in order to account for the effects of dredging or dam removal on the downstream portion of the river in Pennsylvania. It is also expected that people living in the impacted segment would have more WTP for the restoration projects than people in the upstream segment, simply because they would enjoy more benefits from the restoring the river than anybody else.

In the spring of 2003, 2221 surveys were sent by mail to participants in the selected eight counties of the Mahoning River watershed. The number of survey participants in each county was selected in proportion to the population of this county as a percentage of the population of the impacted area (watershed). Reminder cards were

sent out to all participants two weeks after the original survey was sent out of the survey. Four weeks later, a follow-up survey was sent out to those who did not respond to the

County	Sample size	Number of good addresses	Number of respondents	Response rate
Ashtabula	200	73	13	17.81
Columbiana	172	166	24	14.46
Geauga	141	131	23	17.56
Mahoning	391	389	119	30.59
Portage	233	204	27	13.24
Stark	580	549	67	12.20
Trumbull	359	347	86	24.78
Lawrence	145	135	18	13.33
Total	2221	1994	377	18.91

Table 2.1: Survey response rates by county

first one. Of the total surveys mailed, 227 were returned because of bad addresses; addresses that were invalid or the occupant has moved out. The number of valid and usable responses was 377 with a 19% response rate, as shown in Table 2.1 above.

2.3.3 Payment Vehicle

The payment mechanism was a one-time contribution that the respondent was asked to pay through a multi-county trust fund that could only be used for river restoration purposes. The author avoided using other controversial payment devices (for example, increases in taxes and/or utility prices) because of the possible negative effect on

respondents' WTP (payment vehicle bias) – people usually dislike any increases in prices or taxes. On the other hand, the payment vehicle should not be seen by respondents as voluntary or charitable contributions to avoid the worm glow effect. In order to make the payment vehicle as realistic and plausible as possible, respondents will be informed explicitly that the project will not take place unless enough local funds are raised to meet the local responsibility in the project's cost without giving out any cost figures. This is theoretically vital to ensure that WTP answers are based on consumers' own valuations of the good (consumer surplus measures) and are not being anchored to the actual cost of restoration in any way. For example, phrasing of the payment vehicle for the dredging only scenario was as follows:

> "*Now, we want to know how you would vote if this program were on the ballot in a local election.* ***Each household would make a one-time payment to a multi-county special district that would be established to collect and allocate the money for Mahoning River restoration.*** *This is the only payment required and all payments would go into a trust fund that could only be used for Mahoning River restoration efforts. Keep in mind that only people in the Mahoning river valley would be asked to pay for Mahoning River restoration. If the project passes, all residents would be required to make the one-time payment.*
>
> *The restoration program would only be carried out if people are willing to make this one-time payment. There are reasons why you might vote for the program and reasons why you might vote against it. The restoration program would be accomplished within 10 years. Upon restoration, the resulting cleaner Mahoning River will support better fish habitat, increased recreational activities, improved business and commerce, and help lift the health advisories. On the other hand, your household might prefer to spend the money on other social or environmental programs such as air pollution control. Or, the restoration program might cost more money than your household wants to spend for this. Suppose that the proposed program (****dredging****) is estimated to cost your household a one-time payment of* ***$50****. If an election were to be held today, would you vote for or against this program?*"

The trust fund tool is not new to local governments and the public in Ohio and has been used before to collect money to provide public services locally, which makes the proposed payment vehicle more realistic and less voluntary. Following NOAA (1993) Panel's guidelines for value elicitations surveys, respondents were reminded to consider their expenditures on other private and public goods before answering the WTP question for the good being valued. This is to insure that respondents have in mind other likely expenditures and the budget constraint when evaluating the current public good.

CHAPTER 3

ANALYSES OF SCOPE, SEQUENCE AND CONTEXT EFFECTS

3.1 The Issue of Scope

We start off by examining the issue of scope or scale effects and then turn to the issue of embedding. Carson and Mitchell (1995) developed a 'component sensitivity test', which rejected the hypothesis that respondents are insensitive to the scope of the good being valued. That is, respondents in this study were able to perceive different levels of provision of the environmental good and took this difference into account when asked to state a value for that good. Also, Whitehead et al. (1998) found that WTP estimates, including non-use values, were sensitive to the scope of the policy (improving water quality in two recreational sounds in North Carolina), and that the use of inexpensive survey methods such as telephone and mail surveys may not be the cause of the presence of part-whole bias in some recent CVM studies. On the other hand, some critics of the contingent valuation technique (Kahneman and Knetsch 1992) found that WTP did not change significantly between a less inclusive package and more inclusive packages of environmental services, and thus they concluded that the measures of value obtained using CVM might be consequently arbitrary. Loomis et al. (1993) found mixed evidence of scope effects in their valuation of forest protection in Australia. They found that WTP increased significantly for a small addition of forest protection but did not

change much for greater additions of forest protection.

Smith (1992) and Carson and Mitchell (1993) have argued that the absence of scope effects in some contingent valuation studies might be the result of survey design and administration problems such as poor description and framing of the commodity to be valued and improper implementation of the CVM survey. Boyle et al. (1994) suggested that part-whole bias could be an explanation of the insensitivity of contingent valuation estimates of non-use values to marginal changes in environmental commodities. Particularly, they found that willingness to pay of independent samples of non-users did not increase significantly with the number of waterfowl deaths prevented from 2000 to 20,000 to 200,000. Boyle et al attributed this finding to the difficulty of valuing marginal changes in environmental resources when these changes represent small proportions of the resource in question. In their experiment, the proposed changes ranged from less than 1% to 2% of the total waterfowl count in the Central Flyway zone of the United States (about 8.5 million migratory waterfowls). However, one could argue also that it is not the size of change in the environmental resource that matters; rather, it is the size of the potential effect of that change on the individual's utility. That is, the metric used to measure damages to the environmental resource must be given great consideration when designing the CV instrument since the choice of the appropriate measure affects how people perceive and therefore value the proposed change. In another study, Brown and Duffield (1995) argued that sensitivity of contingent values to scope or scale of the environmental good depends upon whether the good is valued separately or within an agenda and on the information available about potential substitutes. They found that past users of a specific river are more knowledgeable about the unique characteristics

of that river compared to other rivers and thus are less likely to consider rivers to be complete substitutes for each other than non-users. Consequently, WTP of river users were more sensitive to changes in the environmental good, the number of rivers protected in Montana, than non-users. This result is similar to the conclusion of Boyle et al that part-whole bias is more likely to be present in contingent valuation estimates of non-use values.

In explaining why some CV studies fail the scope or scale test, another possibility is that the presence of part-whole valuation effects is dependent on the type of the good being valued and on whether the proposed change in the environmental good is considered a change of scale (size) or a change of scope (dimensions or attributes of the environmental good). Carson and Mitchell (1995) have classified nesting in environmental goods and services into two types: "Quantitative (numerical) nesting" and "categorical nesting". Numerical nesting concerns goods that are measured along a common scale so that one good represents a higher value on that scale than the other good. An example of scale effects is the above experiment by Brown and Duffield on evaluating the protection of instream flow in 1 or 5 rivers in Montana. Categorical nesting, on the other hand, concerns goods that are complements but not necessarily measured on the same scale. An example is a policy agenda that contains different programs where each generates a distinct set of amenities to individuals. A change in the number of programs included in the policy is a change in scope because the sets of benefits generated by the different programs may or may not be measured on the same common scale. We did not find any studies that looked at the distinction between increases of the same good and adding other goods to the good being valued and how this

is related to sensitivity to scale or scope in CV surveys. In other words, the literature on contingent valuation does not seem to distinguish, except by definition, between scale or size effects and scope effects. Moreover, it seems that studies that evaluate more (quantitative or geographic) units of the same good (for example, Carson and Mitchell 1995; Whitehead et al. 1998) are more likely to find size or scale effects than studies that value additions of other goods (scope) to the good in question (for example, Kahneman and Knetsch 1992). The purpose of the current study is not to conduct a comprehensive investigation of the part-whole bias problem in contingent valuation or to test for differences between valuation of scope and valuation of scale. Rather, the author considers only one type of part-whole bias— whether contingent valuation estimates are sensitive to scope (categorical) changes in the environmental good of interest, projects (alternatives) proposed to restore the Lower Mahoning River in northeastern Ohio to pre-industrialization conditions. In this case, both use and non-use values are represented.

3.1.1 Defining the Good and Designing the Survey

The study case is restoring the Lower Mahoning River in northeast Ohio to its pre-industrialization conditions. This segment of the River is filled with contaminated sediments that have polluted the river and degraded its ecosystem for almost a century. Contaminated sediments are from waste disposal of the early steel mills that developed along the river banks, and from the disposal of adjacent communities into the river. In addition, there are 10 low-head dams that impede the continuous flow of the river in this stretch and as a result prohibit the spawning of some fish species. Two programs have been proposed by the Army Corps of Engineers to restore the biotic and aquatic integrity

of the river to pre-contamination conditions. These programs are: (1) dredging of the contaminated sediments (D) without any dam removal and (2) dredging and removal of some of the low-head dams (D-DR), with the second program providing more and longer-lasting benefits than the first. Restoring the lower Mahoning River using either program would improve water quality, enhance fish habitat, increase recreational activities (especially fishing and boating), increase property value, attract businesses, and help eliminate the human health advisories currently in place against swimming, wading, and eating fish caught in this segment of the river.

However, dredging only would result in partial restoration of the river since sediments will eventually build behind the dams and reduce the benefits of restoration over time. Dredging with dam removal would allow the above benefits to be observed for a longer period of time. Additionally, partial removal of the dams would allow fish to migrate freely in the river and thus make the improvement in fish habitat more sustainable. Having said that, benefits of the first program (D) are nested within those of the second program (D-DR), and this allows testing for scope effects.

Version	Program/Agenda
1	(D)
2	(D-DR)
3	(D) → (D-DR)
4	(D-DR) → (D)

Table 3.1: Mahoning River survey scenarios

The data for this study are from a 2003 mail survey of a randomly selected sample of respondents in northeastern Ohio. To test for scope and other effects four versions of the CVM survey were sent to seven counties within the Mahoning River Watershed (MRW). The four versions are listed in Table 3.1 above. Version 1 contained a contingent market for the dredging only (D) program. Version two contained a contingent market for the dredging with dam removal program (D-DR) program. In Version 2 (dredging with dam removal), we specified that partial dam removal would be undertaken in addition to dredging and then explained the benefits of dredging (as in Version 1) and the additional benefits of dam removal per se.

For the dredging only program, respondents were told:

> One of the proposed restoration programs is dredging of the contaminated sediments using hydraulic or mechanical methods. Dredged materials will then be dewatered and contained in a safe non-leaking disposal facility.
>
> Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories.

For the dredging with dam removal program, respondents were told:

> One of the proposed restoration programs is dredging with selective dam removal, in which, contaminated sediments will be dredged using hydraulic or mechanical methods. Then, dredged materials will be dewatered and contained in a safe non-leaking disposal facility. In addition, some of the low-head dams along the contaminated segment of the river will be selectively removed. There are 10 low-head dams in the project area, of which 4 or 5 will be removed.
>
> Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories. Dredging only may result in partial restoration of the Lower Mahoning River since sediments will eventually re-build behind the dams and cause some damage to the river ecosystem. Additionally, the removal of some dams would allow fish to migrate in the river and therefore make the improvement in fish habitat more sustainable.

Version 3 contained a contingent market for an agenda in which (D) is valued first then (D-DR) is valued second. And version 4 contained a contingent market for an agenda in which (D-DR) is offered first then (D) is offered second. Versions 3 and 4 are identical in every way except for the order of the valuation questions. Copies of the survey instruments for the different versions (scenarios) are included in the Appendix. Version 3 of the survey was pre-tested on members of the Mahoning River Consortium[2] and adjustments in wording and question ordering were made to all survey versions so that the questionnaire would be clearly understandable by all respondents. First, a focus group was conducted during a monthly meeting of the Consortium in which approximately 25 members were asked to complete the survey on their own and then answer debriefing questions about how they viewed the commodity of restoring the Mahoning River and the difference between the two proposed restoration programs. The results of the debriefing were used to further revise the survey instrument. Second,

[2] An environmental organization concerned with educating people in the MRV about the Mahoning River restoration projects and advocating for its clean-up.

respondents who did not attend the meeting were asked to complete the survey and send it back to the author through mail or email. Results of the mail pre-test and the focus group were used to design the bid range and distribution of WTP for the two programs.

The demographic profile of the sample is similar to that of Northeast Ohio (Table 3.2) except for median age. The median age of the sample (56 years) is higher than that of the population (36 years) but this is typical of mail surveys where older people tend to respond more than the young. In previous work, age tends to have mixed effect on WTP for environmental goods and the sign of the effect is not usually predictable. Whitehead et al (1998) found that the effect of age on WTP was negative and significant; Payne et al (2000) found that the effect was positive but insignificant; and Boyle et al (1994) found the effect to be negative and significant for some level of the good provision but negative and insignificant for higher levels. In the present study, the coefficient on age was negative and significant in only one of the probit regressions indicating that older people were less favorable of dredging only project. However, for the dredging with dam removal regression, age was negative but insignificant. This might indicate the effect of age differs with the scope of the good but the direction of this change is not predictable. Using simple T tests for the difference in mean, none of the demographic or behavioral characteristics is statistically different at the 0.05 level among the four versions of the survey. This confirms the overall randomness of the assignment of scenarios to respondents and indicates that our statistical results are not attributed to differences among subsamples. The PROTECT variable is a 5-point scale variable asking respondents about how important is the goal of protecting the environment including water resources. The YEARSIN variable is measuring how long a respondent has been

living in the Mahoning River valley and PERSONS means the number of persons per household. The rest of the variables are self explanatory.

