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Despite several decades of research developments, the survey-based contingent valuation (CV) method remains one of the most controversial topics in environmental economics. As the procedure matures and more applied studies are completed, there is increasing pressure to make the results policy relevant. This research is composed of three distinct yet related manuscripts and investigates several important issues in the application of CV for measuring the economic value of nonmarket goods. Specifically, this dissertation explores the accuracy, applicability and transferability of CV measures, with a focus on the dichotomous choice (DC) elicitation format.

The first study asks whether individuals directly questioned about their willingness-to-pay (WTP) for a public good respond differently, in a setting of apparent social pressure, than those provided with additional anonymity. This question is explored in a quasi-experimental setting using a split sample design to compare a *randomized response* questioning format with a direct questioning format. Econometric models assess the robustness of explanatory effects across survey types.

The results support the hypothesis of compliance bias.

The second manuscript investigates an experimental fee hunt pheasant stocking program that developed subsequent to a previous CV. This case study evaluates the performance of the original study, and addresses the question of how CV may be used in converting WTP into public revenues. The results are a mix of good news and bad news; while WTP appears to be a real value, the findings indicate the difficulty of conducting any external validation against a real market.

The third study explores several issues in the derivation of demand curves from DC-CV models. Application of an available specification test provides a technique for addressing endogeneity questions on measure-of-use variables. Absent endogeneity, there is still the opportunity for considerable bias in demand curves. A typology is presented and used to distinguish how CV models incorporate such variables. The empirical results from applying the specification test to a previous study provide initial confirmation of the proposed typology. Caution is urged in reconstructing demand curves from "off-the-shelf" DC-CV models for benefits transfer purposes.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to Nonmarket Valuation

Competing demands for scarce public resources necessitate difficult social choices.[1] Alternative management choices alter the mix of goods and services provided. Accurate assessment of the tradeoffs implied by each choice poses challenges, including the investigation of relative values. Economic values are preference-based, and represent only one type of assigned or held values (Brown, 1984). Decision criteria which are based on economic values, such as efficiency and benefit-cost tests, reflect a particular utilitarian philosophical perspective. Nevertheless, economic analyses are important informational inputs to the full social accounting of public resource management.

The measurement of *total economic value* (TEV) refers to systematic attempts, either holistic or sequential, to assess combined component values of an environmental asset or resource system (Pearce, 1993; Peterson and Sorg, 1987; Randall, 1991b). One taxonomy of economic values is:

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[1] From a regional perspective, continuing debate over the forest and water resources of the Pacific Northwest (PNW) attest to the difficulty of managing publicly-owned natural resource systems.

(1) Direct use values (e.g., timber harvest, recreation)
(2) Indirect use values (e.g., watershed protection, ecological services)
(3) Option value (refers to individual's value for the potential future use of a resource)
(4) Bequest value (refers to an individual's preferences for bequest to future generations)
(5) Existence values (contemplative value for the existence of a resource, independent of any current or expected future *in situ* use of the resource)

A number of similar value taxonomies exist; the critical distinction for decisionmaking is whether a good or service's economic value is fully captured in market price. Many goods and services are traded in organized markets and can be valued in a relatively straightforward manner. For example, timber products have a direct commercial use whose marginal value is reflected by market equilibrium prices. Public recreation may also have a direct use value, but minimal or nonexistent fees in incomplete markets do not accurately reflect this value. Nonuse values by definition, have no discernible trail or link to market behavior. Missing or incomplete market values do not imply a lack of economic value. Specialized techniques must be used to assess these values in a manner commensurate with more conventional commodities.

Over the last several decades economists have developed and refined a battery of techniques to assess the economic value of nonmarket goods and services (Braden and Kolstad, 1991; Cummings et al., 1986; Mitchell and Carson, 1989; Smith, 1993). While the most common applications are to natural resource and environmental assets, the concepts extend to public goods (nonexclusive and/or nonrival) in general.

Nonmarket valuation techniques are of two basic types. *Indirect approaches* rely on observed behavior to infer values. Examples include the travel cost model where the relationship between visits and travel expenditures is used to infer the value of a recreational site, and hedonic pricing methods which attempt to decompose the value of market goods, say recreational real estate adjacent to a national forest, to extract embedded values for environmental assets. *Direct approaches* use a variety of survey-based techniques to directly elicit preferences for nonmarket goods and services. While there are variants on these constructed markets, the most common is the contingent valuation (CV) method. All of these techniques share a common foundation in welfare economics where measures of maximum willingness-to-pay (WTP) and minimum willingness-to-accept (WTA) compensation are taken as the basic data for individual benefits and costs.

From a measurement perspective, "passive" or nonuse values (i.e., option, existence, and bequest) are the most problematic component of TEV. CV is the only technique for assessing these values. The topic of existence values for environmental assets is one of the most controversial in environmental economics.[2] Substantial evidence shows that individuals will contribute to environmental organizations, and express positive WTP on CV surveys to preserve environmental assets with no

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[2] The discussion originates with Krutilla (1967) and is recently updated by Bishop and Welsh (1992), Desvouges et al. (1993), Edwards (1992), Kopp (1992), Randall (1991b, 1993a), and Rosenthal and Nelson (1992).

expectation of current or future use of the resource.[3] Evidence that existence values exist is something less than demonstrating they can be measured on a sufficiently comprehensive and reliable basis for use in formal decision rules (Castle and Berrens, 1993; Rosenthal and Nelson, 1992; Stevens et al., 1991a, 1991b; Vatn and Bromley, 1993).

As evidence of the public controversy concerning the measurement of passive use values, a blue-ribbon panel, containing several Nobel Laureate economists, was convened by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) in 1992. The Panel was convened to provide guidance on promulgating regulations, pursuant to the Oil Pollution Act of 1990, concerning the potential use of CV in measuring lost passive or nonuse values. The potential of assessing these nonuse values through application of CV was essentially reaffirmed by the NOAA Panel, provided rigorous guidelines are followed (Arrow et al., 1993).

Empirical estimates of nonmarket use values are substantially less controversial, and are also important to the planning process. Hundreds of site-specific studies valuing recreational services and environmental quality have been completed.[4] Viewed in the aggregate, these numerous valuation studies document the

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[3] Several PNW examples of the application of CV to measure existence values can be found for old-growth forest preservation and spotted owls (Hagen et al., 1992; Rubin et al., 1991), and Columbia River salmon (Olsen et al., 1991).

[4] There have been numerous studies completed for PNW natural resources. Recent examples include Adams et al. (1989), Berrens et al. (1993), Donnelly et al. (1990), Fried (1993), Johnson and Adams (1988, 1989), Johnson et al. (1990), Morey et al. (1991), and Olsen et al. (1991).

considerable economic worth of nonmarket goods and services. However, many of these individual studies are characterized by out-dated techniques or changing circumstances. There is great variability in the quality of CV studies, and a need to be an informed consumer of the results.

Given the costs and complexity of conducting *de novo* studies, an emergent issue in the nonmarket valuation literature is the transferability of results out of their original context (AERE, 1992; Brookshire and Neil, 1992; Walsh et al., 1992). *Benefit transfer* refers to the transfer of some existing benefit estimate (or function) from its study setting to an alternative policy setting. The practice has long been used on an ad hoc basis in legal and policy debates; the issue lies in developing acceptable protocols for doing so (Smith, 1992c; Loomis, 1992).

1.2 Structure of the Research

The overarching theme for this dissertation is the use and application of the contingent valuation (CV) method in environmental and resource economics. A second connecting theme is the use and exploration of a particular format for asking valuation questions. The dichotomous choice format has recently emerged as the most commonly used approach in applied studies. While there are a variety of conceptual and econometric/statistical tools used in these studies, dichotomous choice valuation is the focus of considerable discussion.

Although some original survey results are generated and used, the general objectives of this dissertation are not focused on new study-specific application(s) of the CV method. The motivating question for this research endeavor can be stated as: When can the use of these measured values be justified in a policy context? As the CV research procedure matures and as more applied studies are added to the literature, there is increasing pressure, from both funding agencies and the demands of resource management conflicts, to make these estimates policy relevant -- to put them to use. The objective of this dissertation is to explore the accuracy,[5] applicability and transferability of measured CV values. While all of these issues have been explored to some degree elsewhere, the dust is still unsettled on CV (Randall, 1993b).[6] This dissertation represents my attempt at providing incremental insights through careful scholarship.[7]

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[5] Accuracy refers to both validity (measurement of the intended construct), and reliability (the variability around an estimate and its stability over time).

[6] Much of the recent debate over CV, "against a backdrop of big money litigation" (Randall, 1993b), has been quite adversarial. In some cases, the use of CV in litigation has also hindered the open review process of research results (Hoehn, 1992).

[7] This research was motivated by involvement in a set of earlier studies. A CV study on recreational fishing served as an introduction to "close-ended" elicitation formats and maximum likelihood techniques (Berrens et al., 1993). An unpublished report (Berrens and McLeod, 1992) on yard debris services provided introduction to DC-CV estimation techniques. Involvement in the study design for potential CV applications to recreational losses from reservoir drawdowns on the Columbia River produced an annotated bibliography (Berrens and Kavanaugh, 1992), a design plan (Kavanaugh et al., 1992), and an unpublished discussion paper on substitution issues (Berrens, 1992). Finally, a policy piece on PNW endangered species issues explored the use of existence values in formal decision rules (Castle and Berrens, 1993).

The research is comprised of three "stand alone" manuscripts presented in Chapters 2 through 4. Each manuscript explores one or more issue related to the general theme, and contains its own introduction and conclusions.[8] Chapter 5 presents some brief concluding thoughts on the overall research.

Chapter 2 is entitled: "Evidence of Compliance Bias in Dichotomous Choice Contingent Valuation." The application of the CV method to sensitive environmental and public policy issues remain highly controversial. Despite several decades of research developments, much remains to be learned about response biases in particular survey settings and questioning formats. The study reported in Chapter 2 asks whether individuals directly questioned about their willingness-to-pay for a public good respond differently, in a situation of apparent social pressure, than those provided with additional anonymity. This question is explored in a quasi-experimental setting using two separate survey instruments. A control group is administered the traditional direct questioning (DQ) format for a dichotomous choice contingent valuation question. The rest of the sample is administered a randomized response (RR) questioning format (Warner, 1965). Econometric probability models are developed for assessing the impacts of a set of explanatory variables, and the robustness of these impacts across survey types. The results support the hypothesis of "yea-saying" or compliance bias.

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[8] While there is general conformity across manuscripts, there are some subtle distinctions in the notation.

Appreciation for the potential contribution of this experimental research can be motivated by considering a recent development in the public debate over CV. As mentioned previously, the NOAA Panel was convened to provide guidance on promulgating regulations for the potential use of CV in valuing lost passive or nonuse values (Arrow et al., 1993). Panel recommendations include support for overall conservative design choice, the use of personal interviews, and the use of dichotomous choice or referendum-style formats for eliciting values. Despite the many advantages of the referendum format, the Panel also implicitly recognizes the potential for compliance bias (Arrow et al., 1993:22):

> There is no strategic reason for the respondent to do other than answer truthfully, although tendency to overestimate often appears even in connection with surveys concerning routine market goods. ...There are, however, several other reasons why one's response to a hypothetical referendum question might be the opposite of one's actual vote on a real ballot. ...a respondent unwilling to pay D dollars in reality might feel pressure to give the "right" or "good" answer when responding to an in-person or telephone interviewer. This could happen if the respondent believes that the interviewer herself would favor a yes answer.

Additionally, accumulating empirical evidence appears to indicate that DC-CV value estimates tend to be larger than those from open-ended elicitation formats (Kristrom, 1990b; Kealy and Turner, 1993).

The justification for exploring compliance bias in DC-CV is clear; the development of a potential test to detect its presence is the primary contribution of the first manuscript. The approach merges CV with a social survey research method for asking sensitive questions which itself has been the source of considerable discussion among statisticians and social survey researchers. To my knowledge this is the first combination of CV with the RR technique and may raise more questions than it answers. However, the strength of the experimental results appear to justify further investigations.

Chapter 3 is entitled: "Converting Willingness to Pay into Public Revenues: Evidence from a Pheasant Stocking Program." The provision of a public stocking program for pheasant hunting in Western Oregon through user fees was initially evaluated by Adams et al. (1989) using the contingent valuation method. The study reported in Chapter 3 continues the investigation of the economic aspects of a fee-access public stocking program. Since the initial CV survey, an experimental "put-and-take" stocking program has been conducted at the study area by the Oregon Department of Fish and Wildlife (ODFW). Several fee levels have been charged for harvesting pheasants at the site, and visitation records kept. This creates a unique opportunity for evaluating the performance of a CV study, *ex post facto.*

The fundamental question is: Why go back and look at a seven-year-old CV study? The answer lies not in the importance of the individual study, but in the uniqueness of this opportunity for external validation. The importance of this contribution also can be motivated by reference to the NOAA Panel on CV. It was stated in the Panel report (Arrow et al., 1993:9) that:

> External validation of the CV method remains an important issue. A critically important contribution could come from experiments in which state-of-the-art CV studies are employed in contexts where they can in fact be compared with "real" behavioral willingness to pay for goods that can actually be bought and sold.

The initiation of an external validation exercise allows a "ground truth" check of a previous CV study. It also raises issues that must be confronted in addressing benefit transferability. While the development of the fee-access pheasant hunting market can help to evaluate the accuracy of the original CV study, the information cuts both ways. This study evaluates the performance of the original study, and asks the question of how CV may be used in converting willingness-to-pay into public revenues. There is increasing discussion of applying user fees to public outdoor recreation, and CV may play an important role in designing and evaluating pricing policies.[9]

The practical desire to return to the Adams et al. (1989) study and develop a demand curve for comparison against the actual market results served as the motivation for the research in Chapter 4. With growing interest in the topic of benefit transfer, and increasing use of the DC-CV format, an important question is whether one could use the estimated probability model from an existing study to derive a valuation function and, if desired, derive the demand curve?

Chapter 4 is entitled: "Some Problems with Deriving Demand Curves from Measure-of-Use Variables in Referendum Contingent Valuation Models." This paper explores the derivation of Hicksian (compensated) demand curves from referendum-style, dichotomous contingent valuation (DC-CV) models. Grogger's (1990) specification test for logit and probit models provides a technique for addressing

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[9] This practical application draws out the link between CV and general marketing survey research.

endogeneity questions on measure-of-use variables in DC-CV models. A typology is presented and used to distinguish between different CV models and how they incorporate such variables. The typology is used to generate several hypotheses. The empirical results from applying the specification test to a previously published study (Adams et al., 1989) provide initial confirmation for the proposed typology. The opportunity to conduct specification tests is unlikely to be available in the typical benefit transfer exercise. Thus, the typology may also serve as a screening tool in the emerging protocol for acceptable benefit transfers. Caution is urged in reconstructing demand curves from "off-the-shelf" DC-CV models for benefit function transfer purposes.

Chapter 5 summarizes and presents some concluding thoughts and suggestions for future research. The rest of this introductory chapter contains background information and set-up material for connecting the three separate manuscripts; the chapter proceeds as follows. Section 1.3 builds on the introductory comments by providing some brief history and current trends in CV research. Section 1.4 introduces basic CV design issues. Section 1.5 provides theoretical background, including discussion of the consumer's optimization problem, valid welfare measures, and the general valuation function.

1.3 CV Research: Brief History and Current Trends

The idea of using surveys to elicit values for nonmarket goods and services was first suggested in a little-known article in the *Journal of Farm Economics* (Ciriacy-Wantrup, 1947). More than a decade passed before the first empirical application (Davis, 1964). Research interest grew in the early 1970s (e.g., Randall et al., 1974) and continues to expand. Randall (1993b:27) summarizes:

> the CVM research program developed quite rapidly through the 1970s and 1980s. More and more scholars became involved; theory, methods, and techniques proliferated, and a fragile consensus began to emerge concerning what worked and what did not; refereed articles appeared in mainstream as well as specialized economics journals; and the CVM discourse community established patterns of communication with researchers in incentive theory, econometrics, psychology, and survey research.

CV is now commonly used by federal and state agencies, as well as by academic researchers (Carson, 1991; Peterson et al., 1992). Executive Order 12291 of 1981, requiring benefit-cost analysis (BCA) of major federal regulatory actions, helped promote the growth (Smith, 1993). Application of CV is confirmed in a variety of public planning and natural resource damage assessment (NRDA) procedures (e.g., Moser and Dunning, 1985; USDI, 1986; USDI, 1991; USFS, 1990; WRC, 1983), and judicial review (D.C. Circuit Court, 1989). Discussions and applications outside of the U.S., and the formal constructs of BCA and NRDA, are increasing (Briscoe et al., 1990; Cameron and Quiggin, 1992; Hanemann et al., 1992; Kristrom, 1990b; Loomis et al., 1992; Munasinghe, 1992; Pearce, 1993; Seip and Strand, 1990; Shayamsundar and Kramer, 1992; Whittington et al., 1992).

Hundreds of articles on CV have been published in the last two decades. Two books in the late 1980's introduced the topic to a wide audience (Cummings et al., 1986; Mitchell and Carson, 1989). Several recent books include chapters or selected papers that provide either extensive discussion or applications of CV. These include Braden and Kolstad (1991), Johnson and Johnson (1990), Munasinghe (1992), Pearce (1993), and Peterson et. al. (1988, 1992). Reviews of recent or topic-specific CV studies are also common in contract research for public agencies.[10] In total, several hundred applications of CV, published and unpublished, have been completed. Over that span CV has been a dynamic field of research.

The volatility of the CV research program has increased entering the early 1990s. As the number of applications have multiplied and uses diversified, the attention they attract has increased (Smith, 1993). The "discourse community" has expanded rapidly, fueled by the application of CV to measure lost passive use values in natural resource damage cases (Anderson, 1993; Arrow et al., 1993; Bromley, 1993; Eberle and Hayden, 1991; Harvard Law Review Association, 1992; Kopp and Smith, 1993; Polinsky and Shavell, 1989; Shavell, 1992). Again, Randall (1993b:29) provides commentary:

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[10] As examples, Olsen et al. (1990), and Berrens and Kavanaugh (1992) each provide detailed annotations for more than 40 nonmarket valuation studies.

> This sudden and dramatic expansion of the CVM discourse community, before a backdrop of litigation and unaccustomedly large compensation claims for a newly-recognized category of compensable damages, provides an opportunity to observe the reasoned discourse process in upheaval, before the dust settles. Much of what we see is unappealing. Impressive credentials have been substituted sometimes for careful scholarship, and sweeping generalizations turn out sometimes to hinge on special-case models and relatively arbitrary research decisions about data handling and statistical methods.

No attempt will be made here to provide a full review of the voluminous literature on CV. However, it is possible to offer seven trends that are apparent in the CV literature, and form the general backdrop of this research.

First, there is progression towards placing CV in a full utility-theoretic context. Examples include determination of the relationship between alternative welfare measures (Hanemann, 1991), and consideration of the effects of complex policy and multiple substitution opportunities (Hoehn, 1991; Hoehn and Loomis, 1992; Hoehn and Randall, 1989). Second, there is increasing econometric sophistication, largely motivated by the emergence of a variety of discrete-choice techniques (Cameron, 1988, 1991a, 1991b; Cameron and Huppert, 1989, 1991; Hanemann, 1984, 1989; Hanemann, et al, 1991). Third, there is an increasing interdisciplinary nature to CV research (Fischoff and Furby, 1988; Harper, 1988; Harris et al., 1989; Michelman, 1992; Opaluch and Segerson, 1988; Peterson et al., 1988).[11] Fourth, there is growing interest in transferring CV results out of their original valuation context (AERE,

[11] One recent example is the suggestion for exploring the relationship between CV and marketing research techniques such as "conjoint analysis" (Arrow et al., 1993; MacKenzie, 1993; Michelman, 1992).

1992). Fifth, there is continued debate over the measurement of nonuse values, much of it motivated by natural resource damage assessment and liability concerns (Arrow et al., 1993; Bishop and Welsh, 1992; Carson et al., 1993; Harvard Law Review Association, 1992; Kopp and Smith, 1993; Shavell, 1992). Sixth, there are a surprising variety, and increasing number, of attempts to develop both internal and external tests to assess the accuracy and performance of CV techniques (Adamowicz and Graham-Tomasi, 1991; Bishop and Heberlein, 1990; Duffield and Patterson, 1992; Seip and Strand, 1990; Smith, 1990, 1993). Finally, an emergent trend may be a refocusing on the role and importance of protest responses in CV exercises (Halstead et al., 1991; Sagoff, 1988; Stevens et al., 1991a, 1991b; Stevens, 1992).

1.4 Basic CV Design Issues

There are several common design elements basic to a constructed market (Carson, 1991).[12] The first critical element in the design of any CV experiment is *commodity specification* - the description of what is to be valued. This description should include a reference level of environmental services, and one or more increments or decrements in those services. An integral part of the specification of the commodity is the structure of the rules for how the good is to be bought or sold,

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[12] The selection of basic design elements affects the potential occurrence of various biases in survey responses. While full review of the various types of biases will not be given here (Carson lists over 20 in his 1991 review), Chapter 2 addresses a particular type of response bias that may occur in the DC-CV format.

including definition of the *payment vehicle* or exchange mechanism. A variety of payment vehicles have been used in CV studies.[13] The selection is typically based on two criteria: (i) neutrality, and (ii) realism. The chosen payment vehicle should not introduce any systematic biases, and should be perceived as a realistic possibility. An additional critical issue in designing the constructed market is selection of the *elicitation format*.

There are a variety of formats available for eliciting valuation responses: (i) open-ended questions, (ii) iterative bidding, (iii) payment cards or category checklists, and (iv) dichotomous choice (DC). Although the open-ended format provides the simplest alternative for survey design and modeling, it typically is not selected because of concerns over potential response biases (e.g., strategic "overpledging"), and the cognitive burden on respondents. Complete reliance on open-ended questions is commonly viewed as reducing the credibility of a CV survey (Loomis et al., 1992:3). The following discussion reviews the alternatives with particular attention given to the DC format.

The iterative bidding format begins by offering the respondent an initial bid (a dollar amount) that can either be accepted or rejected. If accepted, the bid is gradually increased, usually following some prescribed rule, until a negative response

[13] Examples include: (i) access fees, such as seasonal recreational pass, or a boat ramp permit (Bergstrom et al., 1990; Sellar et al., 1985); (ii) a protective trust fund (Duffield and Patterson, 1992); (iii) a nondescript "special fund" (Berrens et al., 1993); (iv) general taxes (Hoehn and Loomis, 1992); and (v) an electricity bill (Olsen et al., 1991).

is given. The highest accepted amount is taken as the maximum bid and provides a numerical value measure. If a negative response is given to the initial bid, the amount is iterated downward until a positive response is given. A modified version of the bidding game allows only a single iteration, and thus provides interval or categorical data on the valuation responses (Cameron and Quiggin, 1992; Hanemann et al., 1991; McFadden and Leonard, 1992).

The payment card or checklist presents a range of dollar values that begin at zero and then increase at (possibly fixed) intervals. The respondent is asked to select the interval containing her WTP (or WTA). Many payment cards are "anchored"; e.g., showing what someone in a particular income group typically paid for selected services (Boyle and Bishop, 1988).

In the dichotomous choice (DC) format, the individual is queried for a yes or no answer to a specific payment level (or "bid"). The probability distribution of acceptance/rejection across payment levels is used to recover the underlying valuation function. As one recent commentary states, the DC format is "emerging as the preferred methodology" (Duffield and Patterson, 1991).

The DC format presents a simpler decision to the respondent relative to the open-ended questioning format, and tends to successfully elicit participation in the valuation exercise. The "take-it-or-leave-it" decision is analogous to buying or selling decisions in the market; however, it can also be motivated by reference to a political referendum. It is also free of starting point bias inherent in iterative bidding games (Boyle and Bishop, 1988). Further, it is argued that the DC format is more incentive compatible, in that it reduces the opportunity for strategic bias, such as extreme overpledging (Hoehn and Randall, 1987).[14]

The choice of design elements influences the incentive structure for respondents (Hoehn, 1986; Hoehn and Randall, 1987). The process of developing a constructed market can be thought of as structuring a "conversation" (Smith, 1993) -- a communication process with a specified set of rules. A respondent's value formulation and statement within such a conversation are conditional upon these rules. The choice of elicitation format dictates an allowable *response rule* (e.g., vote yes or no, provide opened-ended value, select a category) (Hoehn, 1992). The chosen response is connected to a particular payment vehicle and level of payment obligation -- sometimes referred to as the *payment rule* (Milon, 1989:294). Finally, an *outcome rule*, also described as a provision or implementation rule, translates collective responses into a particular outcome (e.g., implementation of program or provision of the good, and expected individual payments) (Hoehn, 1992; Milon, 1989; Randall and Kriesel, 1990). An example might be provision of the public good at per capita average costs, provided positive net benefits and implemented by plurality vote. The

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[14] Recent theoretical and econometric advances support increased empirical applications of DC-CV (Cameron and James, 1987a, 1987b; Cameron, 1988, 1991a, 1991b; Cooper, 1993; Loomis, 1988, 1990; McConnell, 1990; Duffield et al., 1992). One disadvantage common with any discrete choice estimator is that the loss of precision may require increased sample size. The DC-CV also requires fairly complex survey design and analysis (Duffield and Patterson, 1991). Some design elements include: (i) total sample size, (ii) the range of the payment levels, (iii) the specific payment levels (the"bid structure"), and (iv) the allocation of payment levels across the sample.

outcome rule is often left implicit or undefined. Taken together, alternative rule structures may induce different disclosure strategies in a CV exercise.

1.5 Theoretical Background

The Consumer's Optimization Problem

Individual preferences are defined over a vector of market goods, $G=(g_1,\ldots g_L)$, a vector of multidimensional environmental services, $Q=(q_1,\ldots q_M)$, and described by the utility function U=U(G,Q). The consumer's constrained optimization problem is to maximize utility subject to a budget, and can be stated as:

$$\max\ U=U(G,Q) \quad \text{s.t. } m \geq PG \tag{1}$$

P is a vector of prices for market goods, and m is household income. It is assumed that Q is a restricted or rationed good that is exogenously determined. The solution to the utility maximization problem is the indirect utility function V=V(P,Q,m), which describes the level of well-being attainable with P, m, and access to environmental services Q. The inverse of the indirect utility function, with P held constant, gives the expenditure function:

$$V^{-1}(P,Q,m) = E(P,Q,U) \tag{2}$$

The expenditure function is the solution to the consumer's cost minimization problem subject to a given level of well-being or utility:

$$E(P,Q,U) = \min PG \quad s.t. \ U(G,Q) \geq U \tag{3}$$

The consumer's cost minimization problem subject to a utility constraint is considered to be the "dual" to the utility maximization problem subject to a budget constraint. In duality theory, the consumer's income is equal to the minimum expenditure level (Deaton and Muellbauer, 1980). For example, at a given initial level of environmental services, Q^0, the initial income of the household will maintain the initial level of utility:

$$m^0 \equiv E(Q^0,U^0) \tag{4}$$

The vector of prices, P, is assumed constant and left implicit. A convenient construction of the expenditure function is to eliminate the unobservable utility level, U, and replace it with V(Q,m), by using the identity:

$$m^0 \equiv E(Q^0,V(Q^0,m^0)) \tag{5}$$

which states that the minimum expenditure to reach $V(Q^0,m^0)$ is m^0. This function is referred to as the indirect money metric (Varian, 1992). Formal definitions of the economic value of changes in environmental services -- money measures of welfare change -- are typically defined in terms of expenditure functions (Bergstrom, 1990; Hoehn, 1991).

Valid Measures of Welfare Change

An economic analyst often attempts to measure empirically the welfare impacts from some real or hypothesized policy changes. The task of CV is to pose a set of one or more hypothetical changes (the contingent scenario), and then determine a money measure of the respondent's expected welfare impacts. The theoretical conditions for a valid money measure of individual utility gains and losses are rather strict. For example, the consumer surplus associated with an ordinary Marshallian demand curve may not provide a unique measure of the welfare change that results from price changes. It is generally accepted that Hicks' (1943) variation and surplus concepts are the theoretically appropriate measures of welfare change.

In consideration of some posited exogenous action or occurrence which changes the level of environmental services from Q^0 to Q^1 (either an increment or decrement), the CV survey designer must select the money measure or "income adjustment" which keeps an individual's utility constant at some specified level.[15]

The Hicksian compensating measure of welfare change, HC, is the amount of money paid or received that leaves the household with the initial (pre-policy) level of well-being at the subsequent (post-policy) level of environmental services.

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[15] As is typically done in CV studies, it is assumed that the vector of market prices P is constant (and left implicit), and that $m^0=m^1=m$.

$$HC = |E(Q^0,U^0) - E(Q^1,U^0)| = |m - E(Q^1,U^0)| \tag{6}$$

For an increment in services, HC can be interpreted as the maximum willingness-to-pay for the gain, WTPc(+). Conversely, for a decrement in services, HC can be interpreted as the minimum willingness-to-accept compensation for the loss, WTAc(-).

The Hicksian equivalent measure of welfare change, HE, is the amount of money paid or received that leaves the household with the post-policy level of well-being at the pre-policy level of environmental services.

$$HE = |E(Q^1,U^1) - E(Q^0,U^1)| = |m - E(Q^0,U^1)| \tag{7}$$

For an increment in services, HE can be interpreted as the minimum willingness to accept compensation to forgo the gain, WTAe(+). Conversely, for a decrement in services, HE can be interpreted as the maximum willingness-to-pay to avoid the loss, WTPe(-).

Thus, there are four possible welfare change measures to consider, depending upon which Hicksian measure is chosen (HC or HE),[16] and whether the change being considered is an increment or decrement (+ or -). These possibilities are summarized in Table 1.1:

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[16] Although simplified here, the analysis of welfare measures is further complicated by whether the Hicksian surplus measures (compensating and equivalent) or variation measures (compensating and equivalent) are called for. The variation measures allow quantity readjustments, the surplus measures do not. See Mishan (1981) for a general discussion, and Brookshire et al. (1980) with reference to CV.

Table 1.1. Valid Money Measures of Welfare Change

Hicksian money measure of welfare change	Reference level of utility	Reference level of environmental services	Income adjustment for increment in services (+)	Income adjustment for decrement in services (-)
compensating measure (c)	U^0	Q^1	WTPc(+)	WTAc(-)
equivalent measure (e)	U^1	Q^0	WTAe(+)	WTPe(-)

In summary, the reference levels as identified in the table represent the level of utility that is to be kept constant, and the level of services that the individual is considered to receive. The simple pneumonic is that the reference level of environmental services will always be the opposite of the reference utility level. It is the variations (or adjustments) in income (WTP and WTA) that keep utility constant.[17] People are stating their terms of trade -- dollars for services.

The above discussion has identified valid money measures of welfare change, and equated them with statements of WTP and WTA. This review helps to establish the CV method within a utility-theoretic framework.

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[17] Although the valid money measures impose a cardinal metric on the welfare change, they do not impose cardinality on the individual utility functions. The cardinalization comes in the form of a monetary value which keeps utility constant (on the same indifference curve).

The General Valuation Function

In practice, the welfare measures (WTP and WTA) are statistically estimated as function of a variety of explanatory variables. As Hoehn (1991:224) states "consistent with the household production literature, the utility and expenditure functions depend on the socioeconomic characteristics of a household..." Along these lines, let SC represent a vector of socioeconomic characteristics, including income m; and let RC represent a vector of physical resource characteristics (which like SC is constant for the individual, but may vary across a sample). The Hicksian welfare change measures can now be expressed as:

$$HE = |m - E(Q^0, SC, RC, V(Q^1, SC, RC))| \tag{8}$$

$$HC = |m - E(Q^1, SC, RC, V(Q^0, SC, RC))| \tag{9}$$

Each of (8) and (9) can be decomposed into two types of statistical functions (WTP and WTA) that might be estimated for some chosen functional form f(.) and assumed error structure, which can all be generally expressed as:

$$HM = f(Q^0, Q^1, SC, RC) \tag{10}$$

where HM refers to the general Hicksian welfare measure. The initial choice of f(.) or E(.) imposes restrictions on the other. The general equation in (10) can be referred to as the valuation function, and is discussed at various points throughout this research; it forms the basis for estimating a function from CV data that represents a money measure welfare change for some change in Q. The inclusion of the covariate vectors (SC and RC) improves statistical efficiency by reducing unexplained variance in estimation, and provides a check on the consistency of results with expected economic relationships (Carson, 1991).

If only a single change is being evaluated [e.g.,WTPe(-) to avoid the loss of access] , then the posited change, $\Delta Q = Q^1 - Q^0$, may not enter into the statistical function at all. Alternatively, the experimental design may attempt to estimate an entire response surface - that is a set of changes (increments or decrements) in Q from the initial reference point, Q^0. To distinguish it from (10), the notion of a response surface for a set of changes in the nonmarket good can be expressed as:

$$HM = f(Q^j, SC, RC) \tag{11}$$

where Q^j is the vector of environmental quantity or quality changes being valued, whose levels j may vary across the sample, for the same individual, or both. Flexibility in choosing f(.) is determined by the chosen elicitation format, and the number of changes in Q^j being valued. As Braden and Kolstad (1991:326) state:

> One of the key technical issues...is whether to value specific changes in commodity quality or quantity, or to derive a valuation function that relates value to quality or quantity in a general way. ...Clearly, value functions are better suited to generalization. Unfortunately, the theoretical baggage is much heavier, even for constructed markets.

One advantage of estimating valuation functions is the ability to further derive marginal valuations, which are often the target of transfer estimates. Following Freeman (1979:228), the Hicksian compensated demand, or marginal valuation, function for a quantity or quality change can be given as, $h(Q,U) = -\,\partial E(Q,U)/\partial Q$.

In summary, this chapter has provided historical background, identified current research trends, and outlined the theoretical framework for the contingent valuation method. Chapters 2 through 4 draw from the introductory material in developing the three distinct studies comprising this dissertation research.

CHAPTER 2

EVIDENCE OF COMPLIANCE BIAS IN DICHOTOMOUS CHOICE CONTINGENT VALUATION

2.1 Introduction

The application of the contingent valuation (CV) method to sensitive environmental and public policy issues remains highly controversial.[1] Despite several decades of impressive research developments, much remains to be learned about response biases in particular survey settings and questioning formats. This study asks whether individuals directly questioned about their willingness-to-pay (WTP) for a public good respond differently, in a setting of apparent social pressure, than those provided with additional insulation or anonymity.

This question is explored in a quasi-experimental setting using a split-sample design. The good being valued is an improvement in a campus cultural program at a public university in the Pacific Northwest -- Oregon State University. A control group of students is given the standard direct questioning (DQ) format for

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[1] Much of this controversy has been fueled by the application of CV to measure nonuse values in natural resource damage assessment and liability cases. Focal points have included: (i) the *Ohio v. the U.S. Department of Interior* case (D.C. Circuit, 1989) upholding the use of CV in liability cases under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended; and (ii) the 1989 *Exxon Valdez* oil spill litigation and subsequent debate over the development of liability rules and regulations pursuant to the Oil Pollution Act of 1990. For recent reviews see Kopp and Smith (1993), and Carson et al. (1993).

dichotomous choice contingent valuation (DC-CV). The rest of the sample is administered a randomized response (RR) questioning format (Warner, 1965). Econometric models are developed to assess both the impacts of a set of explanatory variables and the robustness of impacts across survey types. The empirical evidence supports the hypothesis of compliance bias; the identified bias takes shape in the form of "yea-saying."

The motivation for developing a test to detect the presence of compliance bias lies in the emergence of the DC-CV format for eliciting statements of willingness-to-pay (WTP), and willingness-to-accept (WTA) compensation. In DC-CV, individuals are queried for a yes or no response to pay a specified dollar amount for some proposed change in a public good or service. Varying the specified dollar amount across the sample allows estimation of the underlying valuation function. The presumed properties of the DC-CV format include incentive-compatibility and a reduction in protest responses. The presence of compliance bias negates the claim of incentive-compatibility, and shows that any reduction in protest responses may come at a cost. The development of a test to detect compliance bias in the DC-CV format constitutes the primary contribution of this experimental research.

The paper proceeds as follows. Section 2.2 provides background discussion on social pressure, moral considerations and sensitive CV questions. The randomized response (RR) survey technique is introduced in section 2.3. The potential of response biases is discussed in section 2.4, with further background on the DC-CV format provided section 2.5. The survey instrument is introduced in section 2.6, and followed by modeling considerations in section 2.7. Section 2.8 presents empirical results separately for the DQ and RR models, and also for several pooled models. The results support the hypothesis of compliance bias. An independent statistical test for detecting positive contamination in the DQ sample corroborates the experimental results. In response to these empirical results, a fuller discussion of cognitive and behavioral considerations is given in section 2.9, with a focus on adapting McCain's (1992) impulse-filtering model to a CV context. Section 2.10 summarizes the procedures and results.

2.2 Social Pressure, Moral Considerations, and Sensitive CV Questions

A CV survey is essentially a highly structured conversation (Smith, 1990, 1993). Careful design and construction of this recorded conversation allows the analyst to generate data and conduct empirical hypothesis testing. Information about individual economic preferences may be obtained where market signals for prices and quantities are otherwise nonexistent. The basic preference data to value nonmarket goods and services comes in the form of statements about WTP or WTA in response to some posited, exogenous, change in the nonmarket good or service. A primary concern in these structured conversations is whether people respond truthfully to valuation questions. Considerable research has focused on detection and prevention of strategic misstatements. These purposeful misstatements are typically given a common interpretation -- strategic attempts to influence the level of payment made, or public program provided. An important development in the way analysts structure CV conversations is the introduction of the dichotomous choice elicitation format.

The DC-CV format reduces the cognitive burden on respondents by presenting a simpler decision relative to the open-ended question format. It tends to successfully elicit participation and reduce the level of protest responses often associated with open-ended formats. The "take-it-or-leave-it" decision is analogous to buying and selling decisions in the marketplace; it can also be motivated by reference to political referenda. It is also free of the starting point bias inherent in the iterative bidding games of early CV studies. Perhaps most importantly, it is argued that the DC-CV is incentive-compatible[2] in that it reduces the opportunity for strategic bias such as extreme overpledging. For example, Cameron (1988:355) states that the referendum format "circumvents much of the potential for strategic response bias."

The work of Hoehn and Randall (1987) on the development of satisfactory benefit cost indicators has been particularly influential. They argue that: "In a policy referendum model with individually parametric costs, truth-telling is the individually optimal strategy." This much-cited source is the basis for considerable published support for DC-CV as the preferred elicitation format (Bergstrom and Stoll, 1989; Bockstael et al., 1991; Harris et al., 1989; Mitchell and Carson, 1989). While the full

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[2] A mechanism is *incentive-compatible* if it is in each individual's interests to "behave the way the system's rules instruct him to behave" (Campbell, 1987:5). In the context of the DC-CV format -- answer "Yes" if WTP is greater than or equal to the offered payment level, and "No" otherwise.

conditions of Hoehn and Randall's (1987) policy referendum model are quite strict,[3] this support is usually translated to DC-CV elicitations in general.

However, support for the DC-CV format is not universal. With increased participation comes the need to verify the motivations behind responses. A hint of this can be found in McFadden and Leonard (1992:1), who state:

> In recent years, referendum procedures have tended to replace open-ended elicitation, apparently because they circumvent (or disguise) a relatively high incidence of non-response or "protest" responses found in open-ended studies.

Furthermore, it must be recognized that within these structured conversations a wide variety of social influences and moral considerations may impact responses to sensitive CV survey questions. If the good being valued is unfamiliar to the respondent, then a whole array of context effects may take on increased importance (Schulze, 1993:222).[4] The selection of elicitation format must be sensitive to this

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[3] The policy referendum model is specific with respect to a response rule (a vote for or against), and an outcome or provision rule (e.g., implementation by plurality vote) (Hoehn, 1992:12; Randall and Kriesel, 1990).

[4] Brown and Slovic (1988:29) state: " ...where people's values and attitudes are not at a high level of resolution, their responses tend to be more heavily influenced by contextual cues. ...Because people are not familiar with paying for goods they cannot privately own, they are likely to be particularly susceptible to unintended contextual cues, such as the social acceptability of paying a lot." For the valuation of unfamiliar public goods, preferences may be especially "labile" or subject to change (Fischoff et al., 1980). As Mitchell and Carson (1989:119) state: "respondents will be tempted to minimize effort by resorting to strategies that ease the burden of decision, such as giving an off-the-cuff answer or an answer suggested by an aspect of the scenario that is not intended to convey value."

range of influences. No example better encapsulates the issues then the measurement of existence values and endangered species valuation questions.

An Example: Nonuse Values

Many applications of CV remain contentious, perhaps none more so than the measurement of nonuse values, such as existence values for preserving a wilderness area or protecting an endangered species (Bishop and Welsh, 1992; Castle and Berrens, 1993; Edwards, 1992; Kopp, 1992; Rosenthal and Nelson, 1992). Given that there is often no record of prior use to guide a valuation, the hypothetical choice can be influenced by the setting (context effects), and the structure and content of the information provided (McFadden and Leonard, 1992; Lazo et al., 1992). Further, given that the respondent may be unfamiliar with the good and policy change to be evaluated, it may be difficult to formulate a valuation. A number of philosophers are sharply critical of attempts to measure existence values (Rolston, 1988; Norton, 1987; Sagoff, 1988). Sagoff draws particular attention to protest responses - refusals to "play the game".[5] Not surprisingly, there are a number of recent endangered species and existence value studies utilizing the DC-CV format (Boyle and Bishop,

[5] Sagoff (1988:88) argues that many individuals may reject the normative framework implicit in CV: "It is only in this way - by lodging a protest - that respondents can begin to make their values known. These respondents may perceive of themselves not as bundles of exogenous preferences but as thinking individuals capable of making informed judgements in the context of public inquiry and debate."

1987; Bowker and Stoll, 1988; Hagen et al., 1992; Stevens et al., 1991a, 1991b; and Whitehead and Blomquist, 1991a, 1991b).

Recently, Stevens and colleagues have drawn attention to the problem of protest "no's" in the use of DC-CV in an endangered species setting (Stevens et al., 1991a, 1991b). Only some portion of the no responses represent a rejection based on the size of the offered payment levels. Some responses are not motivated by economic valuation, but rather "represent ambivalence or opposition to some aspect of the valuation exercise" (Stevens, 1992). Thus, individuals who hold a high value on the good may still give a no response in the DC-CV format.

In contrast to private goods, motives now matter (Madariaga and McConnell, 1987), and failure to account for protest zeroes and no's in a CV survey implies a biased measurement of value (Stevens, 1992). Consequently, a common design approach is to provide a set of follow-up questions to identify the motivation behind a zero response. As Stevens (1992:2) further states "Motives underlying positive CV bids also matter, but this issue is more controversial and has received much less attention." Recent debate has focused on the idea of "ideological bids," "warm glow effects," and responding to a "good cause" (Harrison, 1992; Kahneman and Knetsch, 1992a, 1992b, 1992c; Loomis et al., 1992; Smith, 1992a).

Attention here is on the yes responses in the DC-CV format; the focus is on a source of potential bias in the DC-CV format -- the perceived social pressure to support a cause. In the lexicon of popular culture, this is often described as giving the "politically correct" response.[6] In effect, rather than looking at refusals to play the game, we investigate the case where individuals may play the game as a means of ending the survey, or preserving their privacy on a sensitive question. Again, existence values and endangered species issues bring this sharply into focus.

