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Title: An Analysis of Alternative Methods of Nonmarket Valuation: Applications to Whitewater Recreation

Abstract approved:

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This study analyzes and compares alternative methods of valuing nonmarket goods. Using a 1985 study of Rogue River non-commercial whitewater recreationists, benefit estimates of recreational use for this lottery-rationed river are derived using the zonal travel cost method (TCM) and the contingent valuation method (CVM). Two different techniques of the CVM were used: the open-ended question and the dichotomous choice, or take-it-or-leave-it question (TIOLI). Willingness to pay (WTP) and willingness to sell (WTS) were estimated with both CVM techniques. Alternative assumptions and functional forms of the different methods are discussed and empirical results are compared.

Although confidence intervals for the dichotomous choice CVM estimates were not developed, the value estimates of the open-ended and dichotomous choice WTP estimates appear to be inconsistent. The consistency of

the open-ended and linear dichotomous choice CVM results with the TCM results is dependent on the values placed on travel time in the TCM. The TCM model using the more conservative opportunity cost of time spent traveling (1/4 the wage rate) approximates the value estimated with the open-ended CVM ($8.62 per day). The use of a higher opportunity cost of time (1/2 the wage rate) approximates the value estimated with the median of the linear dichotomous choice model ($12.72 per day). The logarithmic dichotomous choice form yields a higher value than any of the other methods. Finally, the flexibility, applicability, and cost of the different methods and techniques are discussed.

An Analysis of Alternative Methods of Nonmarket Valuation: Applications to Whitewater Recreation

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INTRODUCTION

The Rogue River in Southwest Oregon is one of the most popular whitewater rivers in the region. The combination of excellent scenery, and whitewater that is exciting but not exceedingly difficult, has led to a situation where demand exceeds carrying capacity (Shelby and Colvin, 1978). As a result, a lottery system for the distribution of non-commercial whitewater permits was instituted in 1983. The fees for the lottery and the permit are administratively set at $2.00 and $5.00, respectively. These "prices" do not result from the interaction of supply and demand in the market for whitewater trips--they do not reflect the economic value of whitewater recreation to non-commercial river users. It is not the objective of the U.S. Forest Service to set prices at a profit maximizing level. Equity considerations of a pure economic efficiency criterion for setting prices have kept these public agencies from using price as the sole rationing mechanism. At the same time, agencies must allocate the resources under their management to various, sometimes conflicting, uses. As a result, information on the relative economic value of each use could be extremely valuable.

In this study, two frequently used methodologies, the travel cost method (TCM) and the contingent valuation method (CVM), are employed to estimate the economic value of non-commercial whitewater recreation. Alternative assumptions and forms of these methodologies are explored, using the results from a survey of 1984 non-commercial Rogue River users.

Problem Statement

Agencies managing river resources need accurate information about trade-offs between different uses (see, for example, Oregon Senate Bills 225 and 253 regarding minimum flows and water planning). Particularly important are the trade-offs between consumptive uses such as logging of river corridors, hydroelectric or irrigation development, and non-consumptive uses such as recreation or preservation. Because recreational use of rivers is generally a nonmarket commodity, monetary values for recreation are often either unavailable or arbitrary. As a result, different techniques have been developed to establish a market-like framework by which to value nonmarket goods in order to allocate resources to some optimal end. Furthermore, the adaptation of nonmarket techniques for assessment of recreational value under differing management strategies is a research area that holds promise for the integration of economic analysis and recreation management. Value information and improved valuation methodologies would be particularly useful to the interagency group managing the Rogue River, which includes representatives from the U.S. Forest Service, Bureau of Land Management, State Marine Board and State Scenic Waterways, as well as to resource management agencies in general.

The methods and techniques currently used to provide value information, such as CVM and TCM, have frequently been criticized as either unreliable (Schuster and Jones, 1982), or subject to arbitrary assumptions by the analyst (Smith, Desvousges, and Fisher, 1986), or both. However, other researchers, while admitting some "genuine anomalies" in contingent value studies, argue that "some claims of discrepancies reflect problems with particular research designs and naive interpretations of results, rather than inadequacies inherent in the contingent valuation method" (Randall, Hoehn, and Brookshire, 1983, p. 642). Smith et al. (1986) suggest that the travel cost method is not "a mechanical process," but one which requires "judgement, combined with sensitivity analysis and plausibility checks" (p. 289).

The problems addressed in this study are: 1) the provision of information about river recreation benefits that is reliable, valid, and based on economic theory, 2) the evaluation of the different methods with respect to computational costs and applicability to different situations, and 3) the advancement of value methodology research by empirically testing current theory.

Relevance of Study

In the last twenty years the resource decision-making emphasis has shifted from project analysis to multiple-use management (Jubenville, Matulich, and Workman, 1986). This type of management necessitates resource allocation decisions involving both market and nonmarket goods. Specifically, decisions involving recreation resources will require nonmarket valuation techniques that identify the marginal values associated with differing managerial strategies regarding the "product mix" of various recreation opportunities.

If the goal of management is to maximize social welfare from public investments and resource allocation decisions, then nonmarket benefit estimates are needed to make optimal use of resources, both on the project level and on the multiple use level. These benefits will be derived through some form of estimation based either on the expenditure function approach, such as the TCM, or on the income compensation approach, such as the CVM.

Some researchers (Gum and Martin, 1975; Mendelsohn and Brown, 1983; Jubenville et al., 1986) have urged that more attention be focused on the usefulness of valuation estimates and valuation techniques to the resource manager. The focus of research, they argue, should be on both the quality and quantity of the recreation site. This view can be understood as part of the transition from project analysis to multiple use analysis as well as a reaction to a period in which nonmarket valuation was pursued, to a certain extent, as an end in itself. This period corresponds to what Randall et al. (1983) recognize as the "first phase" of contingent value research, in which the objective was to show that contingent markets "worked," that is, the results were consistent with expectations from theory and compatible with results obtained through other methods. The second phase of research suggested by Randall et al. (1983) involves "a systematic conceptual and empirical exploration ...of contingent markets" (p. 648). The result of this research would be the application of CVM techniques to specific situations in which value information is needed. Similarly, there has been an increasing sophistication in the use of TCM for analysis of site quality (Desvousges, Smith, and McGivney, 1983) and use level prediction (Loomis, Provencher, and Brown, 1986).

This study is relevant in that the research provides 1) a clearer interpretation of both direct and indirect benefit estimates, 2) a better understanding of the difficulties and limits of the different methods (particularly given the existence of lottery allocation), 3) the information and expertise needed for the design and use of contingent value techniques to evaluate proposed changes in resource allocation or management, and 4) an estimate of economic value for river recreation on the Rogue. This study is thus a step in building the data base and valuation methodologies needed for better decision-making.

Objectives and Hypotheses

The factors affecting the accuracy and consistency of nonmarket estimates of value are not completely understood empirically. The objective of this study is to test the reliability and accuracy of various methods used to estimate nonmarket value. This will be accomplished by comparing the values estimated by the TCM and two different versions of the CVM. The two CVM techniques are the open-ended question and the dichotomous (yes or no) response to a stated price question, sometimes called the take-it-or-leave-it (TIOLI). In addition, there will be an analysis of the theoretic framework and functional forms of the different methodologies as well as an examination of the survey instrument to determine possible sources of bias. Within this context, it is hypothesized that: 1) the values estimated by different methods and techniques are consistent, and 2) the values estimated by different methods are accurate, that is, the same value would be found if a real market actually existed.

Thesis Organization

The subsequent sections of the study are as follows: 1) a general review of the theory of welfare and efficiency, utility, demand, benefit measures, types of value, and nonmarket benefit estimation, 2) a review of literature relevant to the TCM and the CVM, 3) a presentation of the survey methods and procedures, 4) a presentation of the models, methods, and results from the TCM, 5) a presentation of the models, methods, and results of the CVM, including an extended discussion of dichotomous choice theory and models, 5) a comparison of the benefit estimates, 6) a discussion of the results and assumptions of the different methods including possible sources of error or misspecification, and 7) a summary of results and some conclusions regarding the advantages and disadvantages of the different methods and techniques.

THEORY OF VALUE AND WELFARE

Introduction

The management of public land is required, by legal and administrative mandate, to be in the public interest. Consequently, resources must be allocated among conflicting demands for both market and nonmarket uses, and even among different demands within market or nonmarket uses, e.g., timber harvest versus grazing or jet-boating versus wilderness whitewater rafting. The general acceptance of multiple use management--where several uses are implemented simultaneously with no one use having precedence over the others--has added to the complexity and interdependence of resource allocation decisions. Congress has established guidelines for resource management agencies through such legislation as the Multiple Use Sustained Yield Act (1960), National Forest Management Act (1976), Resources Planning Act (1974), National Environmental Protection Act (1969), and the Endangered Species Act (1969). These statutes either explicitly require or implicitly encourage consideration of economic costs and benefits in the resource allocation decision process (Haigh and Krutilla, 1980). Also, federal agencies such as the Office of Management and Budget and the Water Resources Council have increasingly required resource managers to justify their decisions in light of expected benefits and costs. In general, then, resource allocation decisions are made with economic efficiency as an important, but not necessarily decisive, criterion.

The goal of measuring economic efficiency is accomplished through such related concepts as net present value and benefit-cost ratios. Efficient use of resources is pursued through net present value by maximizing the discounted value of a resource or project, as in the forest planning program, FORPLAN. Efficient resource allocation is achieved with benefit-cost ratios through the precise calculation and explicit comparison of economic costs and benefits so that the "bottom line" provides a policy decision or a ranking of alternative policies. However, since other criteria, such as equity and income distribution, enter the decision-making process, and because decisions are made by differing administrative, legislative, and judicial groups, net present value and benefit-cost analysis (BCA) data is often viewed as an "information system" or policy tool, rather then a strict decision criterion (Randall and Peterson, 1983). Regardless of the precise role of net present value and BCA in policy making, there is a need for accurate and plausible value information gathered in a manner consistent with economic theory.

Efficiency in the economic sense has a specific, technical meaning that is different from the prosaic meaning of efficiency. Understanding the concept of economic efficiency requires a review of the microeconomic concepts of social welfare, individual utility, demand, consumer's surplus, and measures of nonmarket value. The following sections define and elaborate these microeconomic concepts beginning with a discussion of efficiency and social choice, followed by an examination of the individual basis for social decisions, and concluding with an evaluation of the framework for aggregating individual utilities with respect to nonmarket goods and the resulting decision criteria based on that framework.

Welfare and Efficiency

The concepts of utility, demand, consumer's surplus, and value originate at the individual level and are analyzed within the context of partial equilibrium analysis, whereby an individual's (or a market's) behavior is analyzed in isolation from the rest of the economy. Comparative statics, a method in which two points of equilibrium are compared before and after a change in price or quantity, is a useful tool and will provide the conceptual framework for the discussion of the individual basis of utility.

First, however, the issues of decision-making at the societal level will be discussed to provide a context for the following discussion of individual utility and demand.

When an interdependent view of the economy is needed, as it is for evaluating social choices, a more comprehensive tool is needed. The technique applicable to evaluating systemic equilibria is called general equilibrium analysis. It is the primary analytic tool of macroeconomics and it is also used in the microeconomic discipline called welfare economics (or welfare and efficiency). Welfare economics "evaluates the desirability of alternative institutions and the supposed resulting economic choices" (Silberberg, 1978, page 467). Somewhat more to the point, Henderson and Quandt (1980) state that "the purpose of welfare economics is to evaluate the social desirability of alternative allocations of resources" (page 317). Both definitions employ the word "evaluate," suggesting the introduction of a normative component into the economic analysis. Welfare economics deals with society's preferences rather than individual preferences. One of the original problems of welfare economics was how to aggregate individual preferences, or individual utility functions, into a social welfare function (SWF). Intuitively, the SWF could be written as

$$W = f(U_1, U_2, \ldots U_n) \qquad (1)$$

where social welfare, W, is some aggregation of individual utilities. This function can then be maximized using the the optimization techniques of calculus (see Henderson and

Quandt, 1980, page 309). But this solution requires restrictive assumptions regarding the marginal utility of income across individuals. Also, determination of an optimum requires a value judgement about the social preferability of different income distributions, otherwise, income is maximized without regard to differing individual marginal utilities of income and the initial income endowment. Value judgements based on interpersonal utility comparisons, the evaluative or normative aspect of welfare economics, have traditionally been eschewed by many economists as being "outside the scope of positive economics" (Silberberg, 1978, page 479).

Arrow (1963) has argued that a function such as Eq. (1) could not possibly satisfy the reasonable (and, in Arrow's view, necessary) conditions a SWF could be expected to contain.[1/] His argument is frequently referred to as the Impossibility Theorem. Because of the difficulty encountered in deriving a valid SWF, alternative evaluative systems have been explored. One of these criterion is called Pareto-optimality.

Assume a state A and a state B. If a movement can be made to state B and make at least one person better off without making anyone worse off, then state B is called Pareto-superior to state A (or B Pareto dominates A). A

[1/] Arrow's conditions are complete ordering, responsiveness to individual preferences, the independence of irrelevant alternatives, non-imposition, and non-dictatorial behavior (Henderson and Quandt, 1980).

state of Pareto-optimality exists when there is no other state that could be Pareto-superior to the current state.

A state of overall Pareto-optimality, it is hypothesized, is reached when three conditions are met: 1) efficiency in exchange, 2) efficiency in production, and 3) combined efficiency in production and consumption (Silberberg, 1978).[2/] Given these three conditions, the marginal conditions for optimality in production and consumption are that "the marginal evaluation of each commodity must be the same for all individuals and that common marginal evaluation must equal the marginal cost of producing that good" (Silberberg, page 478). From these marginal conditions a utility frontier can be drawn (for a given level of production) and a point identified at which marginal cost equals marginal benefits. An envelope curve tangent to all these partial utility frontiers is called a grand utility possibility frontier (GUPF). It represents the complete set of Pareto-optimal (or efficient) production and consumption combinations.

[2/] Efficiency in production exists when the rate of technical substitution of inputs is equal to their price ratio. Efficiency in consumption occurs when the rate of commodity substitution is equal for all consumers and equal to the commodity price ratio. Efficiency in production and consumption occurs when an efficient product mix is attained, that is, when the rate of product transformation equals the commodity price ratio, resulting in a coordination of production and consumption determined by production and preference relationships (Randall and Peterson, 1984).

A perfectly competitive market economy will attain an efficient Pareto-optimal equiblibrium (Henderson and Quandt, 1980). The assumptions of perfect competition require that property rights are nonattenuated and the available goods and services are rival. If these conditions do not hold, then the result is referred to as nonexclusiveness, for the first condition, and nonrivalry, for the second condition. The maintained hypotheses are that producers maximize their profits and that consumers maximize their utility. In marginal terms, the efficient, perfectly competitive equilibrium will be one in which price equals marginal cost.

Imperfect competition will alter the first-order conditions for Pareto optimality. If goods and services are characterized by nonexclusiveness, then there is no way to exclude those who benefit but do not pay, called "free riders," and the incentives for profit and utility maximization will be absent; there will not be an efficient general equilibrium. A second cause of imperfect competition is the presence of nonrival or nondivisible goods, sometimes referred to as public goods (Randall and Peterson, 1984). Consumption of a nonrival good does not reduce the quantity available for others, or marginal cost equals zero (but price does not). As a result, congestion frequently occurs.

A third cause of imperfect markets is the presence of externalities. Externalities (either positive or negative) occur when the actions of one party affect the well-being of another party who has no influence over the first party's decisions (Randall and Peterson, 1984).[3/] If there are externalities in production or consumption, then "price must equal social marginal cost rather than private marginal cost" (Henderson and Quandt, 1980, page 318). Other factors, such as the existence of natural monopolies, may also result in imperfect markets.

The presence of nonexcludable or nonrival goods or services results in market failure, or the absence of a perfectly competitive market structure that will result in efficient resource allocation. Market failure is particularly relevant to natural resource management. First, natural resources and environmental commodities are frequently nonexcludable, nonrival, nondivisible, and therefore congestible. This occurs either because the cost of exclusion is excessively high or because the government has not established nonattentuated property rights, for various social and political reasons (Randall and Peterson, 1984). Second, market failure is frequently used as a justification for government intervention with, obviously, the assumption that the government can solve

3/ Randall and Peterson (1984) argue that externalities are attributable to nonexclusiveness and/or nonrivalry, and will not cause inefficiency when property rights are nonattenuated.

the problem. Third, imperfect markets do not provide accurate information about the value of goods and services that are produced and consumed. If management of public lands is to have efficiency as one of its goals, then it is necessary to have knowledge of the value of a given resource in order to achieve an efficient allocation.

Having briefly examined the concept of aggregate, social efficiency, the following section reviews the theory of value and measurement of value on a disaggregate, individual level.

Utility Theory

The basic behavioral assumption of consumer demand functions is that individuals maximize their own satisfaction, or utility, by consuming a unique bundle of commodities, where the term commodities may include environmental goods and services (Silberberg, 1978). This assumption can be written as

$$\text{maximize} \quad U(X_1, X_2, ..X_n) \tag{2}$$

where $X_1,...X_n$ represents the commodities and $U(X_1,...X_n)$ represents the individual's utility derived from consumption of the commodities. Since consumers are subject to limited time and income, decisions must be made about which bundles of commodities are to be consumed. This is the income constraint on utility maximization and is written as

$$\sum P_i * X_i = M \tag{3}$$

in the linear form, where P_i represents the unit price of good X_i and M is the amount of money available in a given time period. The neoclassical representation of the rational consumer suggests that the individual will then

$$\begin{aligned} &\text{Max} \quad U(X_1, \ldots X_n) \\ &\text{s.t.} \quad \sum P_i * X_i = M. \end{aligned} \tag{4}$$

A number of assumptions are made about the structure of the individual's preferences as they operate in a utility function. These structural assumptions are based on the concept of the utility function as an ordinal index of preferences. Although early economists theorized a utility function that measured satisfaction in discrete units (e.g., utils) that could be assigned to the consumption of various goods, the concept of cardinality was replaced by one of ordinality when it was shown (through Hicks' indifference analysis) that all of the uses of the utility maximization hypothesis of cardinality were derivable from an ordinal index of preferences (Silberberg, 1978). Given the assumption of ordinality, the consumer can maximize utility by ranking preferences. Let X_1 be a vector representing one commodity bundle and X_2 be a vector representing a second commodity bundle. Then U(X) can take one of three forms:

1. $U(X_1) > U(X_2)$
2. $U(X_2) > U(X_1)$
3. $U(X_1) = U(X_2)$

The preference structure is complete. It is also assumed to be transitive, that is, if A is preferred to B and B is preferred to C then A is preferred to C. Another condition imposed on the preference structure is reflexivity, i.e., commodity X is at least as good as commodity X, a mathematically necessary axiom that is trivial given a properly defined choice set (Deaton and Muellbauer, 1980).

Having established an ordinal utility index, it can then be shown that transformations of the index do not alter the information provided by the ranking. Mathematically, this can be expressed by writing a utility function $U = U(x_1, \ldots x_n)$ and transforming it into a new function, $V = F(U(x_1, \ldots x_n))$, where the derivative of the function V with respect to U is positive, $\partial V/\partial U > 0$, i.e., a monotonic increasing transformation. The two functions always move in the same direction and their ranking is unchanged. Consequently, the three possible forms of the the preference structure will always hold.

Another assumption regarding utility functions which makes them amenable to the optimization techniques of calculus is differentiability. This necessary (but not excessively restrictive) assumption implies that goods are consumed in continuous rather than discrete quantities.

Assuming ordinality and differentiability, the following properties are assigned the utility function (Silberberg, 1978):

1. Non-satiation, or more is preferred to less. Mathematically, this can be expressed as $\partial U/\partial X_i > 0$, or the marginal utility of any good, X_i, is always positive, and there is an increase in the utility index when additional quantities of the good or service are consumed.
2. Substitution, or an individual will trade off one good to receive some other good. The amount of a good traded for another is the amount that will leave the consumer indifferent between the original and new position. This is shown graphically by indifference curves (Fig. 1). Points A and B (and all other points on the curve, U^o) represent points of equal utility, U^o. Utility is constant anywhere along the curve although the amount of goods X_1 and X_2 consumed is not the same. The curve U' represents other combinations of the two goods but these combinations represent greater utility than U^o.

The slope of the indifference curves represent the trade-offs the individual will make; it is called the marginal rate of substitution (MRS) or the rate of commodity substitution (RCS). The concept of trade-offs reflects the basic concept of economic value: exchange value.