Variable	version 1 N=113	version 2 N=84	version 3 N=85	version 4 N=78
PROTECT	4.12	4.1	4.09	3.97
OWNBOAT	0.19	0.23	0.18	0.08
LAKES	4.62	4.54	5.22	3.17
YEARSIN	22	24	20	23
AGE	58	55	57	55
PERSONS	2.25	2.29	2.55	2.64
MALE	0.65	0.59	0.72	0.61
WHITE	0.97	0.95	0.88	0.96
EDU	3.14	2.51	2.98	2.99
INCOME (2000 $)	51649	45365	47833	42279

Table 3.2: Data summary

The first part of the survey was about eliciting information regarding respondents' attitudes (on a scale of 1 to 5) toward environmental awareness and importance of protecting the environment (PROTECT), participation in environmental entities, knowledge about river contamination, and participation in recreational activities on the river and on lakes in the area (LAKES). The second part of the survey contained the policy scenario which compared the status quo of the river with the alternative situation in which a restoration program/agenda is proposed. Questions about respondents' awareness of contaminated sediments and perceived effectiveness of the proposed policy were presented in this part to get people to think about how much they value the policy.

Then, the contingent market was established and a dichotomous choice WTP question followed by an open-ended question was asked to elicit a respondent's maximum WTP for the proposed program regardless of the respondent's answer to the first binary choice WTP question.

Each respondent was asked to vote on a one-time payment to a multi-county special district fund that could only be used for restoration efforts of the river. The author avoided using increases in taxes or utility prices as payment vehicles to reduce protest responses while keeping the payment mechanism as mandatory as possible; the special district fund is not voluntary and usually used by counties in Ohio to collect money for providing local services. The price amounts were randomly selected from four WTP values: 50, 100, 200, and 400. Choice of the bids was based in part on results of the pre-testing survey with members of the Mahoning River Consortium. Bid amounts varied with the scope of the good: $50, $100, and $200 for the dredging only project, and $100, $200, and $400 for the dredging with dam removal project. The last part of the survey contained questions about various demographic characteristics of the respondents, which is used in the bid functions to explain variations in WTP amounts and to generalize WTP sample estimates to the population.

3.1.2 Scope Results

3.1.2.1 Between-Subject Scope Effects

We first test for the scope effects between subjects (independent samples) using Versions 1 and 2 in which each good is valued on its own. Table 3.3 shows frequencies of the no responses for dredging only (D) and dredging with dam removal (D-DR)

dichotomous choice questions. These proportions are then used to calculate the Turnbull distribution-free lower bound estimate of mean WTP (Haab and McConnell 2002). The underlying notion of the distribution free estimator is that when a respondent i answered no to the offered bid t_j we have learned that his willingness to pay is less than t_j. Then, the probability that a randomly chosen respondent having WTP less than t_j is

$$\Pr(WTP_i < tj) = F_W(tj) = F_j$$

Where F_j is the cumulative distribution function of WTP and should be monotonically increasing in the bid amount. This is because we would expect a higher proportion of respondents to answer no at a higher price. The Turnbull estimator guarantees this monotonicity by pooling responses to prices that fail to meet this condition.

Dredging only (D)				Dredging w/ dam removal (D-DR)		
Bid	No	Total		Bid	No	Total
50	17	42		100	12	23
100	24	41		200	25	31
200	18	30		400	22	30
WTP_{LB}[a]	$90.49 (10.45)[b]			$70.78 (12.87)		
Δ WTP			$19.71			
T stat			1.19[c]			

Table 3.3: Frequency of "NO" responses and Turnbull estimation of WTP
[a] Turnbull lower-bound mean WTP
[b] Standard deviation of WTP
[c] Not significant at the 0.10 level

The lower bound estimate of WTP is obtained by multiplying each offered price by the probability that WTP falls between that price and the next highest price:

$$WTP_{LB} = \sum_{j=1}^{M+1} c_{j-1} f_j$$

Where $f_j = F_j - F_{j-1}$, M+1 is the upper bound on the range of WTP, and c is the offered price. From the split-sample data, the difference in mean WTP between the D and D-DR samples is \$19.71, which is insignificantly different from zero at the 0.10 level using a one-tailed test (t critical=1.29). Also, the lower bound on the range of median WTP, the price for which a probability of no response equals 0.5, is \$50-\$100 for D and \$0-\$100 for D-DR assuming a non-negative WTP. These estimates for the lower-bound mean and range of median WTP show that no scope effects are present in the split-sample data; i.e., respondents offered one program or the other are not sensitive to scope of the good being valued.

Regression analysis is used to relate WTP to demographic and behavioral characteristics of the respondents and to calculate willingness to pay for the prescribed goods. Analyzing how WTP changes with respondents' characteristics allows the researcher to gain insights on the validity and reliability of contingent valuation, and to generalize sample results to the general population (Haab and McConnell 2002). The parametric model used to estimate willingness to pay from the dichotomous contingent valuation questions is the random willingness to pay probit model, in which the probability of yes is estimated as a function of exogenous explanatory variables. The dependent variable is the yes/no responses to the posited bid amount and the covariates are responses to the socioeconomic and behavioral questions included in the survey

instrument. Only significant covariates are reported in the regression tables below. A respondent answers yes to the dichotomous choice valuation question if his WTP exceeds the offered bid amount (t_j):

$$\Pr(yes_j)=\Pr(WTP(y_j, X_j, \varepsilon_j)>t_j)$$

Where X is the vector of independent variables, y is household j^{th}'s income, and ε is a normally distributed random error term with mean zero and constant variance σ^2. Estimating a parametric model for dichotomous choice contingent valuation questions involves two linked stages. In the first stage, a preference function or willingness function is estimated and then estimated parameters are used to calculate willingness to pay in the second stage.

First, we test for sensitivity to scope using a dummy variable for the more inclusive good (D-DR) in the probit equation while holding constant other potentially influential variables. Second we test the equality of coefficients in the bid functions for the two scopes of the good using a likelihood ratio test. And third, we test for within sample scope effects using data from versions three and four only, in which each individual had the opportunity to value both goods sequentially within an agenda. Our regression model assumes an exponential WTP function, which bounds WTP from below to be non-negative and does not bound it from above. The functional form is:

$$WTP_j = e^{\beta X_j + \varepsilon_j}$$

Where β is the vector of parameters that corresponds to the vector of covariates X. Mean and median WTP from the probit model are calculated using the following equations:

$$E_{\varepsilon}(WTP \setminus X_j, \beta) = e^{\beta X_j + 0.5\sigma^2}$$

$$MD_{\varepsilon}(WTP \setminus X_j, \beta) = e^{\beta X_j}$$

Since expected WTP for the exponential model is increasing in σ^2, the difference between mean and median WTP will be bigger for higher values of σ^2 (Haab and McConnell 2002). For the current data, $\sigma^2 = 1.03$ so the difference between the mean and the median is relatively large (of a degree of magnitude). As such, the more conservative estimate of WTP (the median) is used to test for between and within sample scope effects.

Variable	Coefficient	t-Value
Constant	-.96	-.94
Protect	.55***	3.93
Lakes	.03**	2.07
Income/1000	.01***	3.63
D-DR	-.2	-.75
Log (Bid)	-.47**	-2.36
Δ WTP	$10.74	
Log Likelihood Function	-91.82***	

Table 3.4: Between-subject scope results
Sample size = 167, $\sigma^2 = 1.03$
* Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level

Table 3.4 shows results of the probit regression on data from Versions 1 and 2 only. The coefficient on the (D-DR) dummy variable is insignificant at the .10 level, meaning that respondents are not willing to pay more for the dredging with dam removal project relative to the dredging only project. The importance of protecting the environment and income coefficients are significantly different from zero at the .01 level while the lakes and bid price coefficients are significant at the .05 level. All coefficients except for the D-DR coefficient have the expected signs. That is, WTP is increasing in household median income, whether the respondents sees that protecting the environment is an important national goal, and whether the respondent recreates on lakes in the Mahoning River Valley. As expected, WTP is decreasing in the logarithm of the bid price. With regard to part-whole valuation effects, WTP is decreasing in the scope of the good but the relationship is insignificant as indicated by the insignificant coefficient on the dummy variable for Version 2 at the .10 level. Moreover, the difference in WTP between the two scopes of the good is $10.74 ─ median WTP is $93.23 for D and $82.49 for D-DR) ─ and is insignificantly different from zero at the .10 level based on a comparison of the 90% confidence intervals for the two goods ─ confidence intervals are [$51-$162] for the dredging only policy and [$28-$126] for the dredging plus dam removal policy.

Another way to test for scope effects between scenarios one and two is to estimate separate probit models for the two scenarios using the same set of independent variables and then test for the null hypothesis that the sets of coefficients estimated for both models are equal. Table 3.5 shows probit equations estimated for each scope of the good and for the pooled data. In the pooled data estimation, we concatenated bid amounts

and yes/no responses from versions one and two to obtain the new bid amount variable and new dependent variable, respectively. Regression results show that all variables maintain their respective signs across the two versions but the magnitude and significance of the coefficients does change from version to version. The bid coefficient increases in magnitude and significance as the scope of the good gets smaller. This indicates that respondents are more responsive to changes in the price of the less inclusive good than to changes in the price of the more inclusive good. A likelihood ratio test was conducted using the log likelihood values from the restricted estimations (versions one and two) (LR) and from the unrestricted pooled data estimation (LU):

$$\chi^2 = -2\,[(LR_D + LR_{D\text{-}DR}) - LU_{Pooled}]$$

Using the likelihood ratio test, we fail to reject the null hypothesis of equal coefficients across scope levels of the good at the .10 level ($\chi^2 = 0.89$, and the critical value at 5 degrees of freedom is 9.24). This indicates that the set of estimated parameters are not significantly different, in total, between the two scopes of the good. In other words, there was no statistically different WTP behavior being exhibited in responses to questions about the values of dredging only and dredging with dam removal programs.

Variable	D (Version 1)	D-DR (Version 2)	Pooled
Constant	-0.7	-1.89	-0.65
	(-0.56)[a]	(-0.94)	(-0.7)
Protect	0.53***	0.61***	0.56***
	(2.99)	(2.57)	(3.97)
Lakes	0.02	0.03*	0.03**
	(1.20)	(1.77)	(2.04)
Income/1000	0.01***	0.02**	0.01***
	(2.8)	(2.33)	(3.69)
Log (Bid)	-0.51*	-0.39	-0.56***
	(-1.92)	(-1.26)	(-3.35)
Log Likelihood	-55.51	-36.15	-92.10
N	95	72	167
LR (d.f.)[b]		0.89 (5)	

Table 3.5: Likelihood ratio test

* Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level
[a] t-Value
b χ^2 (tabulated) = 9.24

3.1.2.2 Past Use of the River and Sensitivity to Scope

In order to study the effect of past use of the Mahoning River on sensitivity to scope in the current CV survey, the pooled sample from scenarios 1 and 2 was classified according to responses to the question about recreation on the Mahoning River in the past year into two separate sub-samples, past users and nonusers, and then a scope test was conducted on each sub-sample. Table 3.6 shows the estimated probit equations for both users and nonusers. Comparing the two regressions, users of the Mahoning River also visit other lakes and reservoirs in the area more than nonusers and this has a positive effect on WTP for the restoring the Mahoning. Household income has positive and more significant effect on WTP for nonusers than for users of the Mahoning, indicating that

income is a more restrictive factor for WTP of nonusers. For past users of the Mahoning, the scope coefficient (D-DR) is positive and significant at the 1% level indicating that users of the river were sensitive to the scope of the restoration program and willing to pay more for the benefits of dredging with dam removal ($213) than for the benefits of dredging only ($97). On the other hand nonusers of the river were insensitive to scope of the good and their responses do not conform to expectations of economic theory, the coefficient on scope (D-DR) is negative and significant at the 1% level.

The foregoing results are consistent with some of the findings of Brown and Duffield (1995) that users of an environmental resource are more likely to see alternative programs or alternative public goods as partial substitutes because of their past knowledge of the resource in question and of its characteristics, and therefore their WTP will not be the same for different levels of provision of the public good. Whereas, nonusers of the river are more likely to treat alternative programs as perfect substitutes since their motive for payment would be to restore the Mahoning without much interest in how the river will be restored or what kinds and levels of benefits are expected of the different programs. The difference between our results and those of Brown and Duffield is that they found that WTP in the whole sample of users and nonusers were sensitive to scale (the number of rivers protected) and attributed that to responses of past users, not nonusers. In the current study, however, respondents were not sensitive to the scope of the restoration program in the whole sample even though the users' valuations were sensitive to scope. Another difference between the two studies is that nonusers' responses in the present study are negatively and significantly related to scope indicating that nonusers are willing to pay less for dredging with dam removal than for

dredging only. An explanation for this negative scope effect might be that nonusers of the Mahoning are more supportive of keeping dams in general for their recreation and other benefits and are less knowledgeable about dams in the Mahoning River and their use, in particular. Descriptive analysis of responses to the open-ended WTP question by past users and non-users of the river leads to the same conclusion about sensitivity to scope. That is, users are willing to pay a median value of $50 for dredging only and $100 for dredging plus dam removal. On the other hand, nonusers are willing to pay $50 for dredging only and $20 for dredging plus removal. Again, this shows that past users are positively sensitive to scope of the good whereas nonusers are negatively sensitive to scope. These results indicate that sensitivity to scope in contingent valuation might be dependent on the characteristics of the individuals included in the survey, especially with regard to previous use or experience with the resource in question.