Consider one stylized example. An individual is telephoned at home and as part of a survey is asked to accept or reject, on the spot, a particular hypothetical payment to an endangered species trust fund. The individual may perceive such a fund as a generally good cause, and that the socially/politically correct response is to say yes -- even though they would never actually pay such an amount, or may be ambivalent or uncertain of their true valuation. This stylized example may illustrate Michelman's (1992:72) "morally dominant", or ethically-laden, DC questions which are hypothesized to introduce an upward bias to valuations of environmental goods.

Policy Relevance and Emerging Evidence

Appreciation for this experimental research can be motivated by considering a recent development in the public debate over CV. Pursuant to the Oil Pollution Act of 1990, a blue-ribbon panel, containing several Nobel Laureate economists, was

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[6] In their analysis of CV responses for wilderness protection, McFadden and Leonard (1992:29) state: "One possible explanation... ...is that a consumer's stated WTP is a blend of personal tastes and a perception of a "politically correct" response." They conclude their analysis, which compares open-ended and discrete choice formats, by stating: "Some of the economic features of stated WTP are sufficiently implausible to raise the issue of whether factors other than preferences, such as a perception of what answers are considered appropriate, are entering responses" (1992:45).

convened to provide guidance on promulgating regulations for the potential use of CV in valuing passive or nonuse values (Arrow et al., 1993). Panel recommendations include support for personal interviews and for use of dichotomous choice valuation questions. Despite the many advantages of the referendum format, the Panel also implicitly recognized the potential for compliance bias:

> There is no strategic reason for the respondent to do other than answer truthfully, although the tendency to overestimate often appears even in connection with surveys concerning routine market goods. ...There are, however, several other reasons why one's response to a hypothetical referendum question might be the opposite of one's actual vote on a real ballot. ...a respondent unwilling to pay D dollars in reality might feel pressure to give the "right" or "good" answer when responding to a in-person or telephone interviewer. This could happen if the respondent believes that the interviewer herself would favor a yes answer. (Arrow et al., 1993:22)

The Panel goes on to state that:

> It is possible that interviewers contribute to "social desirability" bias, since preserving the environment is widely viewed as something positive. (Arrow et al., 1993:48)

In response to these concerns, the Panel recommends that "major CV studies" incorporate experiments to assess such social context effects.

Although the NOAA Panel's recommendation supporting the referendum format is clear, it may be in conflict with their own more general recommendation of conservative CV design and underestimating WTP. A primary concern of the Panel was strategic overpledging in open-ended formats. While this concern may be valid, it does not mean that the referendum format necessarily produces the more conservative estimates. In fact, the emerging empirical evidence shows otherwise.

Based on emerging comparative results, Hoehn (1992) hypothesizes that values elicited from referendum formats "dominate" those from open-ended formats. Study-specific evidence of DC-CV value estimates exceeding open-ended estimates can be found in Johnson et al. (1990), Loomis et al. (1992), and McFadden and Leonard (1992). The meta-analysis of Walsh et al. (1989), covering a large number of CV studies, provides statistical evidence that this disparity is persistent.

In several of the more rigorous comparisons, Kristrom's (1990b) analysis of the WTP distributions from split-sample referendum and open-ended formats supports the hypothesis that the referendum valuations are higher. Lacking any guidance from economic theory, Kristrom attributes the disparity to differences in the way the questions are perceived. Kealy and Turner (1993) develop a test to find whether DC-CV and open-ended formats produce significantly different valuation results. The test is based on joint estimation of responses from the same sample of individuals. The results indicate that DC-CV values significantly exceed open-ended values for a public good but not for a private good. Kealy and Turner conclude that given the disparity in the public good case, further research is needed into psychological and strategic response issues. They argue that given the current evidence, it cannot be concluded that either format is superior.

The justification for exploring compliance bias in DC-CV is clear. The approach used here merges CV with a social survey research technique for asking sensitive questions.

2.3 A Test Procedure: The Randomized Response Survey Technique

Given the hypothesized presence of social pressure, moral considerations and sensitivity of some valuation questions, we explore an available social survey method for eliciting truthful responses, and tailor it to the DC-CV framework. The randomized response (RR) survey method is a set of probability-based approaches which provide respondents with increased insulation or anonymity, and allow them to answer a sensitive question without revealing, with certainty, their true response. In general terms, RR uses the element of chance to "inoculate responses to sensitive inquiries" (Fox and Tracy, 1986). As noted by Bradburn (1983), the name of the technique is somewhat misleading since it is the sensitive question which is randomized, rather than the response to it.

The randomized response survey technique was originally introduced by Warner (1965), and has received considerable use and discussion (catalogued in Nathan, 1988). The RR method is detailed in several book-length monographs (Chauduri and Mukerjee, 1988; Fox and Tracy, 1986) and is reviewed by Greenberg et al. (1988) and Scheers (1992). Examples of RR survey applications include tax evasion, illegal business competition, unreported telephone hook-ups, agricultural production inputs, cheating on exams, drug use, and a wide variety of public health issues. RR has been used in a variety of survey formats (Stern and Steinhorst, 1984).

Early RR applications focus on sample proportions of sensitive characteristics or attributes. Madalla (1983) discusses the modeling of RR responses and identifying statistical determinants of sensitive behavior. Madalla and Trost (1978) estimate logistic regression models with artificially randomized data. Exploration of the correlation between a sensitive response and a continuous covariate can be found in Scheers and Dayton (1987, 1988). Scheers (1992) combines RR with a logit model. Kerkvliet applies logit and probit models with the an RR survey technique to explore the determinants of cocaine use (1993b) and cheating by college economics students (1993a). This study combines RR with censored logistic regression and DC-CV.

The specific RR variant used here is referred to as the "unrelated question" design. In general terms, some type of randomization process is used to direct the respondent, with a probability known to the analyst, to give a yes/no answer to either an unrelated (innocuous) question of fact or the sensitive question. The task of the analyst is then to use the known probability information to statistically "decode" the sensitive responses. At a minimum, insights are gained into the robustness/fragility of statistical results across questioning formats.

Comparative results of RR versus DQ formats in split sample designs have usually shown an increase in self-reports of sensitive characteristics or behaviors under RR. The common interpretation is that the RR responses are the more accurate self-reports (Chauduri and Mukerjee, 1988). Several validation studies with known data have generally corroborated this interpretation; RR tends to outperform DQ in detection of sensitive characteristics or behavior, but may not completely eliminate response bias (Armacost et al., 1991; Himmelfarb and Lickteig, 1982).

While RR may not completely eliminate response bias in a statistical sense, the maintained hypothesis is that the RR format will engender more truthful responses to sensitive questions, compared to DQ formats. The expectation is that individuals will tend to overreport socially desirable behavior, and underreport socially undesirable behavior in a DQ questioning format (Armacost et al., 1991). Thus, the compliance bias or yea-saying hypothesis in a CV context incorporating an RR technique is that, $\mathbf{H_{CB}}$: $\mathbf{WTP_{DQ} > WTP_{RR}}$, against the null hypothesis, $\mathbf{H_{O}}$: $\mathbf{WTP_{DQ} = WTP_{RR}}$. Finally, it is expected that if compliance bias is detected, then it can be systematically linked to statistical determinants such as socioeconomic characteristics and beliefs (Santee and Maslach, 1982).

The RR technique is best understood by following through the actual survey design and modeling approach, presented in sections 2.6 and 2.7, respectively. The following discussion turns to the types of response biases that can arise in DC-CV.

2.4 Response Biases in Dichotomous Choice Contingent Valuation

The referendum or dichotomous choice format has emerged across numerous empirical investigations and professional critiques as a preferred survey design. However, it is unclear why less information is necessarily better. As discussed earlier, the use of yes/no queries to elicit valuation responses may inflate concerns with potential yea-saying by respondents.

Yea-saying can be defined as "the tendency of some respondents to agree with an interviewer's request regardless of their true views."[7] This general survey problem may increase in importance in the CV context when dichotomous choice or referendum formats are used to elicit valuation responses (Desvouges et al., 1993:11). Mitchell and Carson (1989:101) state:

> Also, take-it-or-leave-it may be subject to a non-zero background level of yea-saying. This problem...is the discrete choice analogue of starting point bias and is somewhat harder to detect.

They also state (1989:243):

> The problem of yea-saying may be seen as akin to the biometrician's problem of how to estimate the effects of a stimulus against a non-zero response background.

A non-zero response background refers to the existence of a natural response rate that occurs in an experiment regardless of the level of presented stimuli (Hasselblad et al., 1980). Typically, logit and probit probability models are used as survival functions or tolerance distributions in dose-response studies.

Concern for this non-zero response background has influenced design choice in contingent valuation surveys. In a study of Columbia River salmon existence values, Olsen et al. (1991) chose an open-ended format for eliciting WTP and WTA responses. The dichotomous choice format was discounted because of potential bias caused by "yea-saying". Randall and Farmer (1992) recently examined a DC with

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[7] Discussions of yea-saying can also be found in Arndt and Crane (1975), and Couch and Keniston (1960). A full review of the literature on social desirability bias in survey research can be found in De Maio (1984).

open-ended follow-up format for eliciting valuation responses. Because of concern with "yea-saying" in the original DC question, they focused on calibrating WTP from the continuous responses by accounting for known starting price effects.

Concerns with yea-saying can more properly be placed within a larger framework of potential biases in CV surveys; it can be specifically equated with compliance bias. Mitchell and Carson (1989:236) offer a typology of potential response effect biases in CV studies. Of particular relevance is the category entitled "Incentives to Misrepresent Responses." Biases in this class are said to occur when a respondent gives a valuation statement that misrepresents his or her true value; this comes in two basic forms (i) strategic bias, and (ii) compliance bias. Strategic bias is where a respondent purposefully misstates a valuation response in an attempt to strategically influence either the provision or payment level of the public good. Compliance bias is where a respondent purposefully misstates a valuation response in an attempt to comply with the presumed expectation of a sponsor, or interviewer.

Strategic bias has received considerable CV research attention (e.g., Milon, 1989; Prince et al., 1992); the discussion dates back to Samuelson's (1954) assertion of self-interested "false signals" on questionnaires concerning public good preference revelation. Avoiding strategic bias was a primary impetus in developing the DC-CV format. In contrast, while Mitchell and Carson (1989:238) accept the plausibility of compliance bias, they note that it is "surprisingly poorly documented."

2.5 Background on the DC-CV Format

The utility-theoretic basis for the DC-CV format can be motivated in two distinct ways. Hanemann (1984) first set out the random utility model or "utility-difference" motivation, and also identified the alternative "tolerance distribution" motivation. The latter has been more fully developed in the context of censored regression (Cameron and James, 1987a, 1987b; Cameron, 1988, 1991a, 1991b). McConnell (1990) considers these two approaches to be the "dual" of each other in economic theory. This study utilizes a censored regression approach; theoretical considerations and econometric procedures are discussed below.

Theoretical Considerations

The level of public services is denoted as s, where s^0 refers to the pre-policy level, and s^1 refers to the post-policy level of services. We assume that the respondent is familiar with the initial setting and can assign an initial level of utility, u^0. This initial setting is defined by a vector of prices, p, for market goods, the level of cultural services, s^0, and income, m. Given this initial set of parameters, the individual obtains $u^0 = v(p,s^0,m)$, where:

$$v(p,s,m) = \max_x [\ u(x,s) \mid px \leq m\ ] \tag{1}$$

v(.) is the indirect utility function, x is a vector of market goods, and u(.) is considered to be concave and increasing in x and s. The inverse of the indirect utility function, $v^{-1}(.)$, gives the individual's expenditure function e(p,s,u), which can be defined as the minimum level of expenditure, given some p and s, which provides the level of well-being, u. For an increase in services, an individual's willingness-to-pay (WTP) to acquire the gain provides the Hicksian compensating (HC) measure for the welfare change, defined by:

$$HC(s^0, s^1) = e(p, s^0, u^0) - e(p, s^1, u^0) = m - e(p, s^1, u^0) \tag{2}$$

Substituting v(.) for the unobservable u(.) :

$$HC(s^0, s^1) = m - e(p,s^0,v(p,m,s^1)) \tag{3}$$

which is often more simply written as the WTP or valuation function:

$$WTP = f(m, s^0, s^1) \tag{4}$$

The statistical estimation of the function implicit in (3) is commonly expanded to include additional explanatory variables, such as a vector of taste parameters, T. Again, there is a one-to-one correspondence between HC and $WTP=f(m,s^0,s^1,T)$. In the open-ended CV format, the valuation function can be estimated directly. The DC-CV format does not allow a WTP function to be obtained directly.

Econometric Approach

In the following, the censored regression approach (Cameron, 1988, 1991a) is set out in brief. Begin by assuming that the individual, i, has a continuous linear WTP function over a vector of explanatory variables, X, and an error term, υ_i:

$$WTP_i = X_i'\beta + \upsilon_i \tag{5}$$

The individual's true WTP is taken as an unobservable random variable, but its magnitude can be inferred through a discrete indicator variable, W. With referendum-style data, W is defined in relation to the offered payment level, τ:

$$W_i = 1 \textit{ if } WTP_i \geq \tau_1;\ W_i = 0 \textit{ otherwise} \tag{6}$$

The payment level is thus a stimulus variable to which the individual reacts, accepting or rejecting if her true WTP is above or below this censoring threshold.

The prevailing pattern of DC-CV studies is to use conventional maximum likelihood logit or probit models, with the payment level used as one of the explanatory variables (Cameron, 1988). The censored regression approach does the same, but uses the information more efficiently. The probability of a yes response can be defined for the logistic probability model as:

$$Prob(W_i = 1) = P = [1+e^{-Z(X_i,\ \tau_i)}]^{-1} \tag{7}$$

Finally, forming the odds ratio gives, $P/(1-P)=e^{Z(X,\tau)}$, and then taking the logarithm provides the commonly expressed "log odds-ratio" or "logit", $\ln[P/(1-P)]=Z(X,\tau)$. In full, the likelihood function (L) for the DQ format can be given as:

$$L = \Pi_{W_i=1}[(1+e^{-Z(X,\tau)})^{-1}]\ \Pi_{W_i=0}[\frac{e^{-Z(X,\tau)}}{(1+e^{-Z(X,\tau)})}] \tag{8}$$

If $Z(X, \tau)$ is a linear function of the vector of explanatory variables and payment:

$$Z_i(X_i, \tau_i) = X_i'\lambda + \tau_i\alpha \tag{9}$$

then the logit is said to be "linear-in-the-parameters" (where λ and α are coefficients to estimated). Following Cameron (1988), the logit estimation results can be reparameterized to obtain the underlying valuation function. This transformation of the logit model is accomplished by rewriting the log-likelihood function to exploit the additional information. Given that the stimulus variable is known, is non-zero ($\tau>0$) and is measured in the same units as WTP, the dispersion parameter K in the logit model can be recovered from the estimated coefficient on τ ($\alpha = -1/K$). Then, by dividing the intercept and all other slope coefficients by α:

$$\frac{\lambda_j}{\alpha} = \beta_j \quad \forall\, j \textit{ explanatory variables} \tag{10}$$

the estimated WTP function can be given as, WTP=X'β. The alternative is to perform the algebra prior to estimation, by respecifying the likelihood function, and using a general function optimization algorithm to obtain the WTP function.[8]

As will be seen in section 2.7, incorporation of the RR technique requires that the likelihood function given in (8) be modified to account for the additional

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[8] The log-likelihood function when $\tau_i = 0$, for all i is: Log L = $\sum(1-W_i)(-X_i\beta/K) - \log[1+\exp(-X_i\beta/K)]$. The coefficients β on the underlying valuation function cannot be separated from the dispersion parameter, K. This is implicit in the estimated coefficients in any general logit model. In contrast, when $\tau_i > 0$:

$$\textbf{Log L} = \sum(1-W_i)[(\tau_i-X_i\beta)/K] - \log[1+\exp((\tau_i-X_i\beta)/K)]$$
$$= \sum(1-W_i)[(\tau_i/K) - (X_i\beta/K)] - \log[1+\exp((\tau_i/K) - (X_i\beta/K))]$$

The isolation of K, with a known and nonzero τ_i allows K to be explicitly estimated (K=1/α). Once K is known, then β can be estimated, $\lambda_j/\alpha = \beta_j$.

probability information implicit in the randomization process. Thus, non-traditional likelihood functions must be developed and estimated through general optimization procedures.[9] However, this additional probability information is treated as a set of empirical constants, and otherwise does not impact the censored regression approach.

2.6 The Survey Instrument

The setting is described as "quasi-experimental"; the good being valued is a real public good with considerable importance to the campus community. However, the choice of setting and instrument is not based on a direct policy issue. The setting is a typical American university campus, Oregon State University, with multicultural interaction and misunderstandings.[10] Support by the university administration and print media for cultural understanding and interracial interactions is high. Examples include development of a cultural diversity curriculum, opening of an Office of Multicultural Affairs, and public support statements. Conversely, at the same time there were a series of alleged racial incidents on campus and in the community in 1991-1992. Thus, the survey can be administered in a situation where there may be substantial social pressures to express certain socially acceptable attitudes, which may

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[9] The non-traditional likelihood functions were estimated using the nonlinear function optimizing procedure (with the "logden" option) on version 6.2 of the SHAZAM econometrics program (White et al., 1990).

[10] Race relations on university campuses are reviewed in a number of articles in the April 19, 1993 issue of *U.S. News and World Report* (e.g., Sanoff et al., 1993).

not reflect true attitudes.[11] The experiments are conducted in a classroom situation, which "for experimental purposes" is a variant of the mail survey (Carson, 1991).

The questionnaire was developed, and pre-tested for clarity with a small focus group in Spring term of 1991. Formal permission by the university administration was given in early 1992. Guidelines required that potential respondents be informed prior to the distribution of the questionnaires that participation was voluntary and in no way connected to class. Also, administration of the questionnaire was always performed by someone other than the class instructor. Thirteen undergraduate economics classes were surveyed over Winter, Spring and Summer terms of 1992.

Commodity Specification and Payment Vehicle

The questionnaire begins with a brief description, taken from the *University Guide to Student Life,* of the students' cultural centers[12] on campus:

> **These centers provide separate locations and facilities for the various academic, social, cultural, and recreational events arranged by minority groups. Such events help promote understanding and awareness of the minorities and their concerns through intergroup mixing among segments of the University and the local community. OSU's cultural centers are public facilities**

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[11] Failure to support the cultural centers program cannot be equated with racism or lack of support for diversity. It may indicate lack of support for the expansion of the program; some critics argue that such programs promote separatism (see Sanoff et al., 1993), or for the need for voluntary funding of such an expansion.

[12] As explained in the questionnaire, "there are currently four minority student cultural centers on the OSU campus: (1) the Black Cultural Center, (2) the Hispanic Cultural Center, (3) the Native American Longhouse, and (4) the Asian Cultural Center."

> **and are part of the Memorial Union Activities program. Students of all ethnic backgrounds are welcome to drop by and visit or study. The cultural centers are governed by an advisory committee composed of students, faculty, and administrators.**

The respondents are then told that expansion of the cultural centers program, from its current (1992) level of services, might be funded through a voluntary student payment program. The payment vehicle is a "check-off box" on computerized student quarterly registration forms:

> **Your quarterly class registration form includes an itemized billing for tuition and fees. It also regularly includes a checkoff section for "optional services requests" such as medical insurance and parking permits. This is somewhat similar to checking off on your income tax form to indicate whether you will contribute a dollar to the presidential campaign fund.**

The payment vehicle is believed to be both familiar to the respondents, and neutral with respect to its impact on the valuation statement.

The Randomization Technique

The respondents are then presented with a description of a yes or no decision: a check-off box to be placed on the quarterly registration form for the purpose of supporting an expansion of the facilities and activities of the cultural centers program. They are informed that the situation is hypothetical and not part of any official university plan. Marking a "Yes" in the box would indicate contribution of a specified dollar amount to support the expansion, through the concomitant increase in registration fees; marking a "No" would indicate an unwillingness to contribute the specific dollar amount. The voluntary contribution format matches that commonly used in CV studies for nonexclusive environmental goods, such as preservation "trust" funds (Duffield, 1991; Duffield and Patterson, 1992; Loomis et al., 1992; Stevens et al., 1991a; Whitehead and Blomquist, 1991a, 1991b).

After describing the hypothetical situation, but prior to the valuation question, the randomization technique is introduced. Respondents are asked to compute a random number by summing the last four digits of their Social Security Number:

> **To ensure your privacy, we are using a technique in which you are asked to give a truthful response to a sensitive question or answer a trivial question of fact.**
>
> **So that only you will know which question you answered, it will first be necessary that you compute a random number from your Social Security Number. THIS RANDOM NUMBER IS NOT YOUR SOCIAL SECURITY NUMBER AND CANNOT BE USED TO FIND YOUR SOCIAL SECURITY NUMBER. This random number is the sum of the last four digits of your Social Security Number. For example if your Social Security Number is:**
>
> **517-48-1234**
>
> **your random number is: 1 + 2 + 3 + 4 = 10**
>
> **Now compute your random number using your Social Security Number. Do NOT write or speak this number, but remember it for the first question. Please answer the question honestly. Your answer cannot be traced to you, nor do we have any interest in doing so. We are only interested in trying a statistical procedure.**
>
> **Q1.**
>
> **This question requires a Yes or No to one of two questions. If your random number is between 0 and 10, answer question A below. If your random number is between 11 and 36, answer question B below.**
>
> **A. Is your mother's birthday in May?**

B. Are you willing to pay $X.XX dollars per quarter to support an expansion of the cultural centers program?

Depending on your random number, answer either A or B below:
YES_____
NO_____

The purpose of the randomized response instrument is to generate a perception of increased insulation, while only directing some small proportion of the respondents to the unrelated question A. Question B elicits the WTP for the expansion in services, and can be interpreted as the Hicksian compensating (HC) measure of welfare change. For the RR group, the binary indicator (W_i) may refer to either A or B. In contrast, for the DQ group no randomization technique is used and B is asked directly; the binary indicator (W_i) refers only to B. Each student, in both DQ and RR, is presented with only a single payment level to be accepted or rejected.

The Structure of the Payment Levels

A total of 468 questionnaires were collected, with a 97 percent (455/468) response rate on the valuation question. The structure of the payment levels used in the surveys is given in Table 2.1. Acceptance rates are given for each payment level, with and without the randomization technique.[13]

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[13] A pretest of the original survey was conducted on a graduate resource economics class of 15 people, and also allowed for some short follow-up discussions with respondents on survey wording. All pretest surveys were for the RR format. Originally, the payment levels ($) were 1, 3, 5, 7, and 9. The first large print-up was for the RR format and these original five payment levels. The project was then delayed while university administration approval was obtained to conduct the full-fledged survey in classrooms. Subsequent analysis using several simple models

Table 2.1 shows an inverse relationship between the probability of acceptance (a yes response to the valuation question) and the payment level. With the RR technique, the overall acceptance rate is 0.31. For the DQ survey, the rate increases to 0.43. Eleven payment levels were used with the mean offer at $6.05 ($5.74 for RR, and $6.67 for DQ). For payment levels $5 and below, the acceptance rates were 0.38 for the RR, and 0.58 for the DQ. For payment levels $7 and above, the acceptance rates were 0.21 for the RR, and 0.26 for the DQ.

Figure 2.1 provides a plot of acceptance rates for the two survey types, across the eleven payment levels. It can be seen that the DQ acceptance rate is everywhere equal to or greater than the RR acceptance rate. As a crude preliminary indicator, a small sample one-tailed *t*-test of the difference between the RR and DQ mean probabilities of acceptance for all payment levels is conducted. The evidence supports the hypothesis of a significant difference ($p<0.10$). A similar conclusion is derived using the nonparametric Wilcoxon rank-sum test.[14] Thus, an initial scan of

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suggested a mean WTP of $1-3. In response, three additional payment levels were added near the vicinity of the expected mean (0.50, 1.50, and 2.00). Three additional payment levels were also added in the upper tail (10, 12, and 20), based on interpretation of then emerging research results (Cooper, 1993; Cooper and Loomis, 1992). In the second, and final printing, all 11 payment levels were used evenly. This circuitous path explains the fairly large apportionment of surveys in the RR format for the payment levels ($) of 1, 3, 5, 7 and 9. The original design goal was to obtain a minimum control sample (DQ) of 100 usable responses, given expected item-nonresponse. Then, based on previous experience with RR surveys (Kerkvliet, 1993a; 1993b), the goal was to obtain at least twice as many usable RR surveys.

[14] In conducting the Wilcoxon rank-sum test, (McClave and Dietrich, 1985), the pair of values for the $9.00 payment levels, which have the same acceptance rate in both samples, is dropped.

the evidence, without accounting for heterogeneity in the sample frame, indicates the *potential* presence of compliance bias in the DQ format. However, this analysis does not take into account heterogeneity in the sample frame, or the probability information in the randomization process for the RR group. The next section turns to the full modeling framework.

2.7 Modeling Considerations

The Probability Models

Estimation of the acceptance rates for the RR format must account for the additional probability information available. Denote ρ as the probability of the respondent constructing a number that falls within the range 11-36, and $(1-\rho)$ as the probability for the range 0-10. The empirical distribution for the sum of the last four digits of the Social Security number is calculated individually for each class from the class rosters. Further, let $P^j(k)$ represent the probability of a yes (k=1) or no (k=0) response to the jth question; where j=1 is the dichotomous choice valuation question and j=2 is the unrelated yes/no question of fact. The probability of obtaining a yes response to the binary indicator variable is expressed as follows:

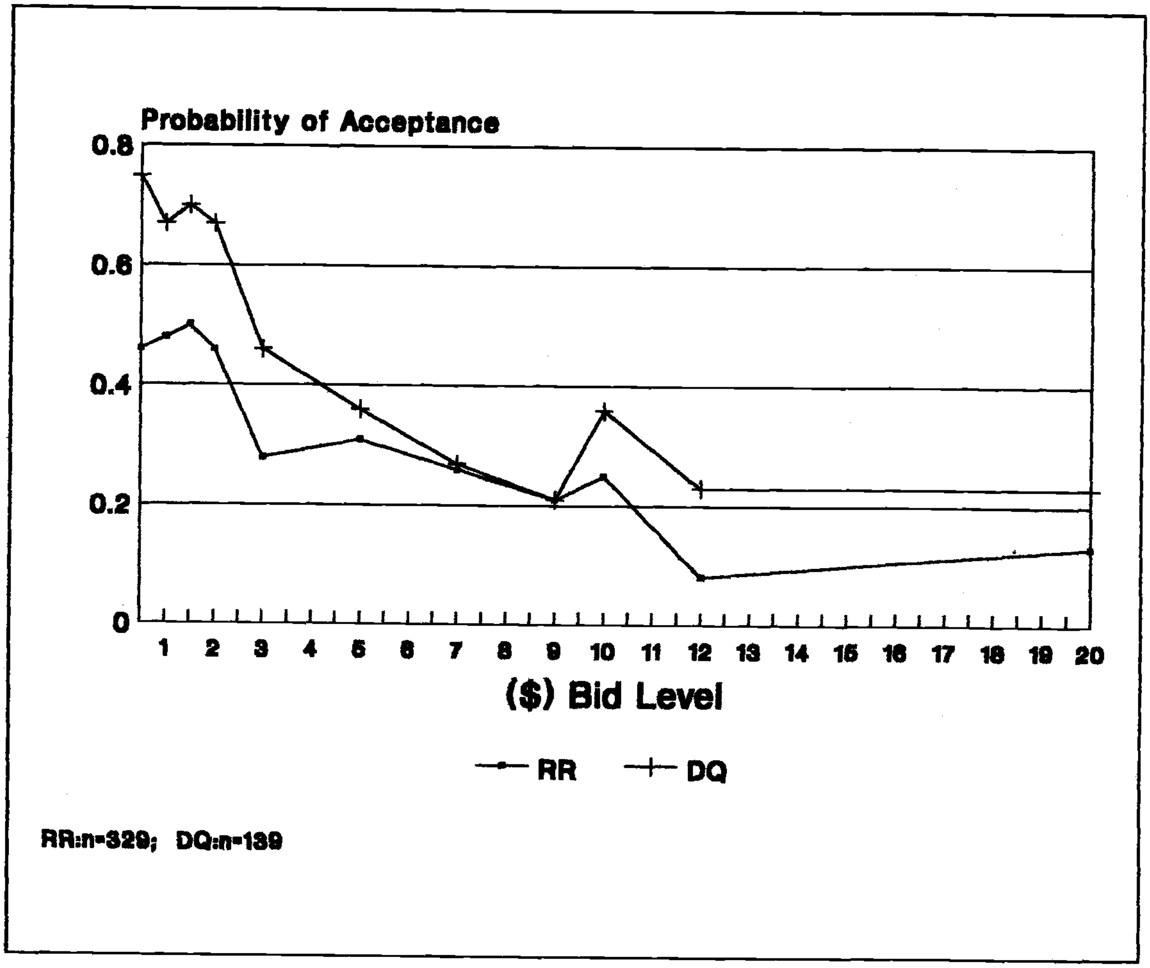
$$Prob(W_i=1) = \rho \cdot P^1(1) + (1-\rho) \cdot P^2(1) \qquad (11)$$

Table 2.1. Payment Levels and Acceptance Rates

Payment Level ($)	Acceptance Rate, RR	Acceptance Rate, DQ	Total Acceptance Rate (RR+DQ)
0.50	5/11 (0.46)	9/12 (0.75)	14/23 (0.61)
1.00	24/50 (0.48) [2]	8/12 (0.67)	32/62 (0.52) [2]
1.50	7/14 (0.5)	7/10 (0.7)	14/24 (0.58)
2.00	5/11 (0.46)	7/11 (0.67)	12/23 (0.52)
3.00	13/46 (0.28) [3]	6/13 (0.46)	19/52 (0.37) [3]
5.00	16/52 (0.31)	5/14 (0.36)	21/66 (0.32)
7.00	12/47 (0.26) [3]	4/15 (0.27)	16/65 (0.25) [3]
9.00	10/47 (0.21) [2]	3/14 (0.21)	12/62 (0.19) [2]
10.00	3/12 (0.25)	4/11 (0.36) [1]	7/23 (0.30)
12.00	1/12 (0.08)	3/13 (0.23)	4/25 (0.16)
20.00	2/15 (0.13) [2]	3/13 (0.23) [1]	5/29 (0.17) [3]
Totals	98/317 (0.310) [11]	59/138 (0.428) [2]	157/455 (0.345) [13]

The numbers in parentheses are percentage rates; The bracketed numbers in selected cells give the number of unusable responses or failures to answer the valuation question; these observations are not used in calculating acceptance rates.

Figure 2.1. Distribution of Acceptance Rates



And similarly, the probability of a no response:

$$Prob(W_i=0) = \rho \cdot P^1(0) + (1-\rho) \cdot P^2(0) \tag{12}$$

The $\mathbf{P^1(k)}$ probability for the kth response is modeled as a logistic probability function. Thus, for a yes response, k=1, the probability can be given as:

$$P^1(1) = [1+e^{-Z(X,\tau)}]^{-1} \tag{13}$$

And for a no response:

$$(1-P^1(1)) = P^1(0) = \frac{e^{-Z(X,\tau)}}{1+e^{-Z(X,\tau)}} \tag{14}$$

Combining the preceding four equations, the likelihood function for the RR question format is:

$$L=\Pi_{W_i=1}[(1-\rho)\cdot P^2(1)+\rho\cdot(1+e^{-Z(X,\tau)})^{-1}]\ \Pi_{W_i=0}[(1-\rho)\cdot P^2(0)+\rho\cdot\frac{e^{-Z(X,\tau)}}{(1+e^{-Z(X,\tau)})}] \tag{15}$$

Whereas, for the DQ models the regular logit likelihood function (8) is used. In the next section, the explanatory variables used in the $Z(X,\tau)$ term are discussed.

Explanatory Variables

An inverse relationship is expected between the payment level, τ, and the probability of acceptance, as shown in Table 2.1. Table 2.2 provides a description of the explanatory variables, the X vector, used in the empirical models, and their *a priori* hypothesized relationships with the underlying valuation function, WTP. Note that the reparameterization in (10) maintains the signs of the coefficients; thus, the directional relationships between WTP and the X vector of explanatory variables will be the same as those on the estimated coefficients in the antecedent logit equation.

Further discussion of the explanatory variables is given in the following section, where empirical results are provided for the DQ, RR, and pooled sample models. A point of interest is the degree of correspondence between the split samples in terms of descriptive statistics for the set of explanatory variables. In general, there is a strong correspondence between the two samples, indicating that they were indeed drawn from the same general population. Descriptive statistics for two important explanatory variables are examined in Tables 2.3 and 2.4. Additional discussion and presentation of descriptive statistics for the remaining explanatory variables is presented in Appendix A. The sample characteristics also correspond roughly with the general university population (OSU, 1992).

Table 2.3 provides a breakdown of responses for perceived cultural tolerance/intolerance in the university community. These responses are used in coding the TOL1, TOL2 dummy variables. The "intolerant" and "very intolerant" categories were combined for estimation due to the small percentage in the latter.

A monthly household expenditure question has the lowest overall response rate on the questionnaire (85 percent). While there is a distinct difference between the RR and DQ groups, this is somewhat deceiving. Several extremely large responses for the RR group greatly skewed the distribution. In a variety of initial probability models, the continuous measure of expenditures was never a statistically significant explanatory variable.[15]

Despite the difference in means, it can be seen in Table 2.4 that the medians were identical for the RR and DQ split samples. Consequently, the dummy variable EXP (=1 if combined expenditures greater than or equal to $500, 0 otherwise) was used in estimation. The low response rate for the expenditures question has implications for the logic of constructing the econometric models. In any survey, each variable may have missing observations given that respondents may not answer all of the questions. The missing responses, referred to as item nonresponses, censor the number of observations that can be used in any model (Bishop et al., 1987:N.3). Given the high item nonresponse, and the potential influence on experimental results, separate models with and without the EXP variable are estimated throughout. Further, item nonresponses are used to censor observations only for those variables included in any given model. This procedure retains the maximum available sample size for every model. The following section turns to the discussion of empirical results.

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[15] In a variety of preliminary models, the continuous expenditure variable was never statistically significant. Imputation methods to generate observations for missing responses (including several outliers that were dropped) performed poorly. For example, the type-two tobit model using the Inverse Mill's Ratio was used to generate predictions for missing or outlier expenditure responses (Amemiya, 1984). The revised expenditure variable was never found to be significant in any estimated logit models. Finally, the household expenditure question may have been poorly conceived. A number of survey respondents undoubtedly belonged to fraternity and sorority houses, and thus been the source of the extremely large responses.

Table 2.2. Description of Explanatory Variables

Variable	Description	Hypothesized Relationship to WTP
SUP	Degree of self-support provided; 1 = less than 25%, 0 otherwise	+
TOL1	Degree of perceived cultural tolerance in the university community, 1=very tolerant, 0=otherwise	-
TOL2	Degree of perceived cultural tolerance in the university community, 1=tolerant; 0=otherwise	-
CIT	1 indicates US citizen, 0 otherwise	-
AWARE	1 indicates having taken cultural awareness or cultural diversity class, 0 otherwise	+
GEN	1 = male, 0 = female	?
SZ	Class size for administering the survey	+
ETH1	1 = caucasian, 0 otherwise	?
ETH2	1 = asian, 0 otherwise	?
R/U	1 indicates a rural background; 0 indicates an urban background	-
AGE(21-26)	1 = age group 21-26; 0 otherwise	?
AGE(27+)	1 = age group 27 +; 0 otherwise	?
EXP	Level of monthly household expenditures on food, clothing, housing, and entertainment (combined); 1= greater than or equal to $500; 0 otherwise	+

Table 2.3. Breakdown by Perceptions of Cultural Tolerance

Perceived Level of Tolerance in University Community	RR n=310	DQ n=136	Total n=446
Very Tolerant of Cultural Diversity	35 (0.113)	18 (0.132)	53 (0.118)
Tolerant of Cultural Diversity	228 (0.735)	96 (0.706)	324 (0.726)
Intolerant of Cultural Diversity	40 (0.129)	18 (0.132)	58 (0.130)
Very Intolerant of Cultural Diversity	7 (0.023)	4 (0.029)	11 (0.025)

Table 2.4. Combined Monthly Expenditures

	RR n=276	DQ n=125	TOTAL n=401
Combined Monthly Expenditures $	mean=1366 median=500 st.dev=6559	mean=874 median=500 st.dev=1787	mean=1216 median=500 st.dev=5544

2.8 Empirical Results

The DQ Models

For the DQ control group, eight separate logit models are presented in Table 2.5. All models were estimated using a packaged logit MLE routine, and range in sample size (n) from 118 to 134. Both the linear and the so-called "log-linear" functional form (where the natural logarithm of the bid, LNBID, is used) are estimated for an extended and a "trimmed" model. These four models are then repeated to include the EXP dummy variable, at the cost of considerable reduction in sample size. All eight models are statistically significant. The statistical significance and signs of the estimated coefficients are generally stable across models. In all models the BID variable (the payment level, τ) is statistically significant and inversely related to the probability of acceptance. The signs of all statistically significant coefficients agree with the expected signs in Table 2.2.

The evidence from separate likelihood ratio tests (LRT), that all slope coefficients are equal to zero, supports the hypothesis that individual DQ models are statistically significant ($p<0.01$). In terms of goodness-of-fit, the Pseudo-R^2 measures are within the range found in many empirical DC-CV studies.

There is no statistical evidence ($p<0.10$ or above) in the DQ models of alternative perceptions of cultural intolerance in the university community having an impact on the probability of accepting any given bid level. The dummy variable TOL1 identifies those individuals who perceived the university community as being "very tolerant" of cultural diversity. Likewise, TOL2 identifies those who perceived the university community as being "tolerant". All others perceived the atmosphere as either "intolerant" or "very intolerant".

There is a significant ($p<0.01$) and positive relationship between the dummy variable SUP, an indicator of the degree of self-support, and the probability of

Table 2.5. Estimation Results from the DQ Logit Models

Variable	DQ-1 n=130	DQ-2 n=118	DQ-3 n=129	DQ-4 n=118	DQ-5 n=134	DQ-6 n=121	DQ-7 n=134	DQ-8 n=121
Intercept	0.742	0.456	0.957	-0.159	1.057	0.45	*1.41	0.841
	(0.46)	(0.27)	(0.39)	(-0.06)	(1.29)	(0.48)	(1.66)	(0.87)
BID (τ)	***-0.20	***-0.21			***-0.16	***-0.19		
	(-3.89)	(-3.67)			(-3.60)	(-3.65)		
LNBID			***-0.92	***-1.05			***-0.85	***-0.95
			(-4.18)	(-4.06)			(-4.18)	(-4.16)
SUP	**1.23	**1.33	**1.12	**1.23	**1.03	**1.10	**1.02	**1.11
	(2.50)	(2.54)	(2.29)	(2.36)	(2.50)	(2.45)	(2.42)	(2.43)
TOL1	0.138	0.460	0.235	0.564	0.046	0.295	0.172	0.377
	(0.17)	(0.56)	(0.30)	(0.68)	(0.06)	(0.39)	(0.23)	(0.49)
TOL2	0.414	0.427	0.296	0.307	0.274	0.03	0.244	0.245
	(0.72)	(0.69)	(0.51)	(0.50)	(0.53)	(0.55)	(0.47)	(0.44)
CIT	-0.367	-0.10	-0.60	-0.390	-0.822	-0.54	-0.879	-0.603
	(-0.46)	(-0.12)	(-0.74)	(-0.47)	(-1.45)	(-0.91)	(-1.54)	(-1.01)
AWARE	0.085	0.259	-0.014	0.179	0.111	0.216	0.072	0.163
	(0.2)	(0.56)	(-0.03)	(0.38)	(0.28)	(0.50)	(0.18)	(0.37)
GEN	*-0.84	-0.817	**-0.95	*-0.97	-0.603	-0.633	*-0.76	-0.788
	(-1.89)	(-1.63)	(-2.07)	(-1.86)	(-1.47)	(-1.37)	(-1.76)	(-1.63)
SZ	-0.001	0.008						
	(-0.06)	(0.54)						
LNSZ			-0.054	0.388				
			(-0.10)	(0.69)				
ETH1	-0.219	-0.979	-0.042	-0.614				
	(-0.21)	(-0.78)	(-0.04)	(-0.53)				
ETH2	0.306	-0.573	0.258	-0.457				
	(0.27)	(-0.44)	(0.23)	(-0.37)				
AGE(21-26)	0.589	0.50	0.498	0.390				
	(1.11)	(0.89)	(0.93)	(0.68)				
AGE(27+)	0.21	0.014	-0.028	-0.319				
	(0.25)	(0.02)	(-0.03)	(-0.35)				
R/U	-0.255	-0.356	-0.275	-0.361				
	(-0.57)	(-0.74)	(-0.61)	(-0.74)				
EXP		0.816		0.91*		0.696		0.742
		(1.50)		(1.67)		(1.51)		(1.57)
LRT	***34.6	***33.7	***35.9	***35.8	***28.9	***30.4	***33.0	***33.8
Maddala R^2	0.23	0.25	0.24	0.26	0.19	0.22	0.22	0.24
McFadden R^2	0.20	0.21	0.20	0.22	0.16	0.18	0.18	0.21
% Correct	0.76	0.75	0.76	0.76	0.72	0.72	0.73	0.76

Numbers in parentheses are asymptotic *t*-statistics: *,** and*** indicate significance at the 0.05, 0.025 and 0.01 levels, respectively.

acceptance. Those students who provided less than 25 percent of their own support were more likely to accept any of the offered payment levels.

GEN is a dummy variable indicating gender (1=male, 0=female); for all models there is an inverse relationship between GEN and the probability of acceptance -- males are less likely, females are more likely to say yes. In half of the models the estimated coefficient is significant ($p<0.10$).

The continuous variable SZ is the class size (number of individuals) for the alternative classrooms where the questionnaire was administered. Class sizes ranged from 16 to 61, with the mean for both RR and DQ slightly larger than 40. It was hypothesized that smaller, more personal settings might affect the perceived social pressures, in particular to accept a given payment level. While the negative sign on SZ is consistent with this hypothesis, there is no evidence of significance ($p<0.10$).

The dummy variable AWARE identifies those respondents who have taken a cultural awareness or cultural diversity class at the university level (yes=1, no=0). There is no evidence ($p<0.10$) that AWARE is a statistically significant variable.

The dummy variables ETH1 (1=caucasian, 0 otherwise) and ETH2 (1=asian, 0 otherwise) identify self-reported ethnicity for the two largest segments of the sample (and university). In all but one case the signs on ETH1 and ETH2 indicate a decreased probability of acceptance. However, in no case is either variable a statistically significant regressor ($p<0.10$).

CIT is a dummy variable that indicates whether or not the respondent is a U.S. citizen (1=yes, 0=no). Across all models CIT is inversely related to the probability of acceptance, but is never significant ($p<0.10$). In all models where the EXP dummy variable is included, it is shown to be positively related to the probability of acceptance. In one of the four models it is shown to be significant ($p<0.05$).

In summary, the payment level and the degree of self-support are important determinants of the probability of acceptance. In addition, a notable difference across genders was detected. Several attitudinal and socioeconomic variables, considered *a priori* to be of importance, showed no evidence of explanatory power.

