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QUANTIFYING THE UNQUANTIFIABLE: BENEFITS FROM
ABATEMENT OF AESTHETIC ENVIRONMENTAL DAMAGE

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Aesthetic damage to a macroenvironment, to the extent that it diminishes the utility of some individuals, is a discommodity and its abatement is a commodity. Abatement of this kind of external diseconomy is both a non-market good, since it is non-exclusive, and a public good in the sense of Davis and Whinston [5], since it is inexhaustible at least over a wide range. Clearly, the empirical quantification and economic valuation of such a good presents very substantial problems at both the theoretical and practical levels.

It is the purpose of this paper to present a theoretical framework for benefit-cost analysis of the provision of such a good, to consider and evaluate a number of alternative benefit valuation techniques which have been proposed and used by environmental economists, and to briefly summarize a case study using bidding game techniques. .If sufficient thought and care are applied to the design of bidding games used, it appears that the bidding game technique provides results which are at least credible and reasonable.

The Theory

Bradford [2] has presented a theoretical framework for the valuation of. public goods. Traditional demand curves are inappropriate for the analysis

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of demand for public goods, since the situation is not one of individuals

responding to a parametric price per unit by choosing an appropriate number

of units. Rather, the individual directly arrives at the total value to

himself of alternative given packages. Further, the nature of a public

good such as aesthetic environmental improvements is such that increases

in the quantity provided are not purely quantitative increases, but are

more in the nature of improvements in quality. Thus, the individual values

alternative packages of a public good, which may differ in quantity and

quality. The values he places upon these alternative packages offer a

basis for any input he may make in the collective choice which determines

the package provided.

Bradford proposes the concept of an aggregate bid curve for public goods.

Individual bid curves are simply indifference curves passing through a

given initial state, with the numeraire good (which can be dollars) on the

vertical axis and the public good on the horizontal axis.[1] The aggregate

bid curve is the algebraic (or vertical, in diagrammatic analyses) summation

of individual bids over the relevant population.