Variable	User		Nonuser	
	Coefficient	t-Value	Coefficient	t-Value
Constant	3.96	1.62	-2.64**	-2.18
Protect	1.33**	2.48	0.49***	3.09
Lakes	0.06*	1.84	0.03	1.14
Income/1000	0.02	1.63	0.01***	2.98
D-DR	1.91***	2.62	-0.91***	-2.72
Log (Bid)	-2.44***	-3.22	-0.01	-0.05
N	44		123	
Log Likelihood	-15.7***		-65.6***	

Table 3.6: Scope results based on past use of the river
* Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level

3.1.2.3 Within-Subject Scope Effects

So far the results of the multivariate analysis and WTP comparisons indicate that there are no scope effects between versions of the CVM survey. Now we turn to testing for the within sample scope effects in which the two levels of the good are being valued by each respondent in a sequence. This is known as within-subject comparisons (Smith 1992), and it provides a way to control for the effects of individuals' characteristics and constraints on their responses to WTP questions. The bivariate probit model, the general parametric model for the two-response surveys, is used to analyze responses from the multiple program agendas (Versions 3 and 4). The general form for the bivariate probit model is:

$$L_j(\mu/t)=\Phi_{\varepsilon_1\varepsilon_2}(d_{1j}(\frac{t_1-\mu_1}{\sigma_1}),d_{2j}(\frac{t_2-\mu_2}{\sigma_2}),\rho)$$

Where L_j is individual j^{th} contribution to the bivariate probit likelihood function, $\Phi_{\varepsilon_1\varepsilon_2}$ is the standardized bivariate normal cumulative distribution function with zero means and unit variances and correlation coefficient ρ, $d_i = 2y_{ij} - 1$, $y_{ij} = 1$ if the response to the i^{th} question is yes, and 0 otherwise, and μ_i = mean WTP for the good i and is a function of the vector of covariates: $\mu_{ij}=x_{ij}\beta$. Table 3.7 shows the results of the bivariate model regression. The first 4 rows are for the (D) responses and the second four rows are for the (D-DR) responses. We included a dummy variable for responses from version four to control for any possible effects that question ordering might have on WTP. The correlation coefficient is 0.85 and significantly different from zero at the .01 level indicating a positive correlation between responses to the two bid questions. That is, respondents that have high WTP for the dredging only project tend also to have high WTP for the dredging with dam removal project. Using parameter estimates of Table 3.7, calculated median WTP was \$88.03 for (D) only and \$135.03 for (D-DR), indicating that people were willing to pay more money for the larger scope project than for the smaller scope. However, by comparing the 90% confidence intervals of WTP for the two projects, \$43-\$160 for (D) and \$66-\$223 for (D-DR), this difference in WTP is insignificant at the 10% level, meaning that within-subject scope effects are also insignificant.

Variable	Coefficient	t-Value
Parameter estimates for D		
Constant	0.741	0.62
Protect	0.311**	2.07
Income/1000	0.010**	2.30
VER4	-0.250	-1.06
Log(Bid $_D$)	-0.547***	-2.47
Parameter estimates for D-DR		
Constant	-0.204	-0.15
Protect	0.599***	3.31
Income/1000	0.016***	3.09
VER4	0.109	0.43
Log(Bid $_{D\text{-}DR}$)	-0.596***	-2.73
ρ	0.847***	13.60
Log-Likelihood	-135.23	
$-2(L_R/L_U)$	40.26	

Table 3.7: Bivariate probit model estimation

[a] n =137

** Significant at the .05 level

*** Significant at the .01 level

The end result is that there were no scope effects in the Mahoning River survey either across or within samples at the 10% level, in general. This result is consistent with the findings of some previous CVM studies where respondents were asked to value programs or policies that are not necessarily providing more of the same good in terms of quantity, geographic scale, or temporal scale. For example, Bergstron and Stoll (1987) did not find significant difference between WTP for a farm land protection program that contained four sub-programs (protection of local and national food supplies, protection of agricultural jobs, more orderly urban development, and protection of environmental amenities) and WTP for one sub-program (environmental amenities protection) when

valued on its own by an independent sub-sample of respondents. Brown et al (1995) did not find scope effects in the valuation of a program to preserve natural areas versus a more comprehensive program to enhance environmental services that included preserving natural areas as a sub-program. And, Kahneman and Knetch (1992) did not find scope differences between the value of environmental services in general (including preserving wilderness areas, protecting wildlife, protecting air pollution, insuring water quality, and preparing for disasters) and the value of preparedness for disasters only.

In all these cases, as well as in the Mahoning River case, respondents are evaluating policies or agendas that differ in scope or in the number of programs included, and these programs may provide distinct sets of benefits to respondents. Assuming that a respondent values a specific program based on the contribution of its potential benefits to his welfare or utility, then the value of a package will depend on whether the benefits of the different programs within the package are measured on the same common scale. In the case of scope valuation, benefits of the different programs are mostly based on different scales and hence aggregating these benefits by the respondent to establish a value for the more inclusive policy or package might be a difficult task. In other words, respondents may not be able to perceive a change in the scope of the policy in the same way they would perceive consuming more apples or more bananas (scale or size changes). In the current study, it might be easier for respondents to perceive and value the difference in the benefits of dredging 10 miles compared to those of dredging 30 miles of the Mahoning River than from dredging only compared to dredging with dam removal.

In the case of scale valuation, respondents are more likely to perceive scale changes in the same good (program), especially when these changes are not minimal.

This is because the benefits associated with different levels of the same good are measured on a common scale and hence could be assigned different values by respondents. For example, Desvousges et al (1992) found significant scale differences between the values of protecting one wilderness area and protecting 57 wilderness areas, but did not find scale differences between the values of protecting one wilderness area and protecting 3 wilderness areas. This later result of insensitivity to scale could be attributed to the fact that protecting 3 wilderness areas is a marginal increase in the provision of the public good compared to protecting 57 wilderness areas (Boyle et al 1994). In another study, Carson and Mitchell (1995), in their investigation of the effect of mining on conservation zoning in Australia, found significant scale effects in the valuation of the degree of the risk of off-site environmental damage of mining activities. That is, respondents were willing to pay more to avoid higher risks of environmental damage of mining than to avoid lower risks. In these cases, sensitivity to scale was, to some degree, more observable than sensitivity to scope in the scope examples above.

In the Mahoning River case, respondents were clearly informed that the more inclusive project (D-DR) would provide the same benefits as the other project (D) for a longer period of time in addition to providing other benefits more specific to dam removal per se such as sustaining fish habitat and allowing for continuous navigation in the river for some kinds of boating. However, these amenities (of dam removal) cannot be considered as having more quantities of the same good. Moreover, the author did not explore the possibility that some residents might be opposing dam removal because they like the dams or benefit from their presence (for example, a steel mill that still uses water behind some of the dams for cooling purposes), although discussion with members of the

Trumbull County Planning Commission, the local sponsor of the restoration project, revealed that very small fraction of the population is employed by the steel industry in Mahoning county. The author could not investigate the possibility of negative preferences toward dam removal because the survey targeted the general public and not specifically stakeholders in the steel industry (owners, workers, and other related industries in the region), and also because dam removal without dredging is not technically feasible. However, the contingent valuation method should in principal be able to account for these effects because respondents are expected to incorporate all components of value including negative values when responding to the WTP question. But since an exponential WTP function was estimated for the discrete choice responses, the possibility of negative WTP was ruled out. Thus, we rely on the open-ended valuation responses to verify whether WTP is nonnegative. Descriptive statistics of the open-ended responses indicate that mean WTP is $97 for dredging only (D) and $83 for dredging with dam removal (D-DR); median WTP is $50 for D and $38 for D-DR, and the standard deviation is $156 for D and $117 for D-DR. These estimates of WTP from the open-ended responses indicate that mean WTP could be negative for any of the proposed projects. This does not provide evidence of negative preferences toward dam removal per se. Using a one-tailed t test mean WTP is not significant between the two scopes of the good at the 10% level.

To summarize, the absence of scope effects in the current CV survey might be a result of the type or multidimensional aspects of the good in question and the proposition that scale effects are easier to be comprehended and then translated into dollar values than scope effects by respondents. Further research should be directed to testing for scope

and scale effects within the same survey to control for the possible effects of respondent's characteristics or constraints on WTP estimates. Furthermore, sensitivity to scope among past users of the river indicates that users of the river are more knowledgeable about its characteristics and thus might be more sensitive to scope variations in the environmental good than nonusers. It is thus concluded that one should not expect to realize scope effects in public goods markets to the same extent as in private goods markets. This is because public and environmental resources are quantity-rationed rather than price-rationed goods, which means that people are not expected to change the quantity demanded of the public good with the change in its price as they do in private good markets. Rather, people are expected to pay more for more provision of the public good(s) up to a certain level, after which they will not pay more.

3.2 The issue of embedding

The problem of embedding has been defined and tested for differently, and sometimes mixed up with the problem of scope in contingent valuation studies. Kahmeman and Knetsch (1992) define perfect embedding as the equality of directly elicited WTP values regardless of the degree of scale the good is defined over. Carson and Mitchell (1995) argue that CV responses are not context free (due to substitution effects and budget constraints), and that the size and nature of the choice set are important determinants of how an individual values a particular good. This is consistent with the notion by Hoehn and Randall (1989) that "…*as the number of policy proposals becomes large, conventional benefit cost procedures* [in which proposals are evaluated independently of each other] *are certain to overstate a valid measure of net benefits*."

A more general definition of the embedding effect is that the value of a particular good depends upon whether it is valued alone or as part of a larger package or agenda (Loomis et al. 1993). This notion is more general because it does not prescribe scale or nesting as part of the embedding problem. The author agrees with this definition because testing for embedding can be accomplished only by comparing a scenario in which the resource is valued on its own to other scenarios in which the resource is valued within an agenda regardless of whether the agenda offers more of the same resource or additional resources for the respondent to value. The author prefers to call this a context effect because it looks at how CV responses are affected by the context in which the valuation question is asked and also because it is less confusing than the term 'embedding'.

The presence of context effects in CV surveys has been attributed to substitution or complementarity effects and budget constraints (Hoehn 1991; Hoehn and Randall 1989): as the number of policy proposals increases, there is more likelihood of substitution or complementarity effects between programs within the larger agenda. In addition, as the dollar value of total WTP approaches a maximum limit in the respondent's expenditure function, budget constraint becomes a restraining factor on WTP for each program.

Another problem that CV elicited values may suffer from is an order or sequence effect: the value of a particular resource depends on the order in which it is valued within an agenda. Payne et al (2000) found a strong sequence effect when respondents were asked to value five environmental programs using WTP and other evaluative attitude ratings. In particular, WTP was higher for a good when evaluated first in the sequence than when evaluated afterwards. They also found that the sum of WTP for the bundle of

the five environmental goods depended on the value of the good evaluated first in the sequence. This result, they claim, contradicts the theoretical prediction by Carson and Mitchell (1995) that "for non-nested goods, the total value for a package of goods (but not the value of the individual goods) should be invariant to the order in which the individual goods are valued". However, the claim by Payne et al that their results contradict with the prediction of Carson and Mitchell is incorrect in the sense that Carson and Mitchell did not define the total value of a package in terms of the sum of the individual programs included in the package as Payne et al did.

3.2.1 Context and Sequence Results

In the current study, we explicitly test for context and sequence effects using the Mahoning River CV data. First, we test for context effects by comparing Versions 1 and 2, in which D and D-DR are each valued alone, to Versions 3 and 4, in which D and D-DR are valued first in an agenda, respectively. Next, we test for sequencing by comparing Scenarios 3 and 4, in which both goods are valued within an agenda but in a different sequence.

Table 3.8 shows a multivariate analysis of the context effect, in which a dummy variable for the multiple-program scenario is included as a covariate. In the second column, the coefficient on the "scenario 3" dummy variable is insignificant at the 0.10 level, indicating that there is no context effect in the valuation of the dredging only project. Respondents are willing to pay $95.13 for D when it is valued on its own, and $91.87 when it is valued first in an agenda offering D-DR after D. In the case of dredging with dam removal project, the coefficient on scenario four in the fourth column of Table

3.8 is significant at the 0.10 level, indicating that context effects are present in the valuation of the more inclusive project. WTP for D-DR is $72.14 when the good is valued alone (scenario 2) and $129.75 when it is valued first in an agenda (scenario 4), indicating that dredging with dam removal is valued more when it is offered to respondents within an agenda than when it is offered alone. The conclusion is that the context in which the good is presented in the CV scenario has a positive effect on the value of the more inclusive good (D-DR); whereas, it does not have any effect on the value of the less inclusive good (D).