The RR Models

Table 2.6 provides the estimation results, using equation (15), for the RR models. The eight DQ models are replicated for the RR questioning format. The sample sizes range from 254 to 302. Both the linear and the "log-linear" functional forms are estimated for an extended and a "trimmed" model. These four models are then repeated to include the EXP dummy variable, with a concomitant reduction in sample size. In preview, a different statistical picture emerges of the determinants of the logistic regression models. Again, the significance and signs of the estimated coefficients are generally stable across all models. As in the DQ models, the censoring threshold BID is statistically significant and inversely related to the probability of acceptance. In fact the estimated coefficients on BID, are comparable in sign and magnitude to the DQ models.[16]

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[16] Since BID is constructed independent to the socioeconomic and attitudinal variables, it is expected that its impacts will be orthogonal to other estimated effects.

The evidence from individual likelihood ratio tests (LRT), that all slope coefficients are equal to zero, supports the hypotheses that all RR models are statistically significant ($p < 0.001$). However, the Pseudo-R^2 measures drop from the DQ models. The most striking RR estimation result is the statistical significance across all models (generally at $p<0.01$) of the estimated coefficients on the dummy variables TOL1 and TOL2. Those individuals who perceived the university community as being either tolerant or very tolerant of cultural diversity have a lower WTP for an improvement in the cultural centers program. There are some other important differences between the RR and DQ models. The negative sign on the CIT variable is consistent with that of the DQ models; however, in contrast, CIT is now shown to be significant ($p<0.10$) in six of the eight models. The SUP and EXP variables show no evidence of statistical significance ($p<0.10$). The sign on the GEN variable is reversed from the DQ models, indicating that women are now less likely to accept any given bid.

Taken together the contradictory results provide a direct connection between the evidence for compliance bias, and socioeconomic characteristics and beliefs. For example, the evidence is consistent with the following plausible story. Individuals who may either conform or may feel pressured to give an affirmative response in the DQ format would not do so in the RR format where insulation around their response is increased. Typical characteristics for these individuals would tend to include: U.S.

Table 2.6. Estimation Results from the RR Logit Models

Variable	RR-1 n=296	RR-2 n=254	RR-3 n=296	RR-4 n=254	RR-5 n=302	RR-6 n=259	RR-7 n=302	RR-8 n=259
Intercept	1.338 (1.52)	1.45 (1.63)	1.682 (1.42)	1.744 (1.41)	**1.26 (2.06)	**1.43 (2.03)	**1.25 (2.07)	**1.45 (2.16)
BID (τ)	***-0.18 (-3.36)	***-0.19 (-3.39)			***-0.17 (-3.71)	***-0.18 (-3.53)		
LNBID			***-0.65 (-3.89)	***-0.72 (-3.97)			***-0.65 (-4.04)	***-0.70 (-4.07)
SUP	0.159 (0.47)	0.439 (1.16)	0.142 (0.43)	0.416 (1.15)	0.078 (0.25)	0.293 (0.89)	0.08 (0.25)	0.284 (0.87)
TOL1	***-2.14 (-2.86)	***-2.48 (-2.98)	***-2.07 (-3.07)	***-2.35 (-3.11)	***-1.70 (-2.75)	***-1.88 (-2.76)	***-1.70 (-2.81)	***-1.87 (-2.87)
TOL2	**-1.04 (-2.45)	**-1.08 (-2.36)	***-1.08 (-2.63)	**-1.11 (-2.50)	***-1.05 (-2.64)	***-1.06 (-2.51)	***-1.09 (-2.75)	***-1.11 (-2.66)
CIT	*-1.07 (-1.82)	-0.939 (-1.59)	*-1.01 (-1.84)	-0.844 (-1.46)	**-0.92 (-2.32)	**-0.90 (-2.10)	**-0.87 (-2.22)	**-0.84 (-1.97)
AWARE	0.529 (1.61)	0.386 (1.12)	0.479 (1.58)	0.331 (1.00)	*0.50 (1.70)	0.371 (1.17)	0.464 (1.58)	0.324 (1.04)
GEN	0.486 (1.35)	0.441 (1.23)	0.48 (1.47)	0.448 (1.27)	0.460 (1.43)	0.379 (1.12)	0.469 (1.50)	0.401 (1.20)
SZ	-0.015 (-1.06)	-0.014 (-0.93)						
LNSZ			-0.357 (-0.75)	-0.327 (-0.65)				
ETH1	-0.709 (-1.23)	-0.982 (-1.60)	-0.748 (-1.43)	*-1.02 (-1.70)				
ETH2	-0.871 (-1.21)	-0.972 (-1.30)	-0.892 (-1.34)	-0.985 (-1.32)				
AGE(21-26)	*1.49 (1.69)	*1.60 (1.80)	1.834 (1.55)	1.896 (1.54)				
AGE(27+)	0.026 (0.05)	0.086 (0.15)	0.042 (0.09)	0.055 (0.1.1)				
R/U	-0.426 (-1.33)	-0.362 (-1.03)	-0.367 (-1.19)	-0.303 (-0.89)				
EXP		-0.029 (-0.08)		-0.046 (-0.14)		-0.055 (-0.18)		-0.073 (-0.23)
LLF	-157.89	-137.71	-158.59	-137.46	-166.03	-145.99	-166.75	-145.30
LLF(0)	-182.41	-159.46	-182.41	-159.46	-186.26	-162.91	-186.26	-162.91
LRT	***49.0	***43.5	***47.6	***44.0	***40.5	***33.8	***39.0	***35.2
McFadden R^2	0.13	0.14	0.13	0.14	0.11	0.10	0.11	0.11

Numbers in parentheses are asymptotic *t*-statistics: *,** and *** indicate significance at the 0.05, 0.025 and 0.001 levels, respectively.

citizenship, female and caucasian;[17] they also tend to provide less than one-fourth of their own support, and are less likely hold the belief that the current university climate is either intolerant or very intolerant of cultural diversity.

Comparisons of fitted probability models are shown in Figures 2.2 and 2.3. Figure 2.2 compares the logit models DQ-5 and RR-5, while Figure 2.3 compares logit models DQ-7 and RR-7. In each, the fitted models are estimated using the total sample means (from Appendix A) for the same explanatory variables. In both figures the probability of acceptance in the DQ model is everywhere above that of the RR. Despite the striking differences in estimated models (Tables 2.5 and 2.6) for each DQ and RR comparison, the general conformity of price responsiveness across survey formats is clear.

Pooled Sample Results

Following Kerkvliet (1993b), the RR and DQ samples are combined to estimate several pooled models to test the equivalence of parameters across questioning formats. This requires a hybrid likelihood function which simultaneously incorporates RR and DQ responses. Likelihood ratio tests can be conducted on the

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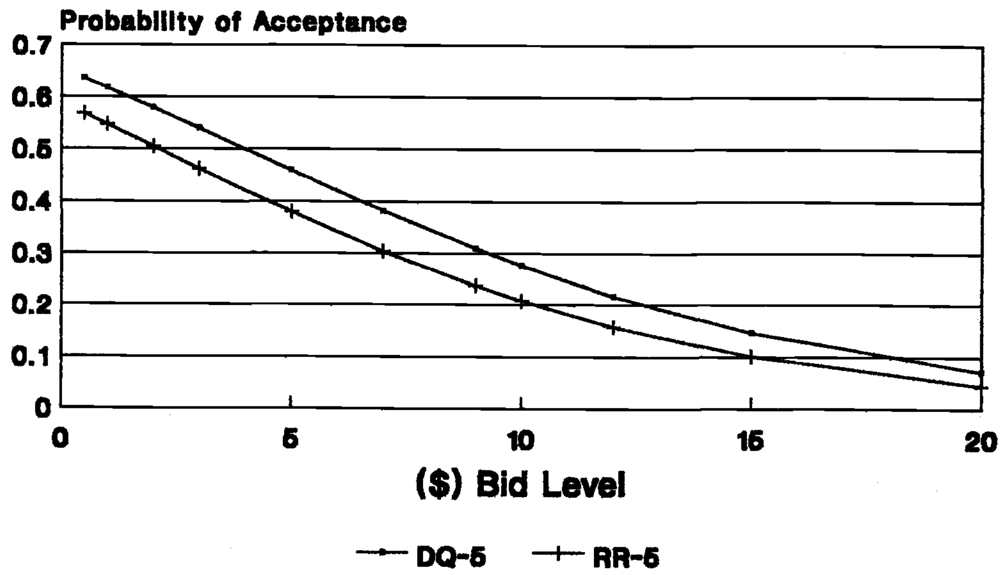
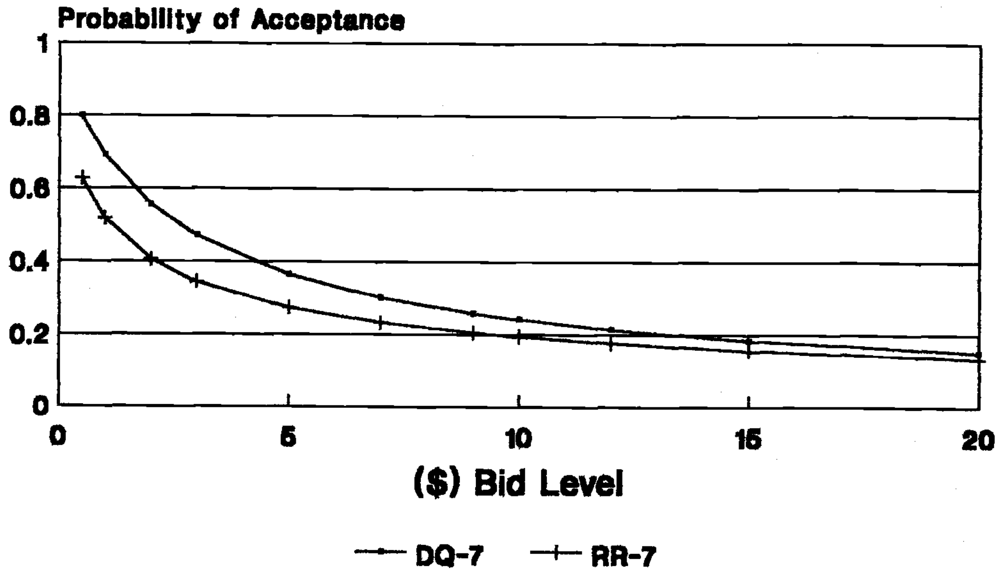
[17] Mitchell and Carson (1989:167) note generally that one of the characteristics of respondents who give WTP outliers is that they are disproportionately female. In a DC-CV study, Cameron and Englin (1992) find that while females are less likely to participate in recreational fishing activity, they have a statistically higher valuation. In reviewing Sudman and Bradburn (1974), De Maio (1984:274) states "Relative response effects are larger for women than for men for items with a strong possibility of a socially desirable answer... Response effects are larger for whites than for blacks for items with a strong possibility of a socially desirable answer..."

Figure 2.2. Comparison of Fitted Probability Models (DQ-5 and RR-5)



Note: each curve is estimated using the total sample means for the same explanatory variables

Figure 2.3. Comparison of Fitted Probability Models (DQ-7 and RR-7)



Note: each curve estimated using total sample means for the same explanatory variables null hypotheses that subsets of estimated coefficients are the same for RR and DQ. The revised likelihood function used to obtain the estimated coefficients is the multiplicative sum of the likelihood functions given in (8) and (15):

$$
\begin{aligned}
L = \Pi_{RR}[\Pi_{W_i=1}[(1-\rho)\cdot P^2(1)+\rho\cdot(1+e^{-Z(X,\tau)})^{-1}]\cdot \\
\Pi_{W_i=0}[(1-\rho)\cdot P^2(0)+\rho\cdot\frac{e^{-Z(X,\tau)}}{(1+e^{-Z(X,\tau)})}]]\cdot \\
\Pi_{DQ}[\Pi_{W_i=1}[(1+e^{-Z(X,\tau)})^{-1}][\Pi_{W_i=0}[\frac{e^{-Z(X,\tau)}}{(1+e^{-Z(X,\tau)})^{-1}}]]
\end{aligned}
\qquad (16)
$$

Tables 2.7 and 2.8 provide the estimation results.

In the restricted model, denoted RR+DQ-1, the coefficients for a set of selected variables for the combined sub-samples are constrained to be equal. In the model denoted RR+DQ-2, this restriction is dropped, for all but the BID variable. A likelihood ratio test supports the hypothesis that the two models (RR+DQ-1, and 2) are statistically different ($p<0.005$ with 7 df). The accepted model, RR+DQ-2, confirms the results found when estimating the split-sample models independently.

Table 2.8 replicates the pooling technique used to obtain the previous results, but expands the models to incorporate the EXP variable, at the expense of reducing sample space. Again, the evidence from a likelihood ratio test supports the hypothesis that the two models (RR+DQ-3, and 4) are statistically different ($p<0.005$, with 8 df).

In summary, the initial potential of compliance bias was identified in the probabilities of acceptance. Distinct differences between the signs and

Table 2.7. Estimation Results from Pooled (RR + DQ) Logit Models

Variable	RR+DQ-1 n=436	RR+DQ-2 n=436	
	Coefficient	Coefficient-RR	Coefficient-DQ
Intercept	**1.153 (2.41)	**1.247 (2.08)	1.068 (1.345)
BID (τ)	***-0.156 (-4.95)	@***-0.166 (-5.26)	@***-0.166 (-5.26)
SUP	0.344 (1.46)	0.075 (0.25)	**1.029 (2.49)
TOL1	**-1.066 (-2.32)	***-1.69 (-2.74)	0.051 (0.07)
TOL2	**-0.65 (-2.10)	***-1.051 (-2.60)	0.278 (0.54)
CIT	***-0.836 (-2.67)	**-0.92 (-2.33)	-0.823 (-1.45)
AWARE	0.35 (1.51)	*0.499 (1.70)	0.115 (0.28)
GEN	0.106 (0.44)	0.459 (1.46)	-0.605 (-1.47)
LLF	-252.22	-242.68	
LLF(0)	-280.0	-280.0	
LRT	***55.56	***74.64	
McFadden R^2	0.09	0.13	

The numbers in parentheses are asymptotic *t*-statistics; @ indicates the coefficients on BID are constrained to be equal.;*, ** and *** indicate significance at the 0.05, 0.025 and 0.01 levels, respectively.

Table 2.8. Estimation Results from Pooled (RR + DQ) Logit Models (with EXP)

Variable	RR+DQ-3 n=380 Coefficient	RR+DQ-4 n=380 Coefficient-RR	Coefficient-DQ
Intercept	**1.086 (2.01)	**1.454 (2.14)	0.433 (0.48)
BID (τ)	***-0.165 (-4.90)	@***-0.181 (-5.00)	@***-0.181 (-5.00)
SUP	*0.50 (1.94)	0.299 (0.92)	**1.095 (2.47)
TOL1	**-1.081 (-2.26)	**-1.895 (-2.77)	0.286 (0.38)
TOL2	**-0.646 (-1.99)	**-1.065 (-2.50)	0.294 (0.54)
CIT	**-0.753 (-2.23)	**-0.907 (-2.12)	-0.54 (-0.92)
AWARE	0.297 (1.20)	0.374 (1.20)	0.211 (0.49)
GEN	0.056 (0.22)	0.382 (1.15)	-0.628 (-1.38)
EXP	0.182 (0.72)	-0.056 (-0.18)	0.693 (1.51)
LLF	-220.78	-213.19	
LLF(0)	-246.33	-246.33	
LRT	***51.1	***66.28	
McFadden R^2	0.10	0.14	

The numbers in parentheses are asymptotic t-statistics; @ the coefficients on BID are constrained to be equal; *, ** and *** indicate significance at the 0.05, 0.025 and 0.01 levels, significantly.

significance of explanatory variables were identified in the censored logistic regressions, and shown to be robust across a variety of modeling formats[18] (differing in variable selection and functional form), including a pooled estimation technique. Systematic explanations for these differences can be made most directly through the valuation functions. In the following sub-section we return to the split-sample models for a comparison of valuation functions and associated WTP estimates. Evidence of compliance bias is most directly seen in the comparable WTP estimates.

Comparison of Estimated WTP

Table 2.9 presents estimation results for the valuation functions corresponding to the logit probability models DQ-5 and RR-5 (labeled WTP-DQ-5 and WTP-RR-5, respectively). Both functions were estimated directly with a general nonlinear optimization routine. Alternatively, the estimated WTP coefficients can also be obtained by reparameterizing the estimated logit coefficients. Direct optimization allows standard errors on the WTP coefficients to also be obtained directly, rather

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[18] One of the "hazards" of using the RR technique with a classroom questionnaire is the potential that respondents may avoid the unrelated question; i.e., some may choose to just go ahead and answer the valuation question. Statistical checks, from direct logit models *ignoring* the additional probability information in the RR models, demonstrate the robustness of the results presented here against this hazard. An example can be given corresponding to logit model RR-5:

logit=1.0-	**.15BID+**	**.06SUP-**	**1.5TOL1-**	**.97TOL2-**	**.86CIT+**	**.45GEN+**	**1.0AWARE**
t-stat. 1.9	**-3.9**	**.20**	**-2.8**	**-2.7**	**-2.4**	**1.6**	**1.8**

where the McFadden $R^2 = 0.13$. While the estimated coefficients have all changed slightly, their general sign and significance is retained.

than approximated through Taylor Series expansions (Cameron, 1988). Examination of Table 2.9 shows that the observed differences in the sign and significance of estimated coefficients in the logit models for the two questioning formats are translated into the valuation functions. The evidence from the LRT shows that both of the linear models in Table 2.9 are statistically significant ($p<0.01$).

Comparative WTP estimates can be generated using the functions given in Table 2.9. The results are presented in Table 2.10, where descriptive statistics for the distribution of fitted values for the split-samples are given. It should be noted that in contrast to the log-linear model, selection of the linear model does not force a positive prediction for WTP; thus, the potential for a negative valuation of the proposed policy change is allowed.

Invoking the Central Limit Theorem, the test for equivalence of two population means can be made for WTP-RR-5 and WTP-DQ-5. The evidence from a one-tailed test, with unequal sample sizes and variances (McCLave and Deitrich, 1985:338), supports the alternative hypothesis ($\mathbf{H_{CB}: WTP_{DQ} > WTP_{RR}}$) at the 99 percent confidence level.[19] Repeating this test across all eight comparisons from Tables 2.5 and 2.6 shows the compliance bias conclusion to be robust; Appendix B provides the full set of comparisons for the fitted WTP values. In Table 2.10, the

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[19] These results are consistent with Duffield and Patterson's (1992) comparison of hypothetical contributions to a trust fund against actual cash contributions to a simulated market for preservation of instream flows in Montana. Their results indicate that there is some significant hypothetical upward bias in survey responses. See also Seip and Strand (1990) and the discussion in Arrow et al. (1993).

Table 2.9. Estimation Results for Selected WTP Models

Variable	WTP-DQ-5 n=134	WTP-RR-5 n=302
Intercept	6.47 (1.36)	**7.46 (2.28)
SUP	*6.28 (2.38)	0.46 (0.27)
TOL1	0.28 (0.07)	**-10.07 (-2.40)
TOL2	1.68 (0.58)	**-6.23 (2.32)
CIT	-5.03 (-1.40)	**-5.46 (-2.17)
AWARE	0.68 (0.29)	*2.97 (1.69)
GEN	-3.69 (-1.49)	2.72 (1.42)
LLF	-76.64	-166.03
LLF(0)	-91.07	-186.27
LRT	***28.86	***40.48

The numbers in parentheses are asymptotic t-statistics; *,** and *** indicate significance at the 0.05, 0.025 and 0.01 levels, respectively.

Table 2.10. Distribution of Estimated WTP ($) for the Fitted Values (Linear Models)

Statistic	WTP-DQ-5 n=134	WTP-RR-5 n=302
Mean	3.72	0.30
Median	3.80	-1.05
St. Deviation	4.25	3.92
Minimum	-2.25	-8.08
Maximum	15.10	13.58

mean of the distribution of fitted values for the DQ model is slightly above $3.70, while the equivalent estimate for the RR model is only $0.30.[20] While the absolute difference is only $3.40, aggregated to the larger population of interest, say the 15,000+ university population in this example, this difference can be considerable.

The results in Table 2.10 also demonstrate the large standard deviations that are sometimes obtained around valuation estimates with the DC-CV format. The common suggestion for reducing this variation around DC-CV WTP estimates is to add a single-iteration follow-up referendum question (Cameron, and Quiggin, 1992; Hanemann et al., 1991). However, there is no reason to believe that this single-iteration referendum would not be susceptible to the type of response bias that has been detected in this study. Yea-saying appears to be a combined function of the setting and the discrete choice format for eliciting a valuation response.

[20] Evaluated at the means of the explanatory variables for the total sample (Appendix A), the WTP-DQ-5 estimate is $3.90, and the WTP-RR-5 estimate is $0.43.

Modeling Positive Bias in the DQ Sample

A recent focus of discrete choice CV research has been the optimal experimental design of the bid structure (Cameron and Huppert, 1991; Cooper, 1993; Cooper and Loomis, 1992, 1993; Kanninen, 1993b; Kanninen and Kristrom, 1993). However, these efforts assume an absence of any systematic response bias. As Kanninen (1993b:139) states:

> It must be noted that in order to apply optimal design techniques directly to the CVM, it must be assumed that survey respondents are "statistical animals"; that is, just as laboratory animals have no choice as to whether or not they will die when administered a particular dose, **survey respondents must be assumed to respond truthfully to the bid amount**. There is substantial literature on potential response biases with CVM (Mitchell and Carson 1989). It will be important to consider the effects of the bid design on response bias, but at present, such biases are assumed not to exist. [Bold emphasis added.]

Thus, it is difficult to criticize the bid structure of this experiment; the current criteria for optimal DC-CV experimental design assume away the bias being tested for.

Kanninen's (1993a) review of the empirical literature, and comparison against the expectations of optimal experimental design, suggests the potential of upward response bias in DC-CV models. She further argues that it may be necessary to investigate modeling approaches which explicitly account for this bias. Following Copas (1988), Kanninen provides several examples of modeling with "contaminated" data. Kanninen formulates the following model if the probability of giving a false acceptance for a posted bid is assumed to be γ. If the probability of a true yes response is P, then the revised probability of a yes response is given as $P^* = P+\gamma(1-P)$, with the corresponding probability of a no response as $(1-P^*) = (1-\gamma)(1-P)$. The revised probabilities are entered into the log-likelihood function in standard fashion. In the application here, the above exploratory model is applied to the DQ control sample (not exposed to the randomization mechanism).

Model DQ-5 from Table 2.5 is redisplayed for comparison against the model allowing for potential contamination, denoted DQ-5C. Based on the prior information from the RR models the γ variable is set at 0.10 for DQ-5C. The estimated coefficient on γ is positive and is significant ($p<0.01$), supporting the hypothesis of positive contamination in the DQ sample.[21] The signs and size of the remaining coefficients are essentially unaltered, with the exception of the intercept. [22]

With the exception of using the RR results to inform the prior for the γ variable, this evidence of positive bias in the DQ sample is independent of the randomization experiment; it corroborates the conclusion of compliance bias from the RR versus DQ comparison. The results of the Kanninen (1993a) approach for

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[21] Note that estimated coefficient on γ times the presumed value of γ equals 0.5. This result translates into an effect on the revised probability of a yes response ranging between 0.0 and 0.5; this is also the range necessary to enable the transposition from a 0 to a 1 prediction in the binary choice model. Selection of alternative values for γ (specifically 0.05 and 0.15) produces an adjustment in the estimated coefficient in γ to maintain this result.

[22] In Kanninen's example using data from Hanemann et al. (1991), evidence of positive response bias is also found. She states (1993a:11) that inclusion of γ in the DC-CV model "does not affect either the parameter estimates or mean WTP. This is because the (DC-CV) model is unable to distinguish between a biased upward response and a positive response. There is no information to distinguish the two phenomenon." However, the contamination modeling approach applied to double-bounded referendum CV does allow for changes in the parameter estimates.

modeling contaminated data in DC-CV should be taken as exploratory. Alternative approaches may be available (e.g., Hasselblad et al., 1980).

Table 2.11. Estimated Coefficients for Positive Response Bias Test.

Variable	DQ-5 n=134	DQ-5C n=134
Intercept	1.06 (1.29)	0.55 (0.77)
BID (τ)	***-0.16 (-3.60)	***-0.18 (-4.18)
SUP	**1.03 (2.50)	***1.15 (3.12)
TOL1	0.05 (0.06)	0.05 (0.07)
TOL2	0.27 (0.53)	0.30 (0.65)
CIT	-0.82 (-1.45)	*-0.87 (-1.79)
AWARE	0.11 (0.28)	0.08 (0.22)
GEN	-0.60 (-1.47)	**-0.75 (-2.05)
γ		***5.0 (12.53)
LRT	***28.9	***40.0
McFadden R^2	0.16	0.08

Numbers in parentheses are asymptotic t-statistics; *,** and *** indicate significance at the 0.05, 0.025 and 0.01 levels, respectively.

Summary

In summary, the experimental evidence supports the hypothesis of significant compliance bias, $\mathbf{H_{CB}:WTP_{DQ}>WTP_{RR}}$. This conclusion is corroborated by an independent statistical test for positive bias contamination in the DQ sample. In response to these results, which are inconsistent with the generally assumed incentive compatibility property of the DC-CV format, a recently developed cognitive model is applied to CV survey responses. The story told by the empirical evidence can be reconciled within McCain's (1992) impulse-filtering model. The applicability of such a cognitive model is admittedly speculative; however, it is intended to motivate continued exploration into the understanding of why people give the answers they do on CV surveys.

2.9 Interpreting the Results

As with general survey researchers, CV analysts have became increasingly interested in the work of cognitive psychologists (Mitchell and Carson, 1989:114). Considerable professional discussion, much of it interdisciplinary, has taken place concerning the cognitive processes that underlie CV survey responses (Bergstrom and Stoll, 1986; Fischoff and Furby, 1988; Harris, 1991; Harris et al., 1989; Mitchell and Carson, 1989; Opaluch and Segerson, 1989; and Peterson et al., 1988). Harris et al. (1989) urge that continued efforts be made in the adoption of psychological paradigms for CV research. The objective here is to show that while DC-CV may be free from some response effect biases, it cannot be considered completely free from all such influences -- they may simply arise in a different form, the operation of a different set of **filters**. McCain's (1992) recent exposition of the impulse-filtering model provides a framework for analyzing the cognitive decision processes involved in CV survey research in general, and the DC-CV format in particular.

Cognitive Considerations and the DC-CV Format

It is common to distinguish between a respondent's "ideal" valuation, the formulated valuation, and the stated valuation. In a survey context, a respondent's true valuation (e.g., WTP or WTA) is unobservable; however, it is an often-used theoretical abstract. It serves as a reference point for the ideal situation where an expression of value is truly held by the respondent, and refers to the intended measure of change in a nonmarket good or service. A valuation refers to the appropriate Hicksian valid money measure of welfare change for some proposed policy. Let HM denote a general expression for a Hicksian measure. Furthermore, let tHM denote the "ideal" value, fHM denote the formulated value, and sHM denote the stated value. Thus, the CV exercise can be decomposed into two basic problems to be solved by the respondent: (i) the valuation formulation problem, and (ii) the valuation statement (Randall and Kriesel, 1990). In the first, the respondent must assess the posited, exogenous, change and cognitively assign it a value. In the second, the respondent must decide whether to express this value, or possibly some transformation of the formulated value. There is considerable evidence that both of these problems must be solved in a constrained or limited context (e.g., cognitive capacity and time to think).

One line of support for DC-CV and the referendum format is that it reduces the cognitive requirements of the valuation formulation problem (fHM). Mitchell and Carson (1989:94) state:

> The voting decision suggests a more complex, and some would say a more realistic... model of decisionmaking than the one implied by the idealized private goods market model. Instead of assuming that people express preexisting, well-realized preferences, the referendum model assumes that people make choices which are influenced by multiple motives, by contextual factors and by less than perfect information.

It was the complexity of the fHM problem that served as a primary impetus for use of the DC-CV format. However, this may unduly draw attention away from stated valuation (sHM) problems which may be particular to the DC-CV framework.

The Impulse-Filtering Model

McCain (1992:68) posits that human choice behavior arises from the interaction of a stream of impulses with a system of filters. The elementary choice is the decision to act or not act on a particular impulse. The term "impulse" carries no explicit neurophysiological content or pejorative connotation, rather it refers simply to mental events that have some unpredictable, random element to them. Not acting on an impulse is to filter it out. The process of filtering is taken as the "deterministic aspect of the choice process."

Rather than a single filter, multiple filters are considered. This system of filters expresses a "wide range of motivations and cognitive processes" (McCain, 1992:107). Taken together this system constitutes the black box of behavioral choice. The essential component of the filter system is the cognitive filter; it is "not simply one among the several filters." It is the initial screen that must be passed.

A characteristic mode of the cognitive filter is the erection of sub-filters, which may then continue on their own as habitual patterns of behavior not requiring cognitive intervention. Often these subfilters take the form of heuristics -- that is, rationales that derive part of their usefulness from the fact that they conserve on cognitive effort. A well-known heuristic is "anchoring", a version of which is commonly found in the starting point bias of iterative bidding used in early CV studies (Mitchell and Carson, 1989).

The elicited value in a CV survey is a statement of indifference, where the individual trades off hypothetical combinations of nonmarket goods and income against some reference point. The elicited values (WTP and WTA) are interpreted as Hicksian welfare measures. McCain (1992:72) describes a striking similar cognitive process in how individuals conceptualize intertemporal choices:

> ...in making intertemporal choices, the act of imagination that conceives of future satisfactions as substitutes for present satisfaction is an act of cognition that transforms another filter (a filter of incremental utility, if such is possible, or of basic needs or aesthetic satisfactions) by translating its satisfaction from present to future time.

The key point in the *hypothetical* choice, between combinations of income and nonmarket services, is the interaction of the cognitive filter with additional filters.

The essence of McCain's multifilter model is that the existence of different kinds of filters reflects the existence of different kinds of motivations (1992:142). As such, the multifilter model provides a convenient vehicle for considering the multiple types of biases that may emerge in CV surveys.[23] We can conceptualize several filters that may be of particular relevance.

The first is the operation of a filter which can encapsulate the idea of compliance bias. McCain (1992) explicitly recognizes the operation of such a filter:

> It is the filter of social pressure. Etzioni (1988a, 1988b) has recently offered powerful arguments that social norms not only are key determinants of human behavior but are also important for economics. One way to incorporate them into the impulse filtering model would be to posit a filter of social conformity.

As evidenced by this research on compliance bias, investigating the influence of such a filter is an important task for future CV research. Addressing social desirability and social conformity effects is also an important research concern of the NOAA Panel on CV (Arrow et al., 1993). Further, in their recent commentary on CV, Vatn and Bromley (1993:3) emphasize the "preeminent role" of social context in preference formation; valuation exercises which fail to recognize this influence may "fail to provide coherent valuation estimates."

The operation of something akin to the social pressure or social conformity filter can also be identified in Ajzen's "theory of planned behavior" (Ajzen and Driver, 1992; Fishbein and Ajzen, 1975; and see Harris et al., 1992). The central

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[23] The impulse-filtering model draws from Simon's (1955) bounded rationality model; both assume a limited cognitive capacity and a lack of well-defined and stable preferences. However, Simon's concept of "satisficing" behavior focuses primarily on the actions of a cognitive filter. McCain's model emphasizes the importance of multiple filters. Some CV researchers (e.g. Michelman, 1992) suggest utilization of bounded rationality models for understanding valuation responses. McCain's impulse-filtering model may provide a more generalizable cognitive model. For example, the focus of this research was on the social conformity filter.

factor in the theory is the intention to engage in a given behavior. For our purposes a CV WTP response can be taken as a stated intention. It is argued that an individual's intention to perform a given behavior is directly influenced by subjective norms. These subjective norms are seen as one of a set of antecedents to intentions, and refer to "perceived social pressure to perform or not perform a behavior" (Ajzen and Driver, 1992:208). Within the structural model of the theory of planned behavior, subjective norms are conceived as also interacting with attitudes and beliefs toward the given behavior. This distinction draws out the argument that if the operation of a social conformity filter is believed active in a CV survey, then it may be systematically connected with individual self-reports about attitudes and beliefs. Evidence of this was shown in the RR models of this study.

In their review of the Fishbein-Ajzen (1975) model in relation to CV research, Mitchell and Carson (1989) emphasize that stated behavioral intentions are a "joint function" of attitudes and subjective norms. They offer the following example, of the importance of this jointness between attitudes and subjective norms:

> ...consider the role both might have played in the 1950s if a liberal white southerner, who lived in the deep South and had nonliberal friends and associates, had been asked about his intention to offer hospitality to freedom riders. As a liberal, this person would have viewed the hospitality as a good thing; as a white participant in southern society, he would have been influenced to some extent by the prevailing norms for how whites should act toward blacks, even if he did not share these norms. (Mitchell and Carson, 1989:180-81).

Conversely, one might consider how a conservative individual in the early 1990s might respond to sensitive questions, in a perceived liberal setting, for environmental goods or a wide variety of other public goods.

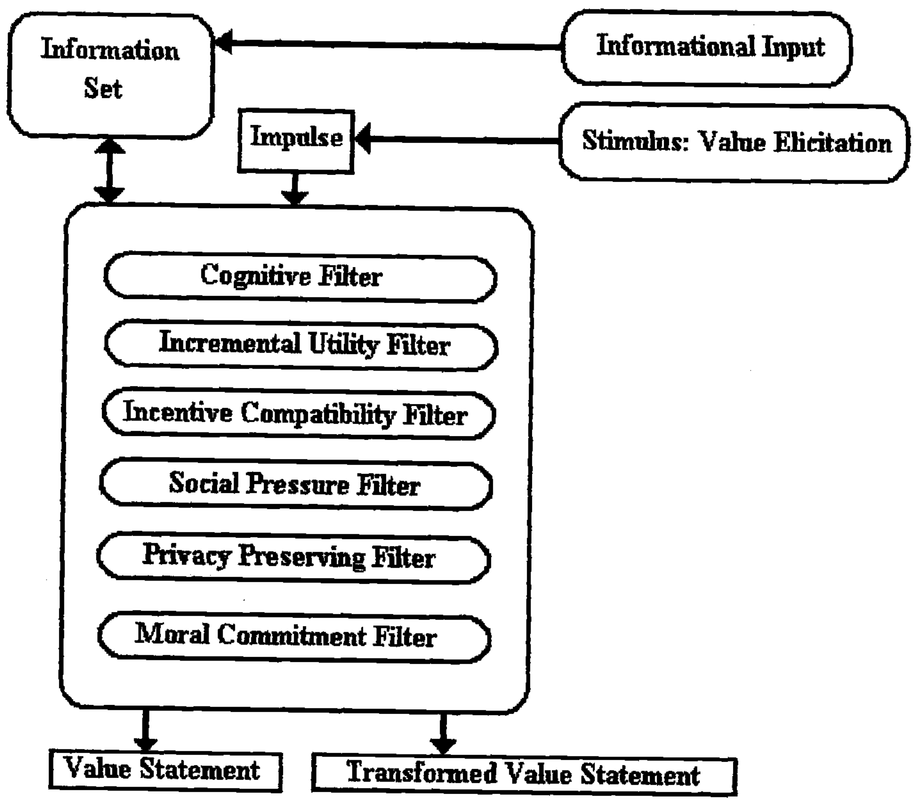
An additional filter that may have relevance to the DC-CV format can be labeled as the moral commitment filter. Conceptual support for the operation of such a filter in cognitive decisionmaking can be found in the writing of prominent economists (Sen, 1989; Frank, 1987) and other social scientists (Elster, 1989; Etzioni, 1988a). In the context of a YES/NO willingness-to-pay question, protest responses may often be hidden within a no response. The work of Stevens et al. (1991a, 1991b) with respect to the use of DC-CV for valuing endangered species has brought this important issue to light. Other CV researchers have discussed the effects of ethical and moral commitments on valuation responses (Edwards, 1992; Michelman, 1992; Opaluch and Grigalunas, 1992).

One conceptualization of the multiple filter model in a CV survey context is presented in Figure 2.4. The description of the contingent scenario is seen as an input to the individual's information set. This input is controlled by the analyst. The information set influences the development of the filter system, which is constantly being refined. The impulse is the mental event, in response to the random event or stimulus, which is sent through the filter system. In the censoring threshold motivation for the DC-CV framework, the offered payment level is the stimulus to which the individual reacts. Figure 2.4 is shown with six distinct filters: (1) cognitive, (2) incremental utility, (3) incentive compatibility, (4) social pressure, (5) privacy-preserving, and (6) moral commitment. They are shown as a linear system, although this would not necessarily be the case. For example, when activated a moral commitment filter may even suppress detailed cognitive effort (Frank, 1987).

The fHM problem is primarily linked with the cognitive and incremental utility filters. The DC-CV format is typically seen as reducing the cognitive burden placed on the fHM decision. Coupled with its believed incentive compatible properties affecting the sHM decision, the attractiveness of the DC-CV format is apparent. However, the multiple filter model explicitly recognizes that the sHM decision can also be influenced by additional filters (and thus sHM $\neq$ fHM). Given that an activated social pressure filter can be thought of as acting in either direction, or several filters may be operating in opposite directions, there is no guarantee that directional arguments will hold; e.g., sHM $\leq$ fHM (Hoehn, 1987; Hoehn and Randall, 1987).

In summary, the impulse-filtering model posits a model of cognitive choice where a stream of impulses interacts with a system of filters. In combination, the filters may "suppress, pass, or transform" an impulse (McCain, 1992:78). This process accommodates a wide variety of motivations. Utility maximization is seen as only one of several important filters that may be operating in a CV survey format. In this way the model offers insight into interpreting the expressions of behavioral intentions that arise from the structured conversations of a CV exercise. It facilitates the testing of hypotheses across changes in the structure of CV surveys. For example, particular formats may be seen as impacting the activation of particular filters. A

Figure 2.4. The Impulse-Filtering Model



theoretical framework for CV research that admits roles for socialization and moral commitment, but does not exclude cognitive or economic determinants would appear to be much needed. The impulse-filtering model formulated by McCain (1992) may offer such a theory.

2.10 Conclusions and Suggestions for Future Research

It is generally held that the DC-CV format is incentive compatible, implying that respondents provide truthful responses. The presence of compliance bias negates general claims of incentive compatibility, and shows that any reduction in protest responses may come at a cost. This experimental exercise identifies clear statistical differences between split-sample designs. These differences are systematic and can be linked to intuitively appealing statistical determinants. The results indicate the potential for compliance bias in DC-CV formats, and at a minimum indicate fragility in statistical valuations across survey types. In addition, the results are consistent with other CV evidence indicating the sensitivity of valuation responses to the amount and type of information disclosed (Bergstrom et al, 1991; Lazo et al., 1992). One interesting result is the consistency of the bid response relationship. As with recent arguments by McFadden and Leonard (1992) this may represent a blending of price responsiveness and providing the "politically correct" answer.

The development of a test to detect the presence of compliance bias constitutes the primary contribution of this experimental research. The research connects two emergent paths in social science survey research. The RR technique deserves further consideration in the design of CV experiments where significant social pressure is expected. In particular, an application to a sensitive nonuse/existence value study appears justified. Further, the RR technique may provide a tool for addressing the Arrow et al. (1990) concerns with social desirability bias. Future RR applications to DC-CV should include an open-ended control group.

There is initial discussion of modeling approaches to account for "positive response bias" in discrete response CV (Kanninen, 1993a), and to calibrate the CV "budget exaggeration factor" by combining CV with revealed preference information (Cameron, 1992a, 1992c); the experimental results found here support continued exploration and investment into such approaches.

The potential for compliance bias shows that the specific NOAA Panel recommendation supporting referendum formats may be inconsistent with their own general recommendation toward conservative design choice (Arrow et al., 1993). Clearly, more research is called for, including further investigations of cognitive models (e.g., McCain, 1992).

A suggestion for future research is that the potential for yea-saying in the DC-CV format may be a function of the full commodity specification, response rule and outcome rule in the CV design. For example, the outcome rule used in the experiment was a voluntary contribution program. It was chosen to match similar outcome rules for dichotomous choice payments and contributions to general environmental preservation funds, and endangered species protection funds. As

Hoehn (1992:12) notes, "Voluntary payment and contribution rules are not exclusive." In any voluntary contribution outcome rule, an individual can appropriate the public good whether or not the payment is made. Non-exclusivity in the broad definition of the policy under consideration may introduce a response bias. Thus, while DC-CV may eliminate the opportunity for strategic bias, the format alone may not provide full protection against response bias.

One hypothesis is that a well-defined commodity, response rule and outcome rule (e.g., exclusivity) in the DC-CV model will reduce the incentives for both strategic bias and compliance bias. However, if the evidence supports this hypothesis, then the tractability of the DC-CV format for measuring nonexclusive public goods (e.g., protection of an endangered species) is severely in question.

The CV research program has been the object of criticism. If CV is to be received as a valid measurement technique, then continued development of cognitive models of intended behavior and survey responses is required. Research must be directed into understanding why people give the answers they do, and into further identifying and explaining the types of biases that can arise in a CV survey; we also cannot avoid exploring the motivations behind responses, including social compliance effects.

CHAPTER 3

CONVERTING WILLINGNESS-TO-PAY INTO PUBLIC REVENUES: EVIDENCE FROM A PHEASANT STOCKING PROGRAM

3.1 Introduction

The feasibility of a public stocking program for pheasant hunting in Western Oregon through user fees was evaluated by Adams et al. (1989) using contingent valuation (CV). Since the initial CV survey, an experimental fee-access "put-and-take" stocking program has been conducted at the study area by the Oregon Department of Fish and Wildlife (ODFW). During the four years of the program, several fee levels have been charged for hunting pheasants at the site; extensive visitation and harvest records have been kept. A unique opportunity therefore exists for an *ex post facto* evaluation of the actual performance of a CV study.[1] Such an

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[1] The initiation of an experimental pheasant stocking program allows a "ground truth" check on a previous CV study. However, falsification of CV survey results is impossible. Any contrary evidence (e.g., unanticipated level of participation for a posted fee) can always be attributed to a change in preferences or the relevant population. The opportunity does exist to check whether stated preferences are consistent with limited observed preferences over a specific time period. In this way, additional evidence on the accuracy of contingent values can be gained. Attempts to assess the accuracy (validity and reliability) of CV results have increased in number and variety in the last several years, and are reviewed in Smith (1993). The unique aspect of this study is that it assesses accuracy against an **actual** fee-access hunting market that developed subsequent to the initial nonmarket valuation study.

evaluation of a CV study can be useful in addressing issues associated with the topic of benefit transfers (AERE, 1992).[2]

While the implementation of the fee-access pheasant hunting program can help evaluate the accuracy of the original CV study, the information cuts both ways. CV studies can also help in evaluating potential markets. Thus, in addition to *documenting* nonmarket values, CV studies can also be used as a tool in *appropriating* nonmarket values. This case study evaluates the performance of the original CV study, and addresses the question of how CV techniques may be used in converting willingness-to-pay (WTP) into public revenues. Given the increasing interest in applying user fees to public outdoor recreation, CV may play an important role in designing and evaluating pricing policies.