Because $\partial X_2/\partial X_1 = -U_1/U_2$, $\partial X_2/\partial X_1 < 0$, the MRS is negative and the indifference curve is convex to the origin. Strict convexity of the indifference curve is based on the assumption that the utility function is quasi-concave.[4/] The assumption of strict quasi-concavity and, therefore, strictly convex indifference curves, ensures the sufficient second-order conditions for a unique solution to the maximization problem. As Silberberg (1978) points out, the assumption is made because it reflects real behavior rather than for mathematical convenience.

3. The marginal value of a good decreases as more of a good is consumed. Mathematically, $\partial^2 x_2 / \partial x_1^2 > 0$. Although the utility index will always increase with the consumption of an additional unit of the good, it will increase at a decreasing rate. This is called the diminishing marginal rate of substitution. It is a less restrictive assumption than diminishing marginal utility and will hold given a quasi-concave utility function, where strict quasi-concavity implies no flat portions of the curve, again ensuring a unique solution.

The utility maximization problem can now be considered. For simplicity, the two good case will be shown, although the solution can be generalized to the n-good case. The budget constraint (Eq. 3) is

[4/] Quasi-concavity is defined as follows (Henderson and Quandt, 1980): consider two distinct points on a given indifference curve where $U^o = f(x_1, x_2) = f(x_1', x_2')$. Strict quasi-concavity ensures that $U[\lambda x_1 + (1-\lambda)x_1', \lambda x_2 + (1-\ )x_2'] > U^o$ for all $0 < \lambda < 1$. This means that an indifference curve shows x_2 as a strictly convex function of x_1.

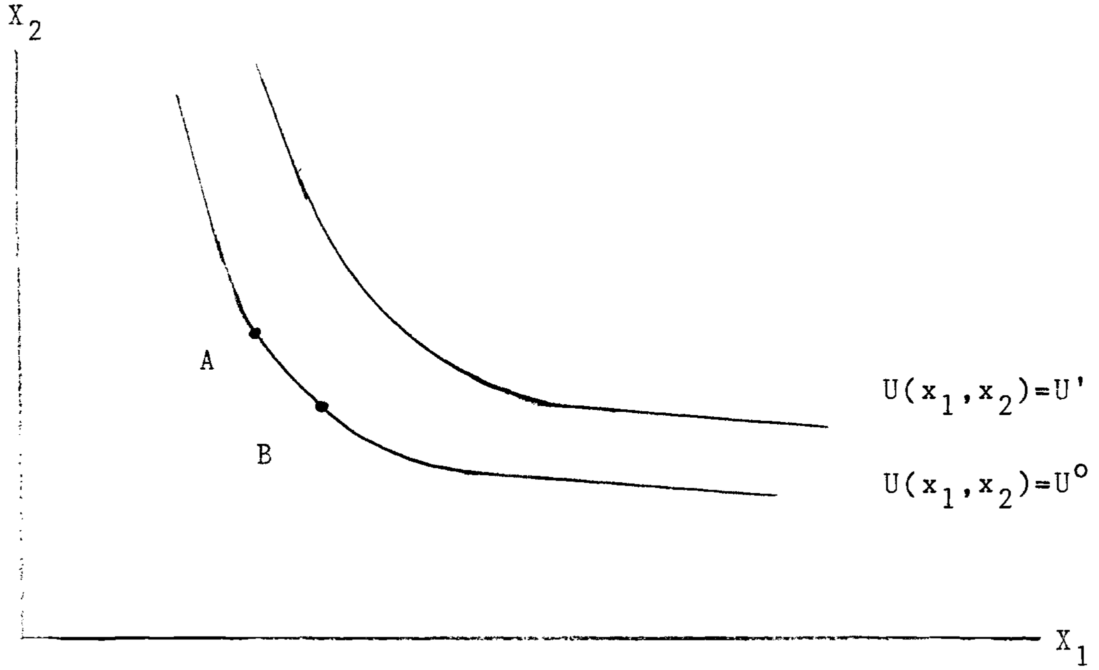


Figure 1. Indifference Curves Representing Loci of Equal Utility.

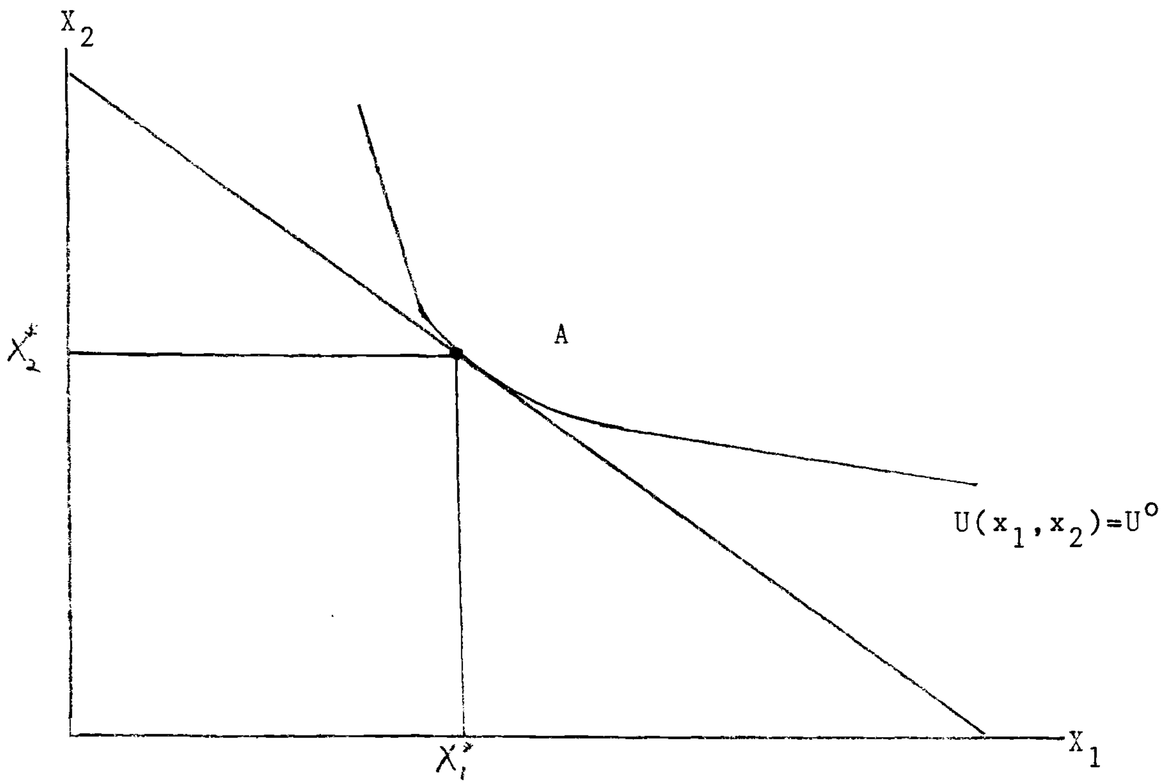


Figure 2. Utility Maximization Occurs at the Tangency of the Budget Line and the Indifference Curve.

$$P_1X_1 + P_2X_2 = M \tag{5}$$

since, given the assumption of non-satiation in Property 1 above, the individual will exhaust the budget because M only has utility for the purchase of X_1 and X_2 and, as a result, does not appear as an argument in the utility function. The problem (Eq. 4) is

$$\begin{aligned} &\max \quad U = U(X_1, X_2) \\ &\text{s.t.} \quad P_1X_1 + P_2X_2 = M \end{aligned} \tag{6}$$

and it can be solved by writing a new function as a Lagrangean

$$L = U(X_1,X_2) + \lambda (M - P_1X_1 - P_2X_2) \tag{7}$$

where λ is the Lagrangean multiplier. Setting the first derivatives equal to zero gives

$$L_1 = U_1 - \quad P_1 = 0 \tag{8}$$

$$L_2 = U_2 - \quad P_2 = 0 \tag{9}$$

$$L_\lambda = M - P_1X_1 - P_2X_2 = 0 \tag{10}$$

Assuming the second-order conditions for a constrained maximum are satisfied, solving Eqs. (8) and (9) for gives

$$\lambda = U_1/P_1 \tag{11}$$

$$\lambda = U_2/P_2 \tag{12}$$

and

$$\lambda = U_1/U_2 = P_1/P_2 \tag{13}$$

Combining Eqs. (11) and (12) gives the tangency conditions--the marginal utility of good one must equal the marginal utility of good two, $U_1/P_1 = U_2/P_2$, and the ratio of utilities must equal the price ratio (Eq. 13) for constrained utility maximization. The conditions are shown graphically in Figure 2.

Additional utility can be obtained by consuming another unit of X and the marginal cost of that additional unit is P. Dividing U by P gives the change in utility per dollar spent. From Eqs. (11) and (12) it is obvious that marginal utility per dollar spent must be equal for both goods at the margin. If the gain in utility from good one is greater than good 2, $U_1/P_1 > U_2/P_2$, then more of good 2 will be purchased until $U_1/P_1 = U_2/P_2$.

The Lagrangean multiplier, λ , can be interpreted as the marginal utility of money. $\partial U^*/\partial M = \lambda$ shows the change in utility with a change in money income.

<u>Demand Theory</u>

To develop demand functions from the first order conditions, write

$$X_1 = X_1^*(P_1, P_2, M) \quad (14)$$

$$X_2 = X_2^*(P_1, P_2, M) \quad (15)$$

$$\lambda = \lambda^*(P_1, P_2, M) \quad (16)$$

where the * denotes the amount of the good which optimizes utility. The simultaneous solution to Eqs. (8), (9), and (10) shows that the demand for any good, X, is a function of the price of that good, the price of other goods and money income. These equations are called money-income held constant demand curves.

The money-income held constant demand functions can be substituted into the utility function $U(X_1, X_2)$ to obtain what is called the indirect utility function:

$$U^*(P_1,P_2,M)=U(X_1^*(P_1,P_2,M),X_2^*(P_1,P_2,M) \quad (17)$$

From the indirect utility function, it can be seen that the demand for a good, X_1, is a function of money income and all prices. This can be generalized and written as $X_i = g_i(P,M)$, where P is a vector of prices, and this relationship is called a Marshallian or uncompensated demand function. It is based on the indirect utility function, has parameters price and money income, and is derived from a constrained utility maximization model.

The income elasticity of these demand functions can be defined as the ratio of the percentage change in consumption of a good to the percentage change in a given amount of income. Mathematically, income elasticity can be written as

$$E_{XM} = \partial X / \partial M \; * \; M / X \quad (18)$$

Because the demand function is determined from the tangency conditions $U_1/U_2=P_1/P_2$ and not from the budget constraint, income can be held constant at all levels, and the income elasticity is unitary for the Marshallian demand curve.

The problem of maximizing utility can also be approached as solving a minimization problem, specifically, minimizing the cost, or expenditure, needed to achieve a given level of utility, U^o. The problem can be written as

$$\text{minimize} \quad E = P_1X_1 + P_2X_2 \tag{19}$$

$$\text{s.t.} \quad U(X_1,X_2) = U^o. \tag{20}$$

The minimization problem can be solved by writing a new Lagrangean function in a manner similar to the solution to the first problem. The demand curves from the solution will be

$$X_1 = X_1^*(P_1,P_2, U^o) \tag{21}$$

$$X_2 = X_2^*(P_1,P_2, U^o) \tag{22}$$

$$\lambda = \lambda^*(P_1,P_2, U^o) \tag{23}$$

The tangency condition from the set of equations derived from the minimization problem is

$$\frac{P_1}{P_2} = \frac{U_1}{U_2} \tag{24}$$

the same conditions derived from the indirect utility function. In other words, there is a unique X_1^* and X_2^* that will solve both the minimization and maximization problems (see Varian, 1978, p. 112, for a concise proof). However, in the expenditure minimization problem, λ is the marginal cost of utility rather than the marginal utility of income and, since the two approaches are compatible, λ can be expressed as the reciprocal of the derived from the first model:

$$\lambda_h = 1 / \lambda_g \tag{25}$$

This relationship can be used to show that the second-order conditions for both the maximization and minimization problem are essentially the same.[5/]

Using the expenditure minimization model to generalize the demand for any given good gives $X_i = h_i(P,U)$. The parameters in this demand function are prices and utility; these utility held constant demand functions are called income-compensated, or Hicksian demand functions. The term compensated is used because when prices change, there must also be a change in income in order to hold utility constant--income is adjusted to compensate the consumer for the change in prices.

Marshallian demand functions are observable because price and income are the arguments in the function and price and income are observable. Marshallian demand curves hold money income constant while evaluating different utility levels. Hicksian demand curves hold utility constant. Because the Hicksian measure considers the effects of a price change on income, they are income-compensated demand curves. If the income effect is negligible or absent (i.e., the marginal utility of income is constant), the two demand curves will be equivalent. If there are income effects, the income-compensated demand curve will have a steeper negative slope (for normal goods) as seen in Figure 3.

[5/] Mathematically, they are the dual of each other, i.e., if the second-order condition (the bordered Hessian) for one is positive the other must be negative.

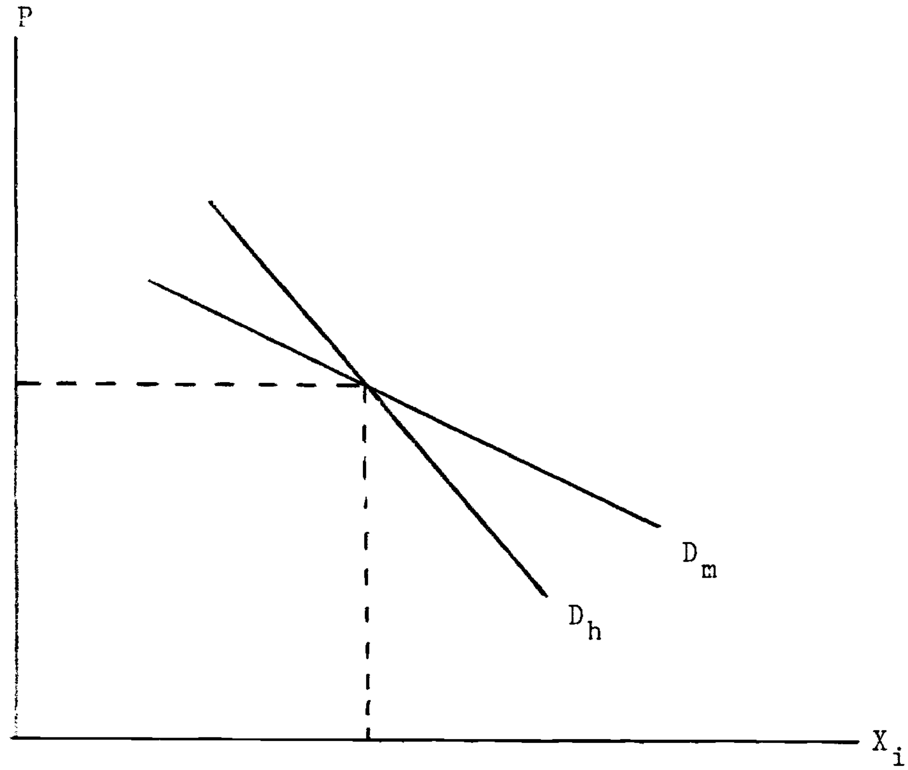


Figure 3. Ordinary, D_m, and Income-compensated, D_h, Demand Curves.

<u>Duality</u>

Duality theory has seen widespread application in production economics analyses of cost functions. Briefly, duality theory in production states that the cost function of a firm summarizes all of the economically relevant aspects of its technology (Varian, 1978). Duality theory can also be applied to the expenditure and indirect utility functions of consumer theory to further develop the relationship between the two functions since, as Deaton and Muellbauer (1980) point out, the two models contain essentially the same information. By specifying an expenditure function, paralleling a cost function of production economics, a utility function is implicitly specified, paralleling a production technology in production economics (the output of production is measurable in units, the output utility is not). Because the indirect utility function is the inverse of the expenditure function (Varian 1978), duality can also be used to show that the specification of an indirect utility function is the same as the specification of a utility function. This relationship provides the analyst with a method of specifying utility and demand functions with information about an individual's expenditure function. An extended analysis of duality is beyond the scope of this study; a complete discussion of the relationship between expenditure, or Hicksian, functions and indirect utility, or Marshallian, functions, using duality theory, can be found in Deaton and Muellbauer (1980, pages 37-50).

Benefit Measurement: Consumer's Surplus

The problem of measuring the gains from trade, in dollar terms, has been one of the most difficult problems of economics (Silberberg, 1978). The concept of a consumer's surplus (CS) was elaborated by Marshall (1920) and defined as the difference between the amount of money a consumer is willing to pay for a good (or quantity of a good) and the amount a consumer actually pays. Figure 4 graphically shows Marshallian consumer's surplus.

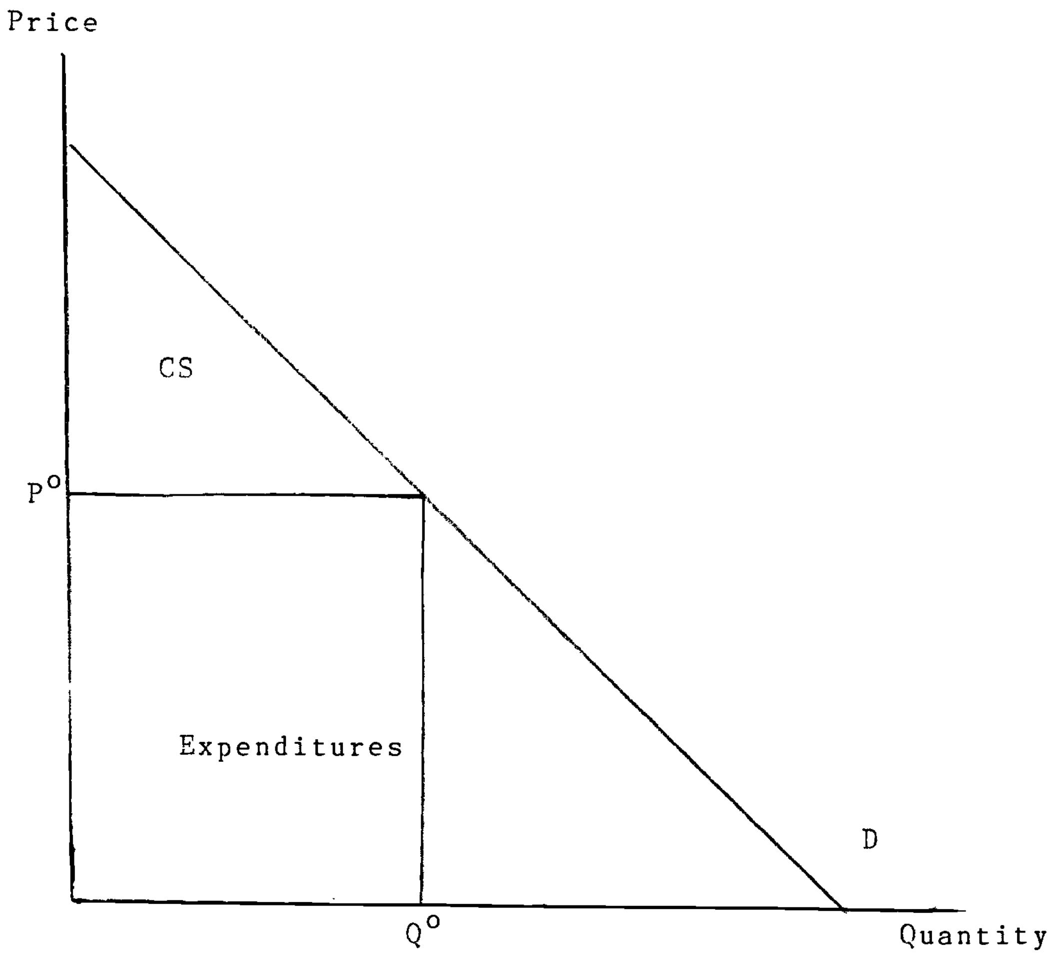


Figure 4. Marshallian consumer's surplus.

Marshallian consumer's surplus, however, is not always a completely accurate dollar measure of individual welfare. Hicksian demand functions can also be used to estimate consumer's surplus and will generally provide a more exact measure of consumer's surplus. Since movement along an ordinary demand curve affects the level of utility an individual can achieve with a given income, a price decrease will result in a higher level of utility with the same income. But for consumer's surplus to give a correct dollar measure of individual welfare, the relationship between dollars and utility must be constant everywhere on the demand curve. Since this is not the case when the marginal utility of income is not constant, the ordinary demand function does not provide a theoretically correct linkage between consumer's surplus and utility (Desvousges et al., 1983).

In order to provide an exact measure of consumer's surplus, Hicks (1943) suggested that utility should be held constant at all points on the demand curve, i.e., the income effect of a price change should be eliminated and only substitution effects should be considered in consumer's surplus calculation. In addition to providing a more precise measure of consumer's surplus, this also allows the comparison of the effects of changes in prices or quantities and utility among individuals because only substitution effects are considered.