Variable	Coefficient	t-Value	Coefficient	t-Value
	D		**D-DR**	
Constant	2.402***	2.61	1.696	1.41
Parks	0.077***	2.53	0.093**	2.70
Own Boat	0.102	0.41	0.655***	2.12
Age	-0.015***	-2.39	-0.005	-0.74
Version 3	***-0.013***	***-0.07***		
Version 4			***0.380***	***1.67****
Log (Bid)	-0.387**	-2.23	-0.441**	-2.05
Log Likelihood	-121.82		-88.22	
Sample Size	190		152	

Table 3.8: Context effects
* Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level

Sequence results are shown in Table 3.9 for both D and D-DR. The coefficient on scenario four in the second column has a negative sign and is significant at the 0.05 level, indicating that D is valued less when it is offered second than when offered first within an agenda. This is reflected in WTP values for dredging only, $104.73 in scenario three and $40.79 in scenario four. The presence of an order effect in valuing D is consistent with previous findings in the literature (Payne et al. 2000), which indicates that a particular resource is valued more when it is presented first than later in a sequence. The coefficient on scenario four in the fourth column of Table 3.9 is negative however insignificant, showing no order effect in the case of the more inclusive good (D-DR) as reflected in WTP amounts for that good─ $183.16 in scenario three and $157.46 in scenario four─ with the difference in WTP being insignificant at the .10 level. In fact, the negative sign on scenario four in the latter case indicates that D-DR might be valued more when it is offered after D as in scenario three. This could be attributed to a possible composite nesting-sequence effect in valuing multiple-program agendas containing nested public goods: a more inclusive good is more likely to be valued more when presented after a less inclusive good (scenario 3) than when presented before (scenario 4). The opposite is also correct and conforms to the negative sequence result in the valuation of D. That is, D (the smaller good) is valued less when it is presented after D-DR (the more inclusive good) than when presented before D-DR in a sequence.

Variable	Coefficient	t-Value	Coefficient	t-Value
	D		**D-DR**	
Constant	1.570	1.53	2.343**	1.99
Parks	0.069**	2.131	0.080**	2.39
YEARS IN	-0.007	-1.167	-0.006	-0.87
EDU	0.183**	1.983	0.279***	2.90
Version 4	***-0.468****	***-2.111***	***-0.096***	***-0.43***
Log (Bid)	-0.467**	-2.272	-0.633***	-2.97
Log Likelihood	-90.34		-87.33	
Sample Size	150		148	

Table 3.9: Sequence effects
** Significant at the .05 level
*** Significant at the .01 level

In assessing the quality of a CV study, it is desirable that WTP amounts can be predicted by the potentially influential covariates in the survey. As shown in Tables 3.8 and 3.9, visiting area parks (Parks), owning a boat (Own boat), and level of education (Edu) of the respondent are all positively (and in most cases significantly) related to willingness to pay. Age is negatively and significantly correlated with WTP for dredging only, and is negatively and insignificantly correlated with WTP for D-DR (Table 3.8). This indicates that younger people have higher WTP than older people. The number of years a respondent lived in the area is negatively (but insignificantly) related to willingness to pay at the 0.10 level for both D and D-DR (Table 3.9). The bid price is negatively (and significantly) related to willingness to pay in all regressions, which is expected by economic theory.

3.3 Summary and Conclusions

In conclusion, there was no evidence of sensitivity of WTP to the scope of the program proposed for restoring the Lower Mahoning River, though scope effects were significant among past users of the river. On the other hand, there was mixed evidence of context and order effects. Particularly, WTP for the dredging only program was affected by the order in which the program was offered within the agenda but not affected by the context or whether the program was valued on its own or within a larger package. Conversely, WTP for the more inclusive program (dredging with dam removal) was sensitive to the context variation but invariant to the order variation. Based on these results, the more important question is how valid the CV instrument is and consequently how relevant the value estimates obtained using this instrument are for policy analysis.

As for the scope results, different studies in the literature have reached different explanations as to why some CV surveys fail to pass the scope test. The most popular explanation is that of Carson and Mitchell (1993, 1995), Smith (1992), and Carson et al (2001) that insensitivity to scope is the result of poor design and implementation of the survey instrument in terms of explaining the survey clearly to the respondent, plausibility of delivering the public good in question, and how realistic is the payment vehicle. This explanation is not applicable to the current study because the CV instrument was carefully pretested and revised so that the description of the good and the contingent market would be clearly understandable by most respondents. Furthermore, about 50% of the respondents have prior knowledge about sediments in the Mahoning and 41% knew about the health advisories in advance. This made the task of explaining the status quo and the proposed improvements easier, which in turn made the CV scenarios less

hypothetical and delivery of the public good more plausible to respondents. Another explanation of insensitivity to scope is that of Boyle et al (1994) that part-whole bias is more likely to be observed in contingent valuation estimates of non-use values. Again, this reasoning is not applicable to the current case since the total economic value of restoring the Mahoning River includes both use and non-use components and; in addition, use value is believed to represent a higher proportion of the total value than non-use value. This is because the sample population was restricted to residents in the Mahoning River watershed who are using or expected to use the river in the near future if it is restored.

Brown and Duffield (1995) offered another explanation for part-whole bias based on the relationship between previous use of the resource and familiarity with other substitutes. They concluded that previous users of an environmental resource are more familiar with its substitutes and hence are more likely to perceive and value changes to the resource than non-users. This explanation, as mentioned before, might be true in the sub-sample of past users in the current survey but does not explain why the scope effect is not observable in the whole sample of users and nonusers. Furthermore, Brown and Duffield indicated that their conclusion is based on the respondent's own allocation of WTP to use and nonuse motives and on the relative sample sizes of users and nonusers.

Another possible explanation of the absence of scope effects in the current CV survey is that the good of interest varies in policy scope (dredging only or dredging with dam removal), whereas, in the case of Brown and Duffield, the good varies in geographic scale (protecting instream flow in one river or in five rivers). The hypothesis of the study at hand, which was proved by its scope results, is that it is not unusual to find part-whole

valuation bias in CV studies in which the good in question varies in policy scope and not in geographic or timescale. Under this maintained hypothesis, WTP estimates of these studies could still be valid for policy analysis even though sensitivity to scope is not apparent in the whole sample. We conclude that sensitivity to scope in the contingent valuation of public and environmental goods could be dependent on the type of the good being valued (e.g., scope versus scale valuations) and on the specific characteristics of the individual being surveyed (e.g., user versus nonuser).

With respect to the mixed evidence of context and sequence effects in the current study, many resource economists have argued that context and sequence effects in CV studies are expected by economic theory. For example, Randall and Hoehn (1996) state that "standard economic theory predicts that the value of a particular prospect will vary in systematic ways, depending on what additional prospects are offered prior to or simultaneously with it". These effects are usually induced by substitution effects and the budget constraint. Carson, Flores, and Hanemann (1998) show that the value of a particular public good should be smaller the later it is offered in a sequence of goods under the assumption that these goods are normal goods and substitutes for each other. The economic explanation for these phenomena is that each new public good the individual obtains reduces his available income to spend on private goods and other public goods and that substitutability among public goods makes each new good added to the package less desirable than when valued by the individual as the only change in public goods (Carson, Flores, and Meade 2001). However, the literature does not provide any prediction on the appropriate sizes on context and sequence effects that should be expected in CV studies. As such, the immediate question is which WTP estimate for a

particular public good should be used for policy analysis? Should independent values obtained by valuing each good as the only change to the status quo be used? Or, should the value obtained for each good within a package be used? And, if so, in what sequence? The obvious answer to the first question is no; independent WTP estimates for public goods should not be used as the only basis for policy analysis if context or sequence effects are deemed significant, as is the case in the current study. For the second and third questions, there is no clear answer since it would be difficult for the researcher to define the only one context and only one sequence in which the public good should be valued. Rather, several contexts and sequence are usually available to the researcher to choose from. A statistical remedy for this situation is to include context and sequence factors in the estimation stage of the bid functions using all available observations on the particular good and then compensate for context and sequence effects, if any, in the calculation stage of WTP. This is shown in detail in the next chapter.

CHAPTER 4

ENVIRONMENTAL EQUITY AND BENEFIT COST ANALYSIS

4.1 Introduction

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.

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 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 disamenities, landfills.

This chapter 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 basically from the steel industry that once dominated the river banks 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 indicate that, on average, townships inside the river corridor have more African Americans (15% vs. 0.8 %), are less educated (78% vs. 89% have completed high school), 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[3], 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 contends that "poor people and minorities, especially African Americans, live along the river despite the environmental degradation, not by choice, but by necessity". He also argues that historical segregation in housing in the area since the steel mills era still persists today and results in barriers discouraging movement of poor and minorities from environmentally impoverished areas along the river.

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 gathered through a mail questionnaire 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' preferences towards river restoration programs. To study distributional effects, CV models are estimated for different groups within each stratum (e.g. black vs. white and rich vs. poor) and then tests are performed 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 the null hypothesis means that different classes of people value environmental improvements differently.

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

This may not indicate evidence of environmental injustice. However, the incidence of these long term river contamination impacts and the disproportionate distribution of minorities and poor households along the polluted river may provide evidence of environmental injustice.

Second, Willingness to pay is estimated for each group and then compared to that 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. Additionally, a break-even weighting approach is implemented in which the economic viability of the project in aggregate is used to infer weights that should be attached to benefits of the more sensitive groups in order to make a specific project economically worthwhile. The objective of the current study 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.

4.2 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. Examining census data by county, Table 4.1 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. This might be an indication of environmental injustice, meaning that minorities and low income groups in the watershed are more exposed to the environmental disamenity (river contamination) than the population at large.

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

Table 4.1: 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 ($\rho = -.1$) 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 4.2 depicts the two classification schemes used throughout this chapter.

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

Table 4.2: Classification Schemes

Table 4.3 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.

Variable	Classification			
	Location		Income	
	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 4.3: Descriptive statistics by location and income categories

4.3 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 4.4 for the location stratification and Table 4.5 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 the likelihood ratio test for the difference between models in each stratum.

4.3.1 Location Stratification Results

Inside the Mahoning River corridor, the probability of voting yes on the dredging only project (Table 4.4) 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 the 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 the sample. The likelihood ratio (LR) 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 4.4, 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 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 4.4 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 ($Bid_{D\text{-}DR}$)	-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 ($WTP_{D\text{-}DR}$)	$67.20		$111.80		$89.40	
Adj. MD ($WTP_{D\text{-}DR}$)	$53.70		$105.00		$80.70	

Table 4.4: 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, it is 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.

4.3.2 Income Stratification Results

The upper part of Table 4.5 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 4.5: 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 4.5. 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 more supportive of restoring the river than poor households who already live away from the river. Also, 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 value 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 may provide 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.

4.4 Benefit-Cost Analysis

An important outcome of any environmental valuation study, from a policy stand point, 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.

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) argued 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 assumptions 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.

4.4.1 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.

4.4.2 MUI Based on the Progressive Income Tax Code

Despite the assertions of social welfare theory 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[4] rate applicable to each group.

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

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 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 4.6 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 4.6: Deriving MUI from Income Tax Rates
* From the federal personal income tax rates for 2003 (head of household)

4.4.3 Benefit-Cost Analysis by Location:

Table 4.7 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 to be 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 alternative . 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 have recreational uses or are still used by the steel industry as water storage for cooling purposes, which may translate to 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
Aggregate B-C Analysis				
Med WTP	$91		$81	
∑WTP	$46,445,672		$41,341,752	
Aggregate B/C	0.70		0.45	
B-C Analysis by Location Groups				
∑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	
Weighted B-C Analysis (Quadratic QLI)				
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	
Weighted B-C Analysis (Square root QLI)				
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	
Weighted B-C Analysis (Progressive Income Tax Code)				
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 4.7: Benefit cost analysis by location

4.4.4 Benefit-Cost Analysis by Income:

Similar to the analysis by location above, Table 4.8 shows the analysis of costs and benefits for both restoration projects by income group under different assumptions about MUI. When MUI is assumed constant for all income groups, benefits of the dredging only project barely cover the cost and the project is economically viable in aggregate. However, when considered by group, BC ratio for the poor is 0.44 and for the rich is 1.39. When more weights are placed on benefits of the poor, BC ration of the dredging project, in aggregate, increases to 1.06 using the quadratic QLI weights, to 1.12 using the income tax weights, and to 1.23 using the square root QLI weights. BC ratio for the poor increases also as more weight is applied to their share of the benefits, and exceeds unity (i.e., benefits outweigh costs) only under the more progressive assumption of MUI calculated using the square root utility function. This might be because their share of the cost is higher than what they could possibly afford given their low average household income compared to that of the rich, $20,145 versus $73,111, respectively.

As for the dredging with dam removal project, BC ratio in aggregate is less than one under any assumption about marginal utility of income. Even though BC ratio of the rich is relatively high; BC ratio of the poor is so low that moderate increases in MUI of the poor are not enough to make the project economically viable in aggregate. The same argument could be made for the BC analysis of the Dredging with dam removal project by location. That is, D-DR is supported more by the outside MR corridor group than by the inside MR corridor group but the project, on the whole, is not economically feasible. In other words, more weight has to be placed on the gains by the disadvantaged for the project to pass the traditional benefit-cost test. Contrary to the analysis by location

groups, dredging only is not supported more by the poor while dredging with dam removal is supported more by the rich. That is, both projects are more supported by the rich than by the poor. This result is consistent with the fact that income stratification is only about income, whereas location stratification is about income as well as other influential demographics such as race, education, and direct exposure to the negative environmental impacts of contamination in the river.