The paper proceeds as follows. In section 3.2, a brief survey of the related wildlife and recreation management issues is given. Section 3.3 provides background information on the fee-access pheasant hunting and stocking program. A primary concern with the current fee hunt program is achieving self-sufficiency. The agency's problem is one of revenue projection, where there are multiple ways to price and package the recreational services. Section 3.4 uses a simplified household production function approach to link hunting behavior with alternative pricing policies. Section

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[2] In a benefit transfer context it provides a direct check on the question of intertemporal transfers. In addition, verifying the reliability of a welfare measure or valuation function is an important diagnostic in selecting an "off-the-shelf" model for possible geographic benefit transfer. For example, stocked sites for public pheasant hunting are now used in western Washington state and would be a transfer candidate for the Adams et al. (1989) results.

3.5 provides background information on the CV approach. The CV model of Adams et al. (1989) assumes a particular pricing policy (a lump-sum fee for access). In the section on procedures and results (3.6), the original dichotomous choice contingent valuation (DC-CV) model is expanded into a censored logistic regression context (Cameron, 1988). This approach is used to generate a confidence interval (CI) on the welfare estimate from the original model. These results are compared against CI's generated through separate techniques applied to the same data set (Bergland et al., 1989). Section 3.7 evaluates the implementation of the fee hunt program, and presents a series of aggregate statistical relationships on visitation, harvest and fee levels. Section 3.8 discusses the results and implications for designing future CV experiments for program and project financing. Section 3.9 concludes with a mix of good news and bad news.

3.2 The Wildlife and Recreation Management Issues

Opportunities for hunting on a national level are characterized by decreasing supply and continued high demand (Benson, 1989; Wallace et al., 1989). High quality pheasant hunting opportunities have declined over the last several decades throughout much of the U.S., and in the Willamette Valley in particular (ODFW, 1987; ODFW, 1991). Urban growth and more intensive agricultural practices have reduced pheasant populations. Habitat requirements for pheasants are affected by farm management decisions and the agricultural policies that influence those decisions. Further, agricultural practices affect habitat availability and influence individual recreation decisions and aggregate recreational use (Shulstad and Stoevener, 1978; Miranowski and Bender, 1982; Matulich and Adams, 1987).

One response to meeting pheasant hunting demand is game-enhancement or propagation and release programs. The merits of public stocking programs are widely debated by wildlife management professionals (e.g., Dahlgren, 1967). Habitat protection and enhancement are preferred options; but in areas of increasing urban population pressures, "stocking for the gun" may be the only alternative for meeting demand. The idea is not new for upland game. Leopold (1933) and Skiff (1948) detail early evidence in the populous northeastern U.S.. In discussing pheasant hunting in New York, Skiff (1948:226) stated prophetically:

> When the natural production is unable to satisfy hunting pressure, stocking may be resorted to as supplement. From that point on the question is strictly one of cost. If sportsmen, in the future, are going to want this type of program, they must be prepared far in excess of what they are now paying for small game licenses. We have some of the oldest paid shooting preserves in the country and in no case...has it been possible to bring a bird before the gun for anything like the usual small game license.

But what price to pay? Unknown hunter responsiveness to price (elasticity of demand) makes setting fees problematic when the goal is program self-sufficiency (Loomis and Thomas, 1992).

The idea of charging for hunting is commonly traced to the Leopold Game Commission of 1930 (Leopold, 1930). Fee or lease hunting on private lands is a growing phenomenon and has been extensively studied for big game species.[3] The lowest percent of fee hunting is in the public lands states of the west (Langer, 1987). Direct user fees to ration hunting opportunities on public lands have never been a popular idea, and appears to rarely have been tried. Increasingly, however, fee-access hunting on public lands and the user-pay principle are being discussed (Thomas, 1984; Davis et al., 1987; Langer, 1987; Morrison, 1989; Benson, 1989; Loomis and Thomas, 1992).

These recent commentaries on fee-access public hunting must be seen within the larger discussion of user fees to ration recreation levels at publicly-provided facilities. This literature extends back at least 25 years (Clawson and Knetsch, 1966), and includes numerous investigations on the economics of pricing policies at public recreational areas and facilities (Harris and Driver, 1987; Rosenthal et al., 1984; Wilman, 1987). Recently, Reiling et al. (1992) investigate the discriminatory impact associated with higher fees at Maine State Park campgrounds. They use a *contingent behavior* survey to elicit behavioral intentions to hypothesized increases in user fees and found evidence of discriminatory impacts on low income groups.[4]

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[3] Examples include Jordan and Workman (1989), Langer (1987), and Livengood (1983). Numerous discussions and references can be found in Decker and Goff (1987).

[4] The Reiling et al. (1992) study is important because it shows there may be contingent behavioral responses to alternative fee levels in a constructed market. This is sometimes overlooked in CV studies, where the analyst assumes a Hicksian surplus measure (quantity readjustments not allowed) is being elicited, and the respondent is providing a Hicksian variation measure (quantity readjustments allowed).

The idea of discriminatory income effects has relevance to fee-access public hunting. While fee-access to publicly provided recreation is common, there has been a resistance to rationing public hunting opportunities through pricing schemes (Davis et al., 1989; Thomas, 1984). [5]

The history of habitat protection and pheasant propagation studies is rich; the history of economic valuation of pheasant hunting is more limited. In many areas, such as the public land states of the west, the nonmarket nature of the good has made it difficult to evaluate and only a handful of studies have been conducted (Adams et al., 1989; Brooks, 1992; Shulstad and Stoevener, 1978; Young et al., 1987). Recently, Smith et al. (1992) surveyed Minnesota small game hunters and found evidence of support for the introduction of fee hunting for pheasants. The results are presented only in terms of the percentage of respondents who would accept a particular fee for various flush and harvest rates. Limited variation in the fee prevent the development of a full economic valuation model.

With many forms of fishing and hunting, a recent phenomenon has been the creation of actual markets. This case study examines the implementation of a fee-access pheasant hunt on a state-owned wildlife management area in Western Oregon's Willamette Valley.

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[5] While the agricultural states of the midwest have a long-history of free-access to pheasant hunters on many private lands; private fee-hunting sites for pheasants also have a long history in the Northeastern U.S. and Europe.

3.3 Background on the Pheasant Hunt and Stocking Program

The ring-necked pheasant (*Phasianus colchicus*) was originally introduced to western Oregon's Willamette Valley from Central Asia in 1881. Subsequently, it was introduced throughout much of the US, and has become the upland game bird preferred by hunters. A century after the introduction of the species, pheasant hunting remained the most popular upland game bird sport in Oregon (Denney, 1983).

Pheasant populations initially flourished in the Willamette Valley due to favorable habitat. Over time this trend was reversed as human population growth, hunting pressure, and changes in agricultural patterns (e.g., more intensively farmed landscapes and a decreasing amount of cereal grains) combined to reduce pheasant populations (ODFW, 1987).

Pheasant management in the Willamette Valley has been a historical mix of strategies, including supplementing naturally propagated stock with pen-reared birds from state game farms.[6] These releases were aimed at meeting hunting demand in the

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[6] Within the first few decades of the 1900's, state agencies were pursuing specific management strategies to promote the spread of the bird and to meet hunting demands. In 1911 a two year closure on ring-necked pheasant hunting was instituted (The Oregon Sportsman, 1913). In the same year the first state game farm was established in the Willamette Valley (Castillo et al., 1984). In 1938, dwindling pheasant populations were again protected with a two-year closure. In the early 1940s an upland game refuge program was established through short-term purchased easements on agricultural lands (Schneider, 1947). The history of state-owned wildlife management areas in Oregon dates to the 1940's and the use of federal Pittman-Robertson Act funds (Meyers, 1946). The E.E. Wilson Wildlife Area (approximately 2000 acres) was initially purchased by the state in 1950 (Lockwood, 1951). The area has a long history of artificial propagation and release of game birds.

populous upper Willamette Valley (Castillo et al., 1984).[7] The stocking program at E.E. Wilson Wildlife Area was typical in that it was funded through general hunting license revenues. These revenues failed to cover the full costs of the program meaning that the price of a general hunting license would be less than the average cost of producing each harvested bird. The ODFW decided to eliminate the pheasant propagation and stocking program in 1987 due to increasing costs:

> The "put and take" program, while popular with hunters who live in an area where they can benefit from it, had simply reached a point where the costs of providing stocked bird hunting opportunity had become unacceptable. (ODFW, 1987:7)

And as stated in Adams et al. (1989:377):

> The decision triggered considerable debate, including a suggested user-supported program involving some form of specialized access fees.

The objective of the initial CV study (Adams et al., 1989) was to elicit WTP for the stocking program and to assess the likelihood that a fee system could sustain the program. A simplified benefit-cost analysis found that estimated annual aggregate WTP exceeded average annual costs of the program. The focus was then shifted to a Ramsey pricing problem of converting this WTP into public revenues to support the

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[7] For example, in 1982, there were over one-third of the reported upland game hunters (39 percent) and days-use (34 percent) in the more heavily populated northwest corner of the state, (composed of the 13 counties of the Columbia and Northwest Regions). However, they took only 14 percent of the total pheasant harvest (Denney, 1983). Continuing urban growth in western Oregon exacerbates these trends.

program.[8] The revenue projection problem was evaluated for several alternative flat-rate fee schedules, with particular attention to discriminatory income effects, and none were found to be adequate for covering program costs. Subsequent to the valuation study, a fee-access system was introduced on the E.E. Wilson.

As requested by the Oregon state legislature, the ODFW initiated an experimental "put-and-take" pheasant hunt program in the Willamette Valley for 1989. The objective was to evaluate "the demand and willingness of hunters to pay an additional fee for the opportunity to hunt for stocked birds on public hunting areas" (ODFW, 1991).

The objective of the ODFW is to price and market recreational services at the site such that the program achieves self-sufficiency. The agency's problem can be characterized as one of revenue projection. The expected total revenue must exceed the expected total cost of the program [E(TR)> E(TC(R))], where expected costs are

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[8] Ramsey pricing is a theory of pricing for goods and services provided by the public sector in the context of a budget constraint. Where long-run average costs are decreasing over the relevant range, marginal cost pricing is incompatible with a budget constraint. As Wilman (1988:235) states: "The general proposition of Ramsey pricing is that prices should be raised above marginal cost to satisfy the budget constraint, and that the prices of goods with the most inelastic demands should be raised the most above marginal cost. Ramsey pricing is the most economically efficient form of public good pricing under a budget constraint, because it is specifically designed to cover costs in the way which reduces consumers' surpluses by the least amount." Despite this promotion of efficiency there are also fairness considerations. Ramsey pricing schemes for multiple public goods can result in outcomes where some portion of the cost of one public good is supported by the fees charged for another public good (Wilman, 1988).

assumed to be a known function of pheasants released, R.[9] In projecting revenue an array of potential pricing schemes must be considered. The flow of services available at the site can be priced and packaged in alternative ways. A variety of different types of fees can be identified, for example:

F_{LS}	=	a lump sum fee, such as an upland game bird stamp
F_{TR}	=	a fee per trip, collected on-site
F_{B}	=	a fee per bird harvested

Any combination of one or more of the fees can then be described as a pricing policy; denote the jth pricing policy as, P^j. Any chosen pricing policy relates both to the way the recreational services are packaged and sold, and the actual level of fees established.

The agency's problem can be more fully characterized as evaluating whether:

$$E[TR(R,P^j)] \geq E[TC(R)] \tag{1}$$

where:

[9] The agency influences the stock S of available pheasants at a site through habitat enhancement **HE**, and the propagation and release **R** of game birds. The allowed hunting pressure or harvest **HA** at the site also influences the size of the stock. Agency control over S would be completely characterized by a dynamic relationship, $\partial S/\partial t = S_t(\mathbf{HE},\mathbf{HA},\mathbf{R},t)$. However, it will be assumed that the static relationship $\mathbf{S=S(R,HA)}$ adequately describes the site. Opportunities for additional habitat enhancement are limited. Additionally, the stocking program is fundamentally a "put and take" program so that the size of the available stock is almost completely determined by current year **R** and **HA**. The stocking is done in the fall, immediately preceding the hunting season, and then daily during the season.

$$TR(R, P^j) = n \cdot \pi(R, P^j) \cdot P^j \tag{2}$$

and n = total number of households for the market; $\pi(R,P^j)$ = probability of participation at P^j, and the number of pheasants released, R. Estimation of $\pi(.)$ for particular pricing policies and fee levels within each policy is the key research question for the agency. There is a need to link each pricing policy P^j with expected behavior. To do this requires explicit modeling of recreational decisionmaking. In the following section, a brief behavioral model is developed, concentrating on how alternative pricing policies can affect one aspect of recreational choice.

3.4 The Behavioral Model

The behavioral model is developed through the household production function (HPF) approach, originally introduced by Becker (1965). Bockstael and McConnell (1981) extended the approach to wildlife recreation. Miranowski and Linder (1982) used an HPF to link farm management practices with pheasant hunting in Iowa.

In the Miranowski and Linder (1982) model it was assumed that the household produced "days" of pheasant hunting. In this model, the household, i, is considered to produce "quality time" (QT) hunting for pheasants at the stocked site. Time is measured in total hours for the typically 30-day season. The output of this production process enters a well-behaved household utility function, and is weakly separable from a vector, G, of other consumption commodities:

$$U_i = U_i(QT_i,\ G_i) \tag{3}$$

The following production function is assumed:

$$QT_i = f\ [E_i,\ C,\ A,\ FL_i(R,E_i,TR_i,HR_i),\ HA_i(R,E_i,TR_i,HR_i)] \tag{4}$$

where:

E	=	level of experience of the pheasant hunter
C	=	level of congestion at the site
A	=	a vector of site amenities
FL	=	total flushes of pheasants during season
TR	=	trips taken during the season
HR	=	hours spent per trip
HA	=	total harvest of pheasants during the season

This splitting of time and trips is consistent with Larson's (1990) travel cost model.

A specific functional form is assumed for the associated cost function:

$$C_i = FC_i + F_{LS} + TC_i \cdot TR + F_{TR_i} \cdot TR + V_i \cdot HR_i + F_B \cdot HA_i(TR_i,HR_i) \tag{5}$$

where:

FC	=	fixed costs of pheasant hunting for the season
TC	=	travel costs per trip
V	=	value, or opportunity cost, of an hour of time

It is also assumed that the household solves the following constrained optimization problem:

$$\max \mathcal{L} = U_i(QT_i,G_i) + \lambda \cdot (m_i - P_G \cdot G_i - C_i(\cdot)) \tag{6}$$

Then the first order conditions of interest are:

$$\frac{\partial U}{\partial TR} = \lambda \cdot \frac{\partial C}{\partial TR}$$
$$\frac{\partial U}{\partial HR} = \lambda \cdot \frac{\partial C}{\partial HR} \tag{7}$$

And it is assumed that the budget constraint holds, $m-P_GX-C=0$, as well as any implicit time constraint. Dividing the first by the second equation in (7), and defining the right hand side as the marginal rate of substitution, average length of stay for number of trips, yields:

$$MRS_{HR,TR} = \frac{\partial HR}{\partial TR} = \frac{\partial U/\partial TR}{\partial U/\partial HR} = \frac{\partial C/\partial TR}{\partial C/\partial HR} \tag{8}$$

Given the specified cost function, (8) can be used to link various pricing policies with the household's marginal rate of substitution between average length of stay and number of trips. Three alternative pricing policies (P^1, P^2, P^3) are of interest.

The first pricing policy, P^1, can be specified as:

$$F_{LS} \geq 0 \qquad F_{TR} > 0 \qquad F_B = 0 \tag{9}$$

A positive F_{TR} indicates a daily fee at the site; by allowing F_{LS} to be positive allows for a two-part pricing scheme where (say) a fixed price for a bird stamp is also required for access to the site. It can be shown that the following marginal condition is obtained:

$$MRS_{HR,TR} = \frac{TC + F_{TR}}{V} \tag{10}$$

It is shown that a daily on-site trip fee impacts the terms of trade in the household's allocation of hours and trips.

If, however, the alternative pricing policy, P^2, is chosen:

$$F_{LS} \geq 0 \qquad F_B > 0 \qquad F_{TR} = 0 \tag{11}$$

Then it can be shown that:

$$MRS_{HR,TR} = \frac{F_B \cdot \frac{\partial HA}{\partial TR} + TC}{F_B \cdot \frac{\partial HA}{\partial HR} + V} \tag{12}$$

Again, the optimal allocation of hours and trips is affected by imposition of the pricing policy. However, there is no reason to believe that the result in (10) will be equated with that in (12).

Finally, if P^3 is such that:

$$F_{LS} > 0 \qquad F_{TR} = 0 \qquad F_B = 0 \tag{13}$$

Then the optimal allocation between hours and trips is not affected by the pricing policy:

$$MRS_{HR,TR} = \frac{TC}{V} \tag{14}$$

This simple model can be extended in a number of ways. For example, the model could incorporate multiple sites and thereby evaluate the impact of alternative pricing policies on the marginal rate of substitution of trips to site 1 for trips to site 2. Additionally, both measure-of-use variables and a quality parameter such as total harvest for the season, could be treated as endogenous variables (Bockstael and McConnell, 1981). The focus in this model was in distinguishing between trips and time, concentrating on the role of alternative pricing policies in affecting recreation behavior.

In summary, it is shown that the definition of a trip changes depending on whether a daily fee, or fee per bird is implemented. Only in the case of a lump-sum fee for access to the site will the definition of a trip be constant. (In the sense that its average length is not influenced by the associated pricing policy.) [10] These simple insights have direct implications for the evaluation and utilization of CV survey results -- the way the good is priced and packaged can induce behavioral responses.

The next two sections explore the CV application by Adams et al., (1989) by providing background on the elicitation format, reassessment of the original model, and determination of the variability around estimates.

[10] A further conceptual complication is that the *imposition* of a market with a particular lump-sum fee may still induce a behavioral response in the number of trips taken. The implication is that for CV models, based on lump-sum fees, the use of historical use levels may be inappropriate in determining per-unit-of-use welfare measures. This issue is explored in detail in Chapter 4.

3.5 Background on the Contingent Valuation Approach

Motivations for Using the Referendum Approach

The original contingent valuation survey was conducted in 1986, and the results published in 1989. The survey format was described as "close-ended", referring to the discrete rather than numerical (open-ended) responses to the WTP question. The type of close-ended survey used was dichotomous choice contingent valuation (DC-CV). DC-CV formats are used to model referendum-style data, where yes/no responses are given to hypothetical WTP questions for specific payment levels.

Use of the DC-CV format can be motivated in two ways. The original study utilized the utility-difference interpretation within a random utility framework (Hanemann, 1984). The response to the valuation question is interpreted as the difference between two indirect utility functions. Numerical integration is used to obtain a point estimate of the welfare measure (e.g., the truncated mean WTP).

The alternative approach, censored normal (Cameron and James, 1987a, 1987b) and logistic regression (Cameron, 1988), is motivated by the idea of a tolerance distribution to the offered fee or threshold values. The censored regression approach permits specification of a WTP (or WTA) function. This conditional statement of WTP (or WTA) as a function of exogenous variables can be interpreted as the difference between two expenditure functions. It is alternatively referred to as the valuation or variation function. The latter refers to its interpretation as a valid money measure of welfare change; it is either the compensating or equivalent variation depending upon the question asked (McConnell, 1990). The valuation function may be obtained directly through maximum likelihood procedures on a general function optimizing program, or by reparameterizing the estimated coefficients from a packaged MLE logit routine.

Selection between the two DC-CV approaches is largely a matter of personal choice (McConnell, 1990; Park and Loomis, 1991). Because of its focus on explanatory variables and covariates in a conditional valuation and the straightforward regression analogy, the censored logistic regression is the preferred motivation in this application.

The original CV study asks respondents for their willingness-to-pay to avoid the loss of access to the stocking program, denoted WTPe(-). The elicited value is interpreted as the Hicksian equivalent measure of welfare change resulting from the quality change from the current (1986) level of stocking services, q^0, to loss of access to the stocking program, q^1:

$$WTPe(-)=E(q^0,u^1)-E(q^1,u^1)=E(q^0,u^1)-m \qquad (15)$$

where E(.) is the expenditure function defined on a level of utility (u), income (m) and stocking level (q). Replacing the unobservable u^1 with the indirect utility function [v(q,m)], and adding a vector of taste parameters to both E(.) and v(.):

$$WTPe(-)=E(q^0,T^0,v(q^1,T^1,m))-m \qquad (16)$$

Equation (16) can be more generally expressed as $WTPe(-)=f(q^0, q^1, T^0, T^1, m)$. In Adams et al. (1989), T is a single measure of avidity, the level of visits, where it is implicitly assumed that $T^1=0$, and T^0 is fixed. Further, the single change from q^1 to q^0 is left implicit, leaving the following function for actual estimation:

$$WTPe(-) = f(T^0, m) \tag{17}$$

In the DC-CV framework, a valuation function, such as (17), cannot be obtained directly, but must be derived from the chosen probability function (e.g., logit or probit) relating acceptance rates to alternative fee levels.

Since the implementation of the original survey, considerable changes have occurred in the theory and application of DC-CV. The original study, reflecting the state of knowledge and standard practice in DC-CV at that time, presents only mean estimates of WTPe(-). However, point estimates of expected value are given across four fee levels and three income groups. This breakdown provides a feel for the distribution of values, but is less than a full statistical confidence interval (CI). Emerging evidence on the statistical inefficiency of DC-CV format (Cameron and Huppert, 1991; Elnagheeb and Jordan, 1992) underlines the importance of computing CI's for estimated welfare measures. The relatively small sample size (n=97) in the original study further emphasizes the need for computing a CI around welfare measures. There are now a variety of ways to obtain CI's on the estimated WTP from DC-CV.

Developing Confidence Intervals Around DC-CV Welfare Measures

The use of statistical confidence intervals allows an assessment of the accuracy of empirical research findings. There is a "paucity" of interval estimates in DC-CV studies (Cameron, 1991b). Since the initial development of the censored regression approaches, a computationally convenient method has been developed for calculating CI's on estimated welfare measures (Cameron, 1991b).

For the utility-difference motivation to DC-CV, an alternative but more computationally intensive set of techniques are available for constructing confidence intervals. This second set of approaches uses logistic regression, numerical integration and subsequent estimation of the CI's using simulation or resampling (bootstrapping) techniques. For example, Park et al. (1989) use a simulation method based on the work of Krinsky and Robb (1986). An unpublished manuscript (Bergland et al., 1989) uses the pheasant hunting data set to illustrate the application of various resampling (bootstrapping) techniques for developing confidence intervals around point estimates of welfare change.

This study utilizes Cameron's analytical formulas to construct CI's around the point estimates of WTP for pheasant hunting. As Cameron (1991b:414) states:

> These simulation and bootstrap methods are useful, but much more involved and computationally intensive than the analytical formulas to be given here. Given that referendum contingent valuation studies are gaining increasing currency for the assessment of costs in environmental litigation and policy making, a good sense of the statistical accuracy of value estimates is imperative. To this end easily computed confidence intervals are imperative.

Emerging interest in information transfer and external validation create *a fortiori* arguments for such an imperative. If a point estimate of welfare change is to be assessed, then it should be done so with some knowledge of the statistical distribution from which it is to be drawn. In this case study, the previous work by Bergland et al. (1989) on the same data set provides a convenient opportunity for comparing the results from alternative approaches.

3.6 Procedures and Results

A distinct advantage of the DC-CV format in evaluating potential program revenues, is that in deriving the valuation function probability equation is estimated. The path for deriving the welfare measure (WTP) resulting from a policy change provides the kind of probability information an agency needs in projecting revenues (i.e., equation 2). Adams et al. (1989) use a logit probability model. In the current case study, the original data set was used in re-estimating the logit model, where the probability of a yes response (π) can initially be given as:

$$\pi(z)=[e^{-z}/(1+e^{-z})] \qquad \textbf{(18)}$$

where $z= \alpha FEE + \gamma'X$; X is a vector of explanatory variables, excluding the FEE; γ is a vector of coefficients, including an intercept term; and α is the coefficient on the FEE.

It is important to emphasize that the variable FEE is controlled by the analyst in DC-CV, and is connected to an implicit pricing policy. Specifically, Adams et al. (1989) use a lump-sum pricing policy to value access. In the context of the earlier notation of section 3.3, this can be expressed as $P^3(F_{LS})$, where FEE = F_{LS} , and the actual bid structure used in the survey was F_{LS}=(1,2,3,...,25). Further, the level of stocking releases, R, was also implicitly set at the current year (1986) level.

Following Cameron (1988, 1991b), the coefficient on the censoring threshold FEE can be used to determine the dispersion parameter K for the logit model ($-1/\alpha$ = K). Once K is obtained, the remaining vector of parameters can be transformed to obtain the underlying valuation function; WTPe(-) =$X\beta$. In effect, the vector γ has been reparameterized into the vector β. The resulting valuation function can be roughly interpreted as the result of an ordinary least squares regression. The estimation results for the logit probability model are given in Table 3.1.

The signs on the estimated coefficients are reversed from Adams et al. (1989) to reflect modeling the probability of a yes response, rather than a no, to the offered fee level. In the threshold interpretation context, it is more appealing to model the probability that WTP>FEE as a yes response. The estimated coefficient on lnFEE of -2.25 corrects a typographical error in the original publication which gave the coefficient as 0.253. This particular error is of some import. For a bid coefficient less than 1, implying K>1, the mean value would be undefined for the log-linear logit model (Duffield and Patterson, 1991). The negative sign on estimated coefficient for lnFEE indicates an inverse relationship between the probability of a yes and the offered payment level for hunting access.[11]

Table 3.1. Results from the Logit Probability Model

Variables	Coefficients
intercept	**3.75 (2.49)
lnFEE	***-2.25 (-4.08)
lnTVIS	*0.664 (1.97)
D_1	0.994 (1.64)
D_2	***2.02 (2.76)
Maddala R^2	.33
McFadden R^2	.29
% Correct Predictions	.76

where: D_1 is a dummy variable indicating income between $15,000 and $30,000; D_2 is a dummy variable indicating income over $30,000; TVIS represents the total visits (actual plus expected) for the season. The numbers in parentheses are t-statistics; *,**, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Using Cameron's censored logistic regression approach, the reparameterized coefficients provide the following valuation function:

[11] The estimated coefficient on lnFEE is not a price elasticity measure. A price elasticity of demand can be recovered, with several caveats, from the DC-CV logit equation. This is done in Chapter 4, and shown to be relatively elastic.

$$\mathit{lnWTPe}(-) = \underset{(1.09)}{1.67} \quad \underset{(0.30)}{+0.44\ D1} \quad \underset{(0.416)}{+0.895\ D2} \quad \underset{(0.362)}{+0.294\ \mathit{lnTVIS}} \tag{19}$$

The numbers in parentheses are the new asymptotic standard errors. Equation (5) is the statistical estimate of the conceptual welfare measure in (15) and (16). Since the natural logarithm of the fee (lnFEE) is used in the underlying logit model, lnWTPe(-) occurs in the resultant valuation function and follows a logistic distribution. Thus, WTPe(-) will have a "log-logistic" distribution [non-negative and skewed to the right] (Duffield and Patterson, 1991).

Although the true WTP is unobservable, the ability to obtain an estimate of β allows the expected value [E(WTPe(-))] to be computed. In order to de-transform the fitted values for lnWTPe(-) to provide values for expected WTPe(-) itself, the fitted estimates, $e^{X\beta}$, are multiplied by a correction factor.[12] Using a K of 0.4438 = 1/2.25, the estimated mean is \$19.91. This compares to an estimated truncated mean of \$20.06 in the utility-difference approach (Bergland et al., 1989).

The variance-covariance matrix for the set of transformed parameters, Σ_β, can be recovered from the information matrix of the original maximum likelihood logit estimation. This result follows from knowledge of how the original information matrix behaves under reparameterizations (Duffield and Patterson, 1991; Cameron, 1991b). The procedure here is to save the parameter variance-covariance matrix from the original maximum likelihood logit estimation, and then use the matrix algebra

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[12] The appropriate correction factor for the logit model can be given as: $\pi K[\sin(\pi K)]^{-1}$ (Cameron, 1991), where π is the irrational number (3.1459...).

programming capabilities of the SHAZAM econometric package (White, 1990) to obtain the desired variance-covariance matrix. The asymptotic standard errors given in (3) are taken from Σ_β. Following Cameron's (1991b) analogy with feasible generalized least squares (GLS) approaches, the analytical formula for developing a 95% CI around the mean WTPe(-) is:

$$CI_{.95}[E(WTP_0)] = X_0\beta \pm t_{.025}\sqrt{X_0\beta \cdot \Sigma_\beta \cdot X_0\beta} \tag{20}$$

where again, Σ_β is the parameter variance-covariance matrix for the censored logistic regression model, and X_0 represents the sample means for the explanatory variables. The 95% CI obtained with the Cameron approach was \$16.27 to \$24.75 for the logit model.

Table 3.2 presents results from Bergland et al. (1989). Their motivation for the DC-CV format follows from the random utility framework. The overall procedure is logistic regression, numeric integration to obtain the welfare measure, and then bootstrapping from the observed data to obtain CI's around mean WTP. The confidence intervals from several alternative bootstrap approaches are given. The STANDARD approach assumes a CI around the mean of the random variable (WTP) that is obtained from a standard normal distribution. The NONPARAMETRIC BC is a bias correction approach which drops any assumptions on the distribution of the random variable; the overall procedure is parametric in the sense that it depends on the initial assumption about the logistic distribution of dichotomous responses to the offered FEE level.

In summary, this section has reassessed the original DC-CV model in a censored regression context, and developed CI's around the welfare estimate. The CI's, generated from several sources, roughly bound the welfare measure, mean WTPe(-), from $15 to $25. The next section turns away from the CV results and towards evaluation of the fee-access hunt.

Table 3.2. CI's from Bootstrapping Approaches

METHOD	95% CI with 2500 iterations	
STANDARD	lower 14.98	upper 23.46
NONPARAMETRIC BC	lower 15.36	upper 24.07

Source: Bergland et al. (1989).

3.7 Converting Willingness-to-Pay into Public Revenues

Although the possibility of a fee hunt helped motivate the CV study, the program has evolved in ways that could not be fully anticipated at the time of the original survey. This section reviews the actual program that has been implemented.

Implementing the Program: From Free-Access to Fee-Access

For 1989, a special tag was developed which entitled the bearer to participate in the hunt and harvest up to four birds. The fee for the tag was set at $10.00.

Additional tags could be purchased if desired. In 1990 a two-part pricing system was introduced, the same fee schedule was kept with a $5.00 upland bird stamp also required of all upland bird hunters (those who hunt anywhere in the state including areas with stocked birds). In 1991, the tag fee was set at $10.50 for two birds, again with additional tag purchases allowed and a one-time $5 upland bird stamp required. A daily check-in system was maintained through self-service check stations. Table 3.3 presents the hunting and stocking statistics from 1984-1991 for the E.E. Wilson Wildlife Area.

In 1989, pheasant tags were sold only at limited outlets (i.e., at the ODFW's Northwest regional office and Portland outlet). Pheasant tags for 1990 were available from all ODFW regular license agents and regional offices. In 1990, the ODFW pheasant fee hunt program was expanded to include Fern Ridge Wildlife Area near Eugene (also in western Oregon's Willamette Valley), and the Denman Wildlife Area near Medford (in Southwestern Oregon's Rogue Valley). The purchased tag allowed access to all three hunting areas. For 1992, Denman Wildlife Area was open for the first two weeks of October (one-half of the standard month-long season).

Early Costs and Revenues

In the original study, it was predicted that a flat fee system would be unlikely to cover the cost of the program. In a 1991 ODFW report to the legislature, it was stated that:

Table 3.3. Hunting and Stocking Statistics: E.E. Wilson Wildlife Area

Year	In*	Out	Hours	Release	Harvest	Fee	Tag Sales
1984	1784	1489	3451	922	535	--	--
1985	2302	2040	5168	1013	747	--	--
1986	1770	1719	4659	609	391	--	--
1987	777	764	1991	0	41	--	--
1988	649	643	1511	0	55	--	--
1989	2327	2228	6879	1187	945	$10/4	1029
1990	2286	2216	6601	1189	999	$10/4 +$5	1727
1991	3004	2852	8541	1285	1012	$10.5/2 +$5	3005
1992	3189	n/a	8900	1181	975	$10.5/2 +$5	2695

In = total hunters checked in; Out = total hunters checked out; Release = total pheasants released at the site; Harvest = total pheasants harvested at the site; Fee = the fee structure, including the price ($) per tag/allowed birds harvested per tag, + price($) for upland bird stamp. * For safety purposes, the site capacity is 150 hunters at any one time; analysis of daily records for 1989 and 1990 indicates this limit is rarely exceeded for a total day. Maximum seasonal use is approximately 4500-4800 hunter days.

> It is clear there is a demand for the opportunity for stocked pheasants in highly populated areas where hunting for wild birds is limited. ...It is also clear that the costs and manpower requirements to provide such a program are high and will not be paid for under the pricing structure used in the pilot program. (ODFW, 1991:5)

Total program costs and revenues are summarized in Table 3.4. Table 3.5 provides a further breakdown of program costs for the three years where all three stocked sites were included.

The large increases in costs for the 1990 season were caused by expanding the stocking program to three areas, increased tag printing costs, and unanticipated costs in acquiring high quality game birds. For 1989-1992 combined, just over $50,000 of deficits were incurred for the fee hunt. Since 1990, a portion of upland bird stamp revenues have been used in covering the deficits and supporting the put-and-take hunts.

Given several years to work out the kinks of where to acquire quality pheasants and print tags, an estimate of the program total cost (TC) curve can be given as:

$$TC = 11{,}800 + 9.4 \cdot (R) \qquad \textbf{(21)}$$

where R is the number of pheasants released. Currently, the birds are purchased from private game farms. While the current tag price of $10.50 (two pheasants allowed) exceeds the constant marginal cost of $9.40 per pheasant, the management expectation was that not all hunters would "fill" their tag. For 1990-1992 the average harvest per tag sold has been 0.85 birds, or 42.5% of the purchased entitlement. Viewed in this

Table 3.4. Early Costs and Revenues from Tag Sales

Year	Total Program Costs	Revenue From Tag Sales	Net Revenues
1989	$11,794	$10,290	-$1,504
1990	$45,557	$17,270	-$28,287
1991	$46,837	$30,340	-$16,497
1992	$34,783	$28,297.5	-$6,480.5

Table 3.5. Breakdown of Program Costs

Year	1990	1991	1992
Misc. Services	$6,737	$7,014	$6,229
Service Supplies	$1,074	$460	$424
Tag Printing Costs	$1,500	$5,773	$3,700
Pheasants	$36,245 (1898 @ $11.50; 540 @ $7.50; 1152 @ $9.00)	$33,590 (3600 @ $9.40)	$24,430 (2589 @ $9.40)
Totals	$45,557	$46,837	$34,783

way, the current tag price exceeds marginal costs. In contrast, strict average cost pricing, as suggested by a Ramsey pricing solution for a single public good with decreasing average costs, would require a fee of approximately $13 per pheasant harvested. A recent suggestion has been to increase the tag fee to $12 (Dufour, 1992).

While the program has failed to cover its cost through tag sales, the argument that the program is a public subsidy is difficult to defend. Deficits have been covered through the upland bird stamp funds. The stocking program is part of the larger ODFW upland bird program; by drawing hunters with specific characteristics, the fee hunt helps to reapportion hunters across time and alternative locations (Davis et al., 1989). The use of two-part pricing systems for exactly such reasons is theoretically consistent with the general Ramsey pricing framework for efficient provision of publicly-provided goods under a budget constraint (Wilman, 1988).

Finally, the ODFW does not have full administrative freedom in setting prices. A $10 maximum for specific hunting fees is allowed by Oregon state regulations. (The additional $0.50 in the current price of the tag, is an administrative fee.) This price ceiling was the justification for reducing the allowable birds harvested per tag from four to two pheasants; unable to calibrate price to cover program costs, the ODFW adjusted the commodity being sold.

In summary, it is clear that the way recreational services have been priced and packaged in the actual market differ from that of the constructed CV market. Drawing from the conceptual model of the household production function, it should be expected that some behavioral response will result In the following, preliminary evidence from the program is examined in a set of aggregate relationships.

Aggregate Relationships: Preliminary Evidence

Tables 3.6 - 3.8 create the initial picture of hunters' response to the fee-access stocking program. The results from a set of ordinary least squares (OLS) regressions are presented using the information from Table 3.3. A variety of relationships are tested. Given the extremely small sample size (n = 9), the results are treated only as preliminary evidence. The variable R indicates the total number of pheasants released at the site. MTAF denotes the minimum total access fee (upland bird stamp fee plus the cost of a tag) required to use the E.E. Wilson site. For those years where no fee was charged, the MTAF was set at zero. F_B1 and F_B2 are dummy variables used to indicate the fee per bird harvested ($F_B1=1$ indicates $2.50 per bird, $F_B1=0$ otherwise; $F_B2=1$ indicates $5.00 per bird, $F_B2=0$ otherwise). The dummy variables are used because of the lack of price variability in the small sample.[13]

In Table 3.6, the number of pheasants released has a positive and significant effect on the total number of visits in both model specifications. There is no evidence that the imposition or the levels of the fees are having a negative impact on the total number of visits to the site. In fact, in the second model, F_B2 has a positive and statistically significant effect ($p<0.05$).

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[13] MTAF and the pair of dummy variables, F_B1 and F_B2, are not used in combination because of multicollinearity concerns.

In Table 3.7, while the level of pheasants released is a significant determinant of total hours at the site, this does not hold for the average hours per visit. In all models the price variables have a positive and significant impact. Of particular note, both F_B1 and F_B2 show a positive and significant impact on average hours per visit.

In Table 3.8, the level of pheasants released is a significant determinant of the total harvest ($p<0.01$) and the average harvest per visit ($p<0.05$) at the site. While MTAF and the F_B1 and F_B2 dummy variables are positive and significant determinants of total harvest, this does not hold for average harvest per trip.

An initial hypothesis then is that current pricing is not influencing hunting access, but it may be creating a behavioral response. Hunters appear to be staying longer, perhaps to take more birds or fill daily bag limits. The total seasonal harvest is significantly influenced by the number of birds released. Additionally, the fee variables, in their separate regressions, demonstrate a positive and statistically significant impact on harvest.

This preliminary evidence appears inconsistent with the DC-CV results where the size of FEE variable had a strong inverse relationship with the probability of accepting or rejecting the posted price for fee hunting. However, this finding is consistent with the national level analysis of Langer (1987:481). She argues that the decision to fee hunt influences the level of activity, rather than level of activity influencing the choice to fee hunt. These initial results also appear consistent with the conceptual household production function results developed in Section 3.4 which indicate that there may be behavioral responses to alternative pricing policies.

Table 3.6. Estimated OLS Models for Total Visits

Variable	Coefficient	Coefficient
Intercept	**757.15 (2.93)	**744.85 (5.75)
R	***1.34 (3.99)	**1.40 (7.25)
MTAF	27.25 (1.04)	
F_B1		-99.75 (-0.49)
F_B2		**627.32 (2.98)
Adjusted R^2	0.88	0.95
Durbin-Watson Statistic	1.29 [c]	1.88

Numbers in parentheses are t-statistics; *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively; c indicates the model estimation used the autocorrelation correction on SHAZAM econometrics package (White et al., 1990).

Table 3.7. Estimated OLS Models for Total and Average Hours per Visit

Dependent Variable	Total Hours	Total Hours	Hours/Visit	Hours/Visit
Variable				
Intercept	**1888.4 (2.91)	**1948.5 (3.97)	***2.48 (15.47)	***2.50 (17.19)
R	**2.84 (3.02)	**2.80 (3.81)	-0.0002 (-1.0)	-0.0003 (-1.4)
MTAF	**173.93 (2.73)		**0.05 (2.95)	
F_B1		1438.1 (1.85)		**0.79 (3.42)
F_B2		***3310.4 (4.13)		**0.70 (2.95)
Adjusted R^2	0.88	0.92	0.53	0.62
Durbin-Watson Stat.	1.58 [c]	1.61 [c]	1.80	1.62

Numbers in parentheses are t-statistics; *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively; c indicates the model estimation used the autocorrelation correction on SHAZAM econometrics package (White et al., 1990).

Table 3.8. Estimated OLS Models for Total and Average Harvest per Visit

Dependent Variable Variable	Total Harvest	Total Harvest	Harvest/Visits	Harvest/Visits
Intercept	-23.95 (-0.30)	-33.45 (-0.43)	0.04 (0.54)	0.03 (0.55)
R	***0.59 (4.81)	***0.59 (4.90)	**0.0002 (2.52)	**0.0002 (3.08)
MTAF	**20.40 (2.59)		0.003 (0.45)	
F_B1		*310.7 (2.49)		0.12 (1.52)
F_B2		*296.36 (2.23)		0.005 (0.06)
Adjusted R^2	0.89	0.88	0.65	0.71
Durbin-Watson Stat.	2.28 [c]	2.52 [c]	2.00	2.22 [c]

Numbers in parentheses are t-statistics; *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively; c indicates the model estimation used the autocorrelation correction on SHAZAM econometrics package (White et al., 1990).

3.8 Deciphering the Results

In the preliminary evidence from the program, there is considerable total demand for the fee-access hunt. This demand has increased with increases in the effective fee per allowed bird harvested. To this point the program has not demonstrated self sufficiency-- from the revenues of tag sales -- but that seems an attainable goal. In this section we explore the question: If these initial fee changes do not matter, why not? Several hypotheses are put forward and discussed.

The original model indicated a strong inverse relationship between probability of participation rates and the level of the fee. To this point, the fee charged essentially has been below or at the low end of the predicted 95% CI of roughly \$15-\$25 (\$1986) for the mean access value. The highest minimum total access fee to this point has been \$15.50.

The preliminary evidence is that the E.E. Wilson Wildlife Area is being hunted more intensively. The total hours spent hunting appears to be positively related to the level of the fee. By pricing and defining the commodity in terms of allowed birds harvested, a behavioral response has occurred that cannot be solely accounted for by any physical changes in the site, such as birds released. The alternative explanation is that the imposition of the fee-access hunt may have "re-apportioned" hunters across a spectrum of available free-access and fee-access pheasant hunting sites, and times of the season. Confounding all of this is the determination of the extent of the relevant market. It is difficult to draw any conclusions without further exploration.[14]

[14] A researchable task would be to survey a random sample of Oregon pheasant hunters, and explore possible participation decisions for the free-access and fee-access sites. Such a sample would reduce the possibility of endogenous stratification from a choice-based on-site sample that occurred in the original survey. The simplest research design would be a logit or probit probability model to explain the participation decision. This has been done at the national level, and suggested at a regional level (Langer, 1987). A more complex research design would be a revealed preference random utility framework to model the discrete choice problem.

The question is whether we can simply compare the price-quantity information from the stocking program against the predictions of the valuation model. The early program results show increasing use with an increasing fee. The CV survey results indicate a strong inverse relationship between participation rates and the size of the hypothetical fee. At this point the challenging issue of commodity specification must be confronted.

Exactly what was being valued in the original survey and is this equivalent to what was sold in the subsequently established market? Contingent values are by their very nature context specific; any attempt to transfer those values or valuation functions out of their original context must proceed with caution. The analyst must evaluate the degree of verisimilitude, past to present or study site to policy site.