Consideration of income and substitution effects is necessary because when the price of a (normal) good, X, increases, a consumer's demand function changes in two different ways. First, a consumer's real income, or utility, is lowered because the higher price reduces the amount of the good or service that can be purchased. This is called the income effect. Second, the consumer will purchase more of a good that is a substitute for X. This is called the substitution effect. The sum of these two effects is the total effect of a price change.

The two effects can be distinguished from one another through the concept of the compensating variation in income. This is the change in money income necessary to allow the consumer to remain on the same indifference curve while the higher price for good X is paid. Figure 5 illustrates this measure.

The quantity of good X is represented by the X axis and all income other than that spent on good X, called the numeraire, is represented on the Y axis. The line I_oI_o/P_o represents the budget constraint and is called the budget line. Point A is the point of tangency with indifference curve U_o. As discussed in the previous section, this point represents a maximum. When the price of good X rises from P_o to P_1, the budget line shifts to I_oI_o/P_1. The new equilibrium point is point B on indifference curve U_1. To find the amount of income necessary to keep the consumer on the original indifference curve U_o, a line is drawn parallel to the new budget line and tangent to U_o. This point of tangency is point C. The horizontal distance from A to C is the substitution effect: the consumer remains on U_o and X_o - $\underline{X}$ is traded off for the numeraire. The horizontal distance from C to B is the income effect. The vertical distance from I_o to I_1 is the compensating variation, the amount of income needed to

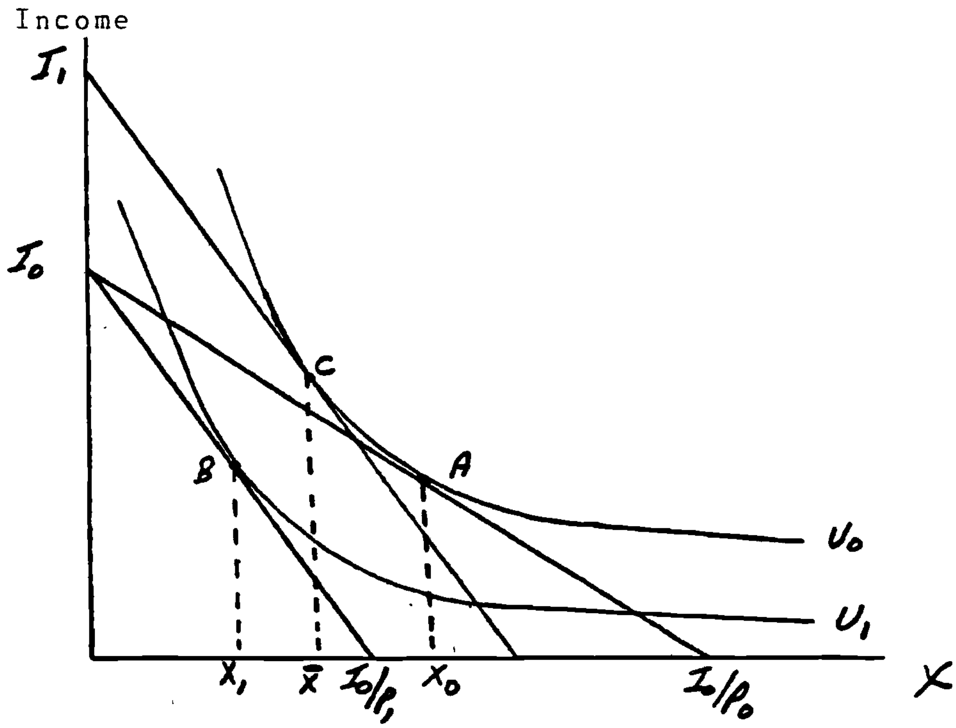


Figure 5. Compensating Variation Illustrating Substitution and Income Effects.

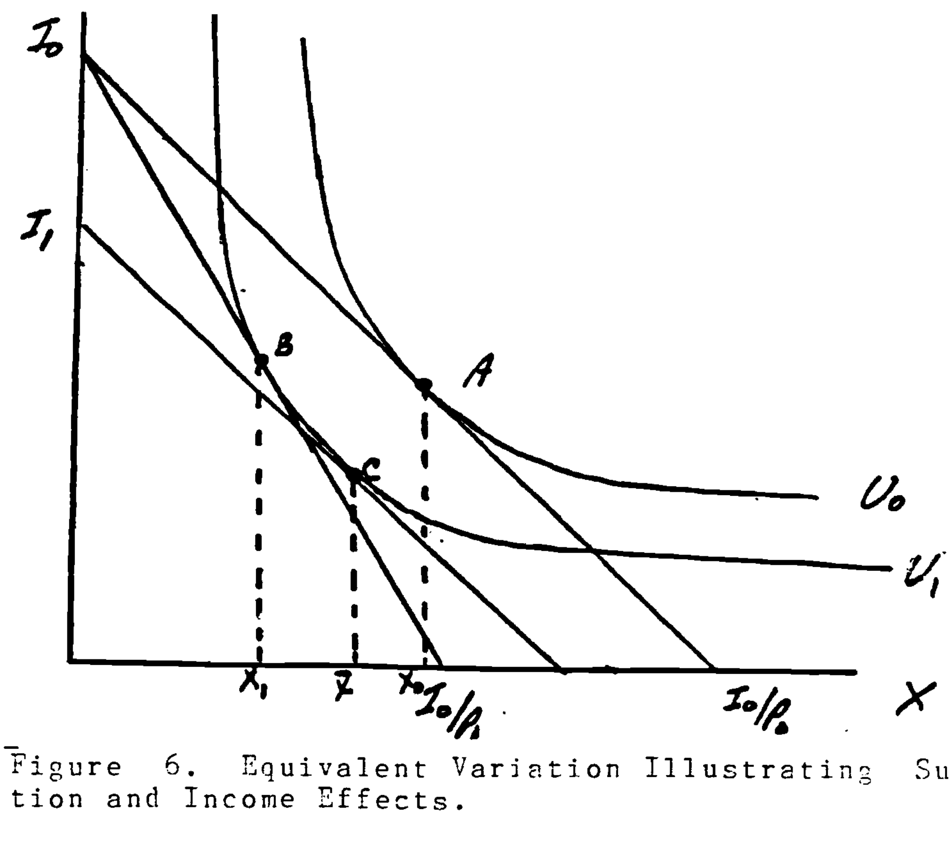


Figure 6. Equivalent Variation Illustrating Substitution and Income Effects.

compensate the consumer for the price change and thereby maintain utility level U_o. The reference level is the original level of utility and the new price ratio.

An alternative approach is to find the amount of money that would provide the individual with the same utility, paying the higher price, that the lower price would provide. Figure 6 shows how this measure, the equivalent variation, is derived. Point A is a utility maximization given indifference curve U_o at price P_o. If price increases to level P_1, then the new point of utility maximization will be point B on indifference curve U_1. To find the point of the new indifference curve that would be a utility maximum given the original prices, a line is drawn parallel to the original budget line and just tangent to U_1. The horizontal distance from point X_1 to X' represents the substitution effect and the horizontal distance from X' to X_o represents the income effect. The equivalent variation in income is the vertical distance from I_o to I_1. The reference level here is the subsequent level of utility and the original price ratio.

Hicks (1946) originally developed these measures of welfare change based on earlier work by Pareto and Slutsky. The exact nature of the relationship between income- and utility-held constant demand functions was shown by Slutsky in the Slutsky equation:

$$\partial x_i/\partial p_j = \partial x_i/\partial p_j \quad - \partial x_j * \partial x_i/ M \qquad (26)$$

substitution effect — income effect

The Slutsky equation shows instantaneous rates of change in consumption with respect to changes in prices and income rather than the finite changes graphically described above. Silberberg (1978) suggests that the difference between the Hicksian and Slutsky compensations will not be great if the price change is not too large.

The difference between Marshallian and Hicksian consumer's surplus, then, will depend on the magnitude of the income effect: if the price change of some good is small and the budget share of the good is small, then the income effect will be negligible, and the two measures will be close. Willig (1979) has provided a formula for placing bounds on the Marshallian consumer's surplus. This enables the analyst to work with more readily observable ordinary demand functions with parameters income and prices rather than compensated functions with parameters utility and prices.

Mathematically, the Marshallian consumer's surplus can be written as

$$CS = \int_{p'}^{p''} g_1\,(p_1, P, M)\,dp \qquad (27)$$

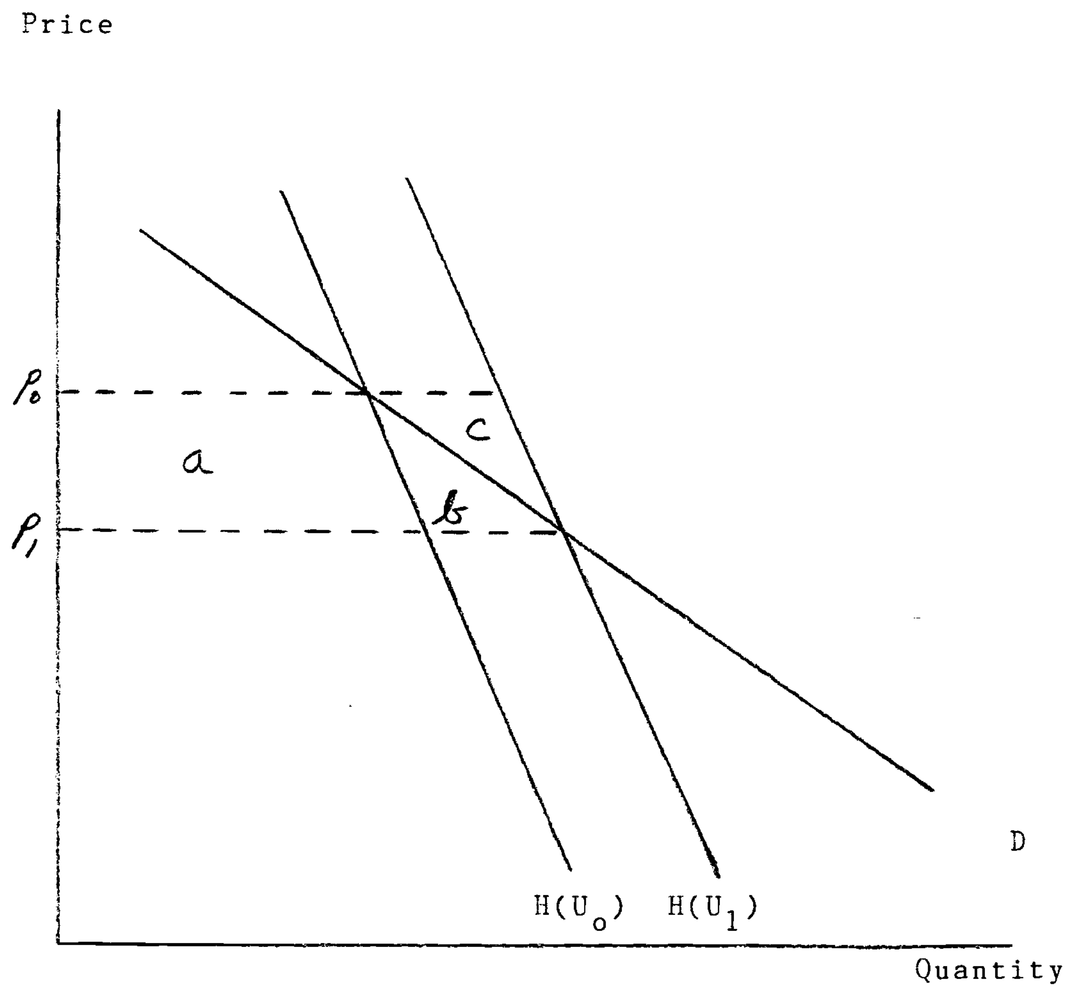
and the Hicksian consumer's surplus as

$$CS = \int_{p'}^{p''} h_1\,(p_1, P, U^o)\,dp \qquad (28)$$

where P_1 is the price of the evaluated good and P is a vector of the prices for all other goods.

Given the development of the uncompensated and income-compensated demand functions from the preceding section, which is the correct demand function to use to estimate CS? Because the Hicksian function measures marginal willingess to pay for additional units, it is the conceptually correct measure (Hanemann, 1980; Randall, 1983). The Marshallian measure will provide a reasonable approximation if income effects are negligible, but if they are pronounced, an overestimate of CS will be derived from the uncompensated curve.

Figure 7 illustrates the difference in welfare measures. $H(U_o)$ and $H(U_1)$ are Hicksian demand curves holding utility constant at the prechange and postchange levels, respectively. The Marshallian, or ordinary demand curve is denoted by D; income rather than utility is held constant. The compensating variation measure is labeled as area a, indicating the amount of compensation that must be taken from an individual to leave her at the original level of utility when the price changes decreases from P_o to P_1. The equivalent variation measure is represented by the area a+b+c, and measures the income change equivalent to the change in prices which would permit the individual to realize the new utility level with the original price P_o. The change in ordinary consumer's surplus is the area



Source: Desvousges et al., 1983.

Figure 7. Ordinary Consumer's Surplus, Compensating Variation, and Equivalent Variation as Welfare Measures.

a+b. From Figure 7, it can be easily seen that the ordinary consumer surplus, called M, will be less than the equivalent measure and greater than the compensating measure, or CV < M < EV, for a price decrease.

Hicks (1943) provided four measures of welfare change given a price change : 1) compensating variation, 2) equivalent variation, 3) compensating surplus, and 4) equivalent surplus. These measures differ because they each imply a differing assignment of property rights to the individual. The equivalent measures assume the individual is entitled, or has a right to a proposed change while the compensating measures assume the individual does not have a right to the proposed change. Compensating and equivalent variations (surpluses) are income adjustments that maintain the individual at some given level of utility. Compensating variation is based on the initial level of utility and equivalent variation focuses on the utility level subsequent to the change. Which measure to use depends on the particular situation and the existing property rights structure.

The concept of consumer's surplus as a measure of welfare gains and losses has been criticized theoretically by Silberberg (1978) who claims that, under some conditions, the "gain from trade" is not unique.[6/] However, if only one allocative change is being evaluated (i.e., a change in quantity and a change in the numeraire, income), then there is an implied unique correspondence

[6/] Silberberg argues that the gain (loss) in utility is generated by a line integral which is generally path-dependent; different adjustments of prices leading to the same initial and final price income vectors will lead to different monetary evaluations of the consumer's gain in utility. Only when the utility function is homothetic (the line integral is path-independent) are changes in utility proportional to changes in income. Homothetic utility functions require that the marginal utility of money income is independent of relative prices, that is the income expansion path is a ray from the origin.

between utility gains or losses and the proportion of income gains or losses. Consequently, the maintained hypothesis of a homothetic utility function will allow the concept of consumer's surplus to be employed as a potentially useful but imperfect decision-making tool. It requires explicit description of the nature of the utility function, whether ordinal, cardinal or some other scale (see Morey, 1984, for a discussion of this problem), as well as a precise statement of the implied property rights and the extent of the proposed resource allocation change.

It can be seen from the preceding discussion that there are a number of different measures of value: the Hicksian compensating measure, the Hicksian equivalent measure, the Marshallian CS, and market prices. Market prices as a value indicator are reasonably accurate estimators of value assuming the conditions of a competitive market and low transactions costs are not grossly violated (Randall, 1983). The Marshallian measure is not a conceptually justifiable measure (Randall, 1983) because it fails to adjust for income effects.

Of Hicks' four distinct measures of CS, the compensating variation (surplus) is the appropriate measure for a price increase if it is assumed that consumers do not have the right to use the resource. If it is assumed that the consumers own the right to the resource, then the equivalent variation (surplus) is the correct measure (Desvousges et al., 1983). The variation measure is used when post-change optimizing adjustments are possible, the surplus measure is used when they are not (Randall, 1983). The following section discusses equivalent and compensating measures using the willingness to pay and willingness to sell measures for nonmarket goods.

Willingness to Pay and Willingness to Accept as Measures of Economic Surplus

The Hicksian analysis discussed above examined changes in welfare with respect to increases or decreases in prices. However, when nonmarket goods, such as environmental service or publicly owned recreation sites, are being valued there is, generally, an absence of market prices. Therefore, the measurement of value is facilitated if the changes are discussed in commodity space rather than in price space as in the traditional Hicksian analysis. As a result, the following discussion proceeds in terms of commodity space.

If the utility function is unobservable, how can Hicksian compensated measures of individual value be estimated for a change in quantity? Assume the change will be measured with incremental or decremental unit differences in the level (or quantity) of goods and services available to the individual. If the individual has an initial endowment of some quantity, Q_o, and income, Y_o, then the individual can either remain at the initial position or obtain an increment of Q. The value of that increment is what an individual is willing to pay (WTP) for the incremental unit. If the individual faces a decrement in Q, the value is represented by the amount of money the individual would accept to relinquish one unit of Q, called willingness to accept (WTA or, frequently, willingness to sell, WTS). Randall (1983) states that WTP and WTA are "identically equal to the Hicksian compensating measure of consumer's surplus" (Randall, 1983, page 28). If the good is considered "lumpy," or not perfectly divisible, then the Hicksian compensating and equivalent measures in commodity space will be equal to the Hicksian surpluses in price space.

The differences between compensating and equivalent measures are important to note. The Hicksian compensating measure of CS for WTP is the value of an increment in quantity to the individual; for WTS, the value of a decrement is the amount of compensation which would induce the individual to voluntarily accept that decrement. The Hicksian equivalent measure for WTP is the amount the individual will pay to avoid a decrement of quantity. For WTS, it is the amount required to induce the individual to forego promised increments. The equivalent measure assumes the individual is assured not the initial levels of quantity and income but the proposed levels. The equivalent measure, then, is defined as the amount of compensation, paid or received, which would bring the consumer to his subsequent welfare level if the change did not take place. The compensating measure is defined as the amount of compensation, paid or received, which would keep the consumer at his initial welfare level if the change did take place" (Randall, 1983, page 59).

Only compensating measures of WTP and WTA are theoretically consistent with the Pareto-improvement criterion (Randall and Stoll, 1980). Although there are equivalent measures of WTP and WTA, the appropriate measure is the compensating measure (see Randall and Stoll, 1980, for an extended discussion of the differences). Randall and Stoll (1980) have provided bounds on the Marshallian consumer's surplus with respect to compensating and equivalent WTP and WTA measures in commodity space similar to those developed by Willig (1976) for price space. A graphical depiction of the different measures of welfare (analogous to Figure 7) for commodity space can be found in Desvousges et al., p. 2-6). Although WTP and WTA are theoretically equivalent, conditions such as high transaction costs, the commodity being a non-normal or superior good, and/or unspecified property rights may produce a WTA much greater than WTP (Randall, 1983). This problem is discussed further in the results section of the study.

Discrete Choice Utility Theory

Some goods are not consumed in divisible or continuous quantities, for example, buying a house or getting a college education. Hence, there are discontinuities in the indifference curve which result in non-unique solutions to the utility maximization problem when approached with the traditional optimization techniques of calculus. However, discrete choice theory (Small and Rosen, 1981; Hanemann, 1984) provides an equally useful but somewhat different approach, that is, the "usual techniques for measuring welfare effects must be modified for discrete choice problems" (Small and Rosen, 1980, page 125).

Discrete choice models used in empirical welfare analysis are, for the most part, probabilistic; that is, they contain a stochastic, or random error term to account for individual tastes and preferences that are unobservable to the analyst. Compensating and equivalent measures of welfare can be obtained with a random utility model. The theory and models used in this study are elaborated in the TIOLI section.

Types of Value

Goods and services are valued by individuals because of the utility which they provide. This value can be either direct or indirect. Researchers have identified four general categories of value (Randall and Peterson, 1983). They are:

1. Use value--the economic value derived from using goods or services in any way.

2. Option value--the expected value from future use modified to include risk discounts and premiums (Bishop, 1982).

3. Quasi-option value--the value gained from delaying disposition of some good or service when there is an expectation that information may be revealed with the passage of time or the value of preserving options given an expected increase in knowledge (Arrow and Fisher, 1974).

4. Existence value--the value gained from simply knowing that something exists (Randall and Stoll, 1983).

Individual Values in the Context of Social Efficiency

It has been shown that value comes from the individual members of a society as an expression of their preferences and the resulting demand for goods and services. But not all preferences can be satisfied in an environment of limited resources. How are decisions to be made and how will it be decided who wins and who loses on an individual and social basis? The following section evaluates the decision criteria that balance the goal of social efficiency against individual changes in welfare.