	D		D-DR	
	Poor	Rich	Poor	Rich
Med WTP	$55	$187	$30	$169
# of Households	226440	283952	226440	283952
Total Cost	$27,859,487	$38,140,513	$38,412,323	$52,587,677
Aggregate B-C Analysis				
Med WTP	$100		$88	
∑WTP	$51,039,200		$44,914,496	
Aggregate B/C	0.77		0.49	
B-C Analysis by Income Groups				
∑WTP	$12,386,268	$53,184,210	$6,793,200	$47,987,888
B/C	0.44	1.39	0.18	0.91
Aggregate B/C	0.99		0.60	
Weighted B-C Analysis (Quadratic QLI)				
MUI	1.36	1	1.36	1
Weighted ∑WTP	$16,845,324	$53,184,210	$9,238,752	$47,987,888
B/C	0.60	1.39	0.24	0.91
Aggregate B/C	1.06		0.63	
Weighted B-C Analysis (Square root QLI)				
MUI	2.27	1	2.27	1
Weighted ∑WTP	$28,116,828	$53,184,210	$15,420,564	$47,987,888
B/C	1.01	1.39	0.40	0.91
Aggregate B/C	1.23		0.70	
Weighted B-C Analysis (Progressive Income Tax Code)				
MUI	1.67	1	1.67	1
Weighted ∑WTP	$20,798,514	$53,099,024	$11,344,644	$47,987,888
B/C	0.75	1.39	0.30	0.91
Aggregate B/C	1.12		0.65	

Table 4.8: Benefit cost analysis by income

4.4.5 Break-even Weighting Approach for Benefit-Cost Analysis

The essence of this approach is not to weight the benefits accrued to different groups of individuals using predetermined weighs (MUI's) as in the above analyses. Rather, break-even or shadow weights for the targeted groups of individuals are inferred from the traditional benefit cost analysis assuming that the proposed project breaks even; that is, total benefits equal total costs. To simplify the analysis, it is assumed, as before, that MUI for the less sensitive group (outside MR corridor and high-income groups) is one. The objective is to calculate the minimum weight (w), which should be applied to benefits of the disadvantaged so that each project would be economically viable. Furthermore, this simple analysis could be done before applying any of the above MUI's as a way to screen out shadow weights that, if used, will not make the proposed project worthwhile in aggregate. In the location strata, and assuming that MUI for the outside MR corridor group is unity, the minimum weight that should be applied to benefits of the inside MR corridor group so that the project will break even is 1.8 for the dredging only project and 5.6 for the dredging with dam removal project. In the income strata, assuming that MUI for the rich group is unity, the minimum weight that should be applied to benefits of the poor is 1.03 for the dredging only project and 6.3 for the dredging with dam removal project. These derived weights indicate that the more inclusive, more expensive dredging with dam removal project is less supported by the more sensitive groups in the valley.

4.5 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 may 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 bed rooms 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. If these people 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 injustice 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 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, is of significant interest.

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 the judgment of the decision maker. This decision could be dependent on several factors

including, for example, the relative size of the disadvantaged group(s) with respect to the aggregate population and whether there is historical evidence of the disadvantaged being unjustly exposed to or affected by environmental disamenities.

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.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1 Problem Statement and Methodology

The research focus of this dissertation is two-fold. First, the theoretical validity of contingent valuation (CV) as a non-market valuation technique is examined through testing for scope, sequence, and context effects in the CV sample. Theoretical validity is concerned with the degree to which the results of a CVM study are consistent with expectations of economic theory; for example, the sign and magnitude of the estimated coefficients in the bid functions, and the relative magnitude of willingness to pay under different scenarios for which theory suggests statistically different or similar values. Second, the study focuses on analyzing the distributional effects of river contamination and clean up including stated preference evaluation of environmental improvements. In particular, the study attempts to answer the question: how valuation methods, such as contingent valuation, can be adapted to study environmental inequality and, if equity is an issue, how can we incorporate environmental quality into public decision making without sacrificing economic efficiency altogether?

Economic efficiency and distributional equity are seen by most applied welfare economists as two competing objectives of any proposed change in public policy that could affect the use or allocation of scarce environmental and natural resources. In fact,

some economists tend to assume that there is always a trade off between social welfare and economic growth, and some even assume that equity concerns are more subjective and could be detrimental to economic growth. However, equity concerns are not less important than efficiency concerns in public policy and should be given considerable attention by the economics profession. Moreover, focusing on economic efficiency and leaving the so called subjective task of income distribution to policy makers may be even more subjective. A main contribution of this research is to demonstrate that equity could be addressed in benefit cost analysis of environmental improvements without sacrificing economic efficiency.

In the current research, the author studies both the efficiency and equity dimensions of public policy analysis using a non-market valuation technique, contingent valuation. The efficiency part of the study is concerned with verifying that economic values of the proposed change in the environmental resource that is obtained using contingent valuation is correct or valid in terms of the conformity of these values to expectations of economic theory. Theoretical validity of the contingent valuation survey was assessed through the use of split sampling to test for scope, sequence, and context effects. The case study was restoring the Lower Mahoning River in northeast Ohio to its pre-industrialization conditions using one of two alternatives: only dredging of the contaminated sediments or dredging with selected low-head dam removal. The equity part of the study, on the other hand, is concerned with testing for any incidence or environmental injustice with respect to river contamination and clean-up; and if incidence is evident, how to go about it? That is, how the traditional benefit cost analysis can be modified so that the concern about inequality is incorporated into policy analysis. Said

another way, the question is: should the neoclassical assumptions of constant marginal utility of money income, costless transfers, and hypothetical compensation 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. However, this only solves part of the inequality problem because even if we assume that compensations are real, we would still underestimate the benefits (or losses) of the disadvantaged under the assumption of equal MUI.

5.2 Research Findings and Implications

Scope results show no evidence of a universal across-subject scope effect in the valuation of dredging only and dredging with dam removal in the Mahoning river survey. This result is in contradiction to an expectation of consumption theory that more units of a good should be valued more than less units, given that the consumer gets a positive utility from consuming additional units of that good. However, there is some evidence of positive scope effects among past users of the Mahoning River but not among non-users. In other words, past users are willing to pay more for the more inclusive program, dredging with dam removal, than for dredging only; whereas, nonusers are willing to pay significantly more for the less inclusive good. Although this result regarding past users of the resource is consistent with previous findings in the literature, it does not provide an explanation as to why sensitivity to scope is not observable in the survey in general.

Based on an examination of the results of past CV studies that analyzed scope or scale effects in valuing environmental changes, along with the results of the current study, the author came to the conclusion that absence of scope valuation effects in some CV studies, including the current study, may be attributed to the type of part-whole effect that the researcher is analyzing; that is, it may be attributed to whether the good of interest varies in geographic or timescale or varies in policy scope. It is expected that scale effects are easier to be comprehended and then translated into dollar values than scope effects by all respondent. This is because scope changes are multidimensional and complex in terms of the sets of benefits that are generated by different scopes of the policy and thus it is not expected that these benefits are measured on a common scale. This is the case in the current study where dredging with dam removal provides a set of benefits that is not necessarily a multiple of the benefits provided by dredging only. Dam removal may provide specific benefits, such as continuous navigation in the river that cannot be provided through dredging only. On the other hand, dam removal may be considered a bad by other individuals who value the dams because of recreation or withdrawal of water by the industry. These contradicting effects of dam removal could make the difference in scope between dredging only and dredging with dam removal unclear to the respondent. We conclude that sensitivity to scope in contingent valuation of public and environmental goods is dependent on the type of the good being valued (e.g., scope versus scope valuation) and on the type of individual being surveyed (e.g., user versus nonuser).

Embedding results show mixed evidence of context and order effects in the Mahoning River survey. In particular, WTP for the dredging only program was

dependent on the order in which the program was offered within the agenda but not on the context or whether the program was valued on its own or within a larger package. Conversely, WTP for the more inclusive program (dredging with dam removal) was sensitive to the context variation but invariant to the order variation. These results are consistent with previous findings in the literature and are expected by economic theory (Randall and Hoehn 1996) as a consequence of substitution effects and the budget constraint.

The economic reasoning behind context and sequence effects is that each new public good the individual obtains reduces his available income to spend on private goods and other public goods and that substitutability among public goods makes each new good added to the package less desirable than when valued by the individual as the only change in the available stock of public goods. All in all, value estimates for MR restoration programs obtained using contingent valuation in the current study should be considered valid theoretically based on the results and interpretations presented so far for scope, sequence, and context tests. However, for policy analysis, all of these effects should be compensated for in both the estimation and calculation stages of WTP, as shown in Chapter 4.

The second part is concerned with analyzing the income distribution impacts associated with river contamination and clean up. To test for the presence of incidence or environmental injustice, the sample was stratified into subsamples using demographic characteristics expected to be the basis for possible environmental discrimination, especially income and location with respect to contamination in the river. Location stratification was used as proxy for race and income stratification together since

stratification based on race only was not possible given the low response rate of African Americans in the sample. Results indicate evidence of environmental injustice with respect to contamination in the Mahoning River, meaning that 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 may provide evidence of environmental injustice. Furthermore, probit model estimations by income groups show that poor households inside the MR corridor are willing to pay more for river clean-up through dredging than poor households outside the MR corridor. This indicates that poor households living along the river, if given the choice, will prefer to move out to more environmentally healthier areas.

Therefore, putting more weight on the benefits that will accrue to disadvantaged groups in the population could be justified in order to compensate for the environmental incidence. Three approaches have been suggested to relax the assumption of equal marginal utility of money income across all groups in the current study. First, the quality of life index function of Blue and Tweeten (1989) was used to infer MUI for the targeted groups assuming that MUI for the fortunate groups is unity. Second, inverse of the effective progressive income tax rates (in 2003) for different income groups were used as a proxy for MUI. And third, a break-even rate defined as the minimum weight that would need to be applied to benefits of the sensitive group for each project to break even (i.e.; total benefits = total costs) was calculated. In doing so, the study does not recommend a specific weighting scheme, but rather presents a sensitivity analysis of the benefits and

costs of environmental changes under different assumptions about MUI including the neoclassical assumption of constant MUI. This kind of analysis could help policy makers make more informed decisions on issues that affect the use of scarce environmental resources if evidence of environmental discrimination against sensitive groups such as minorities and the poor is of significant magnitude. 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 the decision maker to make. This decision might be dependent on several factors including, for example, the relative size of the disadvantaged group(s) with respect to the aggregate population and whether there is historical evidence of the disadvantaged being unjustly exposed to environmental disamenities.

5.3 Limitations of Study and Implications for Future Research

Although it is hoped that the findings of this research will be a valuable contribution to the literature on the validity of contingent valuation as well as to the controversial issue concerning equity in public policy analysis, it is important to point out the limitations of these results and how future research should address or minimize these limitations. These limitations can be summarized in the following points:

- The distinction between scope and scale valuation as a motive for insensitivity to

part-whole effects in contingent valuation studies needs more elaboration since this finding is based only on results of the current study as well as on the comparison of some previous findings in the literature. Future research should focus on two things. First, a comprehensive Meta analysis of all contingent valuation studies to date, which dealt with scope or scale valuations, could be conducted to investigate whether this distinction between scope and scale has any effect on observing part-whole changes in these studies. Second, a contingent valuation study in which the researcher is able to test for both scope and scale effects in the same sample could provide clearer evidence on the effect of scope-scale variations since it would control for the possible effects of respondent-specific and/or good-specific characteristics on sensitivity to scope. In the Mahoning river context, this could have been done by comparing the scope valuation of dredging only and dredging with dam removal to the scale valuation of dredging of 10 miles and dredging of 30 miles of the Mahoning River.

- There is a need to develop a validation matrix or protocol that could be applied to any CV study. Right now, there is no general consensus in the literature on how the different tests of scope/scale, context, and order effects should be combined to validate the results of a particular CV study. Apart from between-sample scope effect, there is no general agreement on whether the presence of context or order effects validates or invalidates CV results. A validation matrix should also account for possible interactions among these effects, for example, the relationship between sensitivity to scope and whether the good is valued on its own or within an agenda. In addition, there is need to codify environmental and public goods using a set of

standard biologic, hydrologic, and man-made characteristics. This codification could be useful in explaining differences between scope and scale valuations and also in attaching economic values to different characteristics or attributes of the environmental good (i.e. recreation benefits, health benefits, and ecosystem benefits)

- One limitation of the distribution analysis in this study is the lack of information about prior knowledge about contamination in the Mahoning River by poor and minorities before choosing to move along the river. This information could be obtained by directly interviewing a sample of these households to investigate whether poor people chose to live there because of cheaper housing or more housing benefits than in other areas away from the river or they did not know about contamination before they moved in.
- While this study presents a sensitivity analysis of the economic worthiness of environmental changes under different assumptions of marginal utility of income, it raises, though does not empirically address, 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. The issue of how some of the benefits (costs) of environmental change could be captured in real world policy context was addressed by Hitzhusen et al (2001) but more research needs to be done. The third assumption, costless transfers, is considered less severe a problem than hypothetical compensation because of its dependence on compensations or payments being actually made and also because transaction costs although can be measured, they usually represents a small fraction of the total benefits or costs.