The original valuation was for access to the hunting site and the implicit physical or quality characteristics. There are several distinct differences between what was valued in the survey, and what was bought with the purchase of the pheasant tag. First, the fee was defined in terms of birds harvested rather than simply access to the site for the normal one month (October) hunting season at E.E. Wilson. Second, in the second year of the fee-access hunt, the entitlement was extended to include access at two additional stocked sites in western Oregon. Third, the level of congestion has increased.

Considerable evidence in the CV literature points to the importance of commodity specification -- the exact description of the good that is to be exchanged in the hypothetical market. Slight changes in this specification can have a significant impact on stated values. The importance of the commodity specification issue is highlighted by this comparison of CV survey results to the actual revealed preferences from the fee access hunt. (A hunt that was anticipated in the original CV survey.) The contingent scenario in any CV survey assumes *ceteris paribus* holds. The difficulty faced in comparing the CV results to the observed behavior is that "other things held constant" -- weren't.

This simple insight lends itself to the issue of information transfer from CV surveys. The issue of commodity specification may be the most difficult assessment that has to be made in the developing protocol of benefits transfer.

Improved utilization of CV in public project financing, and converting WTP into public revenues must account for the non-neutral role of the pricing policy (Ready, 1990). This suggestion can be formalized by returning to equation (15), and redefining the arguments of the welfare measure. A value elicitation is now seen as contingent upon changes in combinations of quality and the pricing policy (q,P^j); e.g., for the Hicksian equivalent measure:

$$WTPe(-) = E(q^0,P^{j,0},u^1) - E(q^1,P^{j,1},u^1) \qquad (22)$$

There are a variety of ways that this conceptual change could be modeled. Changes in the pricing policy could be seen as legitimate context effects or as another dimension of the good. Explicitly recognizing the role of the pricing policy P^j in the experimental design will facilitate the use of CV studies in setting fees, and converting WTP into public revenues. In estimation, P^j would be qualitative in nature, not the level of the fee. Adding P^j and treating the potential policy changes as a response surface Q^{jk} defined on the jth packaging alternative (corresponding to P^j), and the kth dimension of the good:

$$WTPe(-)=f(Q^{jk},P^j,\ T,\ m) \tag{23}$$

Recall that in practice (23) would be recovered from the antecedent logit probability equation for the DC-CV format. DC-CV is particularly well-suited for use in determining fees for recreation program funding. As done in Adams et al. (1989), and suggested by Loomis and Thomas (1992), the probability model (e.g. $\pi(.)$ in equation 18), used in deriving WTP, can be used to assess the acceptance rates of alternative fees and quality dimensions.

In many cases the dual criteria of "realism" and "neutrality" in selecting payment vehicles may be mutually exclusive. Rather than attempting to select a neutral payment vehicle to avoid bias, the focus should be on identifying candidate pricing policies and then mapping their performance characteristics onto valuation results. Further, the recreational commodity can be priced and packaged in a variety of ways. Attention must be directed not only to the acceptance rates of alternative fees, but also to the behavioral responses to alternative pricing and packaging policies.

3.9 Conclusions: Good News, Bad News

The results of this study are a mix of good news and bad news. The good news is that contingent WTP, at least in this case, is a real value that can be converted into public revenues. There is no indication that the original survey results overestimated the value of the nonmarket commodity. There is also some indication that this particular public program will be able to pay for itself. To this point, the program hasn't been given full administrative freedom in setting prices.

On a less positive note, attempts to evaluate the accuracy on any more specific basis appear impossible. The goods being valued are different. This latter result is used in asking how future CV applications can be improved in providing information for setting recreational pricing policies.

If behavior can be linked with how a project or program is financed, then elicited valuations should be explicitly linked with the pricing policy upon which they are conditioned (Ready, 1990). We should expect that valuations will change in response to alternative packaging and pricing policies; this is not unique to constructed markets. The important question is how closely the hypothetical market mirrors the actual market. Research has shown that the money measure of welfare change (WTP or WTA) obtained in a CV survey is strongly influenced by the structure of the hypothetical market including commodity specification and the chosen payment vehicle. If CV surveys are to be used in project or program design then they must tied to realistic pricing policies; experimental designs must accommodate alternative pricing polices, rather than seeking out some neutral or nondescript payment vehicle.

The E.E. Wilson pheasant hunting case is illustrative on this point. The original contingent valuation survey used a lump-sum pricing policy for access to the stocking program in the hypothetical market. In the actual market, a two-part pricing system was introduced, which included a fee per allowed bird harvested. The preliminary evidence is that the behavioral response to this pricing policy has been to hunt the area harder, in the sense of increasing the average hours per trip. Furthermore, the commodity was expanded to include access to two additional stocked sites. In this case it becomes difficult to compare the CV results against the actual market behavior; the commodities for sale, broadly defined, are different.

One implication of these results is that any attempt to externally validate a CV will be difficult because of the impossibility of anticipating all changes and in controlling all side conditions. Rather than focusing on uncovering some elusive "true" value, attention should be directed toward mapping the performance characteristics of alternative decision variables onto valuation results (Randall, 1993b). In the case of project financing, and attempts to appropriate WTP for program funding, the performance characteristics of alternative pricing policies are likely to be a pivotal research question that will have practical value to public resource managers.

CHAPTER 4

SOME PROBLEMS WITH DERIVING DEMAND CURVES FROM MEASURE-OF-USE VARIABLES IN REFERENDUM CONTINGENT VALUATION MODELS

4.1 Introduction

The use of referendum-style, dichotomous choice (DC) questions is popular in recent contingent valuation (CV) studies of nonmarket goods and services.[1] Econometric advances afford the opportunity to review and scrutinize earlier studies. There are some unresolved points in the current literature. One important issue centers around the inclusion of "measure-of-use" variables as regressors in explanatory models.

The use of such quantity information in valuation functions facilitates the derivation of demand curves. However, some authors counsel against the use of such variables because of endogeneity concerns, and avoid their inclusion in model specifications. Others continue to discuss the derivation of demand curves, with the focus on econometric approaches for doing so. The result is a lack of clear guidance for variable selection in *de novo* research, and for assessing the validity of previously

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[1] Recent applied studies include: Adams et al., 1989; Bergstrom et al., 1990; Duffield and Allen, 1988; Duffield et al., 1992; Loomis et al., 1988; Schultz and Lindsay, 1990; and, Whitehead and Blomquist, 1991a, 1991b.

estimated models. The need to derive demand curves and other per-unit-of-use welfare measures is increasingly motivated by the objectives of benefit transfer.[2]

The contribution of this paper is to examine this issue in greater detail. Grogger's (1990) specification test provides a technique for addressing endogeneity questions on measure-of-use variables in DC-CV models. A typology is presented and used to distinguish among different types of CV models and how they incorporate such variables. Empirical results from applying the specification test provide initial confirmation for the proposed typology. The results offer direction for variable selection in designing original models. Juxtaposed against this technical issue is an emerging policy question -- the transferability of DC-CV models out of their original setting. The opportunity to conduct specification tests is unlikely to be available in a benefit transfer exercise. Thus, the typology may also serve as a screening tool in the emerging protocol for acceptable benefit transfers. Caution is urged in reconstructing demand curves from "off-the-shelf" DC-CV models.

The paper proceeds as follows. Section 4.2 provides background discussion on DC-CV. In section 4.3, endogeneity concerns with measure-of-use variables in the DC-CV format are raised, and an available econometric test is introduced for exogeneity/endogeneity in nonlinear discrete choice models (Grogger, 1990). Section 4.4 establishes the policy context; as DC-CV emerges as a common format, it becomes a likely target for benefits function transfer. Section 4.5 reviews the

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[2] Smith (1992b:1083) discusses the "need for marginal values" in the transfer exercises involved in environmental costing for agricultural programs.

derivation of demand curves from DC-CV models, using examples from several previously published sources. Section 4.6 questions the interpretation of the results and compares the approach to the Bradford bid curve framework. Given this foundation, section 4.7 presents a typology of CV models and the incorporation of measure-of-use variables. The typology is used to generate a set of hypotheses that are tested using the original data from Adams et al. (1989). Empirical results are presented in section 4.8. In conducting the specification tests, a consistent nonlinear instrumental variable (NLIV) estimator is generated. When endogeneity is detected, the NLIV estimator is of some interest in itself, and policy implications for derived demand curves and welfare measures are demonstrated in section 4.9. A discussion and comparison with related studies is given in section 4.10.

4.2 Background on DC-CV

The dichotomous choice contingent valuation (DC-CV) approach for referendum data was introduced by Bishop and Heberlein (1979), and is "emerging as the preferred methodology" (Duffield and Patterson, 1991) in many applied studies. In the DC-CV format, the individual is queried for a yes or no response to a specific payment level (bid). With sufficient variation in the payment levels across the sample, and information on the probability distribution of acceptance/rejection, it is possible to estimate willingness-to-pay (WTP), or willingness-to-accept (WTA) payment via statistical inference. Hanemann (1984) provides a utility-difference motivation for interpreting DC-CV in a random utility maximization framework; he also identifies a tolerance distribution or threshold motivation approach. This important alternative interpretation for DC-CV is fully defined in the development of the censored regression models (Cameron and James, 1987a,b; Cameron, 1988 and 1991b). McConnell (1990) regards these alternative interpretations to be the "dual" to each other in economic utility theory.

The censored regression approach allows direct estimation of a valuation function, which can be interpreted as an expenditure-difference function. This function may be obtained either through general optimization procedures, or by simple transformation of the probit or logit probability results (as estimated for the utility-difference model). This conditional statement of WTP (or WTA) as a function of (presumably) exogenous variables can be interpreted as a valid money measure of welfare change; it may be either the Hicksian compensating or equivalent measure, depending upon the question asked, and the implied property right. Directly obtaining the valuation function also facilitates determination of the marginal valuation functions (Hicksian compensated demand).

The computational ease of the censored regression approach facilitates the review of previous DC-CV studies. As Cameron (1988:378) states:

> The logistic censored regression procedure also allows us to go back and reinterpret the results generated by other researchers, since the derivation of this model brings out a more appropriate interpretation of the referendum data parameter estimates yielded by simple logit discrete choice models. It is easy to **recover the underlying demand functions with no more than just the fitted models** in published versions of these papers. [Bold emphasis added]

This opportunity is demonstrated in Cameron (1988) by a reinterpretation of the DC-CV results of Bishop and Heberlein (1979) and Sellar et al. (1986).[3]

Recent research on the DC-CV format is quite comprehensive, focusing on functional form (Bowker and Stoll, 1988; Boyle, 1990), experimental design (Cameron and Huppert, 1991; Cooper, 1993; Cooper and Loomis, 1992; Duffield and Patterson, 1991), and the development of confidence intervals around welfare estimates (Cameron, 1991b; Park et al., 1991). However, the question of recovering demand curves from fitted DC-CV probability models raises an important issue with variable selection that is discussed in the next section. While the focus is on deriving demand curves from the antecedant valuation function, endogeneity bias in estimated coefficients also affects other derived welfare measures, such as the commonly used "consumer surplus per-unit-of-use" (e.g., the WTP per trip, evaluated at the sample means).

4.3 Addressing the Endogeneity Problem

The objective of this section is to explore the issue of possible endogeneity in the specification of the logit or probit probability models. This issue was raised by McConnell (1990) and focused on the use of "quantity demanded" or measures of use

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[3] Bishop and Heberlein's (1979) CV model was for a single trip, where the relevant use variable is the length of stay. In contrast, Sellar, et al.'s (1986) application was for a season, where the relevant use variable is the number of trips. The focus of this paper is on the latter, but the results generalize.

variables as explanatory regressors (either for the RUM framework or the censored regression approach).

The Problem Defined

While endogeneity is a general econometric concern, the following quote from McConnell (1990:30) addresses the issue in relation to DC-CV:

> Whether one deals with utility differences or cost differences, the arguments of the function ought to be exogenous to the consumer, not consumer choice variables. There are several compelling reasons why exogenous variables work better. The basic problem with including quantity demanded in the valuation function is the endogeneity. The quantity of a good changes when exogenous variables change, but a ceteris paribus change in quantity is contrary to the spirit of economics, unless the quantity is rationed. Since the quantity of the good is chosen optimally, its marginal value is zero.

In response to these concerns over endogeneity, some researchers have counseled against, or avoided including measure-of-use variables in DC-CV models (Bergstrom and Stoll, 1993:134; Cameron, 1992:305). For example, Park, Loomis and Creel (1991) in their discussion of both linear and logarithmic DC-CV models note:

> Both specifications examined here are consistent with McConnell's (1990) demonstration that endogenous variables such as the number of trips must be omitted from the valuation function.

This quote demonstrates a distinct shift in variable selection protocol; e.g., in an earlier study, using the same elk hunting data set, Loomis et al. (1988), had previously estimated a set of DC-CV logit models that included measure-of-use variables.[4]

Is it unacceptable to include measure-of-use variables in the DC-CV variable selection process? The one argument is that because of potential endogeneity, you should not.[5] Others might point to the available literature, where such variables are commonly seen, as support for either estimating or interpreting models which include such variables, or possibly transferring models out of their original context. A further counterargument might be that these measure-of-use variables are often better interpreted as measures of "avidity", thus, leaving them out of an equation may induce omitted variable bias. In the logit probability model, the exclusion of relevant variables "biases the estimates of the remaining slope coefficients toward zero" (Cramer, 1992:36). Clearly, there is a need for an empirical test, and a set of guidelines for using previously estimated results.

Consideration of model misspecification in the DC-CV format is only just beginning (Ozuna et. al., 1993). Grogger's (1990) specification test for exogeneity in the logit and probit models offers the opportunity to address this issue in the DC-CV context.

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[4] The measure-of-use variable was total trips to the site, while the frame of reference for the valuation was a single trip.

[5] The implication for benfit transfer is that any CV model which includes a measure-of-use variable on the right hand side must be recognized as biased and not a viable transfer candidate.

An Econometric Specification Test

Grogger motivates his Hausman-like specification test by considering the problem in a nonlinear least squares framework. The test has the advantage of being computationally convenient and is robust to departures from normality. It can be applied to either probit or logit models estimated through standard maximum likelihood (ML) estimation procedures. Furthermore, the nonlinear instrumental variable (NLIV) estimator used in conducting the test is "consistent in the presence of endogenous regressors." The test statistic **h** can be given by:

$$h=(\hat{\gamma}_{NLIV}-\hat{\gamma}_{ML})'[VC(\hat{\gamma}_{NLIV})-VC(\hat{\gamma}_{ML})]^{+}(\hat{\gamma}_{NLIV}-\hat{\gamma}_{ML}) \tag{1}$$

where:[6]

$$\begin{aligned} \hat{\gamma}_j &= \textit{coefficients on } 1\times G \textit{ vector of possibly endogenous variables} \\ VC(\hat{\gamma}_j) &= \textit{a } G\times G \textit{ block of the var-covariance matrix on } \gamma_j \\ [A]^{+} &= \textit{the Moore-Penrose inverse for any matrix } A \end{aligned} \tag{2}$$

Under the null hypothesis of exogeneity (no misspecification), **h** follows a chi-squared distribution with **G** degrees of freedom; the NLIV estimator is consistent under both the null and the alternative hypothesis (misspecification due to endogeneity of one or more independent variable). A significantly large chi-squared test statistic indicates

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[6] The Moore-Penrose inverse or generalized inverse of any matrix A, is another matrix A^+ that satisfies the following: (i) $AA^+A=A$, (ii) $A^+AA^+=A^+$, (iii) A^+A is symmetric, and (iv) AA^+ is symmetric. These conditions held for all empirical applications discussed in this paper. In the special case of an overdetermined system of equations, the formula for finding the Moore-Penrose inverse is given by: $A^+=(A'A)^{-1}A'$ (Greene, 1990:38).

the presence of endogeneity. This test helps to fill a useful gap in the empirical DC-CV literature.

In section 4.7 several applications of this test are given. The applications are to a published DC-CV study on pheasant hunting (Adams et al., 1989), which incorporated a measure-of-use variable. The authors viewed this variable as a measure of hunting "avidity" or intensity of preferences; they made no attempt to derive the Hicksian compensated demand curve.[7]

4.4 The Policy Context: Benefit Function Transfer

Benefit transfer is the transfer of some existing benefit estimate from its study setting to some alternative policy setting.[8] Benefit transfer has been practiced on an ad hoc basis in legal and policy settings; the issue lies in developing acceptable

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[7] The desire to develop a demand curve from the Adams et al. (1989) results was motivated by practical considerations. The original survey was conducted in 1986. In the following year, the stocking program was dropped. An annual fee-access "put-and-take" hunt was initiated in 1989. Thus, several years of actual price-quantity information offered a unique opportunity for a "ground truth" check on a CV survey. The full comparison, and any discussion of the targeted Ramsey pricing systems required that a demand curve be derived from the DC-CV probability results, if possible.

[8] Quantity/quality ambiguity concerning the interpretation of such variables dates to the first application of the CV approach. In discussing a "length of stay" variable included in his estimation, Davis (1964:396) stated that: "The length of time one stays in the area appears to measure the quantity of the good consumed but also reflects a quality dimension, suggesting that longer stays probably reflect a greater degree of appreciation for the area."

protocol for doing so (Smith, 1992c). *Benefit function transfer* refers to the transfer of an existing function rather than simply a point estimate or confidence interval for WTP (Loomis, 1992); it has been described as an "ideal" form of benefits transfer (Desvouges et al., 1992). An estimated function provides a policy analyst with greater flexibility and precision in calibrating a transferred value to a policy setting.

With growing interest in the topic of benefit transfer, and increasing use of the DC-CV format, an important question is whether one could use the estimated model from an existing study to derive a valuation function, and if desired, derive the demand curve. Further, should these demand functions and associated welfare measures per-unit-of-use be part of the accepted protocol for benefit transfer?

Discussion of the use of DC-CV models in a benefits transfer context has begun (Downing et al., 1992; Duffield et al., 1992). It seems likely that the censored regression approach, with its emphasis on covariates and the ordinary regression analogy, will be a particularly attractive candidate for benefit function transfer.

Consider a simple example. A wildlife or water resources agency may be interested in transferring a valuation estimate for upland bird hunting from the study site to an alternative setting. Some proposed change would negatively impact wildlife habitat which currently supports significant hunting activity. As is common, the agency currently may have projections on the changes in the number of trips and may be particularly interested in obtaining a per-trip measure of consumer surplus or preferably, a demand curve. From the limited set of nonmarket valuation studies available on upland game hunting, a particular study may be the most appealing alternative. It would be instructive to agency analysts to know if they could validly reconstruct per-unit welfare measures from the targeted study.

4.5 Deriving Demand Curves from the DC-CV Model

Our focus here is on the review and possible reinterpretation of the DC-CV results from a study (Adams et al., 1989) in a situation similar to the above example.[9] The objective is to explore the suggested derivation of the inverse Hicksian demand curve from the censored logistic regression approach to DC-CV data.

In Adams et al. (1989) [hereafter referred to as ABMJM], the welfare measure was the willingness-to-pay to avoid the loss of a pheasant stocking program. Its format follows that of Sellar et al. (1985,1986) [hereafter referred to as SSC], who valued the loss of access to a recreational boating site. Both studies:

(1) elicit the Hicksian equivalent surplus measure of welfare change, the willingness-to-pay to avoid a loss,
(2) utilize the utility-difference (or random utility) model for DC-CV,
(3) utilize the log-linear specification of the logit probability function with the logarithm of the fee used as an explanatory variable, and a logarithmic transformation of the number of trips (hunting) or launches (boating) as an explanatory variable.

Since its original publication the SSC study has been subjected to additional scrutiny and professional discussion, especially with reference to the development of

[9] The topic of benefits transfer has received increasing professional attention. For further discussions see the compilation of articles in volume 28 of *Water Resources Research* (e.g., Brookshire and Neil, 1992).

the censored logistic regression interpretation of DC-CV (Cameron, 1988; McConnell, 1990; Patterson and Duffield, 1991). Given the general comparability of the format between the two studies, we extend this discussion to the ABMJM study.

The discussion centers around the "measure-of-use" or quantity of visits variable.[10] Following Cameron's notation (1988) we denote this measure-of-use as q. The two motivating questions are: (i) Can we use this variable to construct a marginal valuation function or Hicksian demand curve? and; (ii) If this is a quantity demanded variable, is there potential endogeneity in including it in the probability function and the resultant valuation functions? The first question is addressed below.

A preliminary step is to establish the general correspondence of the SSC and the ABMJM studies. First, define the familiar "log-odds ratio" or logit index from the logistic probability model:

$$\mathbf{LO_i = f(X_i, q_i)} \qquad \mathbf{(3)}$$

where LO_i is the logarithm of the odds ratio of the ith individual responding "yes" to the offered bid or fee, X_i, which is included as an explanatory variable and assumed to vary across the sample. The "crucial" additional explanatory variable is again q,

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[10] Thus, our concern is with variable selection; important considerations with functional form (Hanemann, 1984; Boyle, 1990; Cameron, 1991a) are not addressed. The so-called "log-logistic" has tended to provide the best empirical fit in DC-CV models, but cannot be derived from any valid utility function. It has been shown that it can be traced to a first order approximation of such a function; it is commonly accepted in the threshold interpretation of DC-CV as the best statistical approximation. The empirical tendency has been for WTP errors to follow a log-normal or log-logistic distribution. For further discussion see Cameron (1991b).

the number of trips, and f(.) is the general functional form for the assumed utility-difference in the random utility framework. SSC utilize the "so-called" log-linear specification:

$$f(X_i,q_i) = \gamma_1 + \gamma_2 \cdot \log(q_i) + \alpha \cdot \log(X_i) \tag{4}$$

The results of two site-specific logit models from SSC are given below:

$$\begin{aligned} \textit{Livingston:} \quad LO_i &= 3.06 - 1.37\log(X_i) + 0.67\log(q_i) \\ \textit{Somerville:} \quad LO_i &= 4.78 - 1.26\log(X_i) + 1.75\log(q_i) \end{aligned} \tag{5}$$

From the study site in ABMJM:

$$\textit{E.E.Wilson:} \quad LO_i = 4.88 - 2.25\log(X_i) + 0.664\log(q_i) \tag{6}$$

All other explanatory variables in ABMJM have been evaluated at their sample means and collapsed into a "grand intercept" for conformity between studies. Hereafter, the subscript i will be dropped for simplicity of notation.

To obtain the Hicksian demand curve, SSC first estimate the logit probability model, and numerically integrate the cumulative distribution function of the assumed error on the utility-difference to obtain the expected value of the conditional willingness-to-pay, E(WTP|q). The SSC formula for the demand curve is given by:

$$\frac{\partial E(WTP|q)}{\partial q} = -\int_0^{X_{max}} \frac{f_q \exp[-f(X,q)]}{(1+\exp[-f(X,q)])^2} dX \tag{7}$$

The formula does not have a closed-form solution and is evaluated numerically. While not reproduced here, the formula for the slope of the demand curve is even more complex, and again must be evaluated numerically.

In noting SSC's failure to integrate the expression in (7) to infinity, Patterson and Duffield (1991) correct it to be:

$$\frac{\partial E(WTP|q)}{\partial q} = (1/q)\cdot [\partial E(WTP|q)/\partial \log(q)] = \frac{\gamma_2}{-\alpha}\cdot(1/q)\cdot E(WTP|q) \tag{8}$$

Equation (8) represents the expression for Hicksian demand from the utility-difference interpretation of DC-CV.

The censored logistic regression approach for deriving the Hicksian demand curves and the resultant price elasticities of demand, begins by transforming the original logit probability coefficients to obtain the underlying valuation function (without the bid or fee variable after the reparameterization). Specifically, from (4) we have:

$$\begin{aligned} \log WTP &= (\gamma_1/\alpha) + (\gamma_2/\alpha)\cdot\log(q) \\ &= \beta_1 + \beta_2\cdot\log(q) \end{aligned} \tag{9}$$

Where $(-1/\alpha) = K$ is the alternative dispersion parameter from the logit model; K is used in reparameterizing the original coefficients to obtain the underlying valuation function. With the exponential transformation, this function is expressed as:

$$WTP = e^{\beta_1 + \beta_2 \cdot \log(q)} \tag{10}$$

To obtain the expected WTP requires multiplication of (10) by an exponentiation correction factor, C, given as:

$$C = \frac{(\pi \cdot K)}{\sin(\pi \cdot K)} = \Gamma(1-K) \times \Gamma(1+K) \tag{11}$$

where Γ is the Gamma function (Duffield and Patterson, 1991).[11] Cameron (1988) reparameterizes four site-specific logit equations from SSC. Below are several of the resultant valuation functions:

$$\begin{aligned} &\textit{Livingston:}\ \log(WTP) = 2.23 + 0.489\log(q) \\ &\textit{Somerville:}\ \log(WTP) = 3.79 + 1.389\log(q) \end{aligned} \tag{12}$$

The equivalent function from ABMJM is:

$$\textit{E.E.Wilson:}\ \log(WTP) = 2.17 + 0.294\log(q) \tag{13}$$

To derive the Hicksian demand curve in this censored logistic regression format note that:

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[11] The objective is to obtain E(WTP); however, it is usually lnWTP that has been estimated. By Jensen's Inequality, it can be generally stated that, E(f(x)) ≠ f(E(x), implying in this case, E(ln(WTP)) ≠ ln(E(WTP)). Thus we can not simply take the anti-log of E(ln(WTP)) to obtain E(WTP). Specifically, E(ln(WTP|q)) provides the conditional median, and is not equal to the conditional mean, given the logarithmic transformation (see Goldberger, 1968). The relationship between the two can be determined through the moment generating function (in this case the for the log-logistic distribution). The full derivation of the correction factors (equation 11) can be found in Johnson and Kotz (1970:4).

$$\partial \log WTP / \partial \log(q) = \beta_2 \tag{14}$$

Then it can be shown that:

$$\partial WTP/\partial q = \beta_2 \cdot [(\exp(\beta_1 + \beta_2 \log(q)) \,/\, q)] \tag{15}$$

which follows from the generalized exponential-function rule for taking derivatives (Chiang, 1984:293) for any function f(t) of a random variable t:

$$\frac{d}{dt} e^{f(t)} = f_t \cdot e^{f(t)} \tag{16}$$

This application of the chain rule clarifies the correspondence between (8) and (15), and thus between the random utility and censored regression approaches (Patterson and Duffield, 1991). Specifically, the censored regression approach does not avoid the truncation point/upper limit issue of the utility-difference approach; rather, it implicitly assumes the upper limit to be infinity, and thus beyond the range of the offered bids (also see the discussion by Carson, 1991:144).

If we identify marginal willingness-to-pay as the implicit price of a trip q, $\partial WTP/\partial q = p(q)$, then the presumed demand equation can be expressed as:

$$\begin{aligned} \log p(q) &= \log\beta_2 - \log(q) + \beta_1 + \beta_2 \cdot \log(q) \\ \log p(q) &= (\beta_1 + \log \beta_2) + (\beta_2 - 1) \cdot \log(q) \end{aligned} \tag{17}$$

Rearranging to isolate log(q) on the left-hand side:

$$\log(q)=[(\beta_1+\log(\beta_2))/(1-\beta_2)]-[1/(1-\beta_2)]\cdot\log\ p(q) \quad (18)$$

Cameron (1988) presents the implied Hicksian demand functions for SSC in algebraic form for four separate locations. Two of which are shown below: one adheres to the theoretical notion of a downward-sloping demand curve and one does not:

$$\begin{aligned} \textit{Livingston:}\ \log\ (q) &= 2.96 - 1.96 \log p(q) \\ \textit{Somerville:}\ \log\ (q) &= -10.96 + 2.57 \log p(q) \end{aligned} \quad (19)$$

Similarly, the inverse Hicksian demand for the ABMJM model is:

$$\textit{E.E. Wilson:}\ \log\ (q) = 1.35 - 1.42\cdot\log p(q) \quad (20)$$

The slope coefficient in (20) can be interpreted as the price elasticity of demand, $\partial \log(q) / \partial \log p(q) = -1.42$. The estimated Hicksian demand curve for ABMJM is thus downward-sloping and relatively price elastic.

The first concern is potential fragility in this result. One issue is that the absence or presence of the exponentiation correction factor (11) may influence the result. Cameron (1988, 1991b) asserts that it will not affect the elasticity. The conclusion can be verified more explicitly as follows:

$$E(WTP) = e^{\beta_1 + \beta_2\cdot\log(q)}\cdot C \quad (21)$$

From a minimal extension of (16):

$$\frac{d}{dt}e^{f(t)}\cdot C = Cf_t e^{f(t)} \quad (22)$$

where the estimated C is taken as a multiplicative constant, and which accordingly changes (17) to:

$$\log p(q) = \log\beta_2 - \log(q) + \beta_1 + \beta_2 \log(q) + \log C \tag{23}$$

and modifies (18) to:

$$\log(q) = [(\beta_1 + \log(\beta_2) + \log(C))/(1-\beta_2)] - [1/(1-\beta_2)] \cdot \log p(q) \tag{24}$$

Thus, while the intercept of the Hicksian demand function is impacted by the exponentiation correction factor in the so-called log-linear model, the slope coefficient (elasticity) is not. With an estimated K=0.44 and C=1.416, we can apply this result to the ABMJM study; the revised Hicksian demand function becomes:

$$\textit{E.E.Wilson:} \quad \log(q) = 1.84 - 1.42 \cdot \log p(q) \tag{25}$$

The final result appears to be an appealing looking downward sloping demand curve. Following Cameron (1988:363) this can be described as a "per unit" demand curve. Such per-unit demand curves are discussed in the applied DC-CV research (Duffield and Allen, 1990; Loomis et al. 1988).

In summary, this section traced out the mechanics of deriving a "per-unit" demand curve from the DC-CV format. The correspondence between the utility-difference and the censored regression approaches was discussed. The computational convenience of the latter, which can easily be applied to any fitted logit (or probit) model, may facilitate the recovery of demand curves from historical models (e.g., ABMJM). However, because of potential endogeneity concerns, interpretation of such demand curves is required.

4.6 Interpreting the Result

Putting the endogeneity question aside for the moment, are there other concerns with the above approach to deriving demand curves? First, despite its appearance, one interpretation of the ABMJM result is that you really don't have a demand function; the hypothetical valuation exercise is lumpy, it was intended to elicit the value of the hypothetical change for the entire period. Second, it might also be argued that the number of trips is a measure of avidity or the intensity of preferences; the marginal value is inversely related to the intensity of historical preferences for pheasant hunting at the site. But does this mean that we can interpret this marginal relationship as a Hicksian demand curve where hypothetical price and quantity combinations are identified? The quantity of trips in ABMJM or boat launches in SSC were not goods sold in the hypothetical market; they were measures of use under a previous set of circumstances. They reflect choices where no payment was required, hypothetical or otherwise. These measure-of-use variables are historical, or what Prince and Ahmed (1988) alternatively refer to as **experience-specific**.

The approach taken in SSC and the reinterpretation by Cameron (1988) and others (Duffield and Patterson, 1991) is different from that of eliciting WTP (or

WTA) for successive increments or decrements in a hypothetical quantity or quality of environmental services, and then deriving a marginal valuation function. As introduced into the CV literature by Randall et al. (1974), the Bradford (1970) bid curve is obtained for a set of increments or decrements in a quality or quantity variable. The theoretical Bradford bid curve approach was laid out in detail by Brookshire et al. (1980). The distinction may seem straightforward but is not always so; it is worth reviewing some of the published literature.

Deriving Marginal Valuation Functions

The point of the Bradford bid/valuation function approach is that marginal valuation functions can be obtained from contingent markets, provided that a set of hypothetical increments or decrements are presented for valuation in that market. Consider the following equations taken from Brookshire et al. (1980) in their iterative bidding CV study of elk hunting near Laramie, Wyoming:

$$\begin{aligned} a: WTP &= 59.701 + 8.705 \cdot ENC - 0.284 \cdot ENC^2 \\ b: lnWTP &= 4.362 + 0.142 \cdot lnENC \end{aligned} \qquad (26)$$

The variable ENC is defined as the frequency of elk encounters. The key point is that ENC represents increments (0.1, 1, 5, or 10) that are exogenously provided by the researcher in the hypothetical market. Taking the derivative of WTP of the quadratic equation (a) in (26) with respect to ENC gives the following:

$$p(ENC) = \frac{\partial WTP}{\partial ENC} = 8.705 - 0.568 \cdot ENC \qquad (27)$$

which can be manipulated to provide:

$$ENC = 15.325 - 1.76 \cdot p(ENC) \qquad (28)$$

For the logarithmic specification (b) in (26) we follow the procedure outlined in equations (16-18) to obtain the marginal valuation function for the logarithmic model:

$$\textit{Laramie}: \log(ENC) = 2.811 - 1.17 \log p(ENC) \qquad (29)$$

Another example can be found in Daubert and Young (1981) who provide a total value (TV) or WTP function, and then derive a marginal value (MV) function for fishing:

$$TV = WTP = 0.052 + 0.176 \cdot FLOW - 0.000156 \cdot FLOW^2 \qquad (30)$$

$$MV = \frac{\partial WTP}{\partial FLOW} = 0.176 - 0.000312 \cdot FLOW \qquad (31)$$

Again the key point is that the variable FLOW represents increments in streamflow that are exogenously provided by the researcher in the contingent market.

The record for using the Bradford bid curve approach versus experience-specific variables to obtain marginal valuations of quality changes is mixed. In an early study on recreation congestion, Cichetti and Smith (1973) utilized hypothetical combinations of congestion and levels of use as explanatory variables in their WTP function. As reviewed by Prince and Ahmed (1988), subsequent recreation congestion studies tend to rely instead on experience-specific variables. Several early CV studies on waterfowl hunting (Hammack and Brown, 1974; Cocheba and Langford, 1978) derived marginal values from valuation functions using experience-specific variables. In a more recent CV study on wetlands protection and waterfowl hunting, a Bradford bid curve approach is adopted (Bergstrom et al., 1990).

Thus, both experience-specific variables and hypothetical increments or decrements are used in the derivation of marginal values or marginal valuation functions for quality changes. The interest here lies in extending this concept of obtaining a marginal function onto measure-of-use variables. Marginal valuation functions (with respect to changes in use) could then be interpreted as demand curves.

While the valuation of a set of increments and decrements has been focused on quality variables, it is possible to theoretically construct demand curves for measure-of-use variables, provided that such information is collected in contingent behavior questions. The contingent behavior responses must be elicited in congruence with the elicited valuations for the set of increments or decrements of quality changes. However, valuation functions should not use this contingent behavior information directly as an explanatory variable; it was elicited as an endogenous response to the hypothetical market (McConnell, 1990). And therein lies the rub. We would like to be able include measure-of-use variables in our valuation functions and then take a derivative to obtain a demand curve. But measures of hypothetical use (contingent behavior) introduce endogeneity, and measures of experience-specific use were not chosen in the context of the hypothetical market.

A Twist to the Discussion

Measure-of-use variables can also enter into valuation functions in more disguised forms, such as part of a combined variable. One example can be found in the DC-CV study of wetlands protection by Bergstrom et al. (1990). In their logit function they utilize a set of total annual harvest variables (for waterfowl, shrimp, fresh and saltwater fish) as explanatory variables. As one example, **TWFBAG** is a constructed variable representing the annual number of waterfowl bagged. It can be decomposed as follows:

$$TFWBAG = q \cdot bag \cdot p_j \tag{32}$$

where:

q	=	annual waterfowl hunting days (historical)
bag	=	average bag per day (historical)
p_j	=	a multiplicative factor for percentage of maintained catch levels for the jth scenario

The survey presented three scenarios (**j=1,2,3**) to each individual. Yes/no responses were elicited to a DC valuation question for annual site access given current catch levels (**p_1=1.0**). Additionally, binary responses were obtained for two decrements in quality, a 50 percent decrease (**p_2=0.5**), and a 75 percent decrease (**p_3=0.25**) in current catch levels. These three valuation responses were then stacked in the data set according to the appropriate $\mathbf{p}_j$.

The TWFBAG variable is used as an explanatory variable in the logit function. Bergstrom et al. (1990:138) argue that this probability function:

> ...can be used to derive a bid function for wetlands-based recreation. This bid function can then be used to derive a demand function for wetlands-based recreation (Sellar, Chavas and Stoll, 1986).

In another presentation of their research (Stoll et al., 1989), they develop such a quality demand curve for TWFBG.

This formulation is more appealing in that it incorporates the Bradford bid curve approach in using hypothetical decrements in environmental services. However, q is an experience-specific variable; and there is no guarantee that such included historical information would remain constant over the set of hypothesized increments or decrements in environmental services. In other words, the model does not predict the level of use decision in response to the hypothesized changes in environmental services. Whenever use is revised significantly, a bias may be introduced into any estimated demand functions or welfare measures that do not explicitly model this change.

In conclusion, there is room for improved discussion of acceptable principles and procedures for deriving marginal benefit (demand) curves from CV valuation functions. To this end the following section presents a typology of CV models which incorporate measure-of-use variables.

4.7 A Typology of CV Models with Measure-of-Use Variables

The typology in Table 4.1 is proposed as an aid in sorting out the several types of contingent valuation surveys with respect to measure-of-use variables. The typology will be used to generate several hypotheses which will later be tested empirically using the original data from ABMJM.

In the first type, the constructed market is a counterfactual market. The ith individual might be asked the question: "Think back on your visits, assuming nothing was changed, would you have been willing to pay X_i dollars for access to the site last season?" The only thing that changes in the counterfactual is the presence of the market itself. Such a question would typically be preceded by a measure-of-use question. The collected information on the measure-of-use variable is experience-specific, but is assumed to be incorporated into the statement of the counterfactual market. It is part of the contingent scenario. The quantity of use was user chosen; however it will be predetermined endogenous or exogenous to the actual contingent valuation choice(s). The maintained hypothesis in such approaches is that this level of use is fixed.

A good example of the type I format can be found in the open-ended valuation of Hammack and Brown (1974).[12] The SSC study is also of this type. Other DC-CV

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[12] Hammack and Brown (1974) use the following open-ended question to elicit WTP: "Suppose that your waterfowl hunting costs for 1968-69 season were greater than you estimated in Question 7. Assume these increased costs in no way affected general hunting conditions. ABOUT HOW MUCH GREATER DO YOU THINK

examples include Loomis et al. (1988), and Duffield et al. (1991). Given the maintained hypothesis, of a fixed level of use, it may be acceptable to derive a demand curve.[13]

In the remaining three types, the constructed market is referred to as hypothetical to emphasize that it is forward looking. An individual might be asked the question: "If a seasonal pass were to be sold for access to the site would you be willing to pay X_i dollar for such a pass?" What distinguishes these three types is the description and status of q.

In type II the experience-specific or historical quantity variable is used. This is a common approach; examples include ABMJM and Boyle (1990).[14] Deriving

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YOUR COSTS WOULD HAVE HAD TO HAVE BEEN BEFORE YOU WOULD HAVE DECIDED NOT TO HAVE GONE HUNTING AT ALL DURING THAT SEASON?" They estimated valuation functions that included the historical level of use as an explanatory variable. Derived marginal valuations for quality changes were conditional on the assumption that there would be no changes in the level of use in response to the quality change (Hammack and Brown, 1974:23).

[13] Where the individual is responding to the complete loss of the resource or service, derivation of marginal valuation functions might be complicated if the WTP function is better interpreted as an "all-or-nothing" demand curve; i.e., an average benefit curve rather than a total benefit curve (McKean and Walsh, 1986).

[14] Cameron and Huppert (1991) use the following question to elicit WTP: " What is the MOST you would be willing to pay each year to support hatcheries and habitat restoration that would result in a doubling of current salmon and striped bass catch rates in the San Francisco Bay and Ocean area if without these efforts your expected catch in this area would remain at current levels?" The question was originally structured as a payment card, but then also used in constructing DC-CV models through simulation. Their valuation functions include a TRIPS variable which represents the number of salmon and striped bass fishing trips in the past 12 months; this experience-specific measure-of-use is used in deriving marginal valuations.

Table 4.1. The Proposed Typology

Type	Description of Constructed Market	Description of q	Status of q to the Constructed Choice	Can a Valid Hicksian Demand Function Be Estimated?
I	counterfactual (backward-looking)	experience-specific	exogenous	Yes; directly under the maintained hypothesis of fixed level of use
II	hypothetical (forward-looking)	experience-specific	exogenous	No; unless it holds that the hypothetical mkt induces no changes in use
III	hypothetical (forward-looking)	contingent behavior	endogenous	Conceptually yes; but not directly, must be done in some sort of joint estimation process
IV	hypothetical (forward-looking)	increments or decrements in the contingent scenario	exogenous	Yes; directly provided sufficient variation in q across the sample

demand curves may introduce considerable bias if the level of use is revised significantly in response to the contingent scenario.

In type III, a contingent behavior variable is used. In this case we are soliciting the expected level of use in the contingent market, simultaneously chosen with the valuation response. While this type of information is often collected it is not commonly used in estimating the valuation function. Since it is user chosen in response to the contingent scenario, we expect that it will be an endogenous variable. Incorporating it into the model requires some sort of joint estimation process.

Finally, we consider the *plausibility* of a fourth type. An individual might be asked as part of either a unidimensional or multidimensional contingent scenario to value a set of increments or decrements in the level of use. We expect this measure-of-use variable to be exogenous to the model, and that a Hicksian demand curve (as a function of q) could be constructed provided sufficient variation in q. Type IV adheres to the traditional notion of the Bradford bid curve approach, as typically applied for increments or decrements in a quality variable.

In summary, four separate types of CV models have been identified. In doing so a potential distinction has been drawn between the SSC study and the ABMJM study. In the derivations of section 4.5, both appeared to provide a direct avenue for deriving Hicksian demand curves. This is now called into question by the typology.

4.8 Empirical Evidence

In this section we put our typology to work. We would expect that the measure-of-use variable in ABJM should show no statistical evidence of endogeneity since it follows the type II format. However, if any contingent behavior information is introduced into the DC-CV estimation model, we expect that endogeneity will be an econometric concern. To test these hypotheses we apply Grogger's "simple test for exogeneity" in nonlinear discrete choice models as presented in section 4.3.

Testing for Endogeneity on an Experience-Specific Variable

The first task is to test for endogeneity on the measure-of-use variable, (number of pheasant hunting trips taken) in the original ABMJM model. Conducting this test requires a prediction for this variable from a set of instruments. This was done with a log-linear OLS model whose explanatory variables included the set of exogenous regressors from the original logit model, plus additional variables collected in the survey. (The results are presented in Appendix C.) The predictions from this OLS regression are then utilized in the specification test. The basic inputs for the test are shown in Table 4.2, which provides logit estimation results for both the original model[15] and with the inclusion of predicted trips as an explanatory variable. The chi-

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[15] The signs on the estimated coefficients are reversed from the original ABMJM publication to reflect modeling the probability of a yes response, rather than a no, to the offered fee level. See the discussion in Chapter 3.

squared test statistic is **h=0.069**; thus, there is no statistical evidence ($p<0.001$) to support the hypothesis that q is an endogenous variable. McConnell's (1990) legitimate concerns with endogeneity cannot be given blanket application to the inclusion of measure-of-use variables.