Given the present social and political structure, the conditions of perfect competition (and a resulting Pareto-optimal state) are not likely to be met. Instead, there is a mixed economy with imperfect competition, but this mixed economy does not necessarily preclude an efficient allocation. However, assuming that a state of Pareto-optimality can be reached through government intervention, there is still no of way of identifying the point on the GUPF curve which is best for society without making a value judgement about society's preferences, a social welfare function.

If a SWF is derived, the tangency of the SWF and the GUPF would represent a point at which society's welfare is maximized simultaneous with a state of Pareto-optimal efficiency. This point, Z in Figure 8, is sometimes referred to as the constrained bliss point. This SWF can be defined but it will not meet the reasonable conditions outlined by Arrow (Silberberg, 1978).

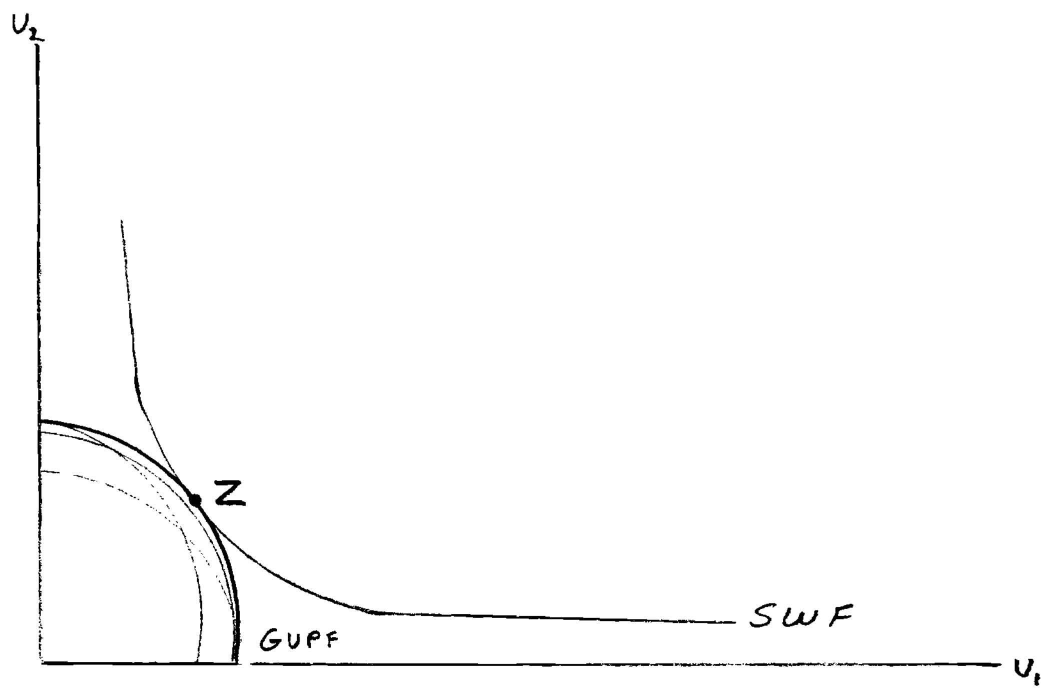


Figure 8. Grand Utility Possibility Frontier and the Social Welfare Function.

The conditions of strict Pareto-safety (no change will be made if it makes someone worse off) are guaranteed in the perfectly competitive market--no one will trade to a position where they are less well off. These conditions would allow a change to be made if only if those who gain from the change actually compensate those made worse off. But extensions of this concept into the public policy process would prove excessively restrictive to a society which endorses, to a greater or lesser degree, some government action in the public interest.

A "solution" to the impasse between the purely individualistic, Pareto-safety position, and what Randall and Peterson (1983) call the "public interest, market failure model," was proposed by both Kaldor and Hicks. They suggested the potential Pareto-improvement test, sometimes referred to as the Kaldor-Hicks criterion. It states that if those who benefit, or win, from an allocation change could hypothetically compensate those who suffer disutility, or lose, the potential Pareto-improvement test will "find the change acceptable even if actual compensation does not occur" (Randall, 1983, page 68). The Kaldor-Hicks criterion, then, implies that the issues of economic efficiency and income distribution can be separated in social policy. This solution appears to satisfy the conditions of Pareto-safety, either in reality or hypothetically.

Even a superficial review of policy, however, clearly shows that income distribution and equity considerations are important to policy decisions. Not uncommonly, social policy chooses to be inefficient so that certain groups can benefit. The use of benefit-cost ratio and net present value as information systems rather than definitive decision criteria, then, allows economic analysis to be used in a normative decision-making context.

One of the objectives of nonmarket valuation is the generation of satisfactory value information regarding individual costs and benefits that will permit the identification of potential Pareto-improvement through the implementation of BCA or maximized net present value (Randall, et al., 1983). BCA is a decision-making framework that establishes decision rules for public investments <u>similar</u> to those that exist for private investments. There are other systems of decision-making (see Lave, 1980, for a review) but BCA (and the goal of economic efficiency) has emerged as perhaps the primary tool for evaluating and ranking policy actions. It is important to distinguish the financial or private concept of efficiency from the economic or social concept of efficiency and to note that BCA is based on social benefits and costs.

BCA tests whether a change will increase aggregate social efficiency through collective action that will benefit some while costing others without, however, a consideration of the initial level of welfare of the winners and losers. The potential Pareto-improvement criterion, then, "represents one very simplistic form of the social welfare function" (Randall, 1983, page 15). In other words, Pareto-improvement efficiency maximizes the dollar value of a good or service but does not specify the *a priori* or *a postieri* distribution of that value.

Nonmarket Benefit Estimates

If all goods were traded in a perfectly competitive market with non-attentuated property rights and no nonrival goods, then market prices could serve as valid estimates of benefits, or economic surplus. But many environmental goods, such as air quality, are characterized by nonexclusiveness and nonrivalry and are not marketed directly. Similarly, many natural resource-based recreational opportunities are considered to be public goods and are provided at administratively determined prices that are not based on actual market equilibrium prices. Thus, a market is absent and information about the value of environmental and recreational goods and services must be estimated through non-market methods. These methods can be divided into two types: 1) those which use an income compensation approach and which reference some original level of utility, and 2) those based on the expenditure approach, which use information based on expenditures for related marketed goods to infer value for the nonmarket good (Randall, 1983). The income compensation approach includes the CVM and utility function estimation. The expenditure function approach includes the TCM, as well as other subsets of the hedonic price method.

All of the above methods have been applied to estimate nonmarket value, with some studies producing consistent results, while others have resulted in inconsistent value estimates. However, a test of the hypothesis that the estimated values are equal to the real values (where the real value is defined as the value that would exist if a real market actually existed), what Randall (1983) calls "the crucial experiment" (page 84), has not, generally speaking, been possible. Instead comparisons of estimates from different methods have been used as surrogates for validation.

Conclusion

The public policy decision environment is complex, contradictory, and frequently characterized by incremental decision-making, disputed property rights, and a compromised mixture of decision criteria. That economic efficiency is not the only decision criterion does not diminish the importance of providing precise and comprehensive value information using economic theory and methodology. A complete inventory of costs and benefits, in comparable dollar values when possible, becomes even more crucial when nonmarket values are evaluated against market-based prices because goods and services with no obvious market value (price) tend to be assigned less than their real value (Randall, 1983). This may result in inefficient allocation decisions that are not based on accurate information.

Consistent with the theoretical framework of value and welfare outlined in the preceding discussion, this study estimates nonmarket value for whitewater recreation on the Rogue River. The travel cost method is used to estimate a Marshallian consumer's surplus and the contingent value method is employed to estimate a Hicksian compensated measure of consumer's surplus. The following section reviews some of the literature relevant to the TCM and CVM.

LITERATURE REVIEW

The U.S. Water Resources Council (1979) sets benefit-cost analysis rules for many government resource management agencies. It designates the TCM and the CVM as the preferred nonmarket valuation methodologies. This section reviews some of the literature relevant to these two methods.

Travel Cost Method

Introduction

The travel cost method (TCM) for estimating the economic value of recreation sites is an indirect, market-based approach to valuation (Hueth and Strong, 1984). The basic assumption of the model is that a demand function for a good or a site can be estimated by observing the actual travel costs incurred by the recreationist in traveling to the site. Since different recreationists will travel different distances to the site, individual or group expenditures can be used to infer the WTP for the site visit. Both actual travel costs and opportunity costs are considered in the analysis.

Hotelling, in 1949, is credited with being the first to suggest this method of valuing a recreation site (the letter suggesting the method is reprinted in Brown, Singh, and Castle, 1964). Clawson (1959) elaborated Hotelling's suggestion to include two distinct demand functions derived from zonal observations. The first stage demand curve, or trip demand curve, represents the demand for the entire experience, that is, planning, traveling, the on-site experience, and recollection. This demand function is estimated by modeling quantity, or visits per capita from a zone, as a function of price, or the round trip travel cost from the zone to the recreation site. The second stage or site demand curve is then estimated by incrementing the cost variable from the trip demand curve. In other words, the trip demand curve is used to estimate the number of trips at zero price and becomes the X intercept of the second stage demand curve. As costs are incremented, the site demand curve is plotted. At the intersection of the Y axis and the demand curve, the number of trips per capita falls to zero. When there is no admission fee, the area under the site demand curve represents total consumer's surplus and is the appropriate measure of benefits from the site (Clawson and Knetch, 1966). This model is referred to as the simple travel cost method (Mendelsohn and Brown, 1983).

Theoretical Basis for TCM

Two important theoretical assumptions in the TCM are weak complementarity (Burt and Brewer, 1971; Maler, 1974) and identical preferences (in the zonal model only). When the relationship between a market and a nonmarket good shows weak complementarity, the demand for the ordinary good shifts as the level of the nonmarket good changes.

The area under the Marshallian demand curve estimates the benefits from the changes. This reasoning assumes non-separability of the respective goods in the utility function, that is, the preference for recreation and travel is composite to some degree, as well as certain other mathematical restrictions on the expenditure function (Maler, 1974). If the utility function is separable for the two goods, then the TCM and other expenditure-based methods, are not applicable and the income compensation approach must be used (Randall, 1983).

The assumption of identical preferences implies that an individual in any given zone will behave similarly to an individual in a different zone if they face the same costs. The restriction of identical preferences ensures that each individual will react in a way consistent with other individuals. If Becker's (1976) assertion that changes in behavior are more a result of changes in prices and incomes than changes in preferences is acceptable, then the assumption of identical preferences is not heroic.

The assumption that individuals react to an increase in travel costs in the same way they would react to an increase in fees is commonly cited as a necessary condition for the TCM to produce reliable results. Although this statement has heuristic value for understanding the model, it has been shown theoretically

(Bowes and Loomis, 1980) that the weak complementarity assumption (which is a weaker assumption than the equivalence of travel costs and fees) is sufficient to allow an unbiased estimation of demand from travel costs. As a result, "the appropriateness of valuation by the complementary input, travel, does not require that recreationists view changes in travel cost as equivalent to equal changes in entry prices" (Bowes and Loomis, 1980, p. 466).

Further Developments of the TCM

Since the introduction of the simple or zonal method, sometimes called the aggregate method (Rosenthal, Loomis, and Peterson, 1984), the TCM has undergone extensive refinement and development in order to overcome some of the limitations of the early model. These developments have focused on the inclusion of demographic variables, specification of the cost variable, the determination of the opportunity cost of travel and onsite time, the use of individual rather than zonal observations, the limited dependent variable problem, specification of substitutes, choice of functional form, and the spatial limits imposed on the TCM by its assumptions.

Differences in recreation behavior related to age, income, occupational status, and intensity of commitment can be obscured by the assumption of homogeneity of preferences in the zonal TCM. Brown et al. (1964)

expanded the early model by including the effect of other variables besides travel cost on the demand function. Besides travel cost, they included income, variable costs, number of fish caught, and number of days spent at the site. Their results suggested that income was an important variable in the travel cost equation.

Specification of the Cost Variable

Because travel cost is the crucial variable in the TCM, correct specification of this variable is important. Typically, travel costs are computed as a function of distance traveled using the average cost of operating a vehicle. Since individual automobiles will vary in their efficiency, the use of individual data is preferable. The problem remains of the individual's perception of variable costs being consistent with the assumptions of the researcher (Bishop and Heberlein, 1979; Smith and Kopp, 1980). Because travel costs are an aggregation of small or subtle costs, some of which may not be obvious to the individual, and are not all imposed on the recreationist at the time recreation is demanded or consumed, recreationists may not perceive their travel costs to be the same as would be calculated with a strict distance factor.

The distinction between exogenous costs to the recreationist and endogenous costs which are chosen by the recreationist to enhance the experience has been explored by Ward (1984). He states that the distinction is needed when the endogenous costs are related to the distance traveled, for example, the possibility that people who travel greater distances tend to incur more discretionary costs. If endogenous costs are not independent of distance, then the estimated cost coefficient will not be an unbiased estimator (Ward, 1984).

Determining the Opportunity Cost of Time

Although the early travel cost models used only transportation costs as the proxy for price, it was suggested by some researchers that there was an opportunity cost of time spent traveling to the site, and to time spent on the site, that should be accounted for in the demand function to avoid an estimate that is biased downwards (Cesario and Knetch, 1970; Wilman, 1980). However, precise identification of opportunity costs has proven extremely difficult and no completely satisfactory solution to this problem has been found (Bishop and Heberlein, 1979; Wilman, 1980; McConnell and Strand, 1981; Desvousges et al., 1983).

There are a number of reasons why the problem of determining the opportunity cost of travel time has been intractable. First, time is itself a nonmarket good and, unlike travel costs which can be estimated from expenditures on gas, and other variable costs, the value placed on time varies among individuals and among situations (Cesario, 1976). Second, there is a high correlation between distance (travel cost) and travel time which makes it extremely difficult to render their separate effects empirically distinct (Cesario, 1976). This correlation causes multicollinearity when the parameters for a model are estimated econometrically. Third, there is the problem of properly evaluating the specification of the time cost variable for recreationists who regard travel time either as a benefit or as neutral, but not as a cost (Walsh, Loomis, and Sanders, 1985).

One solution to these problems that has been suggested is to use the wage rate, or some fraction of the wage rate, as the opportunity cost of time. Although numerous studies have attempted to measure individual's time costs, frequently from a commuter's standpoint rather than a recreationist's (see Winston, 1985, for a survey of studies), no generally acceptable standard formula has been agreed upon. Cesario (1976) suggests one third of the wage rate, and that number has been adopted by the Water Resources Council (1979) in their guidelines. Desvousges et al. (1983), after testing alternative specifications of the time cost variable with a number of different test sites, were unable to conclusively reject the use of a fraction of the wage rate (specifically, Cesario's 1/3 the wage rate) or the full wage rate. As a result, Desvousges et al. (1983) state that "there is no unambiguous choice" for the correct value of time costs.

Research on opportunity cost and travel time has led some economists to model recreation choice with a household production function approach (Bockstael, Strand, and Hanemann, 1985). This approach permits the specification of a time constraint and an income constraint for the individual constrained utility maximization model and allows a more precise identification of the ways in which the time and income endowments constrain the demand for recreational goods and services.

In addition to theoretical importance, the opportunity cost problem has empirical relevance as well. The value placed on travel time has a powerful effect on the estimate of consumer's surplus. For example, Bishop and Heberlein (1979), in a valuation study of hunting permits, showed values ranging from $11, when time cost were not included in the model, to $45 when time was valued at one half of the wage rate.

The Zonal versus the Individual Method

The zonal method of the early travel cost models has the advantage of minimal data requirements since secondary information can be used for a zone's average per capita income, age, and other relevant data. However, the process of aggregation and averaging may result in the loss of information specific to individuals and individual recreation behavior. Also, the existence of multicollinearity may result in biased regression coefficients since both travel time and travel cost are computed on the basis of the distance of an origin zone from the destination site.

Brown and Nawas (1973) showed that recreation demand functions could be estimated more efficiently if individual observations were used rather than observations grouped by origin zone. They suggested that the number of observations needed in the zonal model was much greater than that of the individual model producing the same level of precision. With the individual model, the number of trips taken by the individual per season is the dependent variable and the independent variables are travel costs and other relevant determinants of demand. Multicollinearity will be less of a problem because distance will not be the only factor affecting travel and time costs.

The original individual model developed by Brown et al. (1973), called the unadjusted individual observation method, did not properly account for differing rates of participation at different distances nor the problem of a limited sample of the complete population of users and non-users. Subsequently, Brown et al. (1983, 1984) recommended an adjustment that would account for lower percentages of the more distant population zones participating in a given activity, and adjust for the lack of zero observations. This adjustment requires that the individual observations be adjusted to a per capita basis, similar to that of the zonal model.

The Limited Dependent Variable Problem

Part of the problem encountered by Brown et al. (1973) is a result of the exclusion from the sample of observations in which zero trips were taken. This is an example of a limited dependent variable, specifically, a truncated model (see Maddala, 1982, for a thorough discussion of limited dependent variables). If a researcher only has information on individuals who actually visited the site, that is, there are no zero trip observations, then the sample is truncated and econometric problems will be encountered when model parameters are estimated; biased results will be obtained. In addition to the adjustments to the individual observations discussed by Brown et al. (1983,1984) and Bowes and Loomis (1980), there are two other approaches to this problem. First, there are corrections which can be made to ordinary least squares estimates of truncated (or censored) models (Olsen, 1980; Greene, 1983). Second, maximum likelihood estimation (MLE) can be used to provide an unbiased estimate of consumer's surplus (Smith et al., 1986).

Specification of Substitutes and Site Quality

While the demand for a public good or recreation site is a function of the price of the good or site, demand is also a function of the availability and price of other sites which may be substitutes for the first site. If travel cost models are specified without recognition of substitutes, either perfect or imperfect, biased estimates may result. Burt and Brewer (1971) were among the first researchers to address the issue of substitute sites in demand function estimation. Their model included the price of substitute recreation sites and explicitly acknowledged the interdependence of different recreation sites within a region. Other more complex regional models have since been developed (Dwyer, Kelly, and Bowes, 1977).

Closely related to the substitution issue is the use of site quality indices that measure the extent to which an available site is a substitute for the study site. Morey (1981) developed a constrained utility maximizing behavior model that incorporated site characteristic elasticity estimates. Other researchers (Hanemann, 1982; Bockstael et al., 1985) have developed recreation demand models that incorporate both substitution and site quality effects. Caulkins, Bishop and Bouwes (1986) have compared two methods of incorporating site quality and substitution effects in a multinomial logit model and an alternative travel cost method. They concluded that the capacity of the model to measure substitution at different levels of quality will have an effect on the estimated demand function.

The Choice of Functional Form

The choice of the functional form for the demand equations in TCM can have a significant effect on consumer's surplus values (Ziemer, Musser, and Hill, 1980). Linear forms have been used (Burt and Brewer, 1971; Cicchetti, Fisher and Smith, 1976), as have quadratic (Gum and Martin, 1975), semilog forms (Batie, Jensen, and Hogue, 1976; Donnelly et al., 1985), and log-log forms (Smith, 1975). Ziemer et al. (1980) suggest various procedures that will test the appropriateness of the functional form.

Several researchers have found the semi-log dependent functional form to be the most plausible (Ziemer et al., 1980; Strong, 1983). Strong (1983) has also shown that using the natural logarithm of visits per capita will reduce inconstant variance, or heteroscedasticity, which violates the OLS assumptions for consistent regression estimators. Donnelly et al. (1985) suggest that choice of functional form should depend on whether the model is to be used for benefit estimation or to predict use. For benefit estimation, the functional form with the highest R-squared, rather than the greater predicted versus actual use ratio, should be used (for either TCM model).

Limiting Assumptions of the TCM

Smith and Kopp (1980) identify the three primary assumptions of the zonal TCM as 1) one purpose trips, 2) equal length of stay, and 3) equal unit costs of travel (or same mode of travel). They suggest that the untenablility of these assumptions may affect the structural stability of the regression model, and they operationalize a test for the model's spatial limits stated in terms of the constancy of the parameter vector for each observation (Smith and Kopp, 1980).

If travel cost is to have a complementary relationship to price, the researcher must be able to identify all costs associated with the specific recreation site to be valued. This becomes problematic for multi-site trips (a violation of the weak complementarity assumption) because costs can not be precisely allocated and consumer surplus will be overestimated. Consequently, the TCM can be utilized only when the purpose of the trip is to visit the site. The problem of equal length of stay has frequently been assumed away (Desvousges et al., 1983), with the assumption that onsite time is constant across individuals; therefore the cost of onsite time drops out of the travel cost equation.

Another requirement of the TCM is that there is no unsatisfied demand such as when use of a site is restricted by lottery rationing. Loomis (1982) has suggested a method by which lottery applications rather than trips can be used as the dependent variable in a travel cost model when this is the case.