APPENDIX

SURVEY SCENARIOS

Mahoning River Economic Survey
(Scenario 1)

First, let us know what you think about the following:

1. How important is protecting the environment to you (please check one)?
   - ❑ Extremely important
   - ❑ Very important
   - ❑ Somewhat important
   - ❑ Not very important
   - ❑ Not at all important

2. How informed would you consider yourself on global environmental problems such as climate change (please check one)?
   - ❑ Extremely informed
   - ❑ Very informed
   - ❑ Somewhat informed
   - ❑ Not very informed
   - ❑ Not informed at all

3. Do you belong to any environmental organization (such as Sierra Club, the Mahoning River Consortium, or other?
   - ❑ Yes
     Please list……
   - ❑ No

4. Do you support or contribute to any environmental cause (through, for example, buying scenic license plates or participating in the Ohio Tax "check off" program in support of nature programs, or other (Please list……..)?
   - ❑ Yes
   - ❑ No

5. As a taxpayer, do you think that the amount of money we are spending as a nation to reduce pollution in freshwater lakes, streams, and rivers is (please check one)?
   - ❑ Way too much
   - ❑ Too much
   - ❑ Just about the right amount
   - ❑ Too little
   - ❑ Way too little

6. To the best of your knowledge, how clean is the Lower Mahoning River (from Warren to the Pennsylvania border) (please check one)?
   - ❑ Extremely clean
   - ❑ Very clean
   - ❑ Somewhat clean
   - ❑ Not very clean
   - ❑ Not clean at all

7. To the best of your knowledge, is water quality in the Lower Mahoning River higher, lower, or about the same as it was 20 years ago (please check one)?
   - ❑ Higher
   - ❑ Lower
   - ❑ About the same
   - ❑ Don't know

8. Approximately how many miles do you live from the Mahoning River?
   _____ miles

9. Approximately how many miles do you live from the nearest access point on the Mahoning River (by access points we mean boat ramps, parks, bikeways, parking lots)?
   _____ miles

10. What is your zip code?
    _____

11. Do you own a boat (please check one)?
    - ❑ Yes
      Type of boat……
    - ❑ No

12. Over the last year, about how many times have you visited any of the area parks (Mill Creek park, Yellow Creek Park, etc)(please check the appropriate box)?

0	1	2	3	4	5	6	7	8	9 or more

13. Over the last year, about how many times have you participated in each of these activities **on lakes and reservoirs** in the Mahoning River Valley (for example, lakes Milton and Berlin, Kirwan, Five-Lake-in-the-Valley, and Mosquito Reservoir)?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking /Hiking										
Other Specify										

14. Over the last year, about how many times have you participated in these activities anywhere **on the Mahoning River**?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking or Hiking										
Other Specify										

15. Do you think that the Mahoning River should be more accessible by the public (please check one)?
    - ❑ Yes
    - ❑ No
16. Have you ever fished or boated in the lower segment of the Mahoning River, from Warren to the Pennsylvania border (please check one)?
    - ❑ Yes
    - ❑ No
17. Are you aware of the health advisories in place by the Ohio Department of Health on the Lower Mahoning River (please check one)?
    - ❑ Yes
    - ❑ No
18. Has your knowledge about these advisories prevented you from fishing or boating in this segment of the river (please check one)?
    - ❑ Yes, I would not fish or boat if there were advisories
    - ❑ No, I still would fish or boat
    - ❑ I do not fish or boat

Now, let us introduce **some information about water quality in the Lower Mahoning River (from the Northwest Bridge Road in Warren, Ohio, to the Pennsylvania border)**. Over the years, sediments in this segment of the river have become contaminated with a variety of chemicals. Contaminants are primarily from waste disposal from the steel and related industries, which developed along the riverbanks during the late nineteenth and most of the twentieth century, as well as the disposal of waste from adjacent communities into the river. Pollution levels of the river water, but not the sediments, are now lower than before 1970 according to recent measurements by Ohio EPA researchers. This is due to shut down of most of the steel mills and increased wastewater treatment of discharges into the Mahoning River. However, hazardous chemicals such as Polynuclear Aromatic Hydrocarbons (PAHs) and heavy metals are still present in the bottom sediments and prevent recovery of the river's ecosystem.

As a result of the contaminated sediments, the Ohio Department of Health (ODH) has issued an advisory against swimming and wading in the contaminated stretch of the Mahoning River from the Northwest Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania border. The advisory affects both Mahoning and Trumbull counties. Also, because of the contaminated sediments, there is an advisory against consumption of fish caught in the contaminated area, especially bottom-feeding fish such as carp and catfish.

19. Were you aware of the contaminated sediments in the Lower Mahoning River (please check one)?
    - ❑ Yes
    - ❑ No

The Army Corps of Engineers is considering restoration of the quality of the Lower Mahoning River to conditions similar to those before contamination (or similar to those of the upstream segment of the River, upstream of Warren.) This segment of the River is far cleaner and hosts many recreational activities such as fishing, boating, and hiking.

One of the proposed restoration programs is **Dredging** of the contaminated sediments using hydraulic or mechanical methods. Dredged materials will then be dewatered and contained in a safe non-leaking disposal facility.

Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories.

20. In your view, how would you rate the potential effect of river restoration on improving the economy of the Mahoning River Valley (please check one)?
    - ❑ Strong effect
    - ❑ Good effect
    - ❑ Moderate effect
    - ❑ Little effect
    - ❑ No effect

Now, we want to know how would you vote if this program were on the ballot in a local election. **Each household would make a one-time payment to a multi-county special district that would be established to collect and allocate the money for Mahoning River restoration.** This is the only payment required and all payments would go into a trust fund that could only be used for Mahoning River restoration efforts. Keep in mind that only people in the Mahoning river valley would be asked to pay for Mahoning River restoration. If the project passes, all residents would be required to make the one-time payment.

The restoration program would only be carried out if people are willing to make this one-time payment. There are reasons why you might vote for the program and reasons why you might vote against. The restoration program would be accomplished within 10 years. Upon restoration, the resulting cleaner Mahoning River will support better fish habitat, increased recreational activities, improved business and commerce, and help lift the health advisories. On the other hand, your household might prefer to spend the money on other social or environmental programs such as air pollution control. Or, the restoration program might cost more money than your household wants to spend for this.

21. Suppose that the proposed program (**dredging**) is estimated to cost your household a one-time payment of **$50**. If an election were to be held today, would you vote for or against this program (please check one)?
    - ❑ I would vote for the program
    - ❑ I would vote against the program

22. What is the maximum amount you would be willing to pay for this program?

    $ _____

23. If you voted against the program, you did this because:
    - ❑ The cost of the program is more than what your household could spend
    - ❑ Somebody else should pay Explain_____
    - ❑ Other _____

The next questions are about you and your household. The responses will only be used for statistical purposes and will not be associated to your name in any way. All responses are anonymous and confidential.

24. In what county do you currently live (please check one)?
    - ❑ Ashtabula
    - ❑ Columbiana
    - ❑ Geauga
    - ❑ Mahoning
    - ❑ Portage
    - ❑ Stark
    - ❑ Trumbull
25. What is your township of residence?

    _____

26. How long have you lived in your place (please specify approximately)?

_____ Years

27. How old are you?

_____Years

28. How many people, including yourself, live in your household?

_____

29. What is your gender (please check one)?
    - ❑ Male
    - ❑ Female

30. To what ethnic background or race do you belong?
    - ❑ White
    - ❑ Hispanic
    - ❑ African American
    - ❑ Indian
    - ❑ Others _____

31. What is the highest level of education you have completed?
    - ❑ Some High School
    - ❑ High School
    - ❑ Associate Degree
    - ❑ 2-year College Degree
    - ❑ Bachelors Degree
    - ❑ Master's Degree
    - ❑ Doctoral Degree
    - ❑ Other _____

32. What is your current employment status?
    - ❑ Employed Full-time
    - ❑ Employed Part-time
    - ❑ Retired
    - ❑ Unemployed

33. From the list of income categories below choose the one that best represents your total household income over the past year?
    - ❑ Less than $15,0000
    - ❑ $15,000-$24,999
    - ❑ $25,000-$34,999
    - ❑ $35,000-$44,999
    - ❑ $45,000-$54,999
    - ❑ $55,000-$64,999
    - ❑ $65,000-$74,999
    - ❑ $75,000-$100,000
    - ❑ Greater than $100,000

34. Would you like to be contacted on this survey in the near future by phone?
    - ❑ Yes
      Phone No. ( )
    - ❑ No

Please return this survey in the enclosed self-addressed envelope. Should you have questions or concerns regarding this survey, please call (614)-292-6233 or send an email to hitzhusen.1@osu.edu.

Thank you for your valuable time and input!

Regards,
Fred J. Hitzhusen, Professor
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210

Mahoning River Economic Survey
(Scenario 2)

First, let us know what you think about the following:

1. How important is protecting the environment to you (please check one)?
   - ❑ Extremely important
   - ❑ Very important
   - ❑ Somewhat important
   - ❑ Not very important
   - ❑ Not at all important

2. How informed would you consider yourself on global environmental problems such as climate change (please check one)?
   - ❑ Extremely informed
   - ❑ Very informed
   - ❑ Somewhat informed
   - ❑ Not very informed
   - ❑ Not informed at all

3. Do you belong to any environmental organization (such as Sierra Club, the Mahoning River Consortium, or other?
   - ❑ Yes
     Please list…….
   - ❑ No

4. Do you support or contribute to any environmental cause (through, for example, buying scenic license plates or participating in the Ohio Tax "check off" program in support of nature programs, or other (please list……...……..…)?
   - ❑ Yes
   - ❑ No

5. As a taxpayer, do you think that the amount of money we are spending as a nation to reduce pollution in freshwater lakes, streams, and rivers is (please check one)?
   - ❑ Way too much
   - ❑ Too much
   - ❑ Just about the right amount
   - ❑ Too little
   - ❑ Way too little

6. To the best of your knowledge, how clean is the Lower Mahoning River (from Warren to the Pennsylvania border) (check one)?
   - ❑ Extremely clean
   - ❑ Very clean
   - ❑ Somewhat clean
   - ❑ Not very clean
   - ❑ Not clean at all

7. To the best of your knowledge, is water quality in the Lower Mahoning River higher, lower, or about the same as it was 20 years ago (please check one)?
   - ❑ Higher
   - ❑ Lower
   - ❑ About the same
   - ❑ Don't know

8. Approximately how many miles do you live from the Mahoning River?
   _____ Miles

9. Approximately how many miles do you live from the nearest access point on the Mahoning River (by access points we mean boat ramps, parks, bikeways, parking lots.)?
   _____ Miles

10. What is your zip code?
    _____

11. Do you own a boat (please check one)?
    - ❑ Yes
      Type of boat……
    - ❑ No

12. Over the last year, about how many times have you visited any of the area parks (Mill Creek park, Yellow Creek Park, etc)(please check the appropriate box)?

0	1	2	3	4	5	6	7	8	9 or more

13. Over the last year, about how many times have you participated in each of these activities **on lakes and reservoirs** in the Mahoning River Valley (for example, lakes Milton and Berlin, Kirwan, Five-Lake-in-the-Valley, and Mosquito Reservoir)?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking or Hiking										
Other Specify										

14. Over the last year, about how many times have you participated in these activities anywhere **on the Mahoning River**?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking or Hiking										
Other Specify										

15. Do you think that the Mahoning River should be more accessible by the public (please check one)?
    - ❑ Yes
    - ❑ No

16. Have you ever fished or boated in the lower segment of the Mahoning River, from Warren to the Pennsylvania border (please check one)?
    - ❑ Yes
    - ❑ No

17. Are you aware of the health advisories in place by the Ohio Department of Health on the Lower Mahoning River (please check one)?
    - ❑ Yes
    - ❑ No

18. Has your knowledge about these advisories prevented you from fishing or boating in this segment of the river (please check one)?
    - ❑ Yes, I would not fish or boat if there were advisories
    - ❑ No, I still would fish or boat
    - ❑ I do not fish or boat

Now, let us introduce **some information about water quality in the Lower Mahoning River (from the Northwest Bridge Road in Warren, Ohio, to the Pennsylvania border)**. Over the years, sediments in this segment of the river have become contaminated with a variety of chemicals. Contaminants are primarily from waste disposal from the steel and related industries, which developed along the riverbanks during the late nineteenth and most of the twentieth century, as well as the disposal of waste from adjacent communities into the river. Pollution levels of the river water, but not the sediments, are now lower than before 1970 according to recent measurements by Ohio EPA researchers. This is due to shut down of most of the steel mills and increased wastewater treatment of discharges into the Mahoning River. However, hazardous chemicals such as Polynuclear Aromatic Hydrocarbons (PAHs) and heavy metals are still present in the bottom sediments and prevent recovery of the river's ecosystem.

As a result of the contaminated sediments, the Ohio Department of Health (ODH) has issued an advisory against swimming and wading in the contaminated stretch of the Mahoning River from the Northwest Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania border. The advisory affects

both Mahoning and Trumbull counties. Also, because of the contaminated sediments, there is an advisory against consumption of fish caught in the contaminated area, especially bottom-feeding fish such as carp and catfish.

19. Were you aware of the contaminated sediments in the Lower Mahoning River (please check one)?
    - ❑ Yes
    - ❑ No

The Army Corps of Engineers is considering restoration of the quality of the Lower Mahoning River to conditions similar to those before contamination (similar to those of the upstream segment of the River, upstream of Warren.) This segment of the River is far cleaner and hosts many recreational activities such as fishing, boating, and hiking.