As a check on the robustness of this conclusion, a Tobit model also was used to predict LNVIS, and thus account for possible censoring bias (trips ≥ 1, implying LNVIS ≥ 0). Substantively equivalent results were obtained; the estimated regression coefficients were quite close between the two models (OLS and Tobit), and the same conclusion obtained for the specification test. Estimation results for the Tobit model are given in Appendix C.

Finally, the LNVIS variable merits additional discussion. As is common with intercept (on-site) surveys, LNVIS is a constructed variable which combines actual trips taken prior to the survey plus expected additional trips for the remainder of the season. The inclusion of this expectation heightens initial concern with potential endogeneity on the measure-of-use variable. However, the expectation was not elicited in reference to any hypothetical market scenario, and as noted, there is no evidence to support endogeneity.

Testing For Endogeneity on a Contingent Behavior Variable

Although unreported in the original study, the ABMJM survey also collected a contingent behavior response. After the dichotomous choice valuation question, respondents were asked the following Yes/No question: "If the stocking program were

Table 4.2. Model Estimation Inputs for Endogeneity Test on the Experience-Specific Use Variable

Variable	Coefficient	Coefficient
Intercept	**3.752 (2.48)	*3.436 (1.809)
LNFEE	***-2.253 (-4.081)	***-2.148 (-3.981)
D1	0.994 (1.345)	0.934 (1.266)
D2	***2.017 (2.758)	***1.938 (2.664)
LNVIS	*0.663 (1.972)	
Predicted LNVIS		0.718 (0.970)
Likelihood Ratio Test	***38.865	***35.5804
Maddala R^2	0.330	0.307
McFadden R^2	0.292	0.267
% Correct Predictions	0.784	0.753

The numbers in parentheses are the asymptotic standard errors; *, **, and *** indicate significance at the 0.05, 0.025, and 0.01 levels, respectively. LNFEE=the natural logarithm of the offered fee or bid; D1=a dummy variable for the $15-30,000 income group; D2=a dummy variable for the $30,000+ income group; LNVIS=the natural logarithm of the total visits.

to be eliminated, would you stop hunting pheasants in western Oregon?" The dummy variable CB is used as an indicator of this contingent behavior; where a 1 indicates that all pheasant hunting trips would be eliminated, and a 0 indicates otherwise (either fewer or the same number of trips).

Performing the specification test requires that we estimate a model that can predict the CB response, the decision to revise the level of use. In this case probability of a yes or no response is modeled with a logit function. (Estimation results for predicting CB are given in the Appendix D.)

Table 4.3 provides the estimation results. Model One adds the CB dummy variable as a regressor on the probability of accepting the offered fee. Model Two includes the predicted CB as a dummy variable, where the predictions were converted into a 0,1 value. Model Three utilizes the predicted probabilities directly, with a suggested weighting correction for possible heteroskedasticity (Grogger, 1990).[16] In Model One, the CB variable has no appreciable effect on the coefficients or goodness-of-fit statistics from the original ABMJM model. However, including the predicted probabilities (in either form) from the NLIV estimator changes model results. Notably, the income effects, which drove the ABMJM policy conclusions, are muted.

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[16] The weighting w_i used on each predicted probability was $w_i=[p_i(1-p_i)]^{-1/2}$, where p_i is the predicted probability for the CB model, and may help to correct for potential heteroskedasticity, but will not provide the most efficient estimator (Grogger, 1990).

Table 4.3. Model Estimation Inputs for Endogeneity Test on the Contingent Behavior Variable

Variable	Model One Coefficient	Model Two Coefficient	Model Three Coefficient
Intercept	**3.726 (2.477)	**4.379 (2.593)	**4.262 (2.45)
LNFEE	***-2.222 (-3.995)	***-2.495 (-4.003)	***-2.680 (-3.903)
D1	1.061 (1.395)	0.294 (0.329)	-0.080 (-0.085)
D2	***2.040 (2.788)	**1.698 (2.215)	**1.673 (2.216)
LNVIS	**0.678 (1.998)	0.518 (1.471)	0.393 (1.091)
CB	-0.198 (-0.365)		
Predicted CB from NLIV		0.968 (1.360)	
Predicted CB Probability from NLIV, with Weightings			*1.203 (1.859)
Likelihood Ratio Test Statistic	***38.998	***40.723	***42.685
Maddala R^2	0.331	0.343	0.356
McFadden R^2	0.293	0.306	0.320
% Correct Predictions	0.784	0.763	0.742

Numbers in parentheses are asymptotic standard errors; *, **, and *** indicate significance at 0.05, 0.025, & 0.01, respectively.

As expected, the evidence from the specification test supports the conclusion that CB is an endogenous variable. The chi-squared test statistic is **h=6.36** using the Model Two predicted CB coefficient as the NLIV estimator. The chi-squared test statistic is **h=15.686** using Model Three. The results are significant at the 0.025 and 0.001 levels, respectively.

4.9 Potential Policy Implications

Given the available evidence for endogeneity, Models Two and Three are of interest, in that they provide consistent estimators. Thus, we might consider that the dichotomous choice valuation and the trip revision decisions are jointly determined in response to the contingent scenario. Models Two and Three are estimated in a nonlinear instrumental variables framework, where there is more than one available instrument for the dummy endogenous variable. The models produce consistent (but inefficient) parameter estimates. The potential policy impacts of such a result can be explored further. Figure 4.1 presents the estimated demand curves from the original ABMJM model (Model 1 in Table 4.2) and the revised models (Models Two and Three in Table 4.3) using the unweighted and weighted NLIV estimator .

The impact on the expected conditional willingness-to-pay is seen in Table 4.4. All estimates were calculated using equation (1). The first column gives the expected conditional WTP from the ABMJM model. This value of $21.36 is approximately 10-20 percent higher than the WTP's from the two revised models.

Figure 4.1. Hicksian Demand Curves

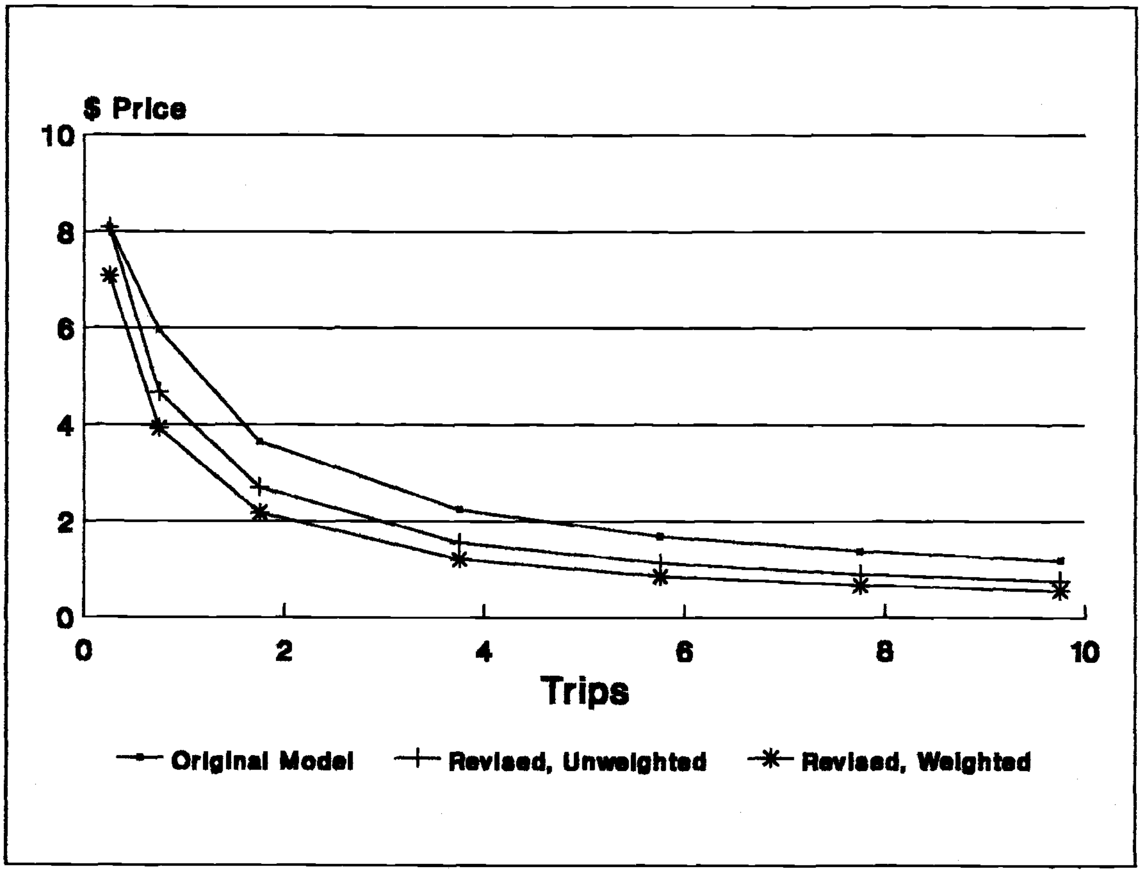

Table 4.4. Comparison of Expected Willingness-to-Pay Results

Original Model	Model Two evaluated at the sample means	Model Two, evaluated at the sub-sample means, with CB=0	Model Two, evaluated at the sub-sample means, with CB=1	Model Three, evaluated at the sample means
$ 21.36	$ 19.27	$ 14.85	$ 23.28	$ 17.50

Disaggregating the sample into those who would (CB=1) and would not (CB=0) completely stop pheasant hunting in Western Oregon with elimination of the stocking program shows two distinct groups ($23.28 vs $14.85).[17] The lower of these two values, $14.85, falls outside of the 95% confidence interval (CI) around the estimated mean WTP value of $21.36 for the original model. The 95% CI of $16.27 to $24.75 was calculated using the analytical formulas from Cameron (1991b) for recovering the variance-covariance matrix for the set of transformed parameters (see equation 9) from the information matrix of the original maximum likelihood logit estimation.[18]

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[17] Alternatively, one might argue that those who answered "no" to the trip revision/contingent behavior question really did not understand the valuation question or the importance of the stocking program, and thereby contaminated the sample. However, this position is difficult to defend. In the year following the ABMJM survey, the pheasant stocking program was dropped. See Chapter 3. Total visits to the site for the next two seasons were about one-third of previous visitation levels.

[18] Verification for this result comes from the unpublished work of Bergland et al. (1989), who obtained very similar 95% CI results using several alternative simulation/bootstrapping approaches applied to the same data set and logit model. For example, they obtained a 95% CI of $15.36 to $24.07, in one representative result. See Chapter 3.

The direction of the change and the size of the policy impacts are specific to the ABMJM survey data. They should not be generalized. However, it does seem likely that demand and valuation per-unit-of-use estimates will be biased upward for hypothesized losses in environmental services, and downward for hypothesized gains. The degree of bias will be proportional to the difference between historical and contingent behavior.

4.10 Discussion and Comparisons with Other Research

Joint Estimation Procedures in CV Models

Joint estimation procedures for valuation functions that include endogenous explanatory variables are a fruitful avenue of CV research. To my knowledge this paper is the first to address such concerns for a measure-of-use variable and the derivation of demand curves. For completeness, several related studies should be discussed.[19]

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[19] For a single iteration dichotomous choice format, Cameron and Quiggin (1992) lay out an estimation procedure that accounts for the endogeneity inherent in the second level fee. Their empirical results demonstrate a statistically significant difference in variance across the two single referendums; additionally, they provide a precise estimate of the correlation across the two binary valuation responses. In their 1991 study of deer hunting, Park and Loomis (1991) use a joint estimation procedure to account for interdependencies across DC-CV valuation scenarios. Each individual responded to a set of quality changes. A system of valuation functions was estimated using seemingly unrelated nonlinear regression.

Whittington et al. (1992) utilized a joint estimation procedure to analyze the effect of "time to think" on CV results. The binary decision to revise the initial open-ended bid is treated as jointly determined with the final amended bid. This is a similar situation to the one addressed in this paper for the CB variable -- the valuation function is believed to have a dummy endogenous variable -- albeit not for a measure-of-use variable. In the first stage, a probit model is estimated to describe the determinants of revising the bid. The final valuation function is estimated with nonlinear two-stage least squares that included the predicted revision decision as an explanatory variable. The decision to revise the bid was a significant explanatory variable.

In an open-ended valuation of congestion, Prince and Ahmed (1988) treat both WTP for a hiking trip and length of stay, their measure-of-use variable q, as endogenous variables. A recursive system argument is used to provide a generalized least squares (GLS) estimate of WTP, where predicted q is included as a regressor. Interestingly while q is experience-specific, it is argued that it may not represent an optimal choice because of potentially unrealized expectations about congestion. While no empirical test for endogeneity was conducted, the predicted q was statistically significant in the valuation function. Thus, in this single trip valuation example they reject the maintained hypothesis of the type I model. It would appear less likely that experience-specific seasonal levels of use could be considered to be nonoptimal, that is to say impacted by unrealized expectations, and an inability to readjust; but this is an empirical question that a specification test can address. (Recall that there was no evidence of endogeneity for the historical q used in the ABMJM model.)

A Conceptually-Related Argument From Revealed Preference Models

In contrast to these procedurally-related works, Morey and colleagues (Morey, 1992; Morey et al., 1992, 1993) provide a conceptually-related argument from a discrete choice revealed-preference standpoint and the modeling of participation levels.[20] Some extracts from this body of work can help to establish the correspondence.

In discrete choice random utility models, the failure to model the participation decision can bias welfare measures. When nonparticipation is not one of the available choices, the derived welfare measures are referred to as consumer surplus "per-trip" or "per-unit-of-use." These per-trip valuations must be combined with some independent estimate of use levels; there is no guarantee that this can be done in a logically consistent manner. Through empirical applications and simulation models, it has been demonstrated that the bias involved can be considerable. The sustained interest in per-unit-of-use measures can be laid out as follows:

> There are a number of reasons why policy makers and economists alike are attracted to per day of use measures, one being that consumer's surplus per day of use lends itself to the topic of benefit transfers. The notion is that once a representative individual's consumer surplus per

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[20] Morey (1992) does reference Cameron (1988) and Cameron and James (1987a), and their DC-CV models; however, his discussions and applications are otherwise geared to the discrete choice RUM's of revealed preference/travel cost methods.

> day of use has been estimated for X-ing, where "X" can represent any recreational activity such as fishing, hiking or skiing at one specific site, the analyst can obtain that individual's consumer's surplus for the first or any similar site by multiplying consumer's surplus per day of use by the number of days spent X-ing at the site. (Morey, 1992:2)

Further, models which fail to consider the decision to participate and changes in the level of use, will produce biased welfare measures of changes in environmental or resource quality. In their application of a repeated nested logit random utility model, and comparison against alternative travel cost models, Morey et al. (1992:15) state:

> For each supply scenario, one could estimate demand for trips...conditional on the total number of trips to all sites not changing when the supply conditions change. However, since the change in supply conditions will likely cause a change in the participation rate, these conditional demand estimates will, in most cases, be biased upward for deteriorations and biased downward for improvements.

This same type of phenomenon has been demonstrated here in the DC-CV context. It must be recognized that hypothetical changes in the access to, or quality of, environmental services can be used to elicit valuation responses; but these valuation responses may be conditional on concomitant changes in expected use levels of the respondent.

4.11 Final Comments and Conclusions

A primary purpose of this research is to sound a note of caution to future DC-CV researchers and policy analysts in reconstructing demand curves from "off-the-shelf" DC-CV models for benefit transfer purposes. The findings suggest that no blanket prescriptions are available concerning the endogeneity of measure-of-use variables. Grogger's test for probit and logit models helps to fill a needed gap in evaluating the econometric specification of DC-CV models. It provides a technique for addressing endogeneity questions on measure-of-use variables. Such variables can enter into CV models in a variety of ways. Absent endogeneity, there is still the opportunity for considerable bias in demand curves or other derived per-unit-of-use welfare measures. For example, a measure of historical avidity should not be misinterpreted as the chosen level of use in the hypothetical market.

The results demonstrate potential policy implications from the incorrect application or interpretation of measure-of-use variables. Whenever a proposed change can impact behavior, the modeling structure must explicitly account for these changes in valuation functions and derived welfare measures. The greater the behavioral response to the change, the greater the probable bias involved in using initial rather than subsequent use-levels.

A typology was presented and used to generate several hypotheses. It distinguishes among different types of contingent valuation models and how they incorporate measure-of-use variables. The empirical results from applying Grogger's test provide initial confirmation for the proposed typology.

The development of the typology, and future refinements, are particularly important in a benefit transfer context. The opportunity to conduct specification tests will not always be available for a benefits function transfer exercise. Policy analysts require accessible tools for discriminating among the many available, published and unpublished, DC-CV studies. This typology may provide an initial screening tool, concerning the incorporation of measure-of-use variables, in the emerging protocol for acceptable benefit transfer.

Finally, the development of joint estimation techniques appears to provide a fruitful area for future CV research. In particular, it may facilitate the incorporation of contingent behavior responses in total and marginal valuations.

CHAPTER 5

SUMMARY AND CONCLUSIONS

CV is both a powerful and a controversial research tool. The hypothetical nature of constructing preferences out of a structured conversation provides great flexibility in designing nonmarket valuation studies. This flexibility to address a wide variety of policy problems accounts for much of its popularity. The converse is that once a hypothetical valuation has been elicited the results are very context specific. Flexibility in design choice implies specificity in the end product. This context specificity is not a condemnation of CV (Randall, 1988), but does reinforce the importance of commodity specification in particular, and survey design in general. What exactly is the respondent being asked to value within the context of a highly structured conversation, and is the good or service amenable to the two-step problem of value formulation and value expression?

Of the class of nonmarket goods and services, it is convenient to think of a gradient or continuum moving left to right with decreasing tangibility of the good. Anchoring the far left of our continuum are the relatively *fungible* nonmarket goods and services These goods and services would have some direct use component and a high degree of familiarity to users; the classic case is outdoor recreation. Such goods would not be characterized by a high degree of uniqueness. Estimation of the economic value of these goods and services via the CV method is generally accepted to be valid, and can be cross-checked experimentally ("convergent validity") with revealed preference approaches.

Moving towards the right on the continuum we encounter decreasing tangibility of the nonmarket good or service. As we continue to move in this direction, the types of goods would likely contain some significant if not complete nonuse value component. These goods may also be characterized by a high degree of uniqueness. At some point along the continuum, CV becomes the only available tool for measuring economic values. Protection of an endangered species or wilderness area are only common examples. There is no clear principle, if any, for what types of contemplative goods might be considered.

Since there is no clear line of demarcation, we might ask if there are any nonmarket goods and services which are not amenable to valuation, and what the appropriate domain for valuation approaches is or should be.[1] Given ethical limitations to markets in various social spheres (Anderson, 1990), then constructed market techniques have some limit to the things they can value.[2] If CV is to mature

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[1] For example, following Bishop and Woodward (1992) and Howarth and Norgaard (1992), we cannot expect nonmarket values to resolve large-scale sustainability issues.

[2] For example, the health and safety of family members is extremely important to me. I derive utility from their health and safety in a number of ways. It has both use value and nonuse value. If I were to know that I would never be with them again, their continued health and safety would still be of extreme importance to me. My WTP to protect their health and safety is constrained by my "time, talent and money." I do not consider the levels of these expenditures and efforts to be the full measure of value. My WTA is undefined since I would accept no amount of money; they are not an exchangeable good. Clearly, it is my opinion that no survey method can accurately account for this value in monetary terms based on a maintained hypothesis

as a research program, then a clear delineation of the absence or presence of such a limit is needed. The marketplace for CV results may have expanded faster than our understanding of the technique.

This research explores the application of CV from distinct points on the imaginary spectrum. The goods being valued include an expansion of a cultural centers program (Chapter 2), and access to a public stocking program for pheasant hunting (Chapters 3 and 4). The former is a rather intangible nonmarket good, with clear public good characteristics (nonexclusivity). The latter is much more tangible; in fact, so much so that after the original CV survey a limited market for the pheasant stocking did develop, and offered the rare opportunity for performing an external validation. The types of research questions asked differ greatly at different points on the spectrum. The experimental survey approach in Chapter 2 is concerned with whether valid responses are given (and thus valid welfare measures derived) in the DC-CV format. Chapter 3 and 4 are primarily concerned with particular policy uses: How can DC-CV be used in converting WTP into public revenues? What cautions are required in reconstructing a demand curve for transfer purposes?

The results in Chapter 2 demonstrate the potential for compliance bias in the DC-CV format; simply asking a dichotomous choice question does not guarantee that the elicitation format is incentive compatible, and thereby free of response bias. The results are provocative, but are specific to a voluntary contribution payment vehicle

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of indifference. However, surveys may provide a window to my unwillingness to accept compensation, and lack of indifference.

with no explicit outcome rule. They are also based on a restricted sample of university students and may represent a fairly unique phenomenon. However, they do coincide with several recent pieces of evidence in DC-CV research. An important question in any future explorations into compliance bias in the DC-CV context is the role of commodity specification. A working hypothesis might be that the more vague the good the greater the susceptibility to the compliance bias phenomenon, and the more strictly defined the good (including the provision or outcome rule) the more susceptible the good is to strategic bias. The implication is that even if DC questions are used, a vaguely defined good and outcome rule (e.g., a preservation trust fund with no explicit rule for providing the posited policy change) may not be immune to significant response biases.

The randomized response (RR) survey technique was shown to have promise for future CV experiments. There are a number of variants to the RR technique and it has considerable history in social survey research. RR provides an additional tool for investigating CV responses, especially social context effects. It provides an additional degree of anonymity to CV survey respondents. For example this may be important in questions about sensitive environmental conflicts, or in attempts to link waves of panel data to check stability of preferences.

The results in Chapter 3 are a mix of good news and bad news. The good news is that in this case study WTP appears to be a real value that can be converted into public revenues, and conversely, the findings indicate the difficulty of conducting any external validation of CV results against an actual market.

The results in Chapter 4 demonstrate the difficulty in transferring benefit functions out of their original context. The results sound a note of caution to applied researchers and policy analysts attempting to reconstruct demand curves from "off-the-shelf" DC-CV studies. Acceptable protocols for transferring benefit estimates are not fully developed, and unjustifiable benefit transfers are occurring. The development of the typology in Chapter 4, and future refinements, are particularly important in a benefit transfer context. The opportunity to conduct specification tests will not always be available for a benefit function transfer exercise. Policy analysts require accessible tools to discriminate among available CV studies. This typology may provide an initial screening tool, concerning the incorporation of measure-of-use variables, in the emerging protocol of benefit transfer.

Finally, I offer my thoughts on future CV applications. First, concerns with identifying or uncovering the "true" value of a nonmarket good should be discarded. Following Randall (1991a, 1993b), attention should be turned to *mapping the performance characteristics* of alternative experimental designs for various sets of nonmarket commodities. Randall (1993b:38) states:

> The hypotheses "attitude surveys are reliable" and "public opinion polls are reliable" are no longer taken seriously. There is implicit recognition that such hypotheses are untestable and perhaps meaningless. Research programs in these fields have moved on to mapping the performance characteristics of alternative approaches and techniques. The CVM program should follow suit.

Randall makes this assessment against the backdrop that all knowledge is "local and contingent". Such an approach would reduce the burden on CV studies to defend their elicited welfare measure as the single correct value, and emphasize the experimental nature of the exercise. While we can never uncover the true valuation -- there can be no crucial test -- this is all the more reason to apply analytical rigor and hypothesis testing.

The obvious criticism of the randomized response (RR) versus direct questioning (DQ) test in Chapter 2 is that there is no way to know the "truth" in the experiment -- regardless of the evidentiary results. The answer to the implicit question is that you do not know, in the same way that you will never know, the true WTP for any nonmarket good. However, one can generate testable hypotheses; e.g., $WTP_{DQ} > WTP_{RR}$. Again, the focus is on assessing the performance characteristics of alternative techniques. The implication of the results in Chapter 3 is that attempts to externally validate a CV are fraught with difficulties because of the impossibility to anticipate all changes and to control all side conditions.[3] Rather than focusing on uncovering some elusive "true" value, attention should be directed toward assessing the impact of alternative decision variables on valuation results. In the case of project financing, and attempts to appropriate WTP for program funding, the performance characteristics of alternative pricing policies is likely to be a pivotal research question.

Second, there is a continued need for further investigation and development of cognitive models for understanding CV responses. CV does not deal with observed

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[3] Duhem's irrefutability thesis holds that no conclusive refutation is ever available; discrepancies can always be attributed to the numerous auxiliary conditions in any hypothesis test (Blaug, 1988). The highly conditional nature of CV studies would seem to be relevant.

behavior, but rather with expressions of behavioral intentions. Where the good being valued is highly unfamiliar, it cannot be expected that well-defined stable preferences exist. Respondents may be constructing their preferences within the CV exercise. The valuation statements that result from such preference construction may be vulnerable to a variety of social context effects. McCain's (1992) impulse-filtering model is offered as a candidate for exploring the cognitive process in a CV experiment. The way alternative filters are activated or suppressed is likely to differ at different points on our imaginary continuum of nonmarket goods. Thus, evidence of compliance bias for a pure public good does not imply that the DC-CV format will engender response biases for familiar recreational consumption goods.

Finally, rejecting the notion of a true value, turning toward mapping performance characteristics, and accommodating alternative cognitive models would allow a reorientation in perspective for determining what constitutes a meaningful CV research result. For example, a large number of protest responses might indicate the inability to collapse the value of a complex environmental good into a single metric, rather than the failure of the survey format (Sagoff, 1988; Stevens, 1992; Stevens et al., 1991a; Vatn and Bromley, 1993). As opposed to simplistic calls to avoid protest responses, further research would be directed toward the who, when and why behind protest responses. As shown in Chapter 2, any reduction in protest responses through the use of the DC-CV format may come at the cost of increased compliance bias. Further, it also should also be *expected* that there will be multiple values across differing contexts, and measurement techniques. Such effects are not unique to CV results (Hoehn, 1992; Randall, 1988), or even nonmarket goods (Smith, 1993). For example, measured WTP and WTA differences may attest to the crucial importance of perceived property rights, endowment effects, and availability of substitutes (Knetsch, 1990; Hanemann, 1991), rather than some unknown measurement error (e.g., Eberle and Hayden, 1991:661). Fully accepting the notion of highly conditional values does not imply acceptance of any value regardless of the method. It only means that things are more complicated. We also must sort out differences due to the quality of the research.

All CV studies are not created equal. Applied studies will continue to accumulate and there is a need to be a discriminating consumer. The contribution of this research is to show that our understanding of responses in the DC-CV format is still incomplete; in particular, there is experimental evidence of a particular type of bias, *yea-saying*, that merits further investigation for nonexclusive public goods. The randomized response survey technique may provide a useful tool for investigating social context effects. There is also case study evidence that measured WTP for a tangible recreational good is a real value that can be converted into public revenues. With sufficient attention to the full policy context, DC-CV may be a particularly appropriate tool for assessing revenue potential. Nevertheless, we should be cautious of attempts to transfer DC-CV results out of their original context.

BIBLIOGRAPHY

Adamowicz, W.L., and Graham-Tomasi, T. 1991. "Revealed Preference Tests of Nonmarket Goods Valuation Methods." *Journal of Environmental Economics and Management* 20:29-45.

Adams, R.M., O. Bergland, W.N. Musser, S.L. Johnson, and L.M. Musser. 1989. "User Fees and Equity Issues in Public Hunting Expenditures: The Case of The Ring-Necked Pheasant in Oregon." *Land Economics* 65 (4):376-385.

Ajzen, I., and B.L. Driver. 1992. "Application of the Theory of Planned Behavior to Leisure Choice." *Journal of Leisure Research* 24 (3):207-224.

Amemiya, T. 1984. "Tobit Models: A Survey." *Journal of Econometrics* 24:3-61.

Anderson, E. 1990. "The Ethical Limitations of the Market." *Economics and Philosophy* 6:170-205.

Anderson, F.R. 1993. "Natural Resource Damages, Superfund, and the Courts." In *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment*, eds. R.J. Kopp, and V.K. Smith. Washington, D.C.: Resources for the Future.

Armacost, R.L., J.C. Hosseini, S.A. Morris, and K.A. Rehbein. 1991. "An Empirical Comparison of Direct Questioning, Scenario, and Randomized Response Methods for Obtaining Sensitive Business Information." *Decision Sciences* 22:1073-1090.

Arndt, J., and E. Crane. 1975. "Response Bias, Yea-saying, and the Double Negative." *Journal of Marketing Research* 12:218-20.

Arrow, K., R. Solow, P.R. Portney, E.E. Leamer, Radner, R., and H. Schuman. 1993. "Report of the NOAA Panel on Contingent Valuation." Report to the National Oceanic and Atmospheric Administration., U.S. Department of Commerce. *Federal Register* 58:4601-4614.

Association of Environmental and Resource Economists (AERE). 1992. "Benefits Transfer: Procedures, Problems, and Research Needs." Workshop proceedings, Snowbird, UT, June 3-5.

Bergland, O., E. Romstad, S. Kim, and D. McLeod. 1989. "The Use of Bootstrapping in Contingent Valuation Studies." Oregon Agricultural Experiment Station Technical Paper; Dept. of Agricultural and Resource Economics, Oregon State University.

Bergstrom, J.C. 1990. "Concepts and Measures of the Economics Value of Environmental Quality: A Review." *Journal of Environmental Management* 31:215-228.

Bergstrom, J.C., and J.R. Stoll. 1986. "Structure, Conduct, and Performance in Contingent Markets." Paper presented at the Annual Meeting of the American Agricultural Economics Association, Reno, NV, August.

Bergstrom, J.C., and J.R. Stoll. 1989. "Applications of Experimental Economics Concepts and Precepts to CVM Field Survey Procedures." *Western Journal of Agricultural Economics* 14 (1):98-109.

Bergstrom, J.C., and J.R. Stoll. 1993. "Value Estimator Models for Wetlands-Based Recreational Use Values." *Land Economics* 69 (2):132-137.

Bergstrom, J.C., J.R. Stoll, and A. Randall. 1990. "The Impact of Information on Environmental Commodity Valuation Decisions." *American Journal of Agricultural Economics* 72:614-621.

Bergstrom, J.C., J.R. Stoll, J.P. Titre, and V.L. Wright. 1990. "Economic Value of Wetlands-Based Recreation." *Ecological Economics* 2:129-147.

Berrens, R.P. 1992. "Using Contingent Valuation to Estimate Recreational Impacts from Proposed Columbia River System Operational Changes: Some Experimental Design and Modeling Considerations." Discussion paper presented to Battelle Pacific Northwest Laboratories, Portland, OR, April.

Berrens, R.P., O. Bergland, and R.M. Adams. 1993. "Valuation Issues in an Urban Recreational Fishery: Spring Chinook Salmon in Portland Oregon." *Journal of Leisure Research.* 25 (1):70-83.

Berrens, R.P., and D.C. Kavanaugh. 1992. "Literature Review of Methods for the Estimation of Recreation Participation and Values: An Annotated Bibliography." Volume II. Prepared for US Army Coprs of Engineers, Portland, Oregon, Bonneville Power Administration, Portland OR, and US Bureau of Reclamation, Boise, ID. Contract Number 91-583. Battelle Pacific Northwest Laboratories.

Berrens, R.P., and D. McLeod. 1992. "Assessing Municipal Solid Waste Management Options: An Application of Contingent Valuation." Report submitted to the Clackamas County Department of Transportation and Development, Clackamas, OR.

Bishop, R.C., K.J. Boyle, M.P. Welsh, R.M. Baumgartner, and P.R. Rathbun. 1987. "Glen Canyon Dam Releases and Downstream Recreation: An Analysis of User Preferences and Economic Values." Glen Canyon Environmental Studies, US Bureau of Reclamation, Upper Colorado Region, Salt Lake City, UT.

Bishop, R.C., and T.A. Heberlein. 1979. "Measuring Values of Extramarket Goods: Are Indirect Measures Biased?" *American Journal of Agricultural Economics* 61:926-930.

Bishop, R.C., and T.A. Heberlein. 1990. "The Contingent Valuation Method." In *Economic Valuation of Natural Resources: Issues Theory and Applications*, eds. R.L. Johnson, and G.V. Johnson. Boulder, CO: Westview Press.

Bishop, R.C., and M.P. Welsh. 1992. "Existence Values in Benefit-Cost Analysis and Damage Assessment." *Land Economics* 68 (4):405-417.

Bishop, R.C., and R.T. Woodward. 1992. "Efficiency and Sustainability in Imperfect Market Systems." Unpublished Manuscript, Department of Agricultural Economics, University of Wisconsin.

Blaug, M. 1988. *The Methodology of Economics: Or How Economists Explain.* Cambridge, MA: Cambridge University Press.

Bockstael, N.E., and K.E. McConnell. 1981. "Theory and Estimation of the Household Production Function for Wildlife Recreation." *Journal of Environmental Economics and Management* 8:199-214.

Bockstael, N.E., K.E. McConnell, and I.E. Strand. 1991. "Recreation." In *Measuring the Demand for Environmental Quality*, eds. J.B. Braden, and C.S Kolstad. New York: Elsevier Science Publishers.

Bowker, J.M., and J.R. Stoll. 1988. "Use of Dichotomous Choice Nonmarket Methods to Value the Whooping Crane Resource." *American Journal of Agricultural Economics.* 70:372-381.

Boyle, K.J. 1990. "Dichotomous-Choice, Contingent-Valuation Questions: Functional Form is Important." *Northeastern Journal of Agricultural and Resource Economics* (Oct.):125-131.

Boyle, K.J., and J.C. Bergstrom. 1992. "Benefit Tranfer Studies: Myths, Pragmatism, and Idealism." *Water Resources Research* 28 (3):657-663.

Boyle, K.J., and Richard C. Bishop. 1987. "Valuing Wildlife in Benefit Cost Analysis: A Case Study Involving Endangered Species." *Water Resources Research* 23:943-950.

Boyle, K.J., and R.C. Bishop. 1988. "Welfare Measurements Using Contingent Valuation: A Comparison of Techniques." *American Journal Agricultural Economics* 70 (1):20-28.

Bradburn, N.M. 1983. "Response Effects." In *Handbook of Survey Research*, eds. P.H. Rossi, J.D. Wright, and A.B. Anderson. New York: Academic Press.

Braden, J.B., and C.D. Kolstad, eds. 1991. *Measuring the Demand for Environmental Quality*. New York: Elsevier Science Publishers.

Bradford, D.F. 1970. "Benefit-Cost Analysis and Demand Curves for Public Goods." *Kyklos* 23 (4): 775-791.

Briscoe, J. P. Furtado de Castro, C. Griffin, J. North, and O. Olsen. 1990. "Toward Equitable and Sustainable Rural Water Supplies: A Contingent Valuation Study in Brazil." *The World Bank Economic Review* 4 (2):115-134.

Bromley, D.W. 1993. "Property Rights and Natural Resource Damage Assessments: Law and Economics in the Service of Public Policy." Paper presented to the American Association for the Advancement of Science, Boston, MA, February.

Brooks, R. 1992. "A Contingent Valuation Assessment of Upland Game Bird Hunting: Hunter Attitudes and Economic Benefits." Montana Bioeconomics Study, Montana Department of Fish, Wildlife and Parks.

Brookshire, D.S., and H.R. Neil. 1992. "Benefit Transfers: Conceptual and Empirical Issues." *Water Resources Research* 28 (3):651-655.

Brookshire, D.S., A. Randall, J.R. Stoll. 1980. "Valuing Increments and Decrements in Natural Resource Service Flows." *American Journal of Agricultural Economics* 62 (3):478-488.

Brown, T.C. 1984. "The Concept of Value in Resource Allocation." *Land Economics* 60 (3):231-246.

Brown, T.C., and P. Slovic. 1988. "The Effects of Context on Economic Measures of Value." In *Amenity Resource Valuation: Integrating Economics with other Disciplines*, eds. G. Peterson, B. Driver, and R. Gregory. State College, PA: Venture Publishing.

Cameron, T.A. 1988. "A New Paradigm for Valuing Non-Market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression." *Journal of Environmental Economics and Management* 15:355-379.

Cameron, T.A. 1991a. "Cameron's Censored Logistic Regression Model: Reply." *Journal of Environmental Economics and Management* 20:303-304.

Cameron, T.A. 1991b. "Interval Estimates of Non-Market Resource Values from Referendum Contingent Valuation Surveys." *Land Economics* 67 (4):413-421.

Cameron, T.A. 1992a. "Combining Contingent Valuation and Travel Cost Data for the Valuation of Nonmarket Goods." *Land Economics* 68 (3):302-317.

Cameron, T.A. 1992b. "Estimation Using Contingent Valuation Data from a 'Dichotomous Choice with Follow-up' Questionnaire." Unpublished Manuscript, Department of Economics, University of California at Los Angeles.

Cameron, T.A. 1992c. "Nonuser Resource Values." *American Journal of Agricultural Economics* 74 (5):1133-1137.

Cameron, T.A., and J. Englin. 1992. "Cost-Benefit Analysis for Nonmarket Resources Under Individual Uncertainty." Unpublished Manuscript, Department of Economics, University of California at Los Angeles.

Cameron, T.A., and D.D. Huppert. 1989. "OLS Versus ML Estimation of Non-market Resource Values with Payment Card Interval Data." *Journal of Environmental Economics and Management* 17:230-246.

Cameron, T.A., and D.D. Huppert. 1991. "Referendum Contingent Valuation Estimates: Sensitivity to the Assignment of Offered Values." *Journal of the American Statistical Association* 86 (416):910-918.

Cameron, T.A., and M.D. James. 1987a. "Efficient Estimation Methods for Close-Ended Contingent Valuation Surveys." *Review of Economics and Statistics* 69:269-277.

Cameron, T.A., and M.D. James. 1987b. "Estimating Willingness to Pay from Survey Data: An Alternative Pre-Test-Market Evaluation Procedure." *Journal of Marketing Research* 24:389-395.

Cameron, T.A., and J. Quiggin. 1992. "Estimation Using Contingent Valuation Data from a "Dichotomous Choice with Follow-Up" Questionnaire." Draft Manuscript, Department of Economics, University of California at Los Angeles.

Campbell, D.E. 1987. *Resource Allocation Mechanisms.* Cambridge: Cambridge University Press.

Carson, R.T., N.F. Meade, and V.K. Smith. 1993. "Introducing the Issues." *Choices* 8 (2):5-8.

Carson, R.T. 1991. "Constructed Markets." In *Measuring the Demand for Environmental Quality*, eds. J.B. Braden, and C.S. Kolstad. New York: North-Holland.

Castillo, W.J., J.A. Crawford, T,F. Haensly, and S.M. Meyers. 1984. "Survival, Production and Habitat Selection of Pheasant Stocks Released in the Willamette Valley, OR, 1980-1983." Wildlife Research Report #13, Oregon Department of Fish and Wildlife.

Castle, E.N., and R.P. Berrens. 1993. "Endangered Species, Economic Analyses and the Safe Minimum Standard." Unpublished Manuscript, Dept. of Agricultural and Resource Economics, Oregon State University.

Chaudhuri, A., and R. Mukerjee. 1988. *Randomized Response: Theory and Techniques*. New York: Marcel Dekker, Inc.

Chiang, A.C. 1984. *Fundamental Methods of Mathematical Economics.* 3rd ed. New York: McGraw Hill Book Company.

Cichetti, C.J., and V.K. Smith. 1973. "Congestion, Quality Deterioration, and Optimal Use: Wilderness Recreation in the Spanish Peaks Area." *Social Science Research* 2:15-30.

Ciriacy-Wantrup, S.V. 1947. "Capital Returns from Soil-Conservation Practices." *Journal of Farm Economics* 29:1181-1196.

Cocheba, D.J., and W.A. Langford. 1978. "Wildlife Valuation: the Collective Good Aspect of Hunting." *Land Economics* 54:490-504.

Cooper, J.C. 1993. "Optimal Bid Selection for Dichotomous Choice Contingent Valuation Surveys." *Journal of Environmental Economics and Management* 24:25-40.

Cooper, J.C., and J. Loomis. 1992. "Sensitivity of Willingness to Pay Estimates to Bid Design in Dichotomous Choice Contingent Valuation Models." *Land Economics* 68 (2):211-24.

Cooper, J., and J. Loomis. 1993. "Sensitivity of Willingness to Pay Estimates to Bid Design in Dichotomous Choice Valuation Models: Reply." *Land Economics* 69 (2):203-208.

Copas, J.B. 1988. "Binary Regression Models for Contaminated Data." *Journal of Royal Statistical Society, B.* 50 (2):225-265.

Couch, A., and K. Keniston. 1960. "Yeasayers and Naysayers: Agreeing Response Set as a Personality Variable." *Journal of Abnormal and Social Psychology* 60:151-174.

Cramer, J.S. 1992. *An Introduction to the Logit Model for Economists.* New York: Routledge, Chapman and Hall Inc.

Cullen, R. 1985. "Rationing Recreation Use of Public Land." *Journal of Environmental Management* 21:213-224.

Cummings, R.G., D.S. Brookshire, and W.D. Schulze, eds. 1986. *Valuing Environmental Goods: A State of the Arts Assessment of the Contingent Method.* Totowa, NJ: Rowman and Allanheld.

Dahlgren, R. 1967. "Pheasant Stocking: Why It Fails!" *South Dakota Conservation Digest* 34 (4):19-21.

Daubert, J.T., and R.A. Young. 1981. "Recreational Demands for Maintaining Instream Flows." *American Journal of Agricultural Economics* 63 (4):666-676.

Davis, R.K. 1964. "The Value of Big Game Hunting in a Private Forest." *Trans. 29th N.A. American Wildlife Conference* pp. 393-403.

Davis, R.K., E.G. Parsons, and R.M. Randall. 1987. "Role of Access Fees in Managing Wildlife Habitat on the Federal Lands." *Trans. 52nd N.A. Wildl.& Nat. Res. Conf.* pp. 545-551.

Deaton, A., and J. Muellbauer. 1980. *Economics and Consumer Behavior.* New York: Cambridge University Press.

Decker, D.J., and G.R. Goff, eds. 1987. *Valuing Wildlife: Economic and Social Perspectives.* Boulder, CO: Westview Press.

De Maio, T. 1984. "Social Desirability and Survey Measurement: A Review." In *Surveying Subjective Phenomenon, Volume 2,* eds. C.F. Turner, and E. Martin. New York: Russell Sage Foundation.

Denney, R. 1983. "Upland Bird Harvest Drops in 1982." *Oregon Wildlife* 38 (8):12-13.

Desvouges, W., M.C. Naughton, and G.R. Parsons. 1992. "Benefit Transfer: Conceptual Problems In Estimating Water Quality Benefits Using Existing Studies." *Water Resources Research* 28 (3):675-683.

Desvouges, W.H., A.R. Gable, R.W. Dunford, and S.P. Hudson. 1993. "Contingent Valuation: The Wrong Tool to Measure Passive Use Values." *Choices* 8 (2):9-11.

Donnelly, D.M., C.Sorg-Swanson, J.B. Loomis, and L.J. Nelson. 1990. "Net Economic Value of Hunting and Fishing in Idaho." In *Social Science and Natural Resource Recreation Management,* ed. J. Vining. San Francisco, CA: Westview Press.

Downing, M., and T. Ozuna. 1992. "Testing the Feasibility of Intergeographic Benefit Function Transferability." Paper presented at the 1992 American Agricultural Economics Association Annual Meeting, Baltimore, MD, August 9-12.