The aggregate bid curve is an aggregate benefit curve, as it measures

precisely what an accurate benefit-cost analysis of provision of a public

good would measure as benefits. Using the approach of methodological

collectivism, efficiency in the provision of a public good can be achieved

by maximizing the excess of aggregate bid over total cost, or equating the

first derivative of aggregate bid (i.e. marginal bid) with the marginal cost

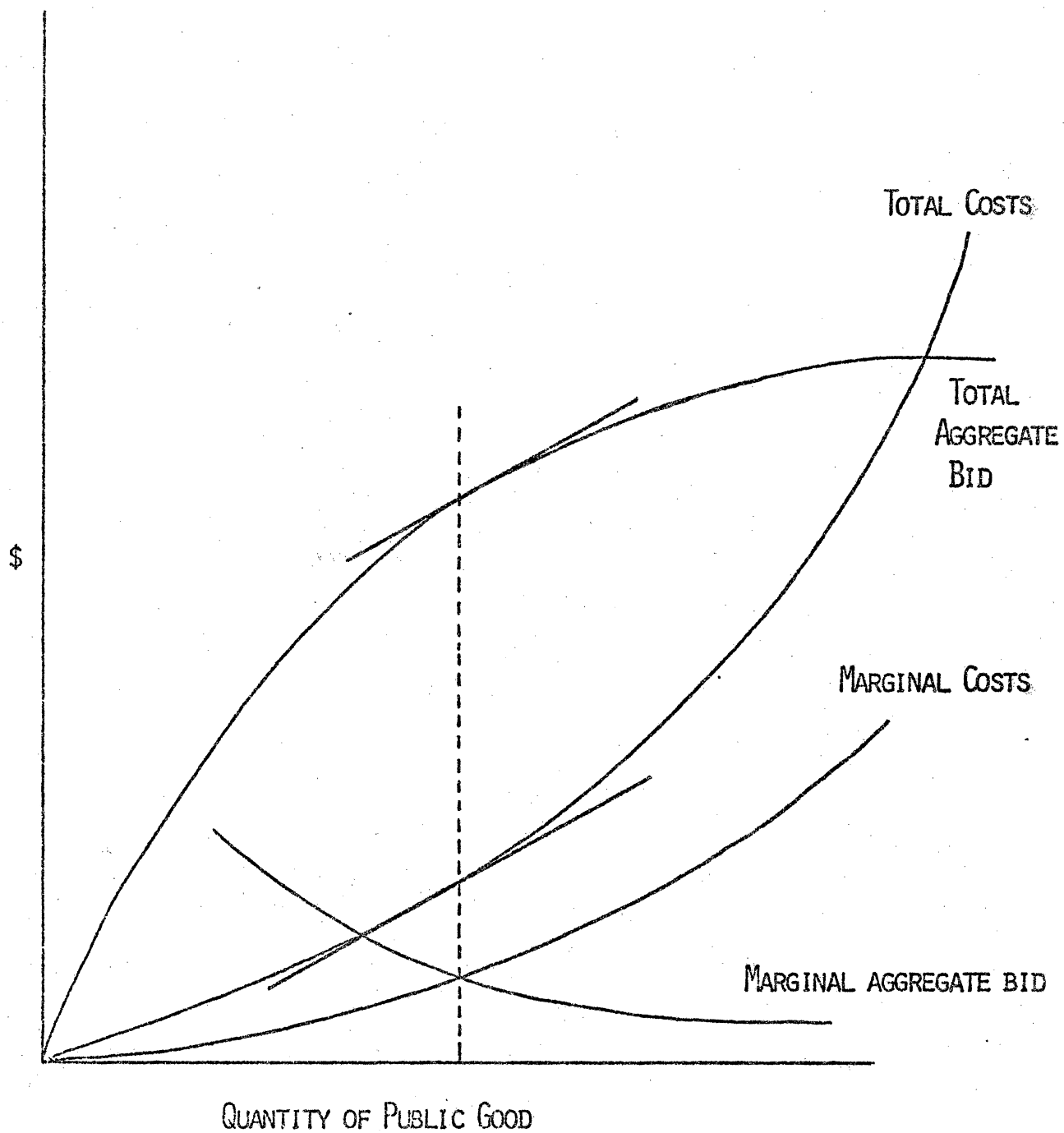of provision.[2] Figure 1 shows the efficient level of provision of the public

good.

Figure 1.   Collective Optimization of the Quantity of Public Good Provided

Methods of Measuring the Benefits
of Environmental Improvements

At least three general classes of methods of empirical estimation of the

benefits of environmental improvements can be conceived. These are (1) direct

costing of damage caused by environmental degradation, (2) methods which

attempt to measure the revealed demand for environmental improvements by

focusing on the revealed demand for appropriate proxies, and (3) techniques

which attempt to fit Bradford's individual bid curves by direct questioning

of consumers of the good. This third group of techniques usually involves

some type of game playing with respondents, often bidding games. Each of

these classes of methods will be briefly discussed and evaluated.

(1) Direct costing methods. Implicit in the concept of a "marginal

value of damage avoided by abatement" curve, as proposed by Kneese and

Bower [10], is the idea of estimating the benefits of abatement of

environmental damage by directly estimating the costs attributable to that

damage. Several workers have made progress along these lines. For example,

Lave and Seskin [11] have had some success in relating the costs of impair-

ment of human health to levels of air pollution. If all relevant costs of

a particular incidence of environmental damage can be identified, evaluated

and summed, a curve relating the value of damage avoided to levels of

environmental improvements can be fitted. The first derivative of this curve

is the "M.V.D.A." curve of Kneese and Bower [10].