One of the proposed restoration programs is

Dredging with selective dam removal, in which, contaminated sediments will be dredged using hydraulic or mechanical methods. Then, dredged materials will be dewatered and contained in a safe non-leaking disposal facility. In addition, some of the low-head dams along the contaminated segment of the river will be selectively removed. There are 10 low-head dams in the project area, of which 4 or 5 will be removed.

Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories. Dredging only may result in partial restoration of the Lower Mahoning River since sediments will eventually re-build behind the dams and cause some damage to the river ecosystem. Additionally, the removal of some dams would allow fish to migrate in the river and therefore make the improvement in fish habitat more sustainable.

20. In your view, how would you rate the potential effect of river restoration on improving the economy of the Mahoning River Valley (please check one)?
    - ❑ Strong effect
    - ❑ Good effect
    - ❑ Moderate effect
    - ❑ Little effect
    - ❑ No effect

Now, we want to know how would you vote if this program were on the ballot in a local election. **Each household would make a one-time payment to a multi-county special district that would be established to collect and allocate the money for Mahoning River restoration.** This is the only payment required and all payments would go into a trust fund that could only be used for Mahoning River restoration efforts. Keep in mind that only people in the Mahoning river valley would be asked to pay for Mahoning River restoration. If the project passes, all residents would be required to make the one-time payment.

The restoration program would only be carried out if people are willing to make this one-time payment. There are reasons why you might vote for the program and reasons why you might vote against. The restoration program would be accomplished within 10 years. Upon restoration, the resulting cleaner Mahoning River will support better fish habitat, increased recreational activities, improved business and commerce, and help lift the health advisories. On the other hand, your household might prefer to spend the money on other social or environmental programs such as air pollution control. Or, the restoration program might cost more money than your household wants to spend for this.

21. Suppose that the proposed program (**dredging with dam removal**) is estimated to cost your household a one-time payment of **$100**. If an election were to be held today, would you vote for or against this program (please check one)?
    - ❑ I would vote for the program
    - ❑ I would vote against the program

22. What is the maximum amount you would be willing to pay for this program?

    $ _____

23. If you voted against the program, you did this because:

- ❑ The cost of the program is more than what your household could spend
- ❑ Somebody else should pay Explain_____
- ❑ Other _____

The next questions are about you and your household. The responses will only be used for statistical purposes and will not be associated to your name in any way. All responses are anonymous and confidential.

24. In what county do you currently live (please check one)?
    - ❑ Ashtabula
    - ❑ Columbiana
    - ❑ Geauga
    - ❑ Mahoning
    - ❑ Portage
    - ❑ Stark
    - ❑ Trumbull
25. What is your township of residence?

    _____
26. How long have you lived in your place (please specify approximately)?
    _____ Years
27. How old are you?
    _____Years
28. How many people, including yourself, live in your household?
    _____ Persons
29. What is your gender (please check one)?
    - ❑ Male
    - ❑ Female
30. To what ethnic background or race do you belong?
    - ❑ White
    - ❑ Hispanic
    - ❑ African American
    - ❑ Indian
    - ❑ Other _____
31. What is the highest level of education you have completed?
    - ❑ Some High School
    - ❑ High School
    - ❑ Associate Degree
    - ❑ 2-year College Degree
    - ❑ Bachelors Degree
    - ❑ Master's Degree
    - ❑ Doctoral Degree
    - ❑ Other _____
32. What is your current employment status?
    - ❑ Employed Full-time
    - ❑ Employed Part-time
    - ❑ Retired
    - ❑ Unemployed
33. From the list of income categories below choose the one that best represents your total household income over the past year?
    - ❑ Less than $15,0000
    - ❑ $15,000-$24,999
    - ❑ $25,000-$34,999
    - ❑ $35,000-$44,999
    - ❑ $45,000-$54,999
    - ❑ $55,000-$64,999
    - ❑ $65,000-$74,999
    - ❑ $75,000-$100,000
    - ❑ Greater than $100,000
34. Would you like to be contacted on this survey in the near future by phone?
    - ❑ Yes
    - ❑ No

Please return this survey in the enclosed self-addressed envelope. Should you have questions or concerns regarding this survey, call (614)-292-6233 or send an email to:
hitzhusen.1@osu.edu

Thank you for your valuable time and input!

Regards,
Fred J. Hitzhusen, Professor
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210

Mahoning River Economic Survey
(Scenario 3)

First, let us know what you think about the following:

1. How important is protecting the environment to you (please check one)?

   - ❑ Extremely important
   - ❑ Very important
   - ❑ Somewhat important
   - ❑ Not very important
   - ❑ Not at all important

2. How informed would you consider yourself on global environmental problems such as climate change (please check one)?

   - ❑ Extremely informed
   - ❑ Very informed
   - ❑ Somewhat informed
   - ❑ Not very informed
   - ❑ Not informed at all

3. Do you belong to any environmental organization (such as Sierra Club, the Mahoning River Consortium, or other)?

   - ❑ Yes
     Please list……...
   - ❑ No

4. Do you support or contribute to any environmental cause (through, for example, buying scenic license plates or participating in the Ohio Tax "check off" program in support of nature programs, or other (please list…… ……..)?

   - ❑ Yes
   - ❑ No

5. As a taxpayer, do you think that the amount of money we are spending as a nation to reduce pollution in freshwater lakes, streams, and rivers is (please check one)?

   - ❑ Way too much
   - ❑ Too much
   - ❑ Just about the right amount
   - ❑ Too little
   - ❑ Way too little

6. To the best of your knowledge, how clean is the Lower Mahoning River (from Warren to the Pennsylvania border) (please check one)?

   - ❑ Extremely clean
   - ❑ Very clean
   - ❑ Somewhat clean
   - ❑ Not very clean
   - ❑ Not clean at all

7. To the best of your knowledge, is water quality in the Lower Mahoning River higher, lower, or about the same as it was 20 years ago (please check one)?

   - ❑ Higher
   - ❑ Lower
   - ❑ About the same
   - ❑ Don't know

8. Approximately How many miles do you live from the Mahoning River?

   _____ miles

9. Approximately How many miles do you live from the nearest access point on the Mahoning River (by access points we mean boat ramps, parks, bikeways, parking lots)?

   _____ miles

10. What is your zip code?
    _____

11. Do you own a boat (please check one)?

    - ❑ Yes
      Type of boat……
    - ❑ No

12. Over the last year, about how many times have you visited any of the area

parks (Mill Creek park, Yellow Creek Park, etc)(please check the appropriate box)?

0	1	2	3	4	5	6	7	8	9 or more

13. Over the last year, about how many times have you participated in each of these activities **on lakes and reservoirs** in the Mahoning River Valley (for example, lakes Milton and Berlin, Kirwan, Five-Lake-in-the-Valley, and Mosquito Reservoir)?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking / Hiking										
Other Specify										

14. Over the last year, about how many times have you participated in these activities anywhere **on the Mahoning River**?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking / Hiking										
Other Specify										

15. Do you think that the Mahoning River should be more accessible by the public (please check one)?

    - ❑ Yes
    - ❑ No

16. Have you ever fished or boated in the lower segment of the Mahoning River, from Warren to the Pennsylvania border (please check one)?

    - ❑ Yes
    - ❑ No

17. Are you aware of the health advisories in place by the Ohio Department of Health on the Lower Mahoning River (please check one)?

    - ❑ Yes
    - ❑ No

18. Has your knowledge about these advisories prevented you from fishing or boating in this segment of the river (please check one)?

    - ❑ Yes, I would not fish or boat if there were advisories
    - ❑ No, I still would fish or boat
    - ❑ I do not fish or boat

Now, let us introduce **some information about water quality in the Lower Mahoning River (from the Northwest Bridge Road in Warren, Ohio, to the Pennsylvania border)**. Over the years, sediments in this segment of the river have become contaminated with a variety of chemicals. Contaminants are primarily from waste disposal from the steel and related industries, which developed along the riverbanks during the late nineteenth and most of the twentieth century, as well as the disposal of waste from adjacent communities into the river. Pollution levels of the river water, but not the sediments, are now lower than before 1970 according to recent measurements by Ohio EPA researchers. This is due to shut down of most of the steel mills and increased wastewater treatment of discharges into the Mahoning River. However, hazardous chemicals such as Polynuclear Aromatic Hydrocarbons (PAHs) and heavy metals are still present in the bottom sediments and prevent recovery of the river's ecosystem.

As a result of the contaminated sediments, the Ohio Department of Health (ODH) has issued an advisory against swimming and wading in the contaminated stretch of the Mahoning River from the Northwest Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania border. The advisory affects both Mahoning and Trumbull counties. Also, because of the contaminated sediments, there is an advisory against consumption of fish caught in the contaminated area, especially bottom-feeding fish such as carp and catfish.

19. Were you aware of the contaminated sediments in the Lower Mahoning River (please check one)?

    - ❑ Yes
    - ❑ No

Different alternatives are being considered by the Army Corps of Engineers to restore the quality of the Lower Mahoning River to conditions similar to those before contamination (or similar to those of the upstream segment of the River, upstream of Warren.) This segment of the River is far cleaner and hosts many recreational activities such as fishing, boating, and hiking.

Two restoration alternatives (programs) are proposed:

1) **Dredging only**, and

2) **Dredging plus removal of some of the low-head dams**.

In the first alternative, contaminated sediments will be dredged using hydraulic or mechanical methods. Then, dredged materials will be dewatered and contained in a safe non-leaking disposal facility. In the second alternative, contaminated sediments will be dredged as in the first alternative. In addition, some of the low-head dams along the contaminated segment of the river will be selectively removed. There are 10 low-head dams in the project area, of which 4 or 5 will be removed.

Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories. Dredging without dam removal may result in partial restoration of the Lower Mahoning River since sediments will eventually re-build behind the dams and cause some damage to the river ecosystem. Additionally, the removal of some dams would allow fish to migrate in the river and therefore make the improvement in fish habitat more sustainable. To summarize, dredging without dam removal would result in restoration of the river but with some degradation as sediments accumulate behind the dams. Dredging with dam removal would result in full or near full restoration of the river and would allow the benefits of restoration to continue into the future.

20. In your view, how would you rate the potential effect of river restoration on improving the economy of the Mahoning River Valley (please check one)?

    - ❑ Strong effect
    - ❑ Good effect
    - ❑ Moderate effect
    - ❑ Little effect
    - ❑ No effect

21. In your opinion, do you consider the benefits resulting from adopting the second restoration alternative (dredging + dam removal) to be higher than those of the first alternative (dredging only)?

    - ❑ Yes
    - ❑ No

Now, we want to know how would you vote if each of these programs were on the ballot in a local election. **Each household would make a one-time payment to a multi-county special district that would be established to collect and allocate the money for Mahoning River restoration.** This is the only payment required and all payments would go into a trust fund that could only be used for Mahoning River restoration efforts. Keep in mind that **only one restoration program (alternative) will be implemented** depending on the voting outcomes. If both projects pass, the second project (dredging with dam removal) will be implemented. Also, note that only people in the Mahoning river valley would be asked to pay for Mahoning River restoration. If the project passes, all residents will be required to make the one-time payment.

There are reasons why you might vote for the program and reasons why you might vote against. Any of the restoration programs would be accomplished within 10 years. Upon restoration, the resulting cleaner Mahoning River will support better fish habitat, increased recreational activities, improved business and commerce, and help lift the health advisories. Furthermore, the second program (dredging with dam removal) would provide more of these benefits, especially enhancing fish habitat, and would make river restoration sustainable into the future. On the other hand, your household might prefer to spend the money on other social or environmental programs such as air pollution control. Or, the restoration program might cost more money than your household wants to spend for this.

22. Suppose that the first restoration program (**dredging only**) is estimated to cost your household a one-time payment of **$50**. If an election were to be held today, would you vote for or against this restoration program (please check one)?

    ❑ I would vote for the program

    ❑ I would vote against the program

23. What is the maximum amount you would be willing to pay for the first restoration program (**dredging only**)?
    $ _____

24. Suppose that the second restoration program (**dredging with dam removal**) is estimated to cost your household a one-time payment of **$100**. Keep in mind that if this program is to be adopted, the first program (dredging only) will be disregarded. If an election were to be held today, would you vote for or against this restoration program (please check one)?

    ❑ I would vote for the program

    ❑ I would vote against the program

25. What is the maximum amount you would be willing to pay for the second restoration program (**dredging with dam removal**)?
    $ _____

26. If you voted against any of the above programs, you did this because:

    ❑ The cost of the program is more than what your household could spend

    ❑ You prefer one of the alternatives over the other because
    _____

    ❑ Somebody else should pay
    Explain
_____

    ❑ Other
    _____
    __

The next questions are about you and your household. The responses will only be used for statistical purposes and will not be associated to your name in any way. All responses are anonymous and confidential.