Duffield, J. 1991. "Existence and Nonconsumptive Values for Wildlife: Application to Wolf Recovery in Yellowstone National Park." Western Regional Research Publication, USDA: W-133, Benefits and Costs in Natural Resource Planning. Fourth Interim Report.

Duffield, J., and S. Allen. 1988. "Contingent Valuation of Montana Trout Fishing by River and Angler Subgroup." Angler Preference Study, Final Economics Report, Prepared for Montana Department of Fish, Wildlife and Parks.

Duffield, J.W., C.J. Neher, and T.C. Brown. 1992. "Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers." *Water Resources Research* 28 (9):2169-2181.

Duffield, J.W., and D.A. Patterson. 1991. "Inference and Optimal Design for a Welfare Measure in Dichotomous Choice Contingent Valuation." *Land Economics* 67 (2):225-239.

Duffield, J.W., and D.A. Patterson. 1992. "Field Testing Existence Values: An Instream Flow Trust Fund for Montana Rivers." Paper presented at the USDA's W-133/Western Regional Science Association Annual Meeting, South Lake Tahoe, NV, February 26.

Dufour, T. 1992. "Intradepartmental Memorandum: Pheasant Fee Hunt" Oregon Department of Fish and Wildlife. To K. Durbin, dated February, 21.

Durbin, K. 1987. "Game Farm Sets New Course." *Oregon Wildlife* 43 (3):7.

Edwards, S.F. 1992. "Rethinking Existence Values." *Land Economics* 68 (1):120-122.

Eberle, W.D., and F.G. Hayden. 1991. "Critique of Contingent Valuation and Travel Cost Methods for Valuing Natural Resources and Ecosystems." *Journal of Economic Issues* 3:649-687.

Elnagheeb, A.H., and J.L. Jordan. 1992. "Differences in Contingent Valuation Estimates from Referendum and Check-List Questions." Paper presented at the annual meeting of the American Agricultural Economics Association, Baltimore MD, August 9-12.

Elster, J. 1989. *Nuts and Bolts for the Social Sciences.* Cambridge, MA: Cambridge University Press.

Etzioni, A. 1988a. *The Moral Dimension: Toward a New Economics.* New York: Free Press.

Etzioni, A. 1988b. "Normative-Affective Factors: Toward a New Decision-Making Model." *Journal of Economic Psychology* 9:125-150.

Fischoff, B., and L. Furby. 1988. "Measuring Values: A Conceptual Framework for Interpreting Transactions with Special References to Contingent Valuation of Visibility." *Journal of Risk and Uncertainty* 1 (2):147-184.

Fischoff, B., P. Slovic, and S. Lichtenstein. 1980. "Knowing What You Want: Measuring Labile Values." In *Cognitive Processes in Choice and Decision Behavior*, ed. T.S. Wallsten. Hillsdale, N.J: Lawrence Erlbaum Associates.

Fishbein, M., and I. Ajzen. 1975. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.

Fox, J.A., and P.E. Tracy. 1986. *Randomized Response: A Method for Sensitive Surveys*. Sage University Paper Series on Quantitative Applications in the Social Sciences, 07-058. Beverly Hills, CA: Sage Publications.

Frank, R. 1987. *Passions Within Reason: The Strategic Role of the Emotions*. New York: W.W. Norton and Company.

Freeman, M.A., III. 1979. "Approaches to Measuring Public Goods Demands." *American Journal of Agricultural Economics* 61:917-920.

Fried, B. 1993. "Using Valuation Functions to Measure Quality Changes in Elk Hunting on the Starkey Research Forest." Unpublished M.S. Thesis, Department of Agricultural and Resource Economics, Oregon State University.

Goldberger, A.S. 1968. "The Interpretation and Estimation of Cobb-Douglas Functions." *Econometrica* 35 (3-4):464-472.

Greenberg, B.G., J.R. Abernathy, and D.G. Horvitz. 1988. "Randomized Response." In *Encyclopedia of Statistical Sciences. Vol. 7*, eds. S. Kotz, and N.L. Johnson. New York: John Wiley and Sons.

Greene, W.H. 1990. *Econometric Analysis*. New York: MacMillan Publishing Company.

Grogger, J. 1990. "A Simple Test for Exogeneity in Probit, Logit and Poisson Regression Models." *Economic Letters* 33:329-332.

Hagen, D.A., J.W. Vincent, and P.G. Welle. 1992. "Benefits of Preserving Old-Growth Forests and the Spotted Owl." *Contemporary Policy Analysis* 10:13-26.

Halstead, J.M., A.E. Luloff, and T.H. Stevens. 1992. "Protest Bidders in Contingent Valuation." *Northeastern Journal of Agricultural and Resource Economics* (Oct.):160-168.

Hammack, J., and G.M. Brown, Jr. 1974. *Waterfowl and Wetlands: Towards Bioeconomic Analysis.* Washington, D.C.: Resources for the Future.

Hanemann, W.M. 1984. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." *American Journal of Agricultural Economics* 66 (Aug.):332-341.

Hanemann, W.M. 1989. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Reply." *American Journal of Agricultural Economics* 71 (Nov.):1057-1061.

Hanemann, W.M. 1991. "Willingness to Pay and Willingness to Accept: How Much Can They Differ?" *The American Economic Review* 81 (3):635-647.

Hanemann, W.M., P. Johansson, B. Kristrom, and L. Mattsson. 1992. "Natural Resources Damages from Chernobyl." *Environmental and Resource Economics* 2:523-525.

Hanemann, W.M., J. Loomis, and B. Kanninen. 1991. "Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation." *American Journal of Agricultural Economics* 73:1255-1263.

Hanley, N. and S. Craig. 1991. "Wilderness Development Decisions and the Krutilla-Fisher Model: The Case of Scotland's 'Flow Country'." *Ecological Economics* 4:145-164.

Harper, C.R. 1989. "Rational Roots of Irrational Behavior: Discussion." *Northeastern Journal of Agricultural Economics* (Oct.):96-97.

Harris, C.C., B.L. Driver, and W.J. McLaughlin. 1989. "Improving the Contingent Valuation Method: A Psychological Perspective." *Journal of Environmental Economics and Management* 17: 213-229.

Harris, C.C., T.A. Miller, and K. Reese. 1992. "Possible Influences on Donation Behavior: The Case of Idaho's Nongame Wildlife and Endangered Species Tax Checkoff Fund." *Society and Natural Resources* 5:53-66.

Harrison, G.W. 1992. "Valuing Public Goods with the Contingent Valuation Method: A Critique of Kahneman and Knetsch." *Journal of Environmental Economics and Management* 23:248-257.

Harvard Law Review Association. 1992. "Ask a Silly Question...:Contingent Valuation of Natural Resource Damages." *Harvard Law Review* 105 (8):1981-2000.

Hasselblad, V., A.G. Stead, and J.P. Creason. 1980. "Multiple Probit Analysis with a Nonzero Background." *Biometrics* 36:659-663.

Heckman, J.J. 1978. "Dummy Endogenous Variables in a Simultaneous Equation System." *Econometrica* 46 (6):931-959.

Hicks, J.R. 1943. "The Four Consumer Surpluses." *Review of Economics Studies* 8:108-116.

Himmelfarb, S., and C. Lickteig. 1982. "Social Desirability and the Randomized Response Technique." *Journal of Personality and Social Psychology* 43 (4):710-717.

Hoehn, J.P. 1987. "Contingent Valuation in Fisheries Management: The Design of Satisfactory Contingent Valuation Formats." *Transactions of the American Fisheries Society* 116:412-419.

Hoehn, J.P. 1991. "Valuing the Multidimensional Impacts of Environmental Policy." *American Journal of Agricultural Economics* 73 (2):289-299.

Hoehn, J.P. 1992. "Natural Resource Damage Assessment and Public Lands Management: Issues and Needed Research." Presented for discussion at the conference entitled, "Management of Public Resources," organized by the Resource Policy Consortium, American Society of Executives, Washington, D.C., May 21-22.

Hoehn, J.P., and J.B. Loomis. 1992. "Substitution Effects in the Contingent Valuation of Multiple Environmental Programs: A Maximum Likelihood Estimator and Empirical Tests." Unpublished Manuscript, Department of Agricultural Economics, Michigan State University.

Hoehn, J.P., and A. Randall. 1987. "A Satisfactory Benefit Cost Indicator from Contingent Valuation." *Journal of Environmental Economics and Management* 14:226-247.

Hoehn, J.P., and A. Randall. 1989. "Too Many Proposals Pass the Benefit Cost Test." *American Economic Review* 79:544-551.

Howarth, R.B, and R.B. Norgaard. 1992. "Environmental Valuation Under Sustainable Development." *American Economic Review* 82 (2):473-477.

Johnson, N.S. and R.M. Adams. 1988. "Benefits of Increased Streamflow: The Case of the John Day River Steelhead Fishery." *Water Resources Research* 24 (11):1839-1846.

Johnson, N., and R.M. Adams. 1989. "On the Marginal Value of a Fish: Some Evidence from a Steelhead Fishery." *Marine Resource Economics* 6:43-55.

Johnson, N.L., and S. Kotz. 1970. *Continuous Univariate Distributions - 2*. Boston, MA: Houghton Mifflin Company.

Johnson, R.L. and G.V. Johnson, eds. 1990. *Economic Valuation of Natural Resources: Issues, Theory and Applications*. Boulder, CO: Westview Press.

Johnson, R.L., S. Bregenzer, and B. Shelby. 1990. "Contingent Valuation Question Formats: Dichotomous Choice Versus Open-Ended Responses." In *Economic Valuation of Natural Resources: Issues, Theory and Applications*, eds. R.L. Johnson, and G.V. Johnson. Boulder, CO: Westview Press.

Jordan, L.A., and J.P. Workman. 1989. "Overview of Fee Hunting for Deer and Elk on Private Land in Utah." *Trans. 54th N.A. Wildl. & Nat. Res. Conf.* pp. 191-195.

Kahneman, D., and J.L. Knetsch. 1992a. "Contingent Valuation and the Value of Public Goods: Reply." *Journal of Environmental Economics and Management* 22:90-94.

Kahneman, D., and J. Knetsch. 1992b. "Issues of Method in the Study of Embedding: Reply to Harrison." Unpublished Manuscript. University of California, Berkeley.

Kahneman, D., and J.L.Knetsch. 1992c. "Valuing Public Goods: The Purchase of Moral Satisfaction." *Journal of Environmental Economics and Management* 22:57-70.

Kanninen, B.J. 1993a. "Bias in Discrete Response Contingent Valuation." Paper presented at the USDA's Western Regional Research Project W-133: Benefit and Cost Transfers in Natural Resource Planning. Santa Fe, NM, March.

Kanninen, B.J. 1993b. "Optimal Experimental Design for Double-Bounded Dichotomous Choice Contingent Valuation." *Land Economics* 69 (2):138-146.

Kanninen, B.J., and B. Kristrom. 1993. "Sensitivity of Willingness to Pay Estimates to Bid Design in Dichotomous Choice Valuation Models." *Land Economics* 69 (2):199-202.

Kavanaugh, D.C., R. Berrens, D.M. Anderson, K.R. Hughes, and J.E. Englin. 1992. "Phase I Completion Report: Approaches and Plan for the Analysis of Recreation Participation and Valuation on Federal Projects on the Columbia River System." Volume I. Prepared for the US Army Corps of Engineers, Bonneville Power Administration, and US Bureau of Reclamation. Batelle, Pacific Northwest Laboratories. Contract #91-583.

Kealy, M.J., and R.W. Turner. 1993. "A Test of Equality of Close-Ended and Open-Ended Contingent Valuations." *American Journal of Agricultural Economics* 75 (2):321-331.

Kerkvliet, J.R. 1993a. "Cheating by Economics Students: A Comparison of Survey Results." *Journal of Economic Education* Forthcoming.

Kerkvliet, J.R. 1993b. "Estimating a Logit Model with Randomized Data: The Case of Cocaine Use." *Australian Journal of Statistics* Forthcoming.

Knetsch, J.L. 1990. "Environmental Policy Implications of Disparities between Willingness to Pay and Compensation Demanded Measures of Values." *Journal of Environmental Economics and Management* 18:227-237.

Kopp, R.J. 1992. "Why Existence Values Should be Used in Cost-Benefit Analysis." *Journal of Policy Analysis and Management* 11 (1):123-130.

Kopp, R.J., and V.K. Smith, eds. 1993. *Valuing Natural Assests: The Economics of Natural Resource Damage Assessment.* Washington, D.C.: Resources for the Future.

Kristrom, B. 1990a. "A Non-Parametric Approach to the Estimation of Welfare Measures in Discrete Response Valuation Studies." *Land Economics* 66 (May):135-139.

Kristrom, B. 1990b. Valuing Environmental Benefits Using the Contingent Valuation Method: An Econometric Analysis. Umea Economic Studies No. 219, University of Umea, Sweden.

Krinsky, I., and A.L. Robb. 1986. "On Approximating the Statistical Properties of Elasticities." *Review of Economics and Statistics* 68:715-719.

Larson, D.M. 1990. "Recreational Choices and the Implied Value of Time." In Benefits and Costs in Natural Resources Planning, Third Interim Report, ed. J.P. Hoehn. Western Regional Research Project W-133, USDA.

Lazo, J.K., W.D. Schulze, G.H. McClelland, and J.K. Doyle. 1992. "Can Contingent Valuation Measure Non-Use Values." Paper presented at the annual meetings of the American Agricultural Economics Association, Baltimore, MD, August 9-12.

Leopold. A. 1930. "Report of the Game Committee on American Wildlife Policy." *Proc.Amer. Game Conf.* 17:281-309.

Leopold, A. 1933. *Game Management.* New York: Charles Scribner's Sons.

Lockwood, C.A. 1951. "1950 in Review." *Oregons State Game Commision Bulletin.* 6 (1):3,6.

Loomis, J.B. 1990. "Comparative Reliability of the Dichotomous Choice and Open-Ended Contingent Valuation Techniques." *Journal of Environmental Economics and Management* 18:78-85.

Loomis, J.B. 1992. "The Evolution of a More Rigorous Approach to Benefit Transfer: Benefit Function Transfer." *Water Resources Research* 28 (3):701-705.

Loomis, J., J. Cooper, and S. Allen. 1988. "The Montana Elk Hunting Experience: A Contingent Valuation Assessment of Economic Benefits to Hunters." Report prepared fo Montana Department of Fish, Wildlife and Parks.

Loomis, J.B., M. Lockwood, and T. DeLacy. 1992. "Some Empirical Evidence on Embedding with Open-ended and Dichotomous Choice Contingent Valuation for Forest Protection." Unpublished Manuscript, Division of Environmental Studies and Department of Agricultural Economics, University of California, Davis.

Loomis, J.B., and M.H. Thomas. 1992. "Pricing and Revenue Capture: Converting Willingness to Pay into State and Private Revenue." In: *Valuing Wildlife Resources in Alaska*, eds. G.L. Peterson, C. Sorg Swanson, D.W. McCollum, and M.H. Thomas. Boulder, CO: Westview Press.

MacKenzie, J. 1993. "A Comparison of Contingent Preference Models." *American Journal of Agricultural Economics.* Forthcoming.

Madalla, G. 1983. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge, MA: Cambridge University Press.

Madalla, G., and R. Trost. 1978. "Estimation of the Logit Model with Randomized Data." Unpublished Manuscript, University of Florida.

Madariaga, B., and K.E. McConnell. 1987. "Exploring Existence Values." *Water Resources Research* 23 (5):936-942.

Matulich, S.C., and R.M. Adams. 1987. "Towards More Effective Wildlife Policies: An Economic Perspective of Wildlife Management Research." *Wildlife Society Bulletin* 15:285-291.

McCain, R.A. 1992. *A Framework for Cognitive Economics.* Westport, CN: Praeger.

McClave, J.T., and F.H. Dietrich. 1985. *Statistics.* 3rd ed. San Fransisco: Dellen Publishing Company.

McConnell, K.E. 1990. "Models for Referendum Data: The Structure of Discrete Choice Models for Contingent Valuation." *Journal of Environmental Economics and Management* 18:19-34.

McFadden, D., and G. Leonard. 1992. "On the Contingent Valuation Method for Measuring Social Value from Passive Use of Environmental Resources." Unpublished Manuscript, Cambridge Economics 70 pp.

McKean, J.R., and R.G. Walsh. 1986. "Neoclassical Foundations for Nonmarket Benefits Estimation." *Natural Resources Modeling* pp. 153-170.

Meyers, A.V. 1946. "Public Owned Wildlife Management Areas." *Oregon State Game Commission Bulletin* 1 (7):1,3.

Michelman, T.S. 1992. "Contingent Valuation Methodology and the Bounded Rationality Perspective." Unpublished Masters Thesis, Department of Resource Economics, University of Rhode Island.

Milon, J.W. 1989. "Contingent Valuation Experiments for Strategic Behavior." *Journal of Environmental Economics and Management* 17:293-308.

Miranowski, J.A., and R.L. Bender. 1982. "Agricultural Management Practices and Wildlife-Related Recreation: Pheasant Hunting Recreation in Iowa." *Trans. 49th N. Amer. Wildl. and Nat. Res. Conf.* pp. 325-333.

Mishan, E.J. 1981. *Introduction to Normative Economics.* New York: Oxford University Press.

Mitchell, R.C., and R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington, D.C.: Resources For The Future.

Morey, E.R. 1992. "What is Consumer Surplus Per-Day of Use? and What Does It Tells Us About Consumer Surplus?" Discussion Paper, Department of Economics, University of Colorado.

Morey, E.R., W.D. Shaw, and R.D. Rowe. 1991. "A Discrete-Choice Model of Recreational Participation, Site Choice, and Activity Valuation when Complete Trip Data Are Not Available." *Journal of Environmental Economics and Management* 20:181-201.

Morey, E.R., R.D. Rowe, and M. Watson. 1993. "A Repeated Nested Logit Model of Atlantic Salmon Fishing with Comparisons to Six Other Travel Cost Models." *American Journal of Agricultural Economics.* Forthcoming.

Morrison, B.L. 1989. "The Sikes Act: A Neglected Partnership Opportunity." *Trans. 54th N.A. Wildl. & Nat. Res. Conf.* pp. 295-297.

Moser, D.A., and C.M. Dunning. 1986. "National Economic Development Procedures Manual - Recreation, Volume II: A Guide for Using the Contingent Valuation Methodology in Recreation Studies." US Army Corps of Engineers. Institute for Water Resources. IWR Report 86-R-5.

Munasinghe, M. 1992. *Water Supply and Environmental Management.* Boulder, CO: Westview Press.

Nathan, G. 1988. "A Bibliography on Randomized Response: 1965-1987." *Survey Methodology* 14 (2):331-346.

Norton, B.G. 1987. *Why Preserve Natural Variety?* Princeton, NJ: Princeton University Press.

Olsen, D., J. Richards, and R.D. Scott. 1990. "A Study of the Existence and Sport Values for Doubling the Size of the Columbia River Basin Salmon and Steelhead Runs." Columbia River and Tributaries Study-73. North Pacific Division. U.S. Army Corps of Engineers. Portland, OR.

Olsen, D., J. Richards, and R.D. Scott. 1991. "Existence and Sport Values for Doubling the Size of Columbia River Basin Salmon and Steelhead Runs." *Rivers* 2 (1):44-56.

Opaluch, J.J., and T.A. Grigalunas. 1992. "Ethical Principles and Personal Preferences as Determinants of Nonuse Values: Implications for Natural Resource Damage Assessments." In: USDA Western Regional Research Project W-133: Benefits and Costs in Natural Resource Planning. Fifth Interim Report.

Opaluch, J.J., and K. Segerson. 1989. "Rational Roots of Irrational Behavior: New Theories of Economic Decision-Making." *Northeastern Journal of Agricultural Economics* (Oct.):81-95.

Oregon Department of Fish and Wildlife (ODFW). 1991. "Experimatal Put & Take Permit Pheasant Hunts: A Report for the 1991 Legislature." Oregon Department of Fish and Wildlife.

Oregon Sportsman, The. 1913. "Open Season on Chinese Pheasant." *The Oregon Sportsman* 1 (2):1.

Oregon State University (OSU). 1992. *Oregon State University Facts, 1992*. Office of Budgets and Planning, June.

Ozuna, T, K.Y. Jang, and J.R. Stoll. 1993. "Testing for Misspecification in the Referendum Contingent Valuation Approach." *Americal Journal of Agricultural Economics* 75(2):332-338.

Park, T.A., and J. Loomis. 1991. "Joint Estimation of Contingent Valuation Survey Responses." Papers of the 1991 Annual Meeting, Western Agricultural Economics Association. Portland, OR, July 7-10.

Park, T.A., and J. Loomis. 1992. "Comparing Models for Contingent Valuation Surveys: Statistical Efficiency and the Precision of Benefit Estimates." *Northeastern Journal of Agricultural and Resource Economics* (Oct.):170-176.

Park, T.A., J.B. Loomis, and M. Creel. 1991. "Confidence Intervals for Evaluating Benefit Estimates from Dichotomous Choice Contingent Valuation Studies." *Land Economics* 67 (1):64-73.

Patterson, D.A., and J.W. Duffield. 1991. "Comment on Cameron's Censored Logistic Regression Model for Referendum Data." *Journal of Environmental Economics and Management* 20:275-283.

Pearce, D. 1993. *Economic Values and the Natural World.* London: Earthscan Publications, Ltd.

Peterson, G.L., B.L. Driver, and R. Gregory. 1988. *Amenity Resource Valuation: Integrating Economics with Other Disciplines.* State College, PA: Venture Publishing.

Peterson, G.L., and C.L. Sorg, eds. 1987. "Toward the Measurement of Total Economic Value." Rocky Mountain Forest and Range Experiment Station, US Department of Agriculture, Forest Service. General Technical Report RM-148.

Peterson, G.L., C.S. Swanson, D.W. McCollum, and M.H. Thomas, eds. 1992. *Valuing Wildlife Resources in Alaska.* Boulder, CO: Westview Press.

Polinsky, A.M., and S. Shavell. 1989. "Economic Analysis of Liability for Natural Resource Damages Caused by an Oil Spill." Paper submitted to United States Department of the Interior in connection with its Advance Notice of Proposed Rulemaking (ANPR). Federal Register, 54 (183):39016-39018.

Prince, R., and E. Ahmed. 1988. "Estimating Individual Recreation Benefits Under Congestion and Uncertainty." *Journal of Leisure Research* 20 (4):61-76.

Prince, R., M. McKee, S. Ben-David, and M. Bagnoli. 1992. "Improving the Contingent Valuation Method: Implementing the Contribution Game." *Journal of Environmental Economics and Management* 23:78-90.

Randall, A. 1988. "A Camel is a Camel is ..." In *Amenity Resource Valuation: Integrating Economics with Other Disciplines*, eds. G.L. Peterson, B.L. Driver, and R. Gregory. State College, PA: Venture Publishing.

Randall, A. 1991a. "Self-Reported Values and Observable Transactions: Is There a Trump in the Deck?" Invited paper, W-133 and Western Regional Science Association, Monterey, CA, February, 27.

Randall, A. 1991b. "Total and Nonuse Values." In *Measuring the Demand for Environmental Quality,* eds. J.B. Braden, and C.D. Kolstad. New York: Elsevier Science Publishers.

Randall, A. 1993a. "Passive-Use Values and Contingent Valuation: Valid for Damage Assessment." *Choices* 8 (2):12-15.

Randall, A. 1993b. "What Practicing Agricultural Economists Really Need to Know About Methodology." Unpublished Manuscript, Department of Agricultural Economics and Rural Sociology, Ohio State University.

Randall, A., and M. Farmer. 1992. "Starting Price Effects in Contingent Valuation Data Sets." Paper presented at the Annual Meeting of the American Agricultural Economics Association, Baltimore, MD, August 9-12.

Randall, A., B. Ives, and C. Eastman. 1974. "Bidding Games for Valuation of Aesthetic Environmental Improvements." *Journal of Environmental Economics and Management* 1:132-149.

Randall, A., and W. Kriesel. 1990. "Evaluating National Policy Proposals by Contingent Valuation." In: *Economic Valuation of Natural Resources: Issues, Theory and Applications,* eds. R.L. Johnson, and G.V. Johnson. Boulder, CO: Westview Press.

Ready, R.C. 1990. "Welfare Measurement and Project Financing." In Benefits and Costs in Natural Resources Planning: Third Interim Report, ed. J.P. Hoehn. Western Regional Research Project W-133, USDA.

Reiling, S.D., K.J. Boyle, M.L. Phillips, and M.W. Anderson. 1990. "Temporal Reliability of Contingent Values." *Land Economics* 66 (2):128-134.

Reiling, S.D., H. Cheng, and C. Trott. 1992. "Measuring the Discriminatory Impact Associated with Higher Recreational Fees." *Leisure Sciences* 14:121-137.

Rolston, H. III. 1988. *Environmental Ethics: Duties to and Values in the Natural World.* Temple University Press.

Rosenthal, D.H., J.B. Loomis, and G.L. Peterson. 1984. "Pricing for Efficiency and Revenue in Public Recreation Areas." *Journal of Leisure Research* 16:195-207.

Rosenthal, D.H., and R.H. Nelson. 1992. "Why Existence Values Should Not be Used in Cost-Benefit Analysis." *Journal of Policy Analysis and Management* 11 (1):116-122.

Rubin, J., G. Helfand, and J.B. Loomis. 1991. "A Benefit-Cost Analysis of the Northern Spotted Owl: Results from a Contingent Valuation Survey." *Journal of Forestry* (Dec.):25-29.

Sagoff, M. 1988. *Economy of the Earth: Philosophy, Law and the Environment* Cambridge, MA?: Cambridge University Press.

Samuelson, P.A. 1954. "The Pure Theory of Public Expenditure." *Review of Economics and Statistics* 36:387-389.

Sanoff, A.P., S. Minerbrook, J. Thornton, and E. Pezzulo. 1993. "Students Talk About Race." *U.S. News and World Report* (Apr. 19):57-64.

Santee, R.T., and C. Maslach. "To Agree or Not to Agree: Personal Dissent Amid Social Pressure to Conform." *Journal of Personality and Social Psychology* 42 (4):690-700.

Scheers, N.J. 1992. "A Review of Randomized Response Techniques." *Measurement and Evaluation in Counseling and Development* 25:27-41.

Scheers, N.J., and C.M. Dayton. 1987. "Improved Estimation of Academic Cheating Behavior Using the Randomized Response Technique." *Research in Higher Education* 26:61-69.

Scheers, N.J., and C.M. Dayton. 1988. "Covariate Randomized Response Model." *Journal of American Statistical Association* 83:969-974.

Schneider, F. 1947. "Willamette Valley Upland Game Refuges." *Oregon State Game Commission Bulletin* 2 (1):1,4.

Schultz, S.D., and B.E. Lindsay. 1990. "The Willingness to Pay for Groundwater." *Water Resources Research* 26 (9):1869-1875.

Schulze, W.D. 1993. "Use of Direct Methods for Valuing Natural Resource Damages." In *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment,* eds. R.K. Kopp, and V.K. Smith. Washington,D.C.:Resources for the Future.

Seip, K., and J. Strand. 1990. "Willingness to Pay for Environmental Goods in Norway: A Contingent Valuation Study with Real Payment." Memorandum from the Department of Economics, University of Oslo. ISBN 82-570-8434-4.

Sellar C., J.P. Chavas, and J.Stoll. 1985. "Valuation of Empirical Measures of Welfare Change: A Comparison of Non-Market Techniques." *Land Economics* 61:156-175.

Sellar, C., J.P. Chavas, and J.Stoll. 1986. "Specification of the Logit Model: The Case of Valuation of Non-Market Goods." *Journal of Environmental Economics and Management* 13:382-390.

Sen, A. 1987. *On Ethics and Economics*. New York: Basil and Blackwell.

Shavell, S. 1992. "Economic Analysis of the Measurement of Losses and Liability for an Oil Spill." Paper submitted to the National Oceanic and Atmospheric Administration (NOAA) for Oil Pollution Act Economics Workshop, Alexandria, VA, November, 20.

Shulstad, R.N., and H.H. Stoevener. 1978. "The Effects of Mercury Contamination in Pheasants on the Value of Pheasant Hunting in Oregon." *Land Economics* 54 (1):40-49.

Shyamsundar, P., and R.A. Kramer. 1993. "Does Contingent Valuation Work in Non-market Economies?" Discussion paper, Center for Resource and Environmental Policy Research, Duke University.

Simon, H. 1955. "A Behavioral Model of Rational Choice." *Quarterly Journal of Economics* 69 (1):99-118.

Skiff, J.V. 1948. "Is There a Place for Stocking in Game Management." *Trans. 13th N.A. Wildl. Conf.* pp.220-227.

Smith, V.K. 1990. "Can We Measure the Economic Value of Environmental Amenities?" *Southern Economic Journal* 54 (4):865-78.

Smith, V.K. 1992a. "Arbitrary Values, Good Causes, and Premature Verdicts." *Journal of Environmental Economics and Management* 22:71-89.

Smith, V.K. 1992b. "Environmental Costing for Agriculture: Will it be Standard Fare in the Farm Bill of 2000?" *American Journal of Agricultural Economics* 74 (5):1076-1078.

Smith, V.K. 1992c. "On Separating Defensible Benefit Transfers from "Smoke and Mirrors." *Water Resources Research* 28 (3):685-694.

Smith, V.K. 1993. "Nonmarket Valuation of Environmental Resources: An Interpretive Appraisal." *Land Economics* 69 (1):1-26.

Smith, J.L.D., A.H. Berner, F.J. Cuthbert, and J.A. Kitts. 1992. "Interest in Fee Hunting by Minnesota Small Game Hunters." *Wildlife Society Bulletin* 20 (1):20-26.

Stem, D.E. Jr., and R.K. Steinhorst. 1984. "Telephone Interview and Mail Questionnaire Applications of the Randomized Response Model." *Journal of American Statistical Association* 79 (387):555-564.

Stevens, T.H. 1992. "Interpretation of Contingent Values for Wildlife Existence." Proceedings Paper, Western Regional Research Project W-133: Benefits and Costs in Natural Resources Planning.

Stevens, T.H., J. Echeverria, R.J. Glass, T. Hager, and T.A. More. 1991a. "Measuring the Existence Value of Wildlife: What Do CVM Estimates Really Show?" *Land Economics* 67 (4):390-400.

Stevens, T.H., R.S. Glass, T.A. More, and J. Echeverria. 1991b. "Wildlife Recovery: Is Benefit-Cost Analysis Appropriate?" *Journal of Environmental Management* 33:327-334.

Stoll, J.R., J.C. Bergstrom, and J. Titre. 1989. "Regional Valuation Models for Recreation Benefits." Western Regional Research Project W-133: Benefits and Costs in Natural Resources Planning. (USDA) Interim Report 2.

Sudman, S., and N. Bradburn. 1974. *Response Effects in Surveys.* Chicago: Aldine Publishing.

U.S. Department of Agriculture, Forest Service (USFS). 1990. "Resource Pricing and Valuation Procedures for the Recommended 1990 RPA Program." Appendix B of The Forest Service Program for Forest and Rangeland Resources: A Long Term Strategy. Washington, D.C.

U.S. Department of Interior (USDI). 1986. "Final Rule for Natural Resource Damage Assessments Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)." *Federal Register* 51 (148):27674-27753.

U.S. Department of Interior (USDI). 1991. "Natural Resource Damage Assessments: Notice of Proposed Rulemaking." 43 CFR Part II. *Federal Register* 56 (62):19753-19774.

Varian, H.R. 1992. *Microeconomic Analysis*. Third Edition. New York: W.W. Norton & Company.

Vatn, A., and D.W. Bromley. 1993. "Choices Without Prices Without Apologies." Unpublished Manuscript, Department of Agricultural Economics, University of Wisconsin-Madison.

Walsh, R.G., D.M. Johnson, and J.R. McKean. 1989. "Issues in Nonmarket Valuation and Policy Application: A Retrospective Glance." *Western Journal of Agricultural Economics* 124 (1):178-188.

Walsh, R.G., D.M. Johnson, and J.R. McKean. 1992. "Benefit Transfer of Outdoor Recreation Demand Studies, 1968-1988." *Water Resources Research* 28 (3):707-713.

Warner, S. 1965. "Randomized Response: A Survey Technique for Eliminating Evasive Answer Bias." *Journal of the American Statistical Association* 60:63-69.

Water Resources Council (WRC). 1983. "Principles and Guidelines for Water and Related Land Resources Implementation Studies." Washington D.C.

White, K.J., S.D. Wong, D. Whistler, and S.A. Huan. 1990. *SHAZAM: User's Reference Manual, Version 6.2*. New York: McGraw-Hill.

Whitehead, J.C., and G.C. Blomquist 1991a. "A Link Between Behavior, Information, and Existence Value." *Leisure Sciences* 13:97-109.

Whitehead, J.C., and G.C. Blomquist. 1991b. "Measuring Contingent Values for Wetlands: Effects of Information About Related Environmental Goods." *Water Resources Research* 27 (10):2523-2531.

Whittington, D., V.K. Smith, A. Okorafor, A. Okore, J.L. Liu, and A. McPhail. 1992. "Giving Respondents Time to Think in Contingent Valuation Studies: A Developing Country Application." *Journal of Environmental Economics and Management* 22:205-225.

Wiggers, E.P., and W.A. Rootes. 1987. "Lease Hunting: Views of the Nations Wildlife Management Agencies." *Trans. 52nd N.A. Wildl. & Nat. Res. Conf.* pp.525-529.

Wilman, E.A. 1988. "Pricing Policies for Outdoor Recreation." *Land Economics* 64 (3):234-241.

Young, J.S., D.S. Donnelly, C.F. Sorg, J.B. Loomis, and L.J. Nelson. 1987. "Net Economic Value of Upland Game Hunting in Idaho." U.S. Dept. of Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO. Resources Bulletin RM-15.

APPENDICES

APPENDIX A

DESCRIPTIVE STATISTICS FOR SELECTED VARIABLES

Corresponding to the study in Chapter 2, Table A.1 provides the breakdown of respondents self-reported ethnic status; the numbers in parentheses are percentage rates. In answering this survey question, respondents were provided a description of ethnic status identification guidelines from the University's Affirmative Action Office. As can be seen from the table, the two largest ethnic groups are White and Asian, together composing over 90 percent of the entire sample. Consequently, they were used in coding the dummy variables ETH1 (1=White, 0=otherwise), and ETH2 (1=Asian, 0=otherwise); the numbers in parentheses are percentage rates.

Table A.1. Breakdown of Ethnic Backgrounds

Ethnic Background	RR n=316	DQ n=137	Total n=453
American Indian of Alaskan Native	10 (0.032)	4 (0.029)	14 (0.031)
Asian or Pacific Islander	58 (0.184)	29 (0.212)	87 (0.192)
Black (not of Hispanic origin)	7 (0.022)	0 (0.00)	7 (0.016)
Hispanic	8 (0.025)	5 (0.036)	13 (0.029)
White (not of Hispanic origin)	232 (0.734)	99 (0.723)	331 (0.731)

Table A.2 provides the breakdown by level of self-support provided. The two split samples are roughly equivalent, especially on the first category (less than 25 percent) which was used to code the dummy variable SUP (1=less than 25 percent, 0=otherwise). Numbers in parentheses are percentage rates.

Table A.2. Breakdown by Level of Self-Support

Percent of Self Support	RR n=318	DQ n=137	Total n=455
Less than 25%	128 (0.403)	56 (0.409)	184 (0.404)
26% to 50%	71 (0.223)	20 (0.146)	91 (0.200)
51% to 75%	30 (0.094)	16 (0.117)	46 (0.101)
Greater than 75%	89 (0.279)	45 (0.329)	134 (0.295)

Table A.3 provides a breakdown of survey respondents by age groups. Table A.4 provides a summary of response rates for selected binary questions. For both tables, the numbers in parentheses are percentage rates.

Table A.3. Breakdown by Age Groups

Age	RR n=322	DQ n=140	Total n=462
Younger than 21	198 (0.62)	58 (0.41)	256 (0.55)
21 - 26	90 (0.28)	67 (0.48)	157 (0.34)
Older than 26	34 (0.11)	15 (0.11)	49 (0.11)

Table A.4. Summary of Affirmative Responses to Selected Binary Questions

Variable	RR	DQ	Total
U.S. Citizen	270/318 (0.849)	116/139 (0.835)	386/457 (0.845)
Gender (males/total sample)	207/321 (0.645)	93/138 (0.674)	300/459 (0.654)
Did Not Vote in Last Election	129/319 (0.404)	57/139 (0.410)	186/458 (0.406)
Rural Background	150/318 (0.472)	63/138 (0.457)	213/456 (0.467)
Taken Cultural Awareness Class	145/322 (0.450)	62/139 (0.446)	207/461 (0.449)

APPENDIX B

WILLINGNESS-TO-PAY COMPARISONS

Corresponding to the study in Chapter 2, Table B.1 provides descriptive statistics for the distribution of the fitted values for the eight possible WTP models, for the split samples (DQ and RR).

Table B.1. Descriptive Statistics for Distributions of the Fitted Values

Model	*n*	Mean ($)	Median ($)	Minimum ($)	Maximum ($)	St. Dev. ($)
WTP-DQ-1	130	3.73	3.19	-3.66	16.70	4.13
WTP-DQ-2	118	3.02	2.81	-8.92	19.04	5.91
WTP-DQ-3	130	3.63	2.31	0.56	35.44	4.25
WTP-DQ-4	118	4.20	2.69	0.30	47.10	5.20
WTP-DQ-5	134	3.72	3.80	-2.25	15.10	4.25
WTP-DQ-6	121	2.95	2.54	-3.64	12.95	4.02
WTP-DQ-7	134	5.48	3.72	2.10	25.40	3.66
WTP-DQ-8	121	3.93	2.25	0.72	20.09	3.60
WTP-RR-1	296	0.10	-0.38	-12.60	14.85	4.70
WTP-RR-2	254	-0.89	-1.34	-11.02	14.60	4.71
WTP-RR-3	296	2.54	0.84	0.05	52.33	5.96
WTP-RR-4	254	2.81	1.00	0.09	48.01	5.78
WTP-RR-5	302	0.30	-1.05	-8.08	13.58	3.92
WTP-RR-6	259	0.96	0.79	-7.50	13.43	3.73
WTP-RR-7	302	2.00	0.77	0.13	32.56	3.42
WTP-RR-8	259	1.53	1.16	0.28	10.81	1.35

In Table B.1, the four linear models (1,2,5 and 6) in each group (DQ and RR) allow negative predicted values. The four log-linear models (3,4,7 and 8) in each group (DQ and RR) force WTP predictions to be non-negative numbers. The distribution of the fitted-values for the log-linear models is for the fitted medians (Cameron, 1988), commonly a more robust measure than the means. One-tailed hypothesis tests for the difference between means, with unequal sample sizes and variances (McClave and Deitrich, 1985:338), were conducted for all eight model comparisons. The evidence supports a statistically significant difference between the means ($p<0.10$) of the fitted values for all paired comparisons except one (WTP-DQ-3 v. WTP-RR-3), which was significant at the 0.13 level.

APPENDIX C

ESTIMATION RESULTS USED IN PREDICTING VISITS

Corresponding to the study in Chapter 4, this appendix provides the estimation results used in predicting visits. To predict the natural logarithm of total visits, **LNVIS**, the ordinary least squares (OLS) estimator was used:

$$E(LNVIS_i) = \beta' \chi_i \quad (1)$$

Where β is the vector of estimated coefficients on a vector of explanatory variables, χ. Table C.1 provides estimation results for the model.

In addition to the income dummy variables, D1 and D2, four other explanatory variables are used. None of these four were used in the original ABMJM study. BAG1 is a dummy variable that indicates an individual's average daily bag (harvest) rate of one or more birds. BAG2 is a dummy variable indicating an individual daily bag rate of greater than zero but less than one. For the total sample of 97, there were 33 zero responses (34.02 percent), and 34 responses (35.05 percent) of a daily bag rate of 1. The rest of the responses were scattered between zero and two. There was a daily bag limit of two at the site. WND is a dummy variable that indicates the presence of weekend use. Finally, the MILES variable gives the total trip miles to the site for each respondent.

Table C.1. Estimation Results for the Log-Linear OLS Model

Variable	Coefficient	t-statistic
Intercept	***1.452	7.817
BAG1	***0.503	2.834
BAG2	***0.932	4.114
WND	0.048	0.294
MILES	-*0.029	-1.828
D1	-0.306	-1.434
D2	-0.112	-0.558

R^2=.2064; ST. Error of the estimate=0.774; *, **, and *** indicate significance at the 0.05, 0.025, and 0.01 levels, respectively; n=97.

In addition to the log-linear OLS model, a tobit model also is used to generate predictions for LNVIS. Tobit analysis for censored regression is used because the dependent variable, LNVIS, is limited to nonnegative values and has a number of observations clustered near zero (Amemiya, 1984).

The Tobit model used here can be specified as **LNVIS*** = $\beta'\chi+v$, where v is the random error assumed to be i.i.d $N(0,\sigma^2)$. The observations are **LNVIS=LNVIS*** when **LNVIS* > 0**, and **LNVIS=0** if **LNVIS*** $\leq$ **0**. The expected value, **E(LNVIS*)** = $\beta'\chi$ can be referred to as the Tobit index; parameter estimates obtained through maximum likelihood procedures measure the impact of explanatory variables on this index, and not on the observed value LNVIS. Through the use of the standard normal probability density function and cumulative distribution function, the tobit index is transformed into the predicted limited dependent variable. More specifically, and in contrast to the OLS estimator, predictions from the tobit model are derived from:

$$E(LNVIS_i) = F(z) \cdot B' \chi_i + \sigma f(z) \tag{2}$$

Where: F(.) and f(.) are the cumulative density and probability function, respectively, of the standard normal distribution evaluated at **z**; **z** = $[(\beta' \chi)/\sigma]$ = the normalized Tobit index; σ = the standard error of the regression, and β/σ is the vector of normalized coefficients. (Thus, the vector of "regression coefficients" is obtained by multiplying the vector of normalized coefficents by the standard error of the regression.)

Table C.2 provides estimation results for the tobit model. The first column provides the set of explanatory variables used in predicting LNVIS. The second column provides the normalized coefficients estimates of the tobit model. The third column provides the asymptotic t-statistics on the normalized coefficients. The final column provides the regression coefficients; as can be seen, the tobit model produces comparable results to OLS model.

Table C.2. Estimation Results for the Tobit Model

Variable	Normalized Coefficient	Asymptotic t-statistic	Regression Coefficient
Intercept	***1.840	6.318	1.423
BAG1	***0.659	2.689	0.510
BAG2	1.255	3.934	0.970
WND	0.110	0.495	0.085
MILES	**-0.004	-1.975	-0.003
D1	-0.407	-1.408	-0.315
D2	-0.155	-0.569	-0.120

Squared correlation between observed and expected=0.206; St. Error of the estimate=0.773; *, **, and *** indicate significance at the 0.05, 0.025, and 0.01 levels, respectively. LLF=-113.887; n=97.