These costing techniques are theoretically sound and may often be

feasible in practice. However, difficulties may be introduced by the

unavailability of information and the pricing and accounting problems

inherent in this type of analysis. These techniques will have limited application in valuation of aesthetic environmental improvements, since the costs of aesthetic damages may seldom be directly reflected in the market.

(2) Revealed demand techniques. Revealed demand techniques have been widely used for estimation of the demand for outdoor recreation, often a non-market good.[3] A number of applications to valuation of the benefits of air pollution abatement have been made, including [1, 9, 12 and 16]. The principle is as follows. The benefits of provision of a non-market good are inferred from the revealed demand for some suitable proxy. In the case of air pollution abatement, the revealed demand for residential land is related by regression analysis to air pollution concentrations. In metropolitan areas, it is possible to obtain information on the concentration of specific air pollutants in different parts of the city. If all other variables relevant to the valuation of urban residential land can be identified[4] and measured, it ought to be possible to determine by regression analysis the extent to which air pollution concentrations affect observed land values. In this way, a proxy measure of the benefits of air pollution abatement is obtained.

There are a number of difficulties with this type of analysis. Since the value ascribed to air pollution control is derived directly from the regression coefficient of the pollution concentration variable, accurate results require perfect and complete specification of the regression equation. In an interesting recent study, Wieand [18] claims that when such regression models are completely specified, the regression coefficient of the pollution

concentration variable may not be significantly different from zero.[5] Another

difficulty, researchers in the field agree, lies in interpretation of the

results. Are all of the benefits of air pollution abatement captured in

residential land values? Most think not. For our purposes, the other side

of that coin is of interest: surely some benefits in addition to the aesthetic

benefits are captured. Which additional benefits?

In the case study reported below, the geographical area affected by

environmental damage includes urban areas, but also rural and agricultural

areas, and substantial areas of Indian reservation and National Parks,

Monuments and Forests (which are not typically bought or sold on the market).

Thus, techniques using property values as basic data are inapplicable to

the case study situation.

(3) <u>Survey techniques involving questioning of consumers.</u> The researcher

using these techniques attempts to ascertain the value of alternative packages

of environmental improvements to individual consumers (i.e. Bradford's

individual bids) by direct questioning of consumers of environmental im-

provements. Such techniques may range from rather naive questioning along

the lines of "how much is a clean environment worth to you?" [8] to the much

more sophisticated game playing techniques used and reported by Sinden [17]

and Randall, Ives and Eastman [14, 15].

In the case study reported below, Randall <u>et al</u> [14, 15] adapted the

bidding game technique pioneered by Davis [6] (in the context of recreation

demand analysis) for use in valuing the benefits of aesthetic environmental

improvements. Through an iterative bidding procedure, an indifference curve

passing through a given initial state, with dollar values on the vertical axis and abatement of aesthetic environmental damage on the horizontal axis, is fitted for each respondent.[6] Vertical summation of individual bids allows calculation of aggregate bids and fitting of an aggregate bid curve.

Bidding games would seem to be the most direct and conceptually satisfactory method of estimating Bradford's aggregate benefit curve, which is derived from vertical summation of individual bid curves.[7] The difficulties of interpretation which are inherent in the revealed demand techniques developed thus far do not occur when the bidding game technique is used. The data obtained with bidding games are not cost observations but individuals' perceptions of value. Thus, bidding games can be used in situations where direct costing techniques are ineffective for lack of data. These advantages of bidding game techinques over revealed demand and direct costing techniques seem sufficient to provide encouragement for efforts, such as [14, 15], to adapt bidding games for use in valuation of aesthetic environmental improvements.

A Case Study: The Benefits of Abating Aesthetic Environmental Damage Associated with the Four Corners Power Plant, Fruitland, New Mexico[8]

As a contribution toward a systematic study of policy alternatives for the coal mining and electricity generation industry in the Four Corners area, it was necessary to estimate the benefits from abatement of aesthetic environmental damages associated with the Four Corners power plant and the Navajo mine near Fruitland, New Mexico. The bidding game technique was used.