Advantages, Disadvantages, and Applicability of the TCM

The advantage of the TCM, and the reason it is preferred by many economists, is its reliance on observed behavior. The three primary disadvantages are 1) the problem of determining a value for travel time, 2) the inapplicability of the method for multiple destination trips, and 3) the inability of the TCM to estimate existence and option value. In order to avoid some of the problems inherent in the TCM and because the method is not applicable to certain situations, alternative valuation methods, such as the CVM, have been developed.

Contingent Valuation Method

Introduction

Because the TCM is not applicable to many nonmarket recreational and environmental goods (Dwyer et al., 1977) and because of methodological problems (Bishop and Heberlein, 1979), more attention has recently been focused on the CVM. This method of quantifying the economic value of non-market goods has various applications. It can be used as an evaluative standard to measure changes in flows of natural resource services (Brookshire, Randall, and Stoll, 1980) or hypothetical changes in recreational quality (Donnelly et al., 1985). Or the CVM can be used to estimate benefits which can be compared across different types of recreation or alternative types of recreation utilizing the same resource (HBRS,1985). Also, the values can be compared with market commodity values such as timber harvest or electricity production in a benefit-cost analysis of the economic efficiency of resource allocation (assuming values and not revenues are compared, Rosenthal et al., 1984; HBRS, 1984). Other nonmarket values such as option value and preservation value can only be realistically estimated with the CVM (Brookshire and Crocker, 1979).

Techniques

There is a wide variety of CVM techniques. All of them establish a hypothetical "market" for a commodity to be valued and then ask the respondent to give her best answer "as if" a real market transaction were taking place.

Iterative Bidding

One of the most commonly employed techniques is the iterative bidding process. It is generally administered by personal interview (Randall, Ives, and Eastman, 1974; Brookshire et al., 1980; Rowe, d'Arge, and Brookshire, 1980; Thayer, 1981; Boyle and Bishop, 1984; Donnelly et al., 1985). With this technique, the respondent is asked if she would be willing to pay (WTP), or willing to accept (WTA) as compensation, an initial amount in exchange for a recreational activity or environmental amenity. If the answer is negative, the bid is lowered until an offered bid is accepted. If the initial answer is positive, then the amount is incremented and the respondent is asked again at the new amount. The process continues until a negative response is given. The final bid is a compensating measure of the respondent's consumer's surplus for the commodity being valued, assuming the respondent did not terminate the iterations by simply accepting an amount before the maximum WTP had been reached. Several variations of this technique using different auction formats (first price auction and second price, or Vickrey, auction) have been operationalized and evaluated (Bishop et. al., 1984).

Payment Cards

Another CVM technique uses payment cards. This technique was developed by Mitchell and Carson (1981) to avoid starting point bias (this problem will be discussed in the bias section). Payment cards provide estimates (or "anchors") of the amount people in different income categories paid for selected services. After this information is given to the respondent, he is asked to state his maximum WTP. The response is final, no bidding is involved. This technique has been used by Mitchell and Carson (1981) and by Desvousges et al. (1983).

Contingent Ranking

A new technique, contingent ranking, has recently been employed by Rae (1981) and Desvousges et al. (1983). This technique asks respondents to rank various combinations of money and the item being valued; it assumes that individuals are more likely to be able to order hypothetical combinations of environmental amenities and fees than to directly express their willingness to pay for any specific change in the amenities (Desvousges et al., 1983). The study by Desvousges et al. used two different estimators of the random utility model, the ordered logit and ordered normal, and concluded that the contingent ranking model was consistent with other estimation techniques.

Open-ended Question

The open-ended question technique simply asks respondents to write in their maximum WTP or WTS for a given level of, for example, environmental quality or a river permit. A mean amount calculated from the sample is a measure of average consumer's surplus (Hammack and Brown, 1974; Bishop, Heberlein, and Kealy, 1983). Because of its "fill in the blank" format, this technique appears particularly prone to protest responses and outliers. The data must be screened to discriminate between authentic responses and frivolous or protest responses (Donnelly et al., 1985).

Dichotomous Choice

The dichotomous choice, or take-it-or-leave-it (TIOLI), format presents the respondent with a dollar amount and asks for a yes (take it) or no (leave it) answer. This scenario, while still hypothetical, attempts to more realistically simulate conditions encountered in the marketplace. This technique has been used by Bishop and Heberlein (1979), Bishop et al. (1983) Loehman and De (1982), Desvousges et al. (1983), Sellar, Stoll, and Chavas (1985), and Boyle and Bishop (1984). Hanemann (1984) has developed a utility-theoretic framework for the TIOLI logit analysis. Stynes and Peterson (1984) have reviewed and analyzed different logit models and assessed their applications to recreational choice modeling.

The TIOLI method is based on discrete choice and random utility theory (Domencich and McFadden, 1975; McFadden 1974; Stopher and Meyburg, 1975; Ameniya, 1981). The dichotomous choice response, the yes or no answer, is the dependent variable in a logit equation, with the dollar amounts and other relevant data as the independent variables. Mean WTP is calculated as the area under the logit curve that is estimated through MLE. Recently, Hanemann (1984) has suggested an alternative measure of welfare--the median of the probability distribution rather than the mean. He finds this measure more robust with respect to outliers and therefore more reliable.

The use of the median also addresses the problem of the tails of the distribution. Since bids can not be offered to an infinite point, the integration must be truncated at some point if the mean, or expected value, of the WTP measure is used. There is some disagreement over where to truncate the range of integration (Boyle and Bishop, 1983). Bishop and Heberlein (1979) and Sellar et al. (1985) used the highest offer as their cut-off point. Boyle and Bishop (1983) have suggested truncating at the offer corresponding to the 90th percentile in an attempt to introduce some standard cut-off point.

Hypothetical Markets

The validity and reliability of CVM results has been questioned for two main reasons. First, the respondent's "cost" of being wrong is very low. Since all payments or changes in consumption or quality are hypothetical (Bishop et al., 1984), the respondent does not incur any penalty for failing to accurately or completely reveal her true valuation. This criticism of the CVM assumes the respondent views the situation as completely hypothetical. Second, because the format gives respondents an opportunity to strategize, i.e., project their own goals onto the outcome of the experiment, the respondent again will not truthfully reveal her true WTP. This criticism assumes that the respondent does not completely accept the suggestion of a hypothetical market.

CVM Validity

Because the hypothetically derived values are presented as estimates of a "true" but unknown market value, the only way that they can be validated is by comparison with an actual market "price". But it may be impossible that an exact replication of the experimental situation can ever be constructed in the real world (Sellar et al., 1985). This is the central problem of CVM.

One alternative to validation through real market values is to compare results of a specific technique with the results of other approaches, particularly the TCM, which is based on actual observed behavior. But basic theoretical and practical problems with the TCM such as time value and choice of functional form have led some researchers to believe that the use of TCM "to assess contingent valuation results may be like the blind leading the blind" (Bishop et al., 1984, p. 7). With respect to this statement, it should be noted that while comparisons across methodologies explicitly test for consistency, they do not explicitly test for validity, that is, estimates could be consistently right or consistently wrong.

Comparisons and Reliability

Comparing the "array" of value estimates derived from different methodologies is one way of testing the consistency, but not the validity, of CVM results. Many studies have compared CVM results with values obtained from the TCM, an empirical result based on actual observed behavior, as well as CVM results estimated with the different techniques mentioned above. Bishop and Boyle (1984) have compared three different CVM techniques. Sellar et al. (1984), Walsh et al. (1985) and Donnelly et al. (1985) have compared CVM and TCM. Brookshire et al. (1982) have compared survey and hedonic approaches. Bishop and Heberlein (1979) have compared the TCM, CVM and simulated market (SM). Desvousges et al. (1983), in their comprehensive study of water quality improvements, compare many different methods through various statistical analyses. Hanemann (1983) has re-analyzed the original Bishop and Heberlein (1979) TIOLI data set using both generalized least squares regression analysis and MLE. He found that results differed with respect to the method of parameter estimation, particularly when there are no positive responses to some of the offers. Generally, comparisons of results from different methods has been encouraging but inconclusive.

Some researchers (Walsh et al., 1985) have used different methods to estimate values that are virtually identical. Desvousges et al. (1983) found that the estimates from the TCM and two CVM techniques were consistent, as were the hedonic and survey approaches compared by Brookshire et al. (1982). Others (Bishop et al., 1984; Bishop and Heberlein, 1979) have estimated a range of values that must contain some inaccuracies (given the assumption that the same thing is being measured with different methods). For example, Bishop et al. (1984), using three different types of the CVM, a TCM and an SM, estimated willingness to pay and willingness to sell amounts ranging from $11 to $101. The discrepancy between WTP and WTS is common to most CVM studies and remains an unresolved research problem.

Several different analytical techniques have been applied to comparisons of results of diverse methodologies. Some studies presented their results in tabular form, identifying the different values estimated with each method (Bishop and Heberlein, 1979; Bishop et al., 1983). Others stated that the results from different methods were within a certain percentage of each other (Knetsch and Davis, 1966). As studies have become more sophisticated and results completely analyzed, more complete statistical analyses have been provided (Desvousges et al., 1983; Boyle and Bishop, 1984; Bishop et al., 1984). Other studies have constructed confidence intervals or established upper and lower bounds around each estimate to determine the likelihood of seemingly different values actually estimating the same value (Sellar et al., 1985; Donnelly et al., 1985). One study (HBRS, 1985) used t-tests to compare mean values estimated from three different methods (iterative bidding, TIOLI, and open-ended), and then tested for significant differences in the distributions of values from each method. They concluded that the mean values estimated from the three methods were not significantly different but that the distributions were (HBRS, 1985). The TIOLI and iterative bidding techniques produced a different distribution than the open-ended technique. The study by Desvousges et al. (1983) provides exhaustive statistical analysis of their results and concludes that three different methods produced approximate if not identical results.

Many comparisons of estimated values across methodology seem to implicitly assume that one of the estimates reflects the "true" value of the commodity against which other values can be tested. The rationale for the choice of the indicator method of the "true" value is not always clearly articulated. This is probably a result of the intractable nature of the "bias" problem. Frequently, the TCM is chosen to represent one of the bounds of value because it is based on actual behavior. The exact nature of the discrepancies found in many methodological comparisons and the biases involved remains unclear. Considerable work has been done on identifying sources of error.

Biases

If the economic values provided by CVM are to be useful, they must be consistent and accurate (HBRS, 1984). Consistency can be tested by comparing values across methodologies. The problem of establishing validity through tests for biases is more difficult. Because of its necessarily artificial nature, CVM is subject to generalized sources of error--hypothetical bias and strategic bias, and instrument related sources of error--information bias, starting point bias and vehicle/protest bias. Bias is defined as any factor that causes the individual's stated value, and, by extension, the estimate derived from the individual's stated value, to be different than it would be in a real market situation. It should be mentioned that, as Bishop et al. (1984) point out, the word bias is used somewhat loosely in the literature and that the customary taxonomy of biases fails to provide definitions that are precise and mutually exclusive.

Strategic and Hypothetical Bias

In the past, strategic behavior was thought to have been a major source of bias in the CVM. Strategic bias results when an individual deliberately over- or understates her WTP (WTS) in order to make the final results of the experiment reflect her own goals. Although a hypothetical market situation is created, the respondent is asked to answer questions as if the situation were real. At the same time, respondents are told that their responses will not affect actual charges to be levied now or in the future. If the respondents accept the situation as completely hypothetical, their responses may not reflect actual preferences. However, if the respondents feel their answers may lead to higher "prices" or fees, they may either protect their self-interest by lowering their stated WTP (or raising their WTA) or, if they think they will be exempt from the increased fee, they may overstate their actual WTP and enjoy the benefits as "free riders" (Bohm, 1972). Numerous studies have shown that strategic bias does not have a major effect in hypothetical valuation (Bohm, 1972, 1979; Brookshire et al., 1976; Bishop et al., 1984) and some researchers have suggested that it can be rejected as a critical factor in CVM results (Schulze et al., 1982). However, there is not a consensus on this issue. Cronin (1979) interprets Bohm's (1972) study as showing no strategic behavior in simulated market but showing evidence of strategic behavior in hypothetical markets. In his own study, Cronin (1979) claims to have found evidence of strategic bias in his hypothetical market results.

Hypothetical bias is a source of error caused by the unreal nature of the transaction situation. The respondent may have little or no incentive to provide an accurate value response to the hypothetical question. As mentioned earlier, hypothetical bias may include other sources of error.

Schulze et al. (1981) and Cronin (1979) make the observation that hypothetical bias and strategic bias may be mutually exclusive. If the respondent perceives a situation as totally hypothetical, there will be no impetus toward strategic behavior. Conversely, if the respondent perceives the situation as totally non-hypothetical, i.e., real, there will be a strong impetus toward strategic behavior. In other words, the more strategic bias, the less hypothetical bias; the less strategic bias, the more hypothetical bias. Mitchell and Carson (1981) suggest this problem can be avoided by creating a high realism level to control hypothetical bias and a low consequence level to control strategic bias. Careful survey design is crucial.

Information Bias

The term information bias can be used in two, somewhat different, contexts. Instrument-related information bias is the influence on an individual's valuation that is attributable to the amount of information given to respondents during the survey procedure (Desvousges et al., 1983). Experience-related information bias reflects bias introduced in the valuation when the respondent has little personal information or ability on which to base an accurate estimate of WTP for a good that is not usually priced in dollars.

Much of the problem with information bias in CVM results from the respondent's lack of previous experience, or information, in quantifying (in dollars) the value of an experience or nonmarket commodity or amenity. Since the respondent's WTP (WTS) is either known, unknown, or uncertain to the respondent (depending on the analyst's assumptions), the lack of "good" information on which to base a decision may produce unstable results. Researchers have theoretically demonstrated that hypothetical WTP will, in the absence of strategic bias, be less than or equal to the respondents true WTP as a result of less than perfect information (Hoehn and Randall, 1985). In the absence of strong incentives to carry the information search process to an optimal end (incentives generally lacking in hypothetical market surveys), the search for information will be terminated at some incomplete state short of perfect information and an underestimate of true WTP will result (Hoehn and Randall, 1985).

Some researchers (HBRS, 1984) have suggested that experience level may be regarded as the next best substitute for perfect information, where perfect information would be the certain knowledge by the individual of their WTP. With a sample stratified to include various levels of experience, similar WTP measures would indicate stability of the estimates (HBRS, 1984). However, results of the study using this method have not yet been published by HBRS.

Approaching information bias from a different direction, Thayer (1980) views the hypothetical market respondent as "information poor" and consequently very sensitive to information given out during the survey process. Thayer explicitly tested for this bias by giving different respondents different amounts of information. Thayer (1980) did not find evidence of information bias.

Starting Point Bias

Starting point bias is a problem specifically associated with the iterative bidding technique. This bias can also be viewed as type of information bias. Thayer (1980) has suggested the hypothesis that the final bid is a function of the starting bid. He bases this assumption on a model of the respondent's utility function in which an optimization process integrates the utility of giving a correct answer as opposed to the disutility of spending time in the bidding process; it is assumed in this model that the individual knows her WTP. The hypothesis is then tested by regressing the independent variable, the starting bid, on the dependent variable, the final bid. Using this procedure, Thayer found the regression coefficient not significantly different from zero--the starting bid had no effect on the final bid; however, he employed only two different starting bids.

Bishop et al. (1984) suggest that the respondent does not actually know her WTP and therefore uses the starting bid as information, a "ballpark" figure, for what the appropriate final bid should be. Using starting bids ranging over a wide interval, they found evidence of starting point bias in three different CVM studies but not in an SM study. Other researchers have also concluded that the starting bid has a significant effect on the final bid (Brookshire and Crocker, 1979; Rowe et al., 1980; Desvousges et al., 1983). Taking the problems of information and starting point bias together, it is clear that the amount of information possessed by the respondent going into the valuation process, and the type and amount of information given the individual during the valuation process, are both potentially influential and should be carefully evaluated.

Vehicle Bias

Vehicle bias is another possible source of error in CVM. Proper survey design should provide a realistic and familiar setting for the respondents to state their WTP for a clearly defined "product" and should present an appropriate vehicle of payment. Failure to do so can result in either biased responses or unusually large numbers of protest responses. In other words, the respondents must understand the trade-offs involved and be presented with a non-controversial and equitable method of transaction. In their study of option value and water quality, Greenley, Walsh and Young (1981) used two different payment vehicles, a sales tax (which everyone, including tourists, would face) and a water-sewer fee (which only property owners would face). They found WTP very sensitive to method of payment; the WTP through water fees was one quarter that of a sales tax payment.

Protest Response Bias

Some researchers (HBRS, 1984) suggest viewing protest responses as a subset of vehicle bias. Protest responses can be either zero bids or extremely large, unrealistic bids. In both cases, the protest bids must be distinguished from genuine zero bids or truly high bids that do reflect user preferences. Techniques for identifying various kinds of protest bids can be found in Desvousges et al. (1983) and Desvousges, Smith, and Fisher (1983).

Simulated Markets and CVM Validity

Some recent studies have attempted to reduce the hypothetical nature of CVM by creating an SM in which actual cash transactions take place (Bishop and Heberlein, 1979; Bishop et al., 1983; Bishop, et al., 1984). These studies attempt to introduce a market-based validity criterion for estimates of the "true" value parameters.

Their results suggest that CVM WTP is an underestimate and WTA an overestimate of respondents' actual values.

<u>WTP versus WTS in Hypothetical and Simulated Markets</u>

The theoretical equivalence of different measures of welfare (and welfare change) has failed to be empirically verified in many studies. The equivalence of WTP and WTS was tested in a study by Coursey, Hovis, and Schulze (summarized in Cummings, Brookshire, and Schulze, 1984). Using a combination of hypothetical and simulated market (auction) techniques in a laboratory setting, the results of this study suggested that WTP is less prone to hypothetical bias than is WTS. This result seems to be empirically supported by many other studies, possibly because of assumptions about property rights to the resource and the compensating and equivalent meausures associated with the initial welfare positions. Despite varying potentials for bias, it is still felt by some researchers (HBRS, 1984) that both measures of welfare, WTS and WTP, should be estimated for theoretical and empirical reasons.

<u>Indirect Assessments of CVM Validity</u>

Assessments of the validity of CVM results can be approached in three ways. First, the methodology must be checked for specification error. Each method should be based on an internally consistent and logical theoretic framework. For example, Hanemann (1984) points out that the functional form (taking the logarithm of the offer) used in the initial TIOLI experiment of Bishop and Heberlein (1979) was not based on utility theory.

Second, the theoretic measure of value must be consistent with the method employed and must be accounted for when compared with other estimates. Three measures of consumer surplus are commonly used: Marshallian, compensating, and equivalent measures. Freeman (1979) and Randall (1983) analyze these measures and show that each measures something different and has a different meaning. Freeman adds that the differences appear to be small for most realistic cases and are probably smaller than errors in parameter estimation by econometric methods (Freeman, 1979). This conclusion concurs with Willig's (1976) assertion that differences between compensating variation, Marshallian consumer's surplus, and equivalent variation are generally small given certain restrictions on income elasticity and the magnitude of the ratio of consumer's surplus to income.

Third, measurement error can be controlled through correct survey instrument design and monitored by including in the instrument, indicators of bias that can be cross-referenced to detect discrepancies across observations (Thayer, 1981; Cronin, 1982).

Conclusion

Bishop et al. (1984) conclude that bias in CVM appears to be inevitable but the degree of bias does not appear great enough to preclude the use of CVM estimates in decision-making. In order to improve CVM techniques and assess their proper application, including a better understanding of the sources of bias and means by which bias can be controlled, Bishop et al. (1984) recommend "carefully designed and executed field and laboratory experiments involving multidisciplinary teams of social scientists..." (p. 33). They argue that a large program of research on contingent valuation is "long overdue." Randall et al., (1983) also suggest that the first phase of CVM research, showing that it "works," is over and a second phase of further development should now begin.

SURVEY METHODS AND PROCEDURES

The Study Area

The Rogue River is one of the best known whitewater rivers of the Pacific Northwest. It provides a wide spectrum of recreational opportunities, from fishing and whitewater boating to cultural and historical sites. The river has been under federal management since 1968 by virtue of the National Wild and Scenic Rivers Act. Eighty miles of the river are classified as either wild, scenic, or recreational. The forty mile "wild" section of the river, from Grave Creek to Watson Creek, contains the most spectacular scenery and best whitewater. Permits are required for use of this section of the river, and since 1983 a lottery system has been used to distribute permits to potential river users.