27. In what county do you currently live (please check one)?
    ❑ Ashtabula
    ❑ Columbiana
    ❑ Geauga
    ❑ Mahoning
    ❑ Portage
    ❑ Stark
    ❑ Trumbull

28. What is your township of residence?

    _____

29. How long have you lived in your place (please specify approximately)?

    _____ Years

30. How old are you?

    _____Years

31. How many people, including yourself, live in your household?
    _____

32. What is your gender (please check one)?

    - ❑ Male
    - ❑ Female

33. To what ethnic background or race do you belong?
    - ❑ White
    - ❑ Hispanic
    - ❑ African American
    - ❑ Indian
    - ❑ Others _____

34. What is the highest level of education you have completed?
    - ❑ Some High School
    - ❑ High School
    - ❑ Associate Degree
    - ❑ 2-year College Degree
    - ❑ Bachelors Degree
    - ❑ Master's Degree
    - ❑ Doctoral Degree
    - ❑ Other _____

35. What is your current employment status?
    - ❑ Employed Full-time
    - ❑ Employed Part-time
    - ❑ Retired
    - ❑ Unemployed

36. From the list of income categories below choose the one that best represents your total household income over the past year?
    - ❑ Less than $15,0000
    - ❑ $15,000-$24,999
    - ❑ $25,000-$34,999
    - ❑ $35,000-$44,999
    - ❑ $45,000-$54,999
    - ❑ $55,000-$64,999
    - ❑ $65,000-$74,999
    - ❑ $75,000-$100,000
    - ❑ Greater than $100,000

37. Would you like to be contacted on this survey in the near future by phone?
    - ❑ Yes
    - ❑ No

Please return this survey in the enclosed self-addressed envelope. Should you have questions or concerns regarding this survey, please call (614)-292-6233 or send an email to hitzhusen.1@osu.edu

Thank you for your valuable time and input!

Regards,
Fred J. Hitzhusen, Professor
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210

Mahoning River Economic Survey
(Scenario 4)

First, let us know what you think about the following:

1. How important is protecting the environment to you (please check one)?

   - ❑ Extremely important
   - ❑ Very important
   - ❑ Somewhat important
   - ❑ Not very important
   - ❑ Not at all important

2. How informed would you consider yourself on global environmental problems such as climate change (please check one)?

   - ❑ Extremely informed
   - ❑ Very informed
   - ❑ Somewhat informed
   - ❑ Not very informed
   - ❑ Not informed at all

3. Do you belong to any environmental organization (such as Sierra Club, the Mahoning River Consortium, or other?

   - ❑ Yes
     Please list……
     .
   - ❑ No

4. Do you support or contribute to any environmental cause (through, for example, buying scenic license plates or participating in the Ohio Tax "check off" program in support of nature programs, or other (please list……..……
   ……..…)?

   - ❑ Yes
   - ❑ No

5. As a taxpayer, do you think that the amount of money we are spending as a nation to reduce pollution in freshwater lakes, streams, and rivers is (please check one)?

   - ❑ Way too much
   - ❑ Too much
   - ❑ Just about the right amount
   - ❑ Too little
   - ❑ Way too little

6. To the best of your knowledge, how clean is the Lower Mahoning River (from Warren to the Pennsylvania border) (please check one)?

   - ❑ Extremely clean
   - ❑ Very clean
   - ❑ Somewhat clean
   - ❑ Not very clean
   - ❑ Not clean at all

7. To the best of your knowledge, is water quality in the Lower Mahoning River higher, lower, or about the same as it was 20 years ago (please check one)?

   - ❑ Higher
   - ❑ Lower
   - ❑ About the same
   - ❑ Don't know

8. Approximately, How many miles do you live from the Mahoning River?
   _____ miles

9. Approximately, How many miles do you live from the nearest access point on the Mahoning River (by access points we mean boat ramps, parks, bikeways, parking lots)?
   _____ miles

10. What is your zip code?
    _____

11. Do you own a boat (please check one)?

    - ❑ Yes
      Type of boat……
    - ❑ No

12. Over the last year, about how many times have you visited any of the area parks (Mill Creek park, Yellow Creek

Park, etc)(please check the appropriate box)?

0	1	2	3	4	5	6	7	8	9 or more

13. Over the last year, about how many times have you participated in each of these activities **on lakes and reservoirs** in the Mahoning River Valley (for example, lakes Milton and Berlin, Kirwan, Five-Lake-in-the-Valley, and Mosquito Reservoir)?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking / Hiking										
Other Specify										

14. Over the last year, about how many times have you participated in these activities anywhere **on the Mahoning River**?

Activity	Number of times participated in activity (check the appropriate box)									
	0	1	2	3	4	5	6	7	8	9 or more
Boating/ Kayaking										
Fishing										
Swimming										
Birding										
Biking										
Picnicking / Hiking										
Other Specify										

15. Do you think that the Mahoning River should be more accessible by the public (please check one)?

    - ❑ Yes
    - ❑ No

16. Have you ever fished or boated in the lower segment of the Mahoning River, from Warren to the Pennsylvania border (please check one)?
    - ❑ Yes
    - ❑ No
17. Are you aware of the health advisories in place by the Ohio Department of Health on the Lower Mahoning River (please check one)?

    - ❑ Yes
    - ❑ No

18. Has your knowledge about these advisories prevented you from fishing or boating in this segment of the river (please check one)?

    - ❑ Yes, I would not fish or boat if there were advisories
    - ❑ No, I still would fish or boat
    - ❑ I do not fish or boat

Now, let us introduce **some information about water quality in the Lower Mahoning River (from the Northwest Bridge Road in Warren, Ohio, to the Pennsylvania border)**. Over the years, sediments in this segment of the river have become contaminated with a variety of chemicals. Contaminants are primarily from waste disposal from the steel and related industries, which developed along the riverbanks during the late nineteenth and most of the twentieth century, as well as waste disposal from adjacent communities into the river. Pollution levels of the river water, but not the sediments, are now lower than before 1970 according to recent measurements by Ohio EPA researchers. This is due to shut down of most of the steel mills and increased wastewater treatment of discharges into the Mahoning River. However, hazardous chemicals such as Polynuclear Aromatic Hydrocarbons (PAHs) and heavy metals are still present in the bottom sediments and prevent recovery of the river's ecosystem.

As a result of the contaminated sediments, the Ohio Department of Health (ODH) has issued an advisory against swimming and wading in the contaminated stretch of the Mahoning River from the Northwest Bridge Road in Warren, Ohio, extending downstream to the Pennsylvania border. The advisory affects both Mahoning and Trumbull counties. Also, because of the contaminated sediments, there is an advisory against consumption of fish caught in the contaminated area, especially bottom-feeding fish such as carp and catfish.

19. Were you aware of the contaminated sediments in the Lower Mahoning River (please check one)?
    - ❑ Yes
    - ❑ No

Different alternatives are being considered by the Army Corps of Engineers to restore the quality of the Lower Mahoning River to conditions similar to those before contamination (or similar to those of the upstream segment of the River, upstream of Warren.) This segment of the River is far cleaner and hosts many recreational activities such as fishing, boating, and hiking.

Two restoration alternatives (programs) are proposed:

3) **Dredging plus removal of some of the low-head dams**, and

4) **Dredging only**.

In the first alternative, contaminated sediments will be dredged using hydraulic or mechanical methods. Then, dredged materials will be dewatered and contained in a safe non-leaking disposal facility. In addition, some of the low-head dams along the contaminated segment of the river will be selectively removed. There are 10 low-head dams in the project area, of which 4 or 5 will be removed. In the second alternative, contaminated sediments will be dredged and contained in a safe disposal facility, as in the first alternative, but no dams will be removed.

Restoring the lower part of the Mahoning River to pre-industrialization conditions would enhance fish habitat (fish species and population), increase recreational activities (fishing, boating, picnicking, etc.), increase property value, attract business and commerce, and eliminate the human health advisories. Dredging only may result in partial restoration of the Lower Mahoning River since sediments will eventually re-build behind the dams and cause some damage to the river ecosystem. Additionally, the removal of some dams would allow fish to migrate in the river and therefore make the improvement in fish habitat more sustainable. To summarize, dredging without dam removal would result in restoring the Mahoning River but with some degradation as sediments accumulate behind the dams. Dredging with dam removal would result in full or near full restoration of the river and would allow the benefits of restoration to continue into the future.

20. In your view, how would you rate the potential effect of river restoration on improving the economy of the Mahoning River Valley (please check one)?
    - ❑ Strong effect
    - ❑ Good effect
    - ❑ Moderate effect
    - ❑ Little effect
    - ❑ No effect

21. In your opinion, do you consider the benefits resulting from adopting the first restoration alternative (dredging with dam removal) to be higher than those of the second alternative (dredging only)?
    - ❑ Yes
    - ❑ No

Now, we want to know how would you vote if each of these programs were on the ballot in a local election. **Each household would make a one-time payment to a multi-county special district that would be established to collect and allocate the money for Mahoning River restoration.** This is the only payment required and all payments would go into a trust fund that could only be used for Mahoning River restoration efforts. Keep in mind that **only one restoration program (alternative) will be implemented** depending on the voting outcomes. If both projects pass, the first program (dredging with dam removal) will be implemented. Also, note that only people in the Mahoning river valley would be asked to pay for Mahoning River restoration. If a project passes, all residents will be required to make the one-time payment.

A restoration program would only be carried out if people are willing to make the respective one-time payment. There are reasons why you might vote for the program and reasons why you might vote against. Any of the restoration programs would be accomplished within 10 years. Upon restoration, the resulting cleaner Mahoning River will support better fish habitat, increased recreational activities, improved business and commerce, and help lift the health advisories. Furthermore, the first program (dredging with dam removal) would provide more of these benefits, especially enhancing fish habitat, and would make river restoration sustainable into the future. On the other hand, your household might prefer to spend the money on other social or environmental programs such as air pollution control. Or, the restoration program might cost more money than your household wants to spend for this.

22. Suppose that the first restoration program (**dredging with dam removal**) is estimated to cost your household a one-time payment of **$100**. If an election were to be held today, would you vote for or against this restoration program (please check one)?

    ❑ I would vote for the program

    ❑ I would vote against the program

23. What is the maximum amount you would be willing to pay for the first restoration program (**dredging with dam removal**)?

    $ _____

24. Suppose that the second restoration program (**dredging only**) is estimated to cost your household a one-time payment of **$50**. Keep in mind that if this program passes, the other program (dredging plus dam removal) will be disregarded. If an election were to be held today, would you vote for or against this restoration program (please check one)?

    ❑ I would vote for the program

    ❑ I would vote against the program

25. What is the maximum amount you would be willing to pay for the second restoration program (**dredging only**)?

    $ _____

26. If you voted against any of the above programs, you did this because:

    ❑ The cost of the program is more than what your household could spend

    ❑ You prefer one of the alternatives over the other because _____ _

    ❑ Somebody else should pay Explain_____ _

    ❑ Other _____

The next questions are about you and your household. The responses will only be used for statistical purposes and will not be associated to your name in any way. All responses are anonymous and confidential.

27. In what county do you currently live (please check one)?
    ❑ Ashtabula
    ❑ Columbiana
    ❑ Geauga
    ❑ Mahoning
    ❑ Portage
    ❑ Stark
    ❑ Trumbull

28. What is your township of residence?

    _____

29. How long have you lived in your place (please specify approximately)?

    _____ Years

30. How old are you?
    _____Years

31. How many people, including yourself, live in your household?

    _____

32. What is your gender (please check one)?

    - ❑ Male
    - ❑ Female

33. To what ethnic background or race do you belong?
    - ❑ White
    - ❑ Hispanic
    - ❑ African American
    - ❑ Indian
    - ❑ Others _____

34. What is the highest level of education you have completed?
    - ❑ Some High School
    - ❑ High School
    - ❑ Associate Degree
    - ❑ 2-year College Degree
    - ❑ Bachelors Degree
    - ❑ Master's Degree
    - ❑ Doctoral Degree
    - ❑ Other _____

35. What is your current employment status?
    - ❑ Employed Full-time
    - ❑ Employed Part-time
    - ❑ Retired
    - ❑ Unemployed

36. From the list of income categories below choose the one that best represents your total household income over the past year?
    - ❑ Less than $15,0000
    - ❑ $15,000-$24,999
    - ❑ $25,000-$34,999
    - ❑ $35,000-$44,999
    - ❑ $45,000-$54,999
    - ❑ $55,000-$64,999
    - ❑ $65,000-$74,999
    - ❑ $75,000-$100,000
    - ❑ Greater than $100,000

37. Would you like to be contacted on this survey in the near future by phone?

    - ❑ Yes
      Phone Number:

    - ❑ No

Please return this survey in the enclosed self-addressed envelope. Should you have questions or concerns regarding this survey, please call (614)-292-6233 or email hitzhusen.1@osu.edu

Thank you for your valuable time and input!

Regards,
Fred J. Hitzhusen, Professor
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210

Cover Letter

Dear Sir/ Madam:

We are sending this survey to a selected group of **people in the Mahoning River Valley** to determine how much restoration of the Lower Mahoning River is worth to them. The identity and responses of individual survey respondents will be kept confidential. This an academic study by the department of Agricultural, Environmental, and Development Economics at the Ohio State University to estimate the benefits of restoring the Lower Mahoning River to people of the Mahoning River Valley.

Please return the completed survey in the enclosed self-addressed stamped envelope. Should you have questions or concerns regarding this survey, please call (614)-292-6233 or send an email to hitzhusen.1@osu.edu

Please keep in mind that all returned surveys postmarked by December 6, 2003 will be entered in a drawing for one of ten $20 gift certificates to local restaurants in addition to free membership to the Mahoning River Consortium.

Thank you for completing this survey.

Best regards,

Fred J. Hitzhusen
Professor
The Ohio State University
Dept of Agricultural, Environmental, and
Development Economics
2120 Fyffe Rd
Columbus, OH 4321

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