The Design of the Bidding Games

Bidding games to determine willingness to pay for aesthetic environmental improvements are designed to elicit information on the hypothetical behavior of respondents when faced with hypothetical situations. Thus, the efficacy of a bidding game used for this purpose depends on the reliability with which the stated hypothetical behavior is converted to action, should the hypothetical situation posited in the game arise in actuality. The accuracy of the results, then, is very much dependent on the design of the games. Some desirable qualities of bidding games are listed below, along with the features of the games used in our case study which were designed to satisfy those quality criteria.

a) The hypothetical situation presented should be concrete rather than symbolic and should have properties similar to those of the actual situation [5, 7]. The alternative environmental quality packages were defined in terms of the polluter's activities (e.g. tons of emissions) rather than in nebulous terms like "hazy skies," and were described to respondents both verbally and with sets of color photographs depicting the actual packages. Most respondents were familiar with the plant and the mine.

b) The test items should involve routinized and institutionalized behavior, where the role expectations of the respondents are well defined [5, 7]. Games were designed using specific vehicles of payment. The vehicles of payment were realistic (for example, an increase in local sales taxes, an increase in the monthly electricity

bill, an increase in use fees at recreation sites). Respondents
were familiar with the concept of agencies increasing taxes or
fees in order to provide additional services (in this case, environ-
mental services). Similarly, they had no difficulty with the idea
that the electricity bill may increase if the industry was required
to meet higher environmental standards. The respondent, always
an adult speaking for his or her household, was placed in the
familiar role of manager of the family finances.

c) Questions should be framed so that a simple, precise answer is
possible. The frame of reference should be specific. The itera-
tive bidding game procedure allows the respondent to answer "yes"
or "no" to questions framed in the form: "would you be willing
to pay an amount, $X, ...?" This type of procedure is to be
preferred to questions asking "how much do you think you would be
willing to pay....?"

d) In the case of bidding games to value public goods, the free rider
problem must be avoided. This was done by simply assuring the
respondent that all other members of the relevant population would
be required to pay at the same rate as himself.

The Conduct of the Survey

Stratified random samples of users of the affected environment (i.e.
residents and visiting recreationists) were personally interviewed by
carefully trained enumerators using prepared instruments which included the

bidding games and also questions to elicit relevant socio-economic and attitudinal data. The respondent was shown the photograph sets, which included one set defined as the starting point (the worst environmental damage), one set which represented an intermediate level of aesthetic environmental improvement, and one set representing a very substantial improvement. Thus, three points on the indifference curve between money and aesthetic environmental improvement could be formed for each respondent using each game. A series of games based on alternative vehicles of payment were used [15], to provide alternative estimates of the benefits of abatement and to test the effectiveness of alternative games.

Results

Individual bids were aggregated over the relevant populations and aggregate bid curves and marginal bid curves (analogous to demand curves for abatement) were fitted. Elasticities of bid with respect to income were calculated. Where several games were used with the same samples of respondents, analysis of the various game results proceeded separately, to provide alternative estimates of aggregate bid, etc. The complete results are reported in [15] and the effectiveness of various game formats is discussed.

Here, the aggregate bids obtained using a sales tax game with residents of the affected region and a use fee game with visiting recreationists are presented (table 1).

Table 1: Aggregate Bids for Abatement of Aesthetic Environmental
Damage Associated with the Four Corners Power Plant, 1972.

Item	Situation A	Situation B	Situation C
Emissions (tons of particulates per year)	96,000	28,000	0
Level of Abatement (tons of particulates per year)	0	70,000	96,000
Estimated Aggregate Bid--Sales Tax Game ($ millions per year)	0	15.54	24.57
Standard Error ($ millions per year)	-	1.24	1.52
95% Confidence Limits ($ millions per year)	-	+2.43	+2.97

Concluding Comments

Validation of bidding game results is desirable. Sinden [17] was able to perform satisfactory validation tests by analyzing the relationship between the results obtained from respondents and the actual recreating behavior of those respondents in the previous year.