The data for this study were obtained from surveys mailed to non-commercial recreationists who were on the Rogue River in the summer of 1984 during the permit season (Johnson, Shelby, and Bregenzer, 1986). The permits for non-commercial users are allocated by the USFS, while commercial use is regulated by the BLM. The study surveyed only non-commercial users.

Sampling Procedures

The study population consisted of three subsets: 1) permit holders who received their permits through the January lottery, 2) permit holders who received their permits after the lottery through either a phone-in distribution of unused commercial permits or through use of a no-show permit, and 3) non-permit holders who were passengers in a permit holder's party. Samples of the first two groups were randomly selected from the total population of permit holders. The passenger sample was randomly selected from the list of passengers that the Forest Service required of each permit holder. Each sub-sample consisted of 200 respondents, for a total sample of 600. The total sample was then divided into two groups of three hundred, one group to receive the open-ended CVM question, the other to receive the dichotomous choice CVM question.

Potential respondents were sent surveys with a cover letter (with the OSU letterhead) explaining the purpose and nature of the study. A follow-up post card was sent within a week and a follow-up letter was sent approximately three weeks after the initial mailing. Finally, a second survey was sent to the open-ended CVM group and a second follow-up letter was sent to the TIOLI group. Both were sent by registered mail.

From the initial mailing of 600 surveys, ten were undeliverable or otherwise unusable. Of the remaining 590, 466 were completed and returned, a response rate of 79%. As expected, the response rate for lottery permit and non-lottery permit holders was higher than passengers in both sub-samples. Also, the group receiving a second survey had a slightly higher response rate. Although no follow-up contact of non-respondents was made, because of the stratified cross-section of river users contacted and the high response rate, it is hypothesized that the survey sample is representative of the population of river users.

Survey Procedures and Areas of Interest

The river survey focused on four areas: 1) the valuation of benefits by the TCM (individual and zonal) and by the CVM (both open-ended and TIOLI, 2) users' socioeconomic characteristics, 3) the lottery rationing techniques and their effects on user behaviors and perceptions, and 4) users' attitudes towards and perceptions of their river experience. This study focuses only on the first two areas. Sections of the Rogue River survey relevant to this study can be found in Appendix A; all of the results of the Rogue River survey can be found in Johnson, Shelby, and Bregenzer (1986).

To construct a demand model based on travel costs, information is needed about users' travel and time costs. Questions were asked regarding the time spent traveling, distance traveled, number of people traveling together, purpose of trip (only to the river or multi-purpose), percentage of time devoted to purpose(s) of trip, days on the river, time off from work, income lost from time off, amount of yearly vacation, and county of residence.

Respondents were also asked for their estimates of transportation, lodging, shuttle, food, and other expenses. Calculated travel costs can then be cross-referenced with users' perceived travel costs. To establish a monetary "cost of time" or opportunity cost, respondents were asked their willingness to pay to reduce travel time to one half hour (see survey in Appendix A).

Substitutability is a potentially important variable in the TCM (Cichetti, Fisher, and Smith, 1976). Respondents were asked, if they had been unable to obtain a permit for the Rogue and still wanted river recreation, what river they would visit instead of the Rogue River.

In order to provide an accurate profile of river users, respondents were asked questions regarding their age, sex, education, income, marital status, number of children, primary occupation, and work status. This provides information of who is using the river as well as control variables for valuation and other analyses.

The survey explored users' attitudes and behavior toward the permit system. Respondents were asked if they applied for a permit through the lottery, and if not, why. The effect of the permit system on the number of trips taken was measured by questions asking for the number of trips that were actually taken followed by a question asking the number of trips that would have been taken if there were no lottery system.

TCM BENEFIT ESTIMATION: METHODS AND RESULTS

The zonal TCM is an indirect method of benefit estimation that uses demand models estimated with regression analysis, frequently ordinary least squares (OLS). Regression analysis is a statistical tool that uses the relation between two (or more) variables to predict one variable from the other(s) (Neter, Wasserman, and Kuter, 1983). The regression coefficients estimated with OLS will have minimum variance among all unbiased linear estimators. However, if the estimated models are to be subjected to statistical testing, assumptions must be made about the error terms, or residuals, the difference between the predicted and actual value of the dependent variable. Generally, it is assumed that the error terms are normally distributed, i.e., $N(m, \sigma^2)$. This assumption requires constant variance of the error terms over all observations and uncorrelated independent variables. If the assumption of constant variance is not met, then inconstant variance, or heteroscedasticity, results. If heteroscedasticity is present, but the other conditions of OLS are met, the estimated coefficients are still unbiased and consistent, but they are no longer minimum variance unbiased estimators (Neter et al., 1983). If there is a strong correlation between independent variables, multicollinearity results.

The first step in building a demand model is the evaluation of the model for its consistency with economic theory; for example, a price variable would be expected to have a negative effect on the variable representing quantity demanded, hence the coefficient would be expected to be negative. If the expectations based on theory are satisfied, the model can then be evaluated econometrically.

There are various formal and informal diagnostic techniques for measuring the presence of multicollinearity and heteroscedasticity. If the results are satisfactory, the model can be further evaluated for its goodness of fit through the T-statistics, R^2, and F-test. The following section details the selection of a demand model in light of the preceding criteria.

The Model

The travel cost method (TCM) can be implemented through either the individual observations model or through the zonal model. Since it has been shown that the individual model is more efficient (Brown et al., 1973), it is the preferred approach. Unfortunately, a model that predicted visits reasonably close to actual visits could not be developed using the adjusted individual observation approach suggested by Brown (1984) or by other techniques suggested by Loomis (1984). These adjustments to the dependent variable are necessary when a truncated ordinary least squares regression model is used. The dependent variable, visits, resulted from a sample consisting of only those who made the trip; the data set did not contain observations for those who make zero trips. Computing Olsen's (1980) adjustment coefficient from the individual observation data suggested the presence of truncation bias.[7/] The failure to construct an adequate individual observation model apparently results from the large number of people taking only one trip (approximately 66% of all observations) regardless of distance to the site, the independent variable (Freeman, 1979). The combination of the lottery allocation system, the expense, and the lumpy nature of the good seems a probable cause for this. A maximum likelihood approach was considered but time constraints prevented the inclusion of those results in this study.

Given these problems, the second best approach, the zonal model, was used. This approach compensates for the limited dependent variable/truncation bias (through a per capita measure of visits) and, through aggregation, mitigates the problem of one-trip observations.

Data for the TCM (see Table 1) were taken from the Rogue River study (Johnson, Shelby, and Bregenzer, 1986). The zones were established by using the county of

7/ The truncated distribution mean divided by its standard deviation gave an adjustment factor of 2.0 (see Olsen, 1980, Table 1).

Table 1. Zonal TCM Data for Travel Origins in Oregon, Washington, and California.

Zone	Visits	Pop.(K)	Income(K)*	One way distance (miles) to: Rogue	Deschutes	Klamath
1	11	59	30	25	303	103
2	4	17	31	50	368	271
3	23	132.5	42	59	273	73
4	2	94	42	88	225	175
5	7	64	38	95	311	246
6	2	59	35	133	195	5
7	11	275	48	152	148	241
8	3	333	22	176	336	136
9	7	157.5	36	195	165	283
10	8	83	27	210	54	146
11	4	250	42	218	186	308
12	4	55.5	62	235	135	338
13	2	56.5	48	244	238	360
14	4	242	42	249	100	350
15	7	246	42	259	120	335
16	10	562.5	38	264	97	355
17	2	192	22	266	104	362
18	1	49	38	273	63	197
19	2	1515	54	280	144	402
20	8	1939	38	350	466	266
21	10	2197.5	42	407	260	518
22	11	5483	26	420	557	357
23	2	508.5	40	453	313	569
24	7	370	30	485	185	450
25	4	12346	34	705	894	684
26	1	2525	60	838	1011	698

*Average income of all visitors from zone.

residence item from the Rogue River survey. Of the original sample of 466 observations, only 156 were used in the zonal TCM model. Certain observations were eliminated from the original data set to satisfy the theoretical requirements of the TCM.

First, observations were used only if the visit to the site was the only purpose of the trip. Second, observations were not used if respondents indicated they would have taken more trips than they actually did _if_ there had been no lottery. This "screening" was necessary to identify the marginal users--to satisfy the theoretical requirement that demand not exceed supply--and to target those users for whom visiting the Rogue River was the only purpose of the trip. Third, observations from very distant origins (such as Connecticut and Missouri) were excluded from the model so that origin zones could be constructed without having to account for large areas with no visits. As a result, the zones delineated were all within the state boundaries of Oregon, Washington and California. Although it has been theorized that there are spatial limits imposed on the TCM through its assumptions (Smith and Kopp, 1980), this study did not explicitly test the limits of the model.[8/]

8/ Smith and Kopp defined the spatial limits of the model in their study as 675 miles from the recreation site but the limits are site-specific. For example, Lampi's (1986) study of cross-country skiers in Mt. Hood National Forest had its most distant zone at approximately 100 miles.

The zonal model takes the following general form:

$$VC_i = f(P_i, S_i, D_i) \quad (29)$$

where VC_i = visits per capita from zone i,

P_i = price per person per trip to the site,

S_i = the price of substitutes,

D_i = demographic characteristics of users.

Variable Specification

The specification of the travel cost variable 1) involves a determination of the respondents' cost (per mile) of travel and 2) a determination of the opportunity cost of time. If the respondent's perceived costs are assumed to be the determinants of travel cost, then the cost variable should represent only perceived costs; for most consumers that is the cost of gasoline. A counter argument would suggest that the total cost of travel should be used. A figure of $.25 per mile, which is the amount cited by the Oregon State Highway Department as the cost of owning and operating an automobile, would then represent the total costs faced by the consumer when visits are made to a recreation site. Other studies have used the marginal cost of operating a automobile, which reflects gas, oil, and general maintainence but not fixed costs such as insurance (Smith et al., 1983; Lampi, 1987).

There is some support for the use of the cost of gas alone as the amount used by consumers in decisions regarding the number of trips to take. Support for the

$.05 per mile figure comes from the Rogue River study (Johnson, Shelby, and Bregenzer, 1986). Respondents were asked to give their transportation costs; the median amount was $20.48. Dividing this amount by 450 miles (the average round trip distance), gives an average per mile cost of $.0455 per mile. Additional support for this figure, and the consumer decision-making framework on which it is based, comes from a study by Lampi (1987).[9/] Since the TCM model used for benefit estimates apportions costs among the number of individuals riding in the same car, gasoline costs may be an appropriate figure to use if these appear to be the costs most likely to be shared by individuals traveling together.

The marginal cost of operating an automobile represents direct costs faced by the consumer, whether perceived by the consumer or not, at the margin. As such, it would seem to be the correct figure if the assumption is made that this is the actual cost faced by the consumer. A cost of $.15 per mile approximately represents marginal costs (Desvousges et al., 1983), that is, costs excluding fixed costs such as insurance, which do not enter into the decision to take an additional trip.

[9/] Lampi (1987) surveyed 273 cross-country skiers in Oregon. When asked about their travel costs, 162 said they were "not sure" but stated that the price of gas was used in their decision. The remaining 111 gave a figure of approximately $.05 per mile.

The determination of the opportunity cost of time is problematic in TCM models. Since identification of the correct opportunity cost is currently a matter of contention among researchers (Desvousges et al. 1983), the model was run using zero opportunity cost of time, one-fourth, one-half and the full wage rate, where the wage rate is $18 per hour.[10/]

There is little support for the use of zero time costs: "theory does imply that travel time should be valued by an opportunity cost" (Desvousges et al., 1983, page 7-10). However, the zero time cost estimate is presented as illustration of the effect of time cost choice and for comparability with other studies that have presented the zero time cost estimate.

Support for the use of a fraction of the wage rate comes from the Rogue River study. Of 446 respondents, 57% said they took time off from work to allow time for preparing for the trip, traveling to and from the river, or running the river. These respondents gave their average loss of income due to taking time off as $230. Dividing this amount by the average trip length (4 days) give $57.50 per day lost or approximately $7.20 an hour,

10/ The $18 per hour figure is calculated by taking the weighted average of zonal per capita incomes given in Table 1, with the total number of respondents equal to 153. Approximately the same figure can be calculated from the Rogue River survey (N=446) in which average household income of river users, $36,000, divided by 52 weeks per year and 40 hours per week gives an average wage rate of $18.30.

based on an eight hour work day. Assuming an $18 per hour wage rate, this is 40% of the wage rate. This survey item shows a majority of river users, 57%, trading off income for travel and onsite time.

Another question on the Rogue River survey asked respondents their WTP to reduce travel time to the site to one-half hour. Of 315 responses, 36% said zero and 64% gave a positive dollar amount averaging $38.40. Dividing this amount by the average travel time, 6.5 hours, gives a per hour value of approximately $5.90, or one third the wage rate. This survey item shows a majority of river users, 64%, placing a significant opportunity cost value on their travel time.

McConnell and Strand (1981) point out that opportunity costs, while reflected as some fraction of the wage rate, will vary across recreation sites. Consequently, the results of other studies may be of dubious value in this particular study. Nonetheless, other studies do support the use of a significant fraction of the wage rate: McConnell and Strand (1981), 60% of the wage rate; Bishop and Heberlein (1979), 1/2 the wage rate for TCM to approximate actual value; Ward (1982) travel time value equal to $7.10 per hour. Water Resources Council (1979) suggests the use of 1/3 the wage rate.

The use of the full wage rate and 1/3 the wage rate has been tested by Desvousges et al. (1983). Using a hedonic wage model that generates specific wage rates for each individual separate from the reported family income, they were unable to conclusively reject either figure, hence the ambiguities involved in the choice of different opportunity costs of time remain unresolved. Unlike the Desvousges et al. study, this study uses the respondents' stated total household income to determine the wage rate.

Other studies have used a very low or zero percentage of the wage rate. Winston (1981) suggests the use of 6% of the wage rate and a study by Walsh et al. (1983) found that a significant number of visitors to Colorado rivers found travel either of positive utility or were indifferent towards their travel costs. Consequently, Walsh et al. did not include opportunity cost of time in their model.

In summary, it seems that the evidence from the Rogue River study in combination with other studies, <u>tenatively</u> suggests that 1) there is an opportunity cost of time, 2) that cost is some fraction of the wage rate, and 3) that fraction is likely to be between 1/4 and 1/2 of the wage rate. If an average speed of 50 MPH is assumed, then 1/2 the wage rate represents a per mile time cost of 18 cents. For 1/4 the wage rate, the per mile cost is 9 cents. Although the opportunity cost of time is different with respect to each individual, the aggregation process of the TCM should not significantly alter the benefit estimate with respect to the opportunity cost of time. It should also be noted that in the TCM time costs do not need to be explicitly identified as the value of wages foregone. Time costs also function as a representation of the deterrent effect of increased travel time on the visitation rate from increasingly distant zones.

The cost variable, time costs plus travel costs, was computed by converting distance into dollars. For travel costs, this was accomplished by multiplying round-trip distance by either five, fifteen, or twenty-five cents per mile, the average cost of travel by car (depending on the assumptions of the analyst), and dividing that figure by three, the average number of people traveling together (equal sharing of all costs is assumed). The cost of travel time was computed by dividing total distance by average car speed (50 MPH) and multiplying that figure by the wage rate, or some fraction of the wage rate.

The second stage of the TCM is the estimation of the site demand curve. It is derived from the trip demand curve by incrementing the cost variable until a price is reached at which the number of visits is zero, the choke price.[11/] The area under this curve and above the price

[11/] With the semi-log dependent model, the demand curve approaches the price axis asymptotically (Smith and Kopp, 1980). Consequently, there will be no choke price when demand is econometrically driven to zero in the second stage of the TCM. This is taken into account in CS estimation through an (iterative) truncation procedure (Rosenthal and Donnelly, 1985).

line[12] represents total consumer's surplus. This area divided by the number of visits provides an estimate of the average WTP for access to the river over and above the recreationist's incurred costs. Mathematically, this can be expressed as

$$CS_i = \int_{p_i}^{P*} F(p_i)\, dP \qquad (32)$$

where CS is the consumer's surplus for an individual facing price p_i, P* is the price at which no trips would be demanded. The demand function is Q=F(P), P is price.

The Rocky Mountain Travel Cost Model (RMTCM) software package (Rosenthal and Donnelly, 1985) was used for exploratory model fitting, regression diagnostics and estimation of consumer's surplus, given alternative assumptions about travel cost and opportunity cost of time.

A number of different functional forms have been used to model demand including the linear, quadratic, semi-log, and double-log. Table 2 shows the different functional forms tested and the regression coefficients estimated from the Rogue River zonal data set and the test statistics used to evaluated goodness of fit.[13]

12/ There is a $5 per party permit fee but if this cost is shared by other party members (average size:7) then the cost is negligible relative to total expense of the river trip; the permit is not calculated as a price.

13/ The R^2 from models with VPC and ln VPC as the dependent variable can not be directly compared with each other (Rosenthal and Donnelly, 1985).

Table 2. Alternative Functional Forms for the Zonal TCM. (n = 26)

FUNCTIONAL FORM: Dependent Variable	Independent Variables	Coefficient	T statistic	R^2* (SEE)	F
Linear:					
VPC	constant	.00012	2.4	.358	6.4
	TC	-.0000058	3.5	(.00003)	
	INC	-.0000002	.025		
Quadratic:					
VPC	constant	.00019	4.9	.632	12.5
	TC	-.00002	5.3	(.00005)	
	TC2	-.000006	4.0		
	INC	-.00019			
Semi-log Independent:					
VPC	constant	.00111	.369	.674	23.8
	ln TC	-.000065	6.80	(.00005)	
	ln INC	.000006	.22		
Double-Log:					
ln VPC	constant	-13.37	1.7	.691	25.6
	ln TC	-1.762	7.2	(1.428)	
	ln INC	.56	.75		
Semi-log Dependent:					
ln VPC	constant	-9.45	15.15	.802	46.6
	TC	-.23864	9.62	(1.540)	
	INC	.000018	1.18		
Semi-log Dependent:					
ln VPC	constant	-9.37	14.50	.812	23.2
	TC	- .2215	3.79	(1.550)	
	TC SUB1	-2.8	1.00		
	TC SUB2	.00859	.15		
	INC	.000017	1.00		

Cost variable = $.15 per mile. Time cost = $0.
VPC=visits per capita, TC=travel cost, INC=income,
TC SUB1 = travel cost to substitute site--Deschutes,
TC SUB2 = travel cost to substitute site--Klamath.
ln indicates base e logarithmic transformation.
*Unadjusted.

The chosen functional form was the semi-log dependent

$$\ln VPC_i = B_o + B_1 C_i + B_2 INC_i \qquad (30)$$

where $\ln VPC_i$ is the natural logarithm of visits per capita, C_i is costs (travel costs plus time costs), INC_i is the average income of visitors from zone i and B_o, B_1, and B_2 parameters to be estimated.

This form had statistically significant t-values at the .001 level for the constant and the travel cost coefficients, but the income coefficient was only significant at the .87 level. Nonetheless, the income variable was kept in the model to avoid omitted variable bias. The F statistic was 46.6; the null hypothesis that all regression coefficients are simultaneously zero can be rejected at the .001 level. This form also had a relatively high coefficient of determination, .802. The signs of the coefficients are consistent with economic theory: the price variable is negative, the income variable is positive.

The logarithmic transformation appears to control heteroscedasticity (Strong, 1983). An examination of a plot of the residuals against the predicted dependent variable showed a distribution with a random pattern. To test for multicollinearity, the model was run after deleting one of the independent variables (income); no great change in the magnitude or sign of the other variable (travel costs) was observed. Secondly, one independent variable was regressed on the other. The coefficient of determination was .045 and the correlation coefficient was .212, indicating the absence of pronounced multicollinearity. Using the form in Eq. (30) the following trip demand model was estimated (t-statistics are in parentheses):

$$\ln VPC = -9.45 - .23864\ TC + .000018\ INC \qquad (31)$$
$$\qquad\quad (15.1) \quad (9.62) \qquad\qquad (1.18)$$

$$R\ squared = .802 \qquad\qquad F = 46.6$$

This model predicted the number of visits within 13% of the actual number of visits, indicative of a good model (Loomis, 1984).

A model was estimated that included substitutes (Rogue River survey respondents listed the Deschutes and Klamath rivers as the most likely substitutes for the Rogue) but they were significant only at unacceptable levels of probablility (.85 for the Deschutes and .56 for the Klamath) and were dropped from the model.

Results

The benefit estimates in terms of Marshallian consumer's surplus using \$.05, \$.15, \$.25 per mile are listed in Table 3. In the subsequent sections of this study, the travel cost variable will be specified as \$.15 per mile. It will also be assumed that the opportunity cost of time is between 1/4 and 1/2 the wage rate. These two fractions will be used as upper and lower limits in lieu of definitive specification of time costs.

Table 3. TCM per Trip Values with Cost Variable Equal to $.05, $.15, and $.25 per Mile with Differing Opportunity Costs of Time.

	CONSUMER'S SURPLUS		
TIME COST	$.05/mile	$.15/mile	$.25/mile
$0	$ 3.63	$10.80	$18.00
$4.50/hour (1/4 wage rate)	23.99	30.14	37.27
$9/hour (1/2 wage rate)	42.27	49.45	56.60
$18/hour (full wage rate)	81.03	88.14	95.39

CVM BENEFIT ESTIMATION: METHODS AND RESULTS

Open-ended Question Methods

The open-ended CVM is a method for directly estimating the willingness to pay for, or the willingness to sell, access to the Rogue River. It directly estimates a Hicksian, compensating measure of welfare.

During the lottery "season," users do not have access to the Rogue River without a permit. For the WTP item, when respondents were asked to state the maximum amount they would pay for a permit, the survey instrument was hypothesizing a price-rationing market, and asking people to respond to that hypothetical market. For the WTS item, respondents were asked to consider a hypothetical market in which they already held a permit and someone was offering to buy it from them.

Instrument-related information bias is hypothesized to be uniform because all respondents receive the same amount of information in the question, in this case, none (aside from establishing the hypothetical market). Experience-related information bias is expected to be minimized, but not completely absent because respondents already pay for a permit and, therefore, already have some experience in "valuing" their permit. However, most respondents presumably have little experience in determining their <u>maximum</u> willingness to pay. Vehicle bias is hypothesized to be minimal because respondents are already familiar with a permit as a payment vehicle. Also, the contingent market attempts to present a clear scenario of the trade-offs involved in the market by what is being offered, access to the river, and what is to be exchanged, dollars. Strategic bias and hypothetical bias are minimized by introducing by a high level of realism and, simultaneously, a low consequence level. The WTP and WTS items can be found in Appendix A.

Surveys employing the open-ended CVM question were sent to three hundred Rogue River users. Of these 300 surveys, 8 were undeliverable and 248 survey were returned, an overall response rate of 85%. Respondents from the three sub-groups sample were not significantly different in their mean response to the open-ended question at the .05 level (Least Significant Difference procedure).

The survey did not incorporate an explicit test for "true" zero responses versus "protest" zero responses, although most protest zeros were readily identifiable. Of the 248 surveys, 92% showed a positive dollar amount in response to the WTP question. The remaining surveys contained either a zero, a written protest or no response. The pattern for WTS was similar but with more zeros and protests, only 76% of the responses showed a positive dollar amount. The results for WTP and WTS do <u>not</u> include zero responses since these were most often clearly identified as protests. Also, one outlier was deleted from WTP and one from WTS. Both outliers were approximately ten standard deviations from the mean.

Open-ended Question Results

Results for the WTP item are shown in Table 4. The mean estimate of WTP (per trip) is $32.66. The median was $25.00 with a range of $1 to $200. The most commonly occurring value was $50. A 95% confidence interval has a lower bound of $28.30 and an upper bound of $36.99.

Table 4. Open-ended CVM WTP per Trip Results.

Mean	$32.66	95% CI:	$28.30---$36.99
Median	$25.00	99% CI:	$27.72---$37.60
Range	$1-$200		
Mode	$50.00		
SD	$33.66		
SE	$ 2.21		N = 229

Results for the WTS (per trip) item are shown in Table 5. The mean estimate was $146.56. The median was $50 with a range of $1 to $1000. The most commonly occurring value was $50. A 95% confidence interval has a lower bound of $115.20 and an upper bound of $177.92.

Table 5. Open-ended CVM WTS per Trip Results.

Mean	$146.56	95% CI:	$115.20---$178.11
Median	$ 50.00	99% CI:	$110.78---$182.34
Range	$1-$1000		
Mode	$ 50.00		
SD	$219.80		
SE	$ 16.00		N = 188

The hypothesis that WTP = WTS can be rejected at the .001 level. Of the 193 surveys that had a positive values for both the WTP and WTS item, 39% showed WTP = WTS, 7% showed WTP > WTS, and 54% showed WTP < WTS. The discrepancy between WTP and WTS is discussed in a following section.

Dichotomous Choice Welfare Measurement Models

The decision to include the TIOLI CVM format in the study was a response to the problems of hypothetical bias and information bias, the recognition of the need for further empirical testing of this relatively new valuation technique, and the accompanying recent advances in discrete choice theory. The following section presents the general framework for the implemented TIOLI model and closely follows Hanemann's (1984) treatment of the subject.

The dichotomous choice logit model is based on a random utility model of consumer decision making. Let an individual face J mutually exclusive alternatives, only one of which may be chosen; in this study there will be two alternatives, so j = 0,1. Zero represents the case in which a hypothetical amount is not paid (a "no" response) and the respondent does not have access to the river, and 1 represents payment of the hypothetical amount (a "yes" response) and the right of access to the river. If the individual has access to the river, the utility function is $U_1 = U(1,y;s)$; if not, then $U_0 = U(0,y;s)$, where y represents income and s is a vector representing characteristics of the individual. U_1 and U_0 are random variables to the analyst, and can be separated into a deterministic part and a stochastic part as

$$U(j,y;s) = V(j,y;s) + e_j, \qquad j = 0,1 \qquad (33)$$

where $V(j,y;s)$ is the deterministic part of the utility function, e_j the stochastic part, and j is the alternative choice index. e_o and e_1 are assumed to be independently and identically distributed (i.i.d.) random variables with zero mean. (The s vector will be suppressed in the following discussion to avoid notational clutter but it remains an argument in the utility function.)

Given the utility functions specified in Eq. (33), the individual will decide to pay for a good or service if the utility of having it, and having income reduced by the price, is greater than not having the good or service and having full income, Y. If the price that the individual faces is $A, then the individual will respond yes to an offer of $A if

$$V(1, Y-A) + e_1 > V(0, Y) + e_0. \qquad (34)$$

Otherwise, the individual will respond no. Since U_0 and U_1 are random variables to the analyst, the probability that the respondent will say yes is given by

$$P_1 = \text{Pr (individual is willing to pay)}$$
$$= \text{Pr } \{V(1,Y-A)+e_1 > V(0,Y)+e_0\} \qquad (35a)$$

$$P_0 = \Pr \text{ (individual not willing to pay)}$$
$$= 1 - P_1. \qquad (35b)$$

Rearranging terms, Eq. (35a) can be rewritten as

$$P_1 = \Pr \{V(1,Y-A) - V(0,Y) > e_0 - e_1 \qquad (36)$$

Isolating the right hand side of Eq. 36, let n denote a random variable that is equal to the difference ($e_0 - e_1$). This random variable will have some cumulative distribution function (c.d.f.), denoted by F_n (.). By definition (Pindyck and Rubinfeld, 1981), the probability that an observed value of n will be less than or equal to any particular n is equal to the c.d.f. of n. Therefore, the probability of a yes response to the WTP question can be written as

$$P_1 = F_n (\Delta V) \qquad (37)$$

where

$$\Delta V = V(1,Y-A) - V(0,Y). \qquad (38)$$

The type of distribution that F_n takes is unknown, so assumptions must be made to specify the model. In the logit model, the assumption is made that F_n (.) is the c.d.f. of a standard logistic variate, resulting in the functional form

$$P_1 = F_n (\Delta V) = (1 + e^{-\Delta V})^{-1} \qquad (39)$$

or

$$P_1 = \frac{1}{1 + e^{-\Delta V}} \qquad (40)$$

A similar derivation can be made for willingness to sell where the probability that an individual will say yes to a an offer, \$A, is

$$P_0 = \Pr \text{ (individual is willing to sell)}$$
$$= \Pr\ V(0,Y+A)+e_0 > V(1,Y)+e_1 \qquad (41a)$$
$$P_1 = \Pr \text{ (individual is not willing to sell)}$$
$$= 1 - P_0 \qquad (41b)$$

The derivations above make it clear that the argument in F_n (.) involves the difference in utilities, ΔV. If a functional form is specified for $V(j,y)$, then the statistical model to be estimated can be derived by calculating the difference, ΔV. This model will be consistent with utility theory. For example, if

$$V(j,y) = a_j + B\ Y, \quad j = 0,1 \qquad (42)$$

then

$$\Delta V = a_1 + B\ (Y-A) - a_0 + B\ Y$$
$$= a_1 - a_0 - B\ A. \qquad (43)$$

Let $(a_1 - a_0) = a$, then write the choice model to be estimated as

$$P_1 = F_n\ (a - B\ A). \qquad (44)$$

An alternative to the linear model in Eq. (42) is

$$V(j,y) = a_j + B \ln Y, \quad j = 0,1 \qquad (45)$$

which gives

$$\Delta V = (a_1 - a_0) - B \ln (1 - A/Y)$$
$$= a - B\ A/Y \qquad (46)$$

Following from Eq. (44), the logit model estimated when the linear functional form is specified is

$$P_1 = \frac{1}{1 + e^{-(a - B\ A)}} \quad (47)$$

Given the binary response model developed above, welfare measures that are consistent with utility theory can be estimated. For WTP, the dollar amount representing an individual's maximum WTP, M, is to be determined by the value of M that satisfies the equation

$$U(1,\ Y-M) = U(0,Y) \quad (48)$$

where M is a random variable whose c.d.f. is denoted by G_M (.). When an individual is confronted with an amount, \$A, for, say, a river permit, she will pay the amount if M, the individual's maximum WTP, is greater than \$A. Therefore, the probability that an individual will pay the amount \$A is

$$P_1 = Pr\ \{M > \$A\} = 1 - G_M\ (\$A) \quad (49)$$

There are a number of ways to estimate the value of M. One is to calculate the average WTP, the mean of the distribution G_M (.), called M+, which is

$$M+ = \text{expected value } \{M\} = \int [1 - G_M\ (\$A)\ dA \quad (50)$$

A second estimate of M, M*, is the median of the distribution. This is defined as the amount of money needed to keep the individual just at the point of indifference between paying for the permit and doing without. The median is defined as

$$Pr\ \{U(1,Y-M^*) => U(0,Y)\} = .5 \quad (51)$$

Another way of interpreting this relationship is to say there is a 50:50 chance that the individual will buy the permit at the amount M*. If $\Delta V\ (M^*) = V(1,Y-A) - V(0,Y)$, then

$$\Pr\ \{F_n < \Delta V(M^*)\} = F_n\ \{(\Delta V(M^*)\} = .5. \qquad (52)$$

With the logistic c.d.f., $F_n\ (0) = .5$, therefore M* satisfies $\Delta V\ (M^*) = 0$. With the model,

$$V(j,y) = a - B\ Y, \qquad j = 0,1 \qquad (53)$$

M* is the value at which

$$a_1 - B\ (Y-M^*) = a_0 - B\ Y \text{ or } M^* = a/B. \qquad (54)$$

The welfare measures above can be related to the utility theory discussed earlier by comparing Eqs. (37) and (49). This clearly shows the relationship between F_n (.) and $G_M(.)$ as

$$P_1 = F_n\ \{\Delta V\ (A)\} = 1 - G_M. \qquad (55)$$

In other words, this ties together utility theory and welfare measurement. It also shows that M*, the median of the distribution of the random variable M is equal to the expected value, or mean, M+, of the distribution, given the model in Eq. (44).

Both M+ and M* are compatible with ordinal utility theory, that is, they are invariant to a monotonic transformation. However, Hanemann (1984) suggests that the median, M*, of the distribution is less sensitive to outliers, hence more robust and a better measure of central tendency. A derivation similar to the one for M can be made for a measure of WTS, called L. Hanemann (1984) discusses the expected divergence of these two measures and the magnitude of the divergence.

Dichotomous Choice Methods

There are few market situations in which the purchaser is allowed to state her price instead of taking or leaving the price that is already set. The take-it-or-leave-it format is designed to avoid this problem and present the respondent with a more realistic situation. The TIOLI format can also help respondents who are "information poor" regarding their actual WTP (WTS). Even if they don't know the maximum amount they would pay, they may know if a given amount is acceptable, too high, or too low (for WTS). With the TIOLI format, this is the only information the respondent (and the analyst) needs. The analyst can estimate the expected value of WTP (WTS) using the discrete (yes or no) responses of individuals to an offer. Each respondent was presented with a different offer which was randomly generated from a prior distribution. The observations, then, are individual, not grouped.

For the TIOLI part of the contingent valuation comparison, another stratified sample of 300 Rogue River users was sent surveys with TIOLI questions for both WTP and WTS. The overall response rate for the second group was 73%. Of the 219 surveys returned, the response rate for the WTP item was 99.2%, for the WTS item, 99%.

If reliable data are to be gathered for the TIOLI analysis, proper attention must be paid to the distribution of offers that are presented to the respondents. In this study, the open-ended results were used to generate a distribution of TIOLI offers. Specifically, the cumulative distribution of 85 of the early open-ended responses was used to generate a dollar offer for each of a series of random numbers. This method was used to determine the range of offers which would cover the most likely actual values without having to send out surveys with amounts that were unlikely ever to be accepted (WTP) or rejected (WTS). The WTP offers ranged from $1 to $300, and the WTS from $1 to $1000.

The surveys using the TIOLI format generated a data set of dependent dichotomous variables (yes or no) with a continuous independent variable (the dollar offer). From the data, maximum likelihood procedures are used to estimate a logit model which shows the probability of responding with a yes or no answer to any given dollar offer.[14/] The resulting equations are integrated, using numerical methods, over the range of dollar offers

[14/] MLE is a non-linear regression that uses an iterative procedure to find a set of coefficients that maximizes the log-likelihood function, i.e., $\partial L^*/\partial B = 0$. Given certain weak restrictions, this point represents a global maximum. MLE estimators are asymptotically efficient and consistent for "large" samples (Judge et al., 1985).

to estimate the expected value of WTP (WTS), or solved to find the dollar amount corresponding to the median of the probability distribution (.50).

<u>Dichotomous Choice Results</u>

The logit equation which was estimated for WTP is reported in Table 6. Using the estimated coefficients, the probability of a "yes" response is

$$Pr(Yes)=1\ /1+e^{-[1.662367\ -.034404\ (\$X)]}. \quad (56)$$

The expected value of WTP (M+) is the area under the logit curve (see Figure 8) which is specified in Eq. (56). The integration was truncated at the dollar amount corresponding to the highest offer accepted, called X-max, which was an offer of \$175. The value of M+ is \$52.93.

Table 6. WTP Linear Logit Equation and Test Statistics.

$$Log \frac{Pr\ (Yes)}{1 - Pr\ (Yes)} = \underset{\substack{(.2817)\\5.9}}{1.662367} - \underset{\substack{(.0076)\\-4.5}}{.034403}\ (\$X) \qquad \substack{(SE)\\T}$$

Observations: 200. Total positive: 121.
Percent positive: 60%.
Overall correct prediction percentage: 72.6%
Log-likelihood at convergence: -107.
Log-Likelihood at 0: -134.
Chi-square = 54. Rho-squared[15/] = .2015.

[15/] The test statistic rho-squared is a so-called "pseudo R-squared" (Judge, 1985). Unlike the R-squared of regression analysis, it does not have an obvious interpretation as percentage of variation explained. Instead, a scalar between .2 and .4 is considered a "good fit" (Hensher and Johnson, 1981).

The median of the probability distribution corresponds to a value of \$48.32. This measure of welfare, M*, can be understood as the dollar offer at which the respondent is indifferent to keeping the dollar amount of the offer (i.e., refusing the offer to pay) or having access to the river and paying (i.e., accepting the offer to pay).

The estimated logit equation for WTS is reported in Table 7. With these coefficients, the probability of a "yes" response to the WTS question is

$$\Pr(Yes)=1\ /1+e^{-[-2.249739\ +.00333\ (\$X)]}. \quad (57)$$

Table 7. WTS Linear Logit Equation and Test Statistics.

$$\text{Log}\ \frac{\Pr(Yes)}{1-\Pr(Yes)} = \underset{\substack{(-.2509)\\ -8.965}}{-2.249739} + \underset{\substack{(.000774)\\ 4.3}}{.00333}\ (\$X)$$

	(-.2509)	(.000774)	(SE)
	-8.965	4.3	T

Observations: 218. Total positive: 34.
Percent positive: 15.6%
Overall correct prediction percentage: 78.5%.
Log-likelihood at convergence: -85.
Log-likelihood at 0: -94.
Chi-square = 18. Rho-squared = .10.

The expected value of WTS (L+) is the area above the logit curve in Figure 9. Truncating the integration at the highest offer sampled, that is, X-max = \$1000, gives an estimate of \$617.96. The truncation procedure for WTS is different than that of WTP because there is no cut-off point for the highest offer--no one rejects the highest selling bids. The median of the probability distribution (L*) corresponds to a value of \$675.59.

Table 8 shows the logit equation for WTP from an alternative model, the logarithmic, in which the offer is divided by income prior to parameter estimation (see dichotomous choice theory section). This model establishes a relationship between the amount of the offer and the respondent's income. Using the coefficients estimated with this model, the mean WTP is $79.64 and the median is $74.44. Truncation procedures were comparable to those used with the linear model. A comparison of the different functional forms is included in the discussion section of the study.

Table 8. WTP Log Logit Equation and Test Statistics.

$$\text{Log} \frac{\text{Pr (Yes)}}{1 - \text{PR (Yes)}} = \underset{\substack{(.218)\\5.5}}{1.2} - \underset{\substack{(.00393)\\-4.1}}{.01612} \quad (\$X/Y)$$

(SE)
T

Observations: 200.
Overall correct prediction percentage: 74%
Log-likelihood at convergence: -114
Log-likelihood at 0: -134.
Chi-square = 40. Rho-squared = .15.

A visual inspection of the linear logit curves (see Figures 9 and 10) illustrates two of the problems with the model: 1) the failure of the curves to intersect the origin, and 2) the problem of truncation, or what to do with the tails. The predicted probability of a yes at $0 for WTP is .82 (when economic theory would suggest 1.0) and the predicted probability of a yes at $0 for WTS is

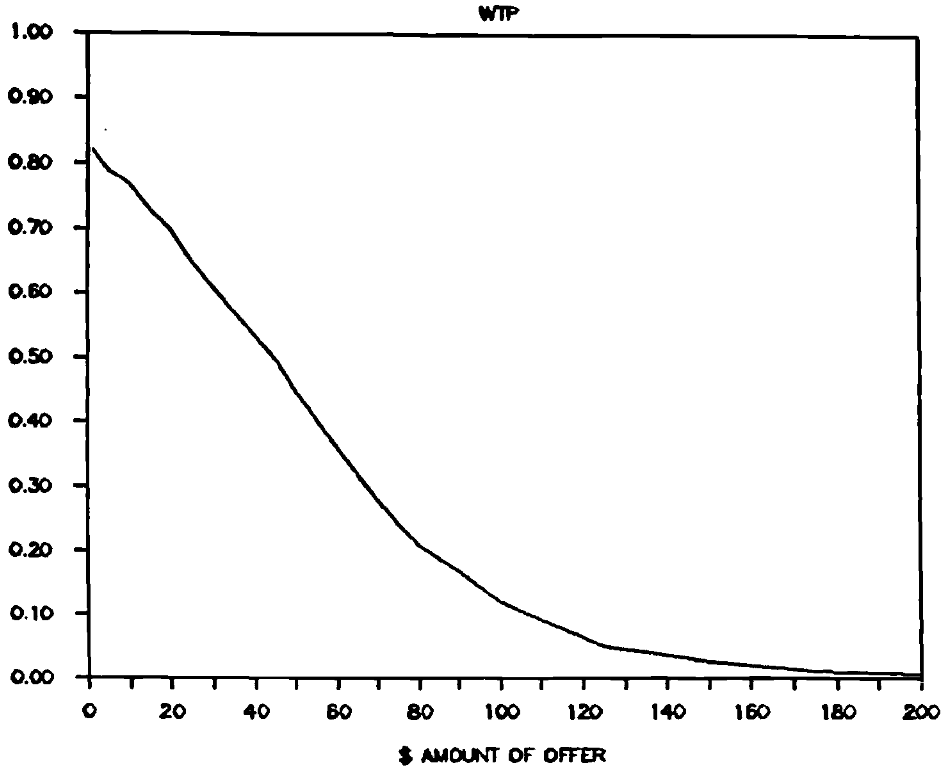


Figure 9. Estimated Logit Curve for WTP.