Our situation permits only validation procedures based on intuitive reasoning. We are prepared to argue that our results are of a reasonable order of magnitude and, if anything, conservative. (1) We believe the design of the bidding games allows confidence in their efficacy. (2) The individual household bid for abatement, on average, is of the same order of magnitude as the estimates of the value of particulate pollution abatement obtained in revealed demand studies [1], when the latter are converted to a comparable basis. Mean individual household willingness to pay for abatement, measured by the sales tax game played with the non-reservation resident sample, was about $50 annually to achieve an intermediate level of abatement and $85 annually to achieve nearly complete abatement. (3) The estimated aggregate bids for abatement are relatively small given the scale of the operation at Four Corners, as indicated by its 1970 emissions (96,000 tons of particulates) and its total annual sales of $146 million. (4) Theoretical analyses indicate that the demand for abatement of an externality will be lower under a zero liability rule than under intermediate or full liability rules [13]. The bidding games used were based on zero liability rules, and they should be expected to yield conservative estimates of the benefits of abatement.

This experience with bidding games leads me to be cautiously optimistic about the use of bidding games for valuation of aesthetic environmental improvements. Bidding game techniques seem amenable to use as a research tool for valuation of a wide variety of non-market goods. It must be understood, however, that bidding games measure the hypothetical responses of individuals faced with hypothetical situations. Thus, considerable care must be exercised in the design of bidding games and the conduct of surveys for data collection, to ensure that the results obtained are as reliable as possible.

FOOTNOTES

*The author gratefully acknowledges the inputs of Berry Ives and Clyde Eastman who were his colleagues and co-researchers during the empirical case study reported herein, and who were his co-authors for several publications emanating from that case study.

[1]Bradford [2] notes that these considerations of the nature of the process of demanding a public good mean that the usual restraints placed on the slope of demand curves may not be relevant for public goods. A priori, nothing can be said about the slope of the "demand," or marginal aggregate bid, curve for a public good.

[2]In the approach of methodological individualism, Pareto-efficiency is still not achieved since the price to the individual cannot equal the marginal cost to the individual (which is zero) and allow collection of sufficient funds to cover the total cost of provision.

[3]See [3].

[4]Some appropriate variables are size and value of structures on the land, distance from places where services and employment opportunities are concentrated, proportion of park land and open space in the neighborhood, density of population, proportion of various racial and ethnic minorities in the immediate vicinity, and the incidence of violent crimes.

[5]The author is aware, through personal conversations with researchers active in the field, that the jury is still out, on this question. Several researchers expect to be able to refute Wieand's conclusion.

[6]Sinden's bidding procedure, which he used to value outdoor recreation opportunities, is somewhat different. He used an iterative procedure based on the Ramsey method of utility estimation to fit indifference curves, with two-alternative recreation opportunities on the axes, for individual consumers. Then, individual demand curves were calculated in the textbook manner by finding points of tangency of indifference curves and budget lines (the latter determined from the price ratio of the two alternative recreation opportunities and the consumer's recreation budget). Some may prefer Sinden's bidding procedure, in which the respondent is never asked to directly place a money value on the non-market good under study. However, the respondent is asked "what is your recreation budget?", which may be difficult for many people to answer precisely (and Sinden observes that his estimates of value are sensitive to the size of the recreation budget). For use in valuing non-market public goods like aesthetic environmental improvement, the problem is much worse. The question, "what is your aesthetic environmental improvement budget?" is meaningless.

[7]It is interesting to note that both Davis [6] and Sinden [17] convincingly claim the conceptual superiority of their bidding techniques for valuing outdoor recreation over the revealed demand technique (i.e. the travel cost method).

[8]A complete report of the study is contained in [15].

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