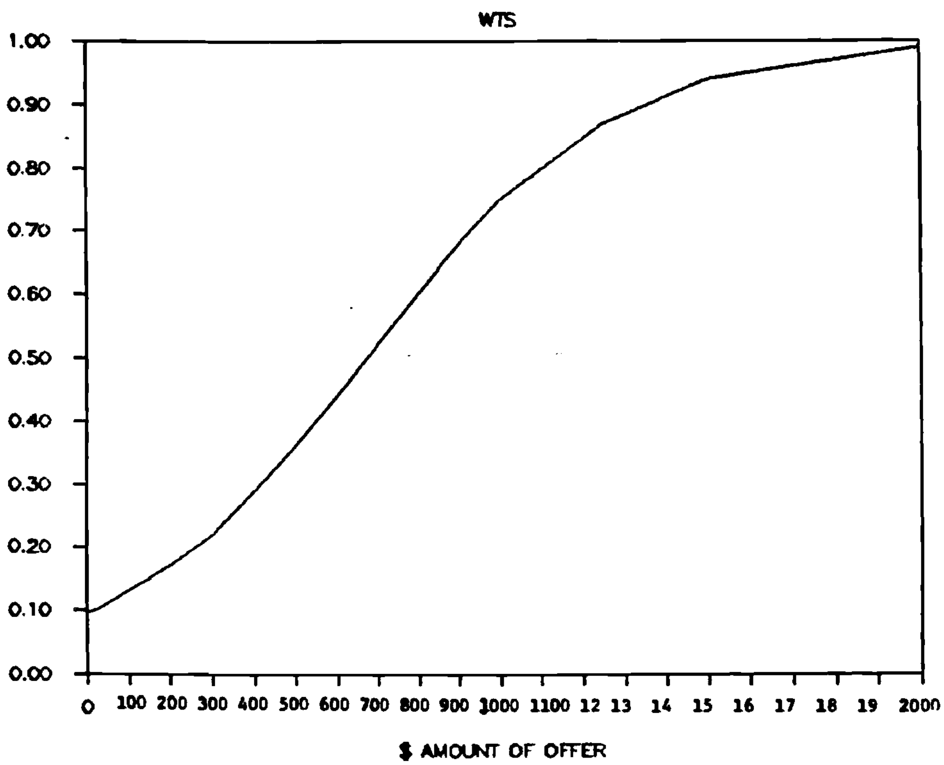


Figure 10. Estimated Logit Curve for WTS.

.10 (when economic theory would suggest 0.0). However, the area under (or above for WTS) the curve would change little by intersecting zero.

The selection of a point at which to truncate can have a large influence on the estimate (Hanemann, 1984). Clearly, the "fit" of the WTP curve is much better than the WTS. By truncating WTP at X-max, which corresponds to the .99 probability level, virtually nothing is lost. But by truncating the WTS logit curve at X-max, which corresponds to the .74 level of probability, a significant area is lost in the truncation. Truncating the WTS offer at the .99 level would correspond to a dollar offer of $2000, an extrapolation far beyond the range of actual offers.

The CVM results show a wide divergence between the WTP and the WTS estimates. There is also a divergence (although considerably smaller) between the open-ended results and the results from the linear and logarithmic dichotomous choice WTP models. The following section compares the results of the contingent value and travel costs methodologies and suggests some possible causes for the divergent results.

COMPARISON OF RESULTS AND DISCUSSION

The per trip benefit estimates from the CVM and TCM are shown in Table 9. The estimates of WTP and WTS are clearly divergent in both the open-ended and TIOLI. This divergence has appeared in many CVM studies and a number of interconnected explanations have been suggested for this occurrence. First, the respondents' perception of the property rights specified in the hypothetical scenario may be different than those intended by the analyst. As discussed in the theory section of the study, the compensating and equivalent WTP and WTS each measure something different. Consequently, if there is a strong discrepancy between the respondents' interpretation of the welfare change and the analyst's, i.e., if the respondent views compensation as a potential welfare gain when the analyst is attempting to measure compensation for a welfare loss, it is unlikely that consistent or accurate measures will result. Also, using the same functional form for the TIOLI WTP and WTA may be a specification error if the respondents view the two situations differently than the analyst (see Hanemann, 1984, for suggestions about alternative functional forms).

There are other complicating factors in hypothetical market comparisons of WTP and WTS. These include the existence of a situation in which the WTP for a good or service is bounded by an individual's income but WTS is

Table 9. Comparison of TCM and CVM per trip results.

	Consumer's surplus per trip	
CVM:	WTP	WTS
Open-ended	$32.66	$146.56
TIOLI		
Linear Models:		
Median	48.32	675.59
Mean	52.93	617.96
Logarithmic Model:		
Median	74.44	**
Mean	79.64	**
TCM:	Consumer's surplus per trip	
1/4 wage rate ($4.5)	$30.14*	
1/2 wage rate ($9)	49.95*	

*cost variable = $.15/mile. **not estimated.

not (Krutilla and Fisher, 1975) and the strong possibility that respondents lack experience as sellers as opposed to buyers (Bishop and Heberlein, 1984).

Past CVM applications have not adequately addressed all of the issues involved in the commonly occuring discrepancies between WTP and WTS, and difficulties with the WTS survey item have caused some researchers to avoid its use even when it appears to be the correct measure of welfare change (Desvousges et al., 1983). Until the problems with WTS are adequately resolved (if they can be), researchers, managers, and decision-makers will probably continue to view WTS estimates with caution.

Aside from the WTS values, the consistency of consumer's surplus across methodologies is more encouraging, but is still subject to judgements on the part of the analyst.

Of the CVM estimates, the open-ended estimate is the lowest. This suggests that theoretical expectations that CVM WTP will generally underestimate true WTP due to the respondents' premature termination of the information search process in the absence of incentives to continue (Hoehn and Randall, 1985) might be correct. Information bias could be more pronounced in this technique than in the TIOLI because the respondent has little experience valuing a nonmarket good finds it difficult to identify her WTP. This could be be the cause of the lower response rate for the open-ended item and suggests that respondents found it difficult to identify their maximum WTP without some "help." Strategic bias may also be a factor.

The open-ended CVM question does not present a realistic market situation and its format appears to encourage bias rather than control it. Its open-ended form forces the respondent into a potentially protracted information search which will, theoretically, result in an underestimate of true maximum WTP. This benefit estimate appears, on theoretical and methodological grounds, to be a biased estimate but may have some use as a lower bound for the value of the good.

For the TIOLI estimates of WTP, the mean and median are relatively close, approximately 8% for both models, confirming theoretical expectations. The difference between the estimates provided by the linear and logarithmic models is significant (although not tested statistically) and seems to reflect the influence of an apparent "income effect," i.e., it can not be assumed that all respondents have an equal marginal utility of income since income varies across respondents by orders of magnitude (incomes ranging from zero to above $92,000 were reported). Consequently, it could be argued that the individual's response to the dollar offer should be compensated to reflect exchange value independent of income endowment. Given the utility maximization framework used in the derivation of the linear model, respondents should make an adjustment relative to the offer with respect to their income before the offer is accepted or rejected and the response made known to the analyst. But, since the decision to accept or reject the offer is based on a utility difference between two states, that is, [0,Y] - [1,Y-A] for WTP, it can be seen that income is constant on both sides and drops out of the equation. Only the response to the offer appears in the linear logit equation. If the respondents' incomes vary by orders of magnitude and an income effect appears to be involved in the utility maximizing decision, then a model that weights the response with respect to income is appropriate. If the researcher feels that there should be a consistent relationship between the bid and the respondent's welfare endowment (Smith et al., 1986), then the model with income in the argument would be the correct model. The poorer fit (rho-squared = .15) of the log model makes comparison of results inconclusive. The discrepancy between the linear and log models suggests that further research is needed on functional form specification.

The linear TIOLI CVM model, using only the dollar offer ($X) rather than the offer divided by income ($X/Y), has a higher rho-squared (.20) than the logarithmic model (.15). Since .20 is considered the minimum measure of a good fit, the first model is superior on that basis. However, the log model predicted better (74%) than the linear model (60%).

A TCM time value estimate between 1/2 and 1/4 the wage rate seems the most appropriate. This is supported by the data from the Rogue study and by some other studies. There is also support for using the $.15 per mile figure as the marginal cost of travel and as a compromise between assumptions about perceived and actual costs. Neither the decision about the opportunity cost of time nor about the cost of travel is an unambiguous choice, but are judgements supported by study data.

Table 10 presents the WTP results from the two TIOLI CVM, the open-ended CVM, and the TCM with the estimates of consumer's surplus adjusted to a per day amount (by dividing the per trip estimates listed above by 3.8, the average number of days spent on the river). The estimates are then aggregated to show the total use value to the non-commercial users during the approximately three month period when permits are required.

If the cost assumptions of fifteen cents per mile and 1/2 the wage rate are are valid, then the TCM estimate and the linear TIOLI are similar, $13.14 and $12.72, respectively, within three percent. If a more conservative assumption is made about opportunity cost (1/4 the wage rate), then the TCM and the open-ended CVM are similar, $7.93 and 8.60, within 8%. Statistical tests of inference are problematic with both the dichotomous

Table 10. Comparison of CVM and TCM per Day Estimates.

	Per Day	Aggregate Value for Season
Open-ended CVM	$ 8.60	$185,099.52
TIOLI CVM (Linear)*	12.72	273,775.10
TIOLI CVM (Logarithmic)*	19.59	421,639.49
TCM (1/4 Wage Rate)**	7.93	170,678.98
TCM (1/2 wage rate)**	13.14	282,814.85

*Median, **Travel cost = $.15/mile

choice models and TCM models[16/] and inferential tests of statistically significant difference were not performed. However, assuming even reasonably large confidence intervals for the CVM estimates, they appear to be inconsistent.

How do the values estimated in this study compare with the values used by resource management agencies, specifically U.S. Forest Service and Water Resources Council? The U.S.F.S. value for standard (i.e., high-quality) nonmotorized boating in the Pacific Northwest is approximately $11 (adjusted from 1982 to 1985 dollars). However, as Loomis and Sorg (1974) point out, this value is based on flatwater rafting and probably represents a substantial understatement of the value of rafting on wild and scenic rivers such as the Rogue. The WRC uses values ranging from $6.66 to $19.56 for specialized recreation. The value for a given recreation site is found by

16/ Because the coefficients in the logit model are estimated with nonlinear methods, MLE, and then appear as exponents in the logistic equation, the standard errors can not be used to establish confidence intervals in the traditional sense. Procedures employing advanced mathematical techniques have recently been developed for statistical analysis of logit results but were not used in this study. The TCM uses a regression analysis to estimate the second stage demand curve based on a regression equation from the first stage demand curve. Consequently, error in the first regression can be carried through into the second regression and into estimation of consumer surplus. As a result, confidence intervals, in the traditional sense, are unavailable. Again, recently developed statistical techniques were not used in this study.

computing a value rating of the site based on five criteria and a one hundred point scale. If the Rogue River was rated between 70 and 80, then it would have a per day value between $13 and $15 dollars. The above values would compare favorably with the estimates from the 1/2 wage rate TCM and the linear logit TIOLI.

Cost, Data Requirements, and Flexibility of Application

Computational cost and data requirements are important criteria in choosing a valuation methodology, particularly if the method is to serve as an evaluative tool applied to marginal changes in quality or amenity levels where repeated calculations of values are necessary. The data requirements and computation time for TCM are high (more so for the individual than the zonal), although new software such as the RMTCM may eliminate some of the extended manipulations necessary when standard econometric software such as TSP is used (Loomis, 1984). Additionally, TCM lacks flexibility; some applications may be impossible or require extensive exploration of models and functional form. The TIOLI method requires very little data. At a minimum, the yes or no response and the offer are needed; income and other information are also required if more complex models are to be used. Data analysis is relatively simple, assuming one has an understanding of the logit framework and has access to software with MLE programs (GAUSS). Numerical integration is straightforward; short, efficient programs for microcomputers are available (for example, Sagan, 1985). Open-ended CVM has the lowest computational costs and data requirements.

One final consideration is the ease with which results can be explained to decision-makers and to the public. Again, the open-ended is the most easily understood. The TCM involves the use of regression analysis which may be unfamiliar to some but the idea of travel costs serving as a proxy for price is helpful in communicating the underlying theory of the method. The TIOLI technique is perhaps the most difficult to explain since it requires some advanced theoretical and quantitative skills.

SUMMARY AND CONCLUSIONS

This study estimated values for whitewater recreation on the Rogue River using two approaches to nonmarket valuation, the travel cost method and the contingent valuation method. The TCM was applied through the use of a zonal model. Two different versions of the CVM were applied, TIOLI and open-ended. Various functional forms and different assumptions about specification of the models were explored and the results presented. Some divergences were found between estimates obtained from the various approaches. These divergences are partially attributable to the underlying assumptions, such as the opportunity cost of time in the TCM. Differing functional forms, e.g., linear or logarithmic, also affect the estimate. A decisive test for validity could not be performed.

This study addressed (but did not completely resolve) questions regarding 1) the discrepancy between WTP and WTS responses, 2) the correct functional form for the TIOLI model, and the role of the respondent's income in the response, 3) the degree of bias present (if any) in CVM measures, particularly the open-ended question, 4) the correct specification of the travel cost variable in the TCM, and 5) the opportunity cost of time.

The results of this study suggest that caution must be used when WTP and WTS items are used and further research is needed with respect to survey design for WTS measures. The results also suggest that different functional forms of the TIOLI analysis may be in order for differing valuation settings, and that the use of the same form for both WTP and WTS items may be a misspecification.

The open-ended CVM question, while easy to apply and interpret, seems more suseptible to bias than the other methods employed in this study but may have some use as a lower bound for value estimates.

The results of the questions regarding the opportunity cost of time and the specification of the travel cost variable show that the choices of opportunity cost and per mile cost do not have to be arbitrary but can be based on the recreationists' behavior and perceptions, specific to the recreation site being studied.

This study has empirically tested some recent theoretical advances in CVM (Hanemann, 1984) that connect welfare measures directly to utility theory. It has shown that, with a careful screening of the data, the TCM valuation can still be effectively applied to sites that apparently do not meet the theoretical requirements of the method and that this can be done by observation of actual travel behavior rather than from an analysis of lottery applications as suggested by Loomis (1983). Finally, this study has produced use value benefit estimates in dollars for whitewater river recreation on the Rogue River.

Although this study resolved some of the difficulties in measuring nonmarket value, unresolved research questions about the TCM and the CVM remain. Further research by economists, social psychologists, and those involved in survey design is needed to adequately resolve these questions.

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APPENDIX

APPENDIX A

Rogue River Whitewater Survey

Everyone wants the Rogue River to remain a high quality recreation area. But this requires careful planning. This survey will provide information about river runners and their feelings about the Rogue River as a recreation site. The information will be used by researchers at Oregon State University who are interested in the recreation value of a wild river.

Please try to answer every question, since a single missing answer will decrease the value of all your answers. There are no right or wrong answers; the best answer is the one which is closest to your own feelings or what you actually did.

You may have run the Rogue River more than once during the 1984 permit season (Memorial Day to Labor Day). We are interested in <u>the most recent trip</u> you took during this period. Please consider only this trip in answering the questions.

For this trip, was the permit issued to you personally?

_____ No
_____ Yes If yes, did you get the permit through the lottery in January?

_____ Yes, I got my permit in the lottery in January.
_____ No, I got my permit at a later time.

In this next section we would like to know about your preparation and travel for the trip.

When you made plans to run the Rogue, how far in advance did you decide to go?

About _____ months, _____ weeks, or _____ days in advance.

How much time did you spend traveling to the river?

About _____ hours (one way).

How many miles did you travel to the river?

About _____ miles (one way).

How many people traveled with you in the same car?

Myself and _____ other people.

Was the Rogue River your only purpose for this trip?

_____ Yes
_____ No If not, please list all your purposes and the percent of the total time devoted to each.

Purpose	% of time
Run Rogue River	_____
_____	_____
_____	_____
Total trip	100%

How may days were spent on the river? Count the first and last days as whole days.

_____ days.

Did you have to take time off from work to allow time for preparing for the trip, traveling to and from the river, or running the river?

_____ No
_____ Yes If yes, how much income did you lose by taking time off?

About $ _____

How many hours do you work in a week? About _____ hours.

How much paid vacation do you have? _____ weeks per year.

The following section asks about the dollar value of river running. This is a serious and important research issue. Even though these questions ask you to put yourself in an imaginary situation, please give us the best answer you can for each question. Your answers will not affect the price of river permits.

Think back to the time before you left home for your river trip. Assume you did not already have a permit, but that you could have purchased one for the date of your actual trip. What is the highest whole dollar amount you would have paid for a permit to get on the river? Think of this amount as the price of admission for yourself only, all of which you would have to pay. Even though this is an imaginary price, we would like you to fill in the same amount you would if it were the real cash price of a permit which you would pay.

The highest dollar amount I would actually have paid for a permit is

$ __________

Once again, think back to the time before you left home for your river trip. Assuming you already had a permit, what is the lowest dollar amount you would accept if someone wanted to buy it form you? Assume that the permit you are selling is for yourself only, so you could keep all the money. Even though this is an imaginary price, we would like you to fill in the same amount you would if it were the real cash price which someone would actually pay you.

The lowest whole dollar amount I would have accepted to give up my permit is

$ __________

Think back to the time before you left home for your river trip. Assuming you did not already have a permit, would you be willing to pay $ ________ for a permit to get on the river? Think of this amount as the price of admission for yourself only, all of which you would have to pay. Even though this is an imaginary price, we would like you to think of it as if it were the real cash price of permit which you would pay.

_____ Yes, I would actually pay $ _____ for a permit.

_____ No, I would not pay this amount for a permit.

Once again, think back to the time before you left home for your river trip. Assuming you already had a permit, would you be will to accept $ ________ if some wanted to buy it form you? Assume that the permit you are selling is for yourself only, so you could keep all the money. Even though this is an imaginary price, we would like you to think of it as if it were the real cash price of a permit which someone would actually pay you.

_____ Yes, I would accept $_____ in payment to give up my permit.

_____ No, I would not accept this amount for my permit.

Please estimate your share of the other expenses for your river trip (do not include boat and related equipment).

Transportation expense $________

Shuttle cost $________

Food and beverages (above normal at-home food expenses) $________

Lodging en route and on river $________

Other expenses $________

We think there are river runners who would like to run the Rogue River and could afford to do so, but they don't want to spend the time it takes to travel form their residence. They might be willing to pay some money if somehow paying cash could reduce the travel time. Assuming some alternatives were available, what would you be willing to pay to reduce to one half hour the travel time from your residence to the Rogue?

I would pay $_______ each way to reduce travel time to one half hour.

The following section asks about your permit applications and the permit system. Answers to some of the questions will be used to help estimate the value of whitewater recreation on the Rogue. Please give what you consider to be accurate estimates.

Did you apply for a permit through the lottery system?

_____ Yes
_____ No   If not, why not?

_____ Didn't know about lottery.
_____ Not willing to pay $2 application fee.
_____ Couldn't plan that far ahead.
_____ Didn't decide to go until after lottery.
_____ Other.

How may attempts did you make to get a permit for this river trip?

_____ Number of lottery applications for this trip.
_____ Number of phone calls for this trip.
_____ Number of walk-in applications for this trip.

How many trips on the Rogue did you actually take during the 1984 season (Memorial Day to Labor Day)? Include the trip you are describing in this questionnaire.

I actually took ______ trips.

How many trips would you have taken on the Rogue this season if there were no permit restrictions? Include the trip you are describing in this questionnaire.

I would have taken ______trips.

If you had been unable to obtain a permit for this Rogue River trip, what would you have done instead?

Run another river?	___ No	___ Yes	What river? _______
Other recreation?	___ No	___ Yes	What activity? ____
Stay home?	___ No	___ Yes	
Work?	___ No	___ Yes	
Other?	___ No	___ Yes	Specify ___________

In this final section we would like to ask some questions about your background and occupation which will help us compare your answers with those of other people. We should stress that all of your answers are confidential.

How old are you?
_____ years old.

Please check the space that comes closest to your total household income before taxes. (Choose one)

______ $0 to $3,999	______ $48,000 to $51,999
______ $4,000 to $7,999	______ $52,000 to $55,999
______ $8,000 to $11,999	______ $56,000 to $59,999
______ $12,000 to $15,999	______ $60,000 to $63,999
______ $16,000 to $19,999	______ $64,000 to $67,999
______ $20,000 to $23,999	______ $68,000 to $71,999
______ $24,000 to $27,999	______ $72,000 to $75,999
______ $28,000 to $31,999	______ $76,000 to $79,999
______ $32,000 to $35,999	______ $80,000 to $83,999
______ $36,000 to $39,999	______ $84,000 to $87,999
______ $40,000 to $43,999	______ $88,000 to $91,999
______ $44,000 to $47,999	______ $92,000 or more

What is your primary occupation? Please be as specific as possible. If retired, give former occupation.

____