APPENDIX D

LOGIT ESTIMATION RESULTS FOR THE PROBABILITY OF ELIMINATING ALL TRIPS

Corresponding to the study in Chapter 4, this appendix provides the logit estimation (whether or not an individual would eliminate all trips in response to elimination of the stocking program). Table D.1 provides the estimation results from the logit model which obtained the best statistical fit, and was used in the prediction model for the specification test. The dependent variable is the binary indicator variable for contingent behavior, CB (1=yes; 0=no); it is elicited in direct response to the proposed policy change.

Table D.1. Logit Estimation Results for Contingent Behavior

Variable	Coefficient	Asymptotic t-statistic
Intercept	**-2.316	2.392
BAG1	0.063	0.115
BAG2	0.281	0.363
EO	**1.376	2.171
WND	*0.799	1.658
LNFEE	0.294	0.921
D1	1.034	1.541
D2	0.297	0.470
LNVIS	0.402	1.276
Likelihood Ratio Test Statistic	**19.462	
Maddala R^2	0.182	
McFadden R^2	0.147	
% Correct Predictions	0.763	

*, **, and *** indicate significance at the 0.05, 0.025, and 0.01 levels, respectively; n=97.

APPENDIX E

RANDOMIZED RESPONSE DATA SET AND DOCUMENTATION

Corresponding to the randomized response survey in Chapter 2, this appendix contains an example SHAZAM (White, 1990) basic input file, which provides the survey data and documents the variables used in the experiment. The probability information for the randomization technique is given in the variables p1 and pie.

```
smpl 1,468
read cls sur p1 bid ab age gen maj col ru vote exp crs edm edf for stay cit frnd &
sup osu corv eth
*cls=class number 1-13.
*sur = survey number within a class.
*p1 = probability mother's b-day is in May (0.083), or May and June (0.167). -- This
*    is the probability information assumed for P^2(1) in equation 11.
*bid=$payment level for WTP per quarter for  support an expansion of the OSU
*     cultural centers program.
*ab = answer to #1a: Is your mother's B-day in May? or
*     #1b: Are you willing to pay $X per quarter to support an expansion of
*     OSU cultural centers program?  yes = 1, no = 0.
*age = < 21 = 1; between and including 21 and 26 = 2; > 26 = 3
*gen = gender; male = 1; female = 0
*maj = Have you decided on a major field of study?  1 = yes; 0 = no
*col = academic college at OSU,1=agricultural;2=business;3=pre-engineering;
*      4=engineering; 5 = forestry; 6 = home economics; 7 = science;
*      8 = pharmacy; 9 = health and human performance; 10 = liberal arts;
*      11=educ;12=exploratory studies;13=oceanography;14=special
*      graduate programs; 15 = veterinary medicine; 16 = other.
*ru = answer to Which of the following best describes your background? 1 = rural; 0
*= urban
*vote = answer to Do you regularly vote in elections when eligible?  1 = no; 0 = yes
*exp = estimated monthly household expenditures on food, clothing, housing,and
*      entertainment (combined) in  U.S. dollars.
*crs = Have you taken a cultural awareness or cultural diversity
*     course at the university level?  1 = yes;  0 = no
```

*ed(m) = education of mother; 1 = no H.S. diploma; 2 = received H.S. diploma;
*	3=received a community coll. or tech. school degree;4=attended a
*	four year coll. or university but did not receive a degree;5=
*	received an undergrad. degree from a 4yr coll. or university; 6=
*	attended grad. school but did not receive a degree;7=received a graduate
*	school degree.
*ed(f) = education father; same as above
*for = Have you ever visited a foreign culture? 1 = yes; 0 = no
*stay = If yes, length of stay in months
*cit = citizenship; 1 = U.S.; 0 = other
*frnd = Have you ever been personal friends with someone not of your
*	own ethnic background? 1 = yes; 0 = no.
*sup = percentage of financial suport provided by self while in
*	school; 1 = < 25%; 2 = 26% to 50%; 3 = 51% to 75%; 4 = >75%
*OSU = climate of intercultural tolerance at OSU; 1 =
*	very tolerant of cultural diversity; 2 = tolerant; 3 = intolerant; 4 = very
*intolerant.
*Corv = climate of intercultural tolerance in Corvallis; same as above.
*eth = ethnic group; 1 = American or Alaskan native; 2 = Asian or Pacific
*	Islander; 3 = Black; 4 = Hispanic; 5 = White; 6 = Other.
*Note: 777 means the question was not answered except for cit and frnd where 7
*means it was not answered;

```
1  1   0.083 3.00 1  3  1  1  5   1  0    450.00 0  2  1  1  11  1 1
3  2   3  5
1  2   0.083 5.00 0  2  1  1  4   1  1   1000.00 0  4  7  1  36  1 1
1  777 2  5
1  3   0.083 1.00 1  1  0  1  15  1  0    300.00 0  2  5  0  777 1 1
1  2   2  5
1  4   0.083 3.00 1  1  1  1  10  1  0    777    1  2  2  0  777 1 1
3  2   3  5
1  5   0.083 5.00 0  2  0  1  9   0  0    500.00 1  2  3  0  777 1 1
3  2   4  5
1  6   0.083 7.00 0  1  1  1  10  0  0   2200.00 1  6  7  1  1   1 1
1  3   3  5
1  7   0.083 1.00 0  1  1  1  3   0  1    600.00 0  4  5  1  1   1 1
2  2   2  5
1  8   0.083 7.00 1  1  0  1  9   0  0    400.00 0  5  5  0  777 1 1
1  3   3  5
1  9   0.083 9.00 0  1  0  1  6   1  1    777    1  4  5  0  777 1 1
1  2   2  5
1  10  0.083 1.00 0  3  1  1  2   1  0    950.00 1  2  2  1  12  1 1
4  2   3  5
1  11  0.083 1.00 0  1  1  1  9   0  1    777    0  2  2  0  777 1 1
1  2   2  3
1  12  0.083 3.00 0  2  1  1  4   1  1    777    0  7  3  0  777 1 0
1  2   2  5
1  13  0.083 3.00 1  1  1  1  7   0  0    777    1  5  5  0  777 1 1
1  2   2  5
1  14  0.083 3.00 0  1  1  1  7   0  0    450.00 1  3  3  1  .25 1 1
4  2   3  5
1  15  0.083 5.00 0  1  1  1  3   1  777  350.00 0  4  4  1  1   1 1
4  1   1  5
1  16  0.083 3.00 1  2  1  1  11  1  0    400.00 0  2  2  1  .25 1 0
3  3   2  5
1  17  0.083 3.00 0  2  1  1  7   1  0    400.00 0  7  7  1  .25 1 1
```

```
4    2    2    1
1    18   0.083 1.00 0   1   0   1   10   0   1    1300.00 0   2   2   1   36   1   1
2    4    4    5
1    19   0.083 5.00 0   1   0   1   2    0   1    100.00  0   7   2   1   1.5  1   0
1    2    2    5
1    20   0.083 9.00 0   2   1   1   9    1   0    15000.00 0  3   5   1   1    1   1
2    1    1    5
1    21   0.083 3.00 0   1   1   1   10   0   0    777     0   2   5   1   192  1   1
2    2    2    5
1    22   0.083 9.00 0   1   1   1   1    1   0    800.00  1   2   7   0   777  1   0
1    2    2    5
1    23   0.083 1.00 0   1   1   1   4    1   1    777     0   7   7   0   777  1   1
3    2    2    5
1    24   0.083 7.00 0   1   1   1   2    0   1    400.00  1   7   5   0   777  1   1
1    2    2    2
1    25   0.083 3.00 0   2   1   1   2    1   1    150.00  0   5   5   0   777  1   1
2    2    2    5
1    26   0.083 5.00 0   3   1   1   1    0   1    600.00  1   2   2   0   777  1   1
4    2    777  5
1    27   0.083 9.00 0   1   1   1   3    0   1    300.00  0   1   1   0   777  0   1
1    2    2    2
1    28   0.083 7.00 0   1   0   1   4    1   0    777     1   4   4   1   6    0   0
1    3    2    2
1    29   0.083 9.00 1   2   1   1   4    0   1    325.00  0   3   3   1   1    0   1
4    3    3    4
1    30   0.083 9.00 0   2   1   1   1    1   1    350.00  0   3   5   0   777  1   1
1    2    2    5
1    31   0.083 7.00 0   1   1   1   2    0   1    777     0   5   4   1   0.5  1   1
1    2    2    1
1    32   0.083 1.00 1   1   0   1   6    0   1    600.00  0   2   5   1   3    0   0
2    777  777  2
1    33   0.083 7    1   2   1   1   4    1   0    400.00  0   3   7   1   60   1   1
1    3    3    5
1    34   0.083 9    0   2   0   1   8    0   0    585.00  0   5   3   0   777  1   1
3    2    3    5
1    35   0.083 9    0   1   1   1   2    0   0    1100.00 0   3   5   0   777  1   1
2    2    2    5
1    36   0.083 7    1   1   1   1   5    0   0    777     0   777 777 0   777  1   1
777  3    4    5
1    37   0.083 5    1   1   1   1   1    0   1    700.00  1   7   5   1   0.5  1   1
4    2    3    5
1    38   0.083 5    0   3   1   1   5    1   0    350.00  1   5   5   1   24   1   1
1    2    2    5
1    39   0.083 5    0   1   1   1   3    0   1    600.00  0   4   5   1   1    1   1
1    2    1    5
1    40   0.083 7    0   1   1   1   3    1   1    300.00  0   2   2   0   777  1   0
2    2    2    5
1    41   0.083 3    1   1   0   1   10   1   0    400.00  1   5   7   1   0.75 1   1
4    3    2    5
1    42   0.083 9    0   2   0   1   2    1   0    777     1   5   5   1   777  0   1
1    1    3    2
1    43   0.083 1    1   1   0   1   2    0   1    1000.00 1   4   7   1   4    1   1
1    2    2    5
1    44   0.083 7    0   1   1   1   3    0   1    500.00  0   3   7   1   12   1   1
1    1    2    5
1    45   0.083 5    0   1   0   1   10   0   1    777     0   5   5   0   777  1   1
1    2    777  5
1    46   0.083 1    1   1   1   1   10   0   0    777     0   5   5   1   1    1   1
2    2    2    5
1    47   0.083 5    1   3   1   1   4    0   1    1200.00 0   7   7   1   1    1   1
4    2    2    5
1    48   0.083 1    0   2   1   1   2    0   1    400.00  0   5   5   1   0.5  1   1
2    2    2    5
1    49   0.083 1    1   2   1   1   4    1   1    600.00  0   1   1   1   24   0   1
3    2    2    5
1    50   0.083 9    0   1   1   1   4    1   0    800.00  0   2   2   0   777  1   1
4    1    2    5
1    51   0.083 7    1   1   1   1   3    0   777  500.00  0   4   6   0   777  1   1
```

```
2   2   2   5
2   1   0.083 3   0   2   0   1   10   0   0   550.00 0   2   2   1   0.5 0   1
4   2   3   2
2   2   0.083 7   0   3   1   1   7    1   0   400.00 1   2   2   1   2   1   1
4   2   2   5
2   3   0.083 5   1   3   0   1   10   0   0   800.00 0   5   7   1   1   1   1
4   777 777 5
2   4   0.083 5   0   3   1   1   10   0   1   600.00 1   2   2   1   1   7   1
4   3   4   2
2   5   0.083 7   0   3   1   1   10   1   0   500.00 0   2   2   1   1   0   1
4   1   1   2
2   6   0.083 9   0   3   1   1   1    0   0   900.00 0   1   2   1   3   1   1
4   2   2   5
2   7   0.083 1   0   2   0   1   10   0   0   1500.00 0  3   2   1   1   1   1
4   2   2   5
2   8   0.083 7   777 777 777 777 777 777 777  777    777 777 777 777 777 7   7
777 777 777 777
2   9   0.083 3   0   1   1   1   2    1   1   350.00 0   4   4   1   0.5 1   1
2   1   2   5
2   10  0.083 5   1   1   1   1   3    1   1   777    1   5   5   1   216 0   1
1   2   2   2
2   11  0.083 1   1   2   0   1   16   1   1   325.00 1   7   3   1   3   0   1
4   3   3   3
2   12  0.083 1   777 1   0   1   2    0   0   400.00 1   4   5   1   1   1   1
1   2   3   5
2   13  0.083 1   777 777 777 777 777 777 777 777     777 777 777 777 777 7   7
777 777 777 2
2   14  0.083 9   1   3   1   1   1    0   0   750.00 1   777 777 1   180 1   1
2   2   1   5
2   15  0.083 9   1   3   1   1   10   0   1   500.00 1   2   2   0   777 1   1
2   3   3   5
2   16  0.083 7   0   1   0   1   7    1   1   777    0   5   7   1   48  1   1
2   1   1   5
2   17  0.083 5   0   1   1   1   1    1   1   200.00 1   4   5   0   777 1   1
4   2   2   5
2   18  0.083 3   1   1   0   1   10   777 1   400.00 0   2   3   0   777 1   1
4   1   1   5
2   19  0.083 9   0   1   1   1   9    0   0   650.00 0   5   7   1   3   0   1
1   1   2   5
2   20  0.083 7   1   1   1   1   10   0   0   400.00 0   7   5   1   1   1   1
1   2   2   5
2   21  0.083 1   0   1   0   1   2    0   0   250.00 1   1   5   0   777 1   1
1   2   2   5
2   22  0.083 9   0   3   0   1   2    1   1   400.00 1   777 2   1   7   0   1
4   2   2   2
2   23  0.083 5   0   1   1   1   5    1   1   777    0   2   2   1   1   1   1
1   2   2   5
2   24  0.083 7   0   1   1   1   2    0   0   450.00 0   4   5   1   .5  1   1
1   1   1   5
2   25  0.083 9   0   3   1   1   5    1   1   800.00 1   2   2   1   1   1   1
4   1   1   1
2   26  0.083 3   0   2   1   1   5    1   0   300.00 1   5   5   1   .25 1   1
1   4   4   5
2   27  0.083 3   0   1   1   1   5    0   0   500.00 0   4   4   1   2   1   1
1   2   3   5
2   28  0.083 7   0   2   1   1   3    0   0   400.00 0   4   3   1   0.5 1   1
2   2   2   2
2   29  0.083 5   1   1   1   1   4    0   0   600.00 0   7   7   1   4   1   1
2   2   2   3
2   30  0.083 1   1   1   0   1   1    1   1   200.00 0   7   5   1   1   1   1
1   2   3   5
2   31  0.083 9   0   1   1   1   2    1   1   8000.00 0  5   7   1   1   1   1
1   2   1   5
2   32  0.083 1   1   1   0   1   1    1   0   300.00 0   5   5   1   1   1   1
4   2   3   5
2   33  0.083 3   0   1   0   1   15   0   0   350.00 0   3   3   0   777 1   0
4   2   2   5
2   34  0.083 5   1   1   1   0   777  0   1   50.00  0   6   7   0   777 1   1
```

```
1   3   3   5
3   1   0.083 3   0   3   1   1   5   0   1   800.00 1   7   7   1   40  1   1
4   2   2   5
3   2   0.083 1   1   2   1   1   10  1   0   500.00 0   5   5   0   777 1   1
2   2   3   5
3   3   0.083 7   0   3   1   1   5   0   0   2000.00 0  2   2   1   2   1   1
4   2   2   5
3   4   0.083 5   1   3   1   1   1   1   0   900.00 0   1   2   0   777 0   1
4   2   2   2
3   5   0.083 9   0   1   0   1   1   1   0   1000.00 1  5   2   1   777 1   1
1   2   2   5
3   6   0.083 3   0   1   0   1   6   777 0   400.00 1   2   2   1   3   1   1
4   2   2   5
3   7   0.083 7   0   1   1   1   4   0   0   450.00 0   5   4   0   777 1   1
1   2   3   5
3   8   0.083 5   0   1   0   1   1   1   1   777    0   3   3   0   777 1   1
1   777 777 5
3   9   0.083 3   0   1   1   1   3   1   0   900.00 1   7   5   1   1   1   1
4   2   2   5
3   10  0.083 1   1   2   1   1   2   1   0   450.00 1   5   5   1   3   1   1
4   2   2   4
3   11  0.083 1   0   3   1   1   5   1   0   1500.00 0  2   2   1   6   1   1
4   2   2   5
3   12  0.083 3   777 777 777 777 777 777 777 777    777 777 777 777 777 7   7
777 777 777 777
3   13  0.083 5   0   1   0   1   9   1   1   200.00 0   3   2   0   777 1   1
4   2   2   4
3   14  0.083 9   0   1   0   1   6   0   1   1400.00 0  2   3   0   777 1   1
1   3   2   5
3   15  0.083 7   0   2   1   1   10  0   0   500.00 1   4   7   0   777 1   1
1   3   777 5
3   16  0.083 7   0   1   0   1   2   0   0   2000.00 1  7   7   1   8   0   0
1   1   2   5
3   17  0.083 5   0   1   0   1   2   1   0   400.00 1   2   1   0   777 1   1
4   2   2   5
3   18  0.083 3   1   1   1   1   7   0   1   777    0   7   5   0   777 1   1
2   3   3   5
3   19  0.083 9   0   1   1   0   2   1   1   600.00 0   5   7   0   777 1   1
4   2   2   5
3   20  0.083 7   1   1   1   1   2   0   1   450.00 1   5   5   1   777 1   1
2   2   2   5
3   21  0.083 9   0   1   1   1   7   0   0   400.00 1   4   5   1   .25 1   1
2   3   3   5
3   22  0.083 5   1   1   0   1   2   0   0   500.00 0   4   5   0   777 1   1
1   2   2   5
3   23  0.083 1   0   1   1   0   777 1   0   1500.00 1  5   5   1   1   1   1
4   1   1   6
3   24  0.083 5   0   1   1   1   9   0   0   325.00 0   2   2   1   .5  1   1
4   2   2   5
3   25  0.083 1   1   1   0   1   8   0   1   1000.00 1  3   3   1   16  1   1
4   3   3   2
3   26  0.083 3   0   1   1   0   2   0   1   1500.00 1  1   1   0   777 0   1
4   2   2   2
3   27  0.083 7   0   1   1   1   1   1   0   777    0   5   5   1   .5  1   1
4   2   2   5
3   28  0.083 9   0   1   0   1   2   1   0   400.00 1   2   5   1   1   1   1
1   2   2   5
3   29  0.083 3   0   2   0   1   11  0   0   1500.00 0  4   7   0   777 1   1
2   2   2   5
3   30  0.083 9   0   1   0   1   2   1   1   777    0   3   2   0   777 1   1
2   2   3   5
3   31  0.083 7   0   1   1   1   5   1   1   350.00 0   2   2   1   .5  1   1
4   2   2   5
3   32  0.083 5   0   1   0   1   2   0   0   350.00 0   2   4   0   777 1   1
2   2   2   5
3   33  0.083 1   1   1   1   1   7   1   0   1000.00 1  5   2   1   1   1   1
3   2   2   5
3   34  0.083 9   0   1   0   1   2   1   0   400.00 1   2   4   1   0   1   1
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3   1   1     5
3   35  0.083 3    1   2   1   1   2   1   0    270.00 0   2   1   1   777 0 1
1   2   2     2
4   1   0.083 3    1   2   1   1   10  0   1    400.00 1   3   3   0   777 1 1
3   4   4     3
4   2   0.083 9    1   1   0   1   2   1   1    400.00 0   7   7   1   .5  1 1
1   2   2     5
4   3   0.083 5    0   1   0   1   2   0   1    400.00 1   4   4   1   3   1 1
1   2   2     5
4   4   0.083 7    0   1   1   1   2   0   0    400.00 1   7   5   0   777 1 1
4   2   2     5
4   5   0.083 3    0   2   0   1   10  1   0   1000.00 0   5   5   1   .5  1 1
3   2   3     1
4   6   0.083 1    1   1   0   1   10  1   1    250.00 0   4   7   1   .5  1 1
1   2   2     5
4   7   0.083 1    1   1   0   1   9   0   1    800.00 1   2   4   1   2   1 1
1   2   3     1
4   8   0.083 3    0   1   0   1   2   777 1    600.00 0   1   1   0   777 0 1
4   3   2     2
4   9   0.083 1    0   2   1   1   9   1   0    350.00 1   2   2   0   777 1 1
4   3   3     5
4   10  0.083 9    1   2   1   1   2   0   1    800.00 1   5   777 1   13  1 1
2   3   2     2
4   11  0.083 7    0   2   1   1   4   1   1   1200.00 1   2   3   0   777 1 1
4   2   2     5
4   12  0.083 5    0   1   1   1   2   0   1    550.00 0   7   7   1   1   1 1
2   1   2     5
4   13  0.083 3    1   1   1   1   2   1   1    900.00 1   2   3   0   777 1 1
4   3   4     4
4   14  0.083 5    0   1   1   1   3   1   1   1300.00 0   5   2   0   777 1 1
1   2   2     5
4   15  0.083 7    0   2   1   1   10  1   1     80.00 0   4   2   1   1   1 1
1   2   2     5
4   16  0.083 5    0   1   1   1   2   1   1    100.00 0   3   5   0   777 1 1
1   2   2     2
4   17  0.083 1    0   1   1   1   2   0   1    100.00 1   777 777 0   777 1 1
2   2   2     2
4   18  0.083 3    777 2   0   1   2   0   1    777    0   777 777 1   777 1 1
2   777 777   777
4   19  0.083 9    0   1   0   1   4   0   1    400.00 0   2   3   1   2   0 0
2   2   2     3
4   20  0.083 1    0   1   0   1   2   0   0    600.00 1   3   4   0   777 1 1
3   2   2     5
5   1   0.167 12   0   3   1   1   10  1   1    100.00 0   3   2   0   777 1 1
4   2   2     2
5   2   0.00  .50  1   3   1   1   1   1   0    100.00 1   2   1   0   777 1 1
4   2   2     5
5   3   0.00  .50  1   2   1   1   1   1   0    350.00 0   2   4   0   777 1 1
4   2   2     5
5   4   0.167 7    0   2   1   1   10  0   1    400.00 1   7   7   1   1   1 1
1   2   2     5
5   5   0.167 7    777 777 777 777 777 777 777  777    777 777 777 777 777 7 7
777 777 777   777
5   6   0.167 20   0   2   1   1   10  0   0    777    1   3   3   0   777 1 1
1   2   2     5
5   7   0.00  .50  1   2   1   1   2   0   1    500.00 0   4   3   1   48  1 1
4   3   4     2
5   8   0.000 1    1   2   1   1   10  0   1    600.00 1   4   2   1   .5  0 1
1   777 777   2
5   9   0.00  5    0   3   0   1   14  1   0   1000.00 0   7   3   0   777 1 1
4   2   2     5
5   10  0.00  1.5  0   2   1   1   1   1   0    700.00 0   2   2   0   777 1 1
3   3   3     5
5   11  0.00  3    1   2   1   1   10  0   0   2000.00 0   5   5   1   .5  1 1
3   2   3     5
5   12  0.167 9    0   2   0   1   1   1   0    450.00 1   5   5   1   1   1 0
4   2   2     5
5   13  0.167 12   1   1   1   1   2   0   0    700.00 1   2   2   1   1   0 1
```

```
1   2   2   2
5   14  0.167 20   0   1   1   1   10   0   0    500.00 0   4   6   0   777 1  1
1   2   2   5
5   15  0.167 9    0   2   1   1   1    1   0   1000.00 1   4   5   1   1   1  1
1   2   2   5
5   16  0.000 9    1   2   0   1   2    0   1    800.00 0   6   6   0   777 1  1
1   2   2   5
6   1   0.00  9    0   1   1   1   2    0   1    600.00 0   2   3   0   777 1  1
1   2   2   5
6   2   0.000 9    0   1   1   1   2    0   1    400.00 0   6   7   1   3   0  1
1   4   4   4
6   3   0.167 20   777 777 777 777 777  777 777  777     777 777 777 777 777 7  7
777 777 777 777
6   4   0.167 1.5  0   2   1   1   10   0   0   1500.00 0   2   2   1   .25 1  0
4   2   2   5
6   5   0.00  7    1   1   0   1   11   0   0    500.00 0   4   7   1   1.5 1  1
1   3   3   5
6   6   0.167 .5   0   2   1   1   10   0   0    450.00 1   3   2   0   777 1  1
3   2   3   5
6   7   0.167 5    0   1   0   1   2    1   0    777    0   3   2   1   1.5 1  1
1   2   1   5
6   8   0.167 .5   0   2   1   1   10   0   0    200.00 0   5   7   0   777 1  1
1   1   2   5
6   9   0.167 9    777 777 777 777 777  777 777  777     777 777 777 777 777 7  7
777 777 777 777
6   10  0.000 5    0   3   1   1   10   0   0    600.00 1   5   6   1   3   1  1
4   2   2   5
6   11  0.167 1    0   2   1   1   10   1   0    800.00 0   2   2   1   1   1  0
2   2   3   5
6   12  0.167 12   0   1   1   1   10   0   1   4000.00 0   7   3   1   2   1  1
1   2   2   2
6   13  0.00  12   0   2   1   1   2    1   1    275.00 1   1   1   1   1   1  1
4   1   2   4
6   14  0.167 1    1   2   1   1   10   1   0    350.00 1   3   3   1   4   1  1
4   2   2   5
6   15  0.167 20   0   2   0   1   11   0   0    700.00 1   2   4   1   1   1  1
4   1   1   5
6   16  0.00  1    1   2   1   1   10   1   1    500.00 0   5   4   0   777 1  1
1   2   2   5
6   17  0.167 5    1   1   1   1   10   1   0    200.00 0   7   7   1   1   1  1
1   2   2   2
6   18  0.000 20   0   2   1   1   10   1   0    300.00 1   3   6   1   1   1  1
3   2   2   4
6   19  0.167 7    0   1   1   1   2    1   0    400.00 0   5   5   0   777 1  1
2   2   2   5
6   20  0.167 7    0   1   1   1   2    0   0    350.00 1   7   5   1   1   1  1
1   1   1   5
6   21  0.167 2    0   2   0   1   10   0   0    777    1   2   7   1   1   1  1
1   2   2   5
6   22  0.167 20   1   1   1   1   2    1   0   1000.00 1   3   5   0   777 1  1
2   1   3   5
6   23  0.000 10   0   1   1   1   2    0   0    500.00 1   3   2   0   777 1  1
1   2   2   5
6   24  0.167 3    0   2   1   1   10   0   1    450.00 0   3   3   1   1   1  1
4   2   2   1
6   25  0.00  7    0   2   1   1   2    0   1    500.00 0   3   5   1   1   1  1
3   3   2   5
6   26  0.167 .5   1   1   1   1   10   0   1    250.00 1   2   2   1   84  0  1
2   2   2   2
6   27  0.167 12   0   3   1   1   4    1   0   1400.00 1   3   3   1   3   1  1
4   2   2   5
6   28  0.00  1    0   2   1   1   10   0   0    400.00 1   4   4   1   12  1  1
2   2   2   5
6   29  0.167 1.5  1   2   1   1   10   1   0    280.00 0   2   2   1   1   1  1
1   2   2   5
6   30  0.167 5    0   2   1   1   11   0   0    400.00 1   3   2   1   1   1  1
1   2   3   777
6   31  0.00  5    1   2   1   1   10   1   0    450.00 1   5   5   1   58  1  1
```

2	2	2	5															
6	32	0.167	2	1	1	1	1	10	0	1	3000.00	1	3	3	1	24	1	1
1	3	2	5															
6	33	0.167	.5	0	2	1	1	10	0	1	777	0	3	3	1	0	1	1
2	3	2	5															
6	34	0.167	.5	1	1	1	1	2	0	1	3500.00	0	2	2	1	2	0	0
1	2	3	2															
6	35	0.167	7	777	1	1	1	4	0	0	2000.00	1	4	4	1	777	0	1
1	2	2	2															
6	36	0.000	9	0	2	1	1	10	0	1	700.00	0	7	4	1	0	1	0
1	4	2	5															
7	1	0.000	20	0	2	1	1	2	1	1	300.00	0	2	2	0	777	1	1
4	2	2	5															
7	2	0.167	7	1	1	1	1	7	1	0	2000.00	1	2	2	777	777	7	7
777	777	777	777															
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1	2	777	2															
7	4	0.000	2	1	1	0	1	2	0	0	777	0	4	5	0	777	1	1
1	2	2	5															
7	5	0.167	5	0	2	1	1	2	0	1	800.00	0	5	7	1	6	1	1
2	3	3	5															
7	6	0.000	.5	1	3	0	1	4	0	0	2000.00	0	6	5	1	1	1	1
3	2	1	5															
7	7	0.167	5	0	3	1	1	4	1	0	750.00	1	2	2	1	27	1	1
4	3	3	5															
7	8	0.000	20	0	1	0	1	6	1	1	150.00	1	4	2	0	777	1	1
1	2	2	5															
7	9	0.167	12	0	1	1	1	10	0	1	1500.00	1	4	4	1	.5	1	1
1	2	2	5															
7	10	0.167	1	0	3	1	1	10	0	0	1500.00	1	2	4	1	3	1	1
4	1	2	5															
7	11	0.000	1.5	0	1	1	1	4	0	0	777	1	5	7	1	72	1	1
4	2	2	4															
7	12	0.000	7	0	1	0	1	1	1	0	400.00	1	3	4	1	.25	1	1
4	2	2	5															
7	13	0.167	.5	0	1	1	1	1	1	0	777	0	5	5	1	.25	1	0
4	2	2	5															
7	14	0.000	12	1	2	1	1	4	0	0	400.00	777	5	5	0	777	1	1
777	2	2	5															
7	15	0.167	20	0	1	0	1	1	1	0	300.00	0	3	2	0	777	1	1
4	2	2	5															
7	16	0.000	3	0	1	1	1	2	0	0	400.00	1	3	4	1	.5	1	1
1	2	2	5															
7	17	0.000	12	0	2	0	1	6	1	0	350.00	1	4	5	0	777	1	1
3	2	2	5															
7	18	0.167	1	0	1	1	1	2	1	1	500.00	0	2	3	0	777	1	1
2	3	2	5															
7	19	0.167	7	0	1	0	1	8	1	0	777	0	7	7	0	777	1	1
1	1	1	5															
7	20	0.167	12	0	1	0	1	2	1	0	777	0	2	2	1	2	1	1
1	2	1	5															
7	21	0.167	9	0	2	0	1	2	1	1	500.00	0	7	7	1	1	1	1
4	2	2	5															
7	22	0.167	9	0	2	0	1	2	0	0	300.00	0	2	5	1	.5	1	1
4	2	2	5															
7	23	0.000	3	1	1	1	1	2	0	777	5500.00	0	4	7	1	.5	1	1
1	2	2	5															
7	24	0.000	3	1	1	1	1	10	0	0	5000.00	1	6	6	1	1	1	1
1	2	2	5															
7	25	0.167	12	0	1	0	1	1	1	0	250.00	0	2	2	1	.5	1	1
1	777	777	5															
7	26	0.000	20	0	1	0	1	2	0	1	100.00	1	3	3	0	777	1	1
2	2	2	2															
7	27	0.167	10	0	1	0	1	2	0	1	250.00	1	2	2	1	12	1	1
1	777	4	2															
7	28	0.167	5	1	1	1	1	1	1	0	375.00	0	5	5	0	777	1	0
4	2	2	5															
7	29	0.167	9	1	1	1	0	777	0	0	5500.00	1	7	7	1	1	1	1

1	2	3	5															
7	30	0.000	1	0	1	1	1	2	0	0	777	0	5	5	0	777	1	1
1	2	3	5															
7	31	0.167	9	0	1	1	1	2	0	1	777	1	2	2	0	777	1	1
2	2	2	5															
7	32	0.167	7	0	1	1	1	10	0	0	350.00	0	5	7	1	4	1	1
3	2	2	5															
7	33	0.167	.5	0	1	1	1	11	1	0	425.00	1	2	2	1	.25	1	1
4	777	777	5															
7	34	0.167	7	0	1	1	1	2	0	1	1500.00	1	4	1	1	1	1	1
1	2	2	5															
7	35	0.167	20	0	1	0	1	6	1	1	450.00	0	4	4	0	777	1	1
1	2	2	5															
7	36	0.167	10	0	1	1	1	8	1	0	300.00	1	2	3	0	777	1	1
2	2	2	5															
7	37	0.000	12	0	2	1	1	10	1	1	300.00	0	4	4	1	1	1	1
4	2	2	5															
7	38	0.000	12	0	2	1	1	7	1	0	350.00	1	4	2	1	.5	1	1
2	2	2	5															
7	39	0.000	3	0	2	0	1	2	1	1	450.00	0	2	3	1	.3	1	0
4	2	2	5															
7	40	0.000	3	0	2	1	1	4	1	0	400.00	0	5	5	1	1	1	1
2	1	1	2															
7	41	0.000	3	1	1	0	1	10	1	0	777	1	7	5	0	777	1	1
3	2	2	5															
7	42	0.000	3	0	1	0	1	6	1	1	175.00	1	4	4	0	777	1	1
4	2	3	5															
7	43	0.000	3	0	1	1	1	7	0	1	500.00	0	2	4	0	777	1	1
2	3	2	5															
7	44	0.000	10	0	1	1	1	9	0	0	777	1	4	7	1	1	1	1
2	2	2	5															
7	45	0.167	5	0	1	1	1	4	0	0	500.00	1	5	5	0	777	1	1
4	2	2	5															
7	46	0.167	20	0	1	0	1	8	1	1	100.00	1	2	2	0	777	1	1
4	2	2	5															
7	47	0.167	.5	1	1	1	0	777	1	0	250.00	0	2	1	0	777	1	1
2	2	777	1															
7	48	0.000	2	1	1	1	0	777	1	1	500.00	0	2	4	0	777	1	1
2	2	3	5															
7	49	0.000	9	0	1	1	1	1	1	1	700.00	0	5	2	0	777	1	1
2	2	2	5															
7	50	0.000	3	1	1	0	1	4	0	0	500.00	0	7	2	0	777	1	1
4	3	2	5															
7	51	0.167	1	0	1	1	1	1	1	1	500.00	0	4	4	0	777	0	0
1	2	2	2															
7	52	0.167	9	0	2	0	1	10	0	1	900.00	1	2	5	1	36	0	1
1	2	2	2															
7	53	0.167	20	0	1	0	1	2	0	0	700.00	0	1	3	1	1	1	1
3	777	3	5															
7	54	0.167	3	0	1	1	1	4	1	0	380.00	1	2	3	0	777	1	1
2	2	2	5															
7	55	0.000	3	0	1	0	1	2	1	1	450.00	0	5	7	1	.5	1	1
2	2	2	5															
7	56	0.167	20	0	2	1	1	4	0	1	500.00	0	7	5	1	1	1	1
1	2	2	5															
7	57	0.167	10	0	3	1	1	4	1	0	800.00	0	1	1	1	60	1	1
3	2	1	5															
7	58	0.000	1	1	1	1	0	777	0	0	240.00	0	4	6	0	777	1	1
4	2	2	777															
7	59	0.000	1	1	3	0	1	2	1	0	500.00	0	4	3	1	12	0	1
4	2	2	2															
7	60	0.167	7	0	2	1	1	1	0	1	350.00	0	4	4	1	1	1	7
777	777	777	777															
7	61	0.167	2	0	1	1	1	2	1	0	830.00	1	6	5	0	777	1	1
1	2	2	5															
8	1	0.083	5	1	3	1	1	1	1	1	1000.00	1	3	3	0	777	1	1
4	2	2	777															
8	2	0.083	9	1	1	0	1	6	1	1	250.00	1	2	2	1	.5	1	1

1	2	3	5															
8	3	0.083	9	0	1	1	1	1	1	1	300.00	0	3	5	1	6	1	1
4	3	3	5															
8	4	0.083	7	0	1	0	1	1	1	0	600.00	0	4	4	0	777	1	1
3	3	2	5															
8	5	0.083	7	0	2	1	1	8	1	0	777	1	3	3	0	777	1	1
2	2	2	5															
8	6	0.083	7	1	1	0	1	2	0	0	1000.00	1	3	3	1	1	0	0
1	2	2	2															
8	7	0.083	1	1	3	0	1	8	1	0	800.00	0	1	2	0	777	1	1
1	2	2	5															
8	8	0.083	7	0	1	0	1	6	1	1	50.00	1	3	3	0	777	1	1
1	2	2	5															
8	9	0.083	9	0	1	0	1	2	0	1	850.00	0	777	777	0	777	1	1
1	2	2	5															
8	10	0.083	5	1	1	0	1	6	0	1	1500.00	1	2	1	1	777	1	1
3	1	3	3															
8	11	0.083	3	0	1	1	1	10	0	0	200.00	0	2	5	0	777	1	1
2	2	2	5															
8	12	0.083	3	1	2	0	1	9	1	0	500.00	1	4	4	1	1	1	1
2	2	2	5															
8	13	0.083	1	1	1	1	1	1	0	0	400.00	0	2	2	1	1	1	1
1	4	4	1															
8	14	0.083	9	0	2	0	1	2	0	0	150.00	0	5	7	0	777	1	1
2	1	2	4															
8	15	0.083	7	0	1	0	1	2	1	0	250.00	1	4	4	0	777	1	0
2	2	2	5															
8	16	0.083	3	0	2	0	1	2	0	0	1200.00	0	2	7	1	1	1	1
3	2	2	5															
8	17	0.083	5	0	2	0	1	10	0	0	250.00	0	1	5	1	24	1	1
1	2	3	2															
8	18	0.083	9	0	2	1	1	10	0	0	550.00	1	6	7	0	777	1	1
1	2	2	5															
8	19	0.083	1	0	1	1	1	2	0	1	450.00	1	2	3	1	.25	1	1
2	2	2	5															
8	20	0.083	9	0	2	1	1	3	1	0	350.00	1	5	2	1	12	1	1
4	2	3	5															
8	21	0.083	5	0	1	1	1	8	0	0	350.00	0	2	2	1	1	1	1
1	2	2	5															
8	22	0.083	3	0	1	1	1	4	0	1	800.00	0	5	5	1	3	0	1
1	2	2	2															
8	23	0.083	1	1	2	0	1	2	0	0	600.00	1	2	2	1	3	1	1
1	2	2	5															
8	24	0.083	1	0	3	1	1	1	1	0	1500.00	0	5	5	1	1	1	1
4	1	2	5															
8	25	0.083	5	0	1	0	1	6	0	1	200.00	0	2	3	0	777	1	1
1	2	2	5															
8	26	0.083	5	0	2	1	1	2	0	0	777	0	5	5	1	7	1	1
4	2	2	5															
8	27	0.083	3	0	3	0	1	6	0	1	250.00	1	4	777	1	36	0	1
1	1	1	3															
8	28	0.083	1	1	2	1	1	2	0	1	400.00	0	7	7	1	1	1	1
2	2	2	5															
8	29	0.083	9	1	1	1	1	2	0	1	777	0	7	7	1	1	1	1
1	2	2	5															
8	30	0.083	7	0	1	0	1	10	1	0	777	0	7	7	0	777	1	1
1	2	2	5															
8	31	0.083	1	1	1	1	1	10	0	0	2000.00	0	4	3	1	1	1	1
2	2	2	5															
8	32	0.083	9	0	1	0	1	5	1	1	800.00	1	7	7	1	.5	1	1
1	2	2	5															
8	33	0.083	3	0	1	1	1	9	0	0	8000.00	0	5	7	0	777	1	0
2	1	1	5															
8	34	0.083	5	0	1	1	1	4	1	0	600.00	0	3	5	0	777	1	0
3	2	2	1															
8	35	0.083	9	0	1	1	1	2	1	0	450.00	1	5	7	0	777	1	1
3	2	2	2															
8	36	0.083	7	0	1	0	1	6	1	0	777	0	7	5	1	.5	1	1

1	2	2	5															
8	37	0.083	5	1	1	0	1	6	0	0	400.00	0	4	4	0	777	1	1
1	2	3	5															
8	38	0.083	5	1	1	0	1	2	0	0	600.00	1	2	3	0	777	0	0
2	3	3	2															
8	39	0.083	7	1	1	1	1	9	0	1	110.00	0	2	2	0	777	1	1
2	2	2	5															
8	40	0.083	7	1	1	0	1	5	0	0	400.00	1	3	3	1	2	1	1
4	3	3	5															
8	41	0.083	3	1	3	0	1	8	0	0	750.00	0	5	5	1	1	1	1
3	2	777	5															
9	1	0.083	3	0	2	0	1	9	0	0	215.00	1	5	5	1	120	1	1
2	2	777	5															
9	2	0.000	.5	1	1	0	1	2	0	0	500.00	0	4	4	1	7	1	1
1	2	2	5															
9	3	0.167	20	0	3	1	1	5	0	0	1500.00	1	7	7	1	25	1	1
2	2	3	5															
9	4	0.083	3	0	1	1	1	8	1	0	250.00	0	2	5	0	777	1	1
1	2	1	5															
9	5	0.083	1	0	2	0	1	2	1	0	600.00	0	5	7	0	777	0	1
1	2	2	2															
9	6	0.167	12	0	1	1	1	10	0	0	400.00	1	5	5	1	1	1	1
2	1	1	5															
9	7	0.167	1.5	0	1	1	1	4	1	0	777	0	5	4	1	1	1	1
1	2	777	4															
9	8	0.083	7	0	1	1	1	2	1	1	1500.00	1	2	2	0	777	1	0
4	4	3	5															
9	9	0.167	3	0	1	1	1	8	1	0	1000.00	0	7	5	0	777	1	1
2	2	2	5															
9	10	0.083	1	0	3	0	1	9	1	0	1500.00	0	2	2	0	777	1	1
4	2	2	5															
9	11	0.167	2	0	1	1	1	1	1	0	400.00	1	5	7	1	.5	1	1
2	2	2	5															
9	12	0.167	1	0	2	1	1	2	1	0	777	0	777	777	1	1	1	1
1	2	2	2															
9	13	0.167	20	0	1	0	1	3	0	1	1000.00	1	3	7	0	777	1	1
4	3	2	5															
9	14	0.167	.5	0	1	0	1	6	0	1	900.00	0	4	4	1	2	0	1
2	2	2	2															
9	15	0.083	3	0	3	777	1	9	1	1	4.00	1	5	3	0	777	1	0
4	4	4	5															
9	16	0.083	9	777	2	1	1	4	1	0	1500.00	1	4	6	1	168	0	1
4	2	2	2															
9	17	0.083	1	1	3	0	1	6	0	0	200.00	1	3	7	1	2	1	1
4	2	3	5															
9	18	0.083	1	1	1	1	1	1	1	1	700.00	1	5	7	1	1	1	1
3	2	2	5															
9	19	0.167	2	1	2	0	1	2	1	0	777	1	1	1	1	144	0	1
3	1	4	4															
9	20	0.167	1.5	1	1	1	1	8	1	0	340.00	0	5	5	0	777	1	1
4	1	2	5															
9	21	0.167	1.5	1	1	1	1	7	0	0	777	1	2	2	1	1	1	1
3	3	4	5															
9	22	0.167	1	1	1	1	1	3	1	777	3500.00	1	5	7	0	777	1	1
1	2	2	2															
9	23	0.167	2	1	1	0	1	7	1	0	650.0	1	3	2	1	36	1	1
4	3	4	1															
9	24	0.000	.5	1	2	1	1	10	0	0	600.00	1	6	7	0	777	1	1
1	2	2	5															
9	25	0.167	2	1	1	1	1	7	1	0	550.00	1	2	5	0	777	1	1
2	2	2	5															
9	26	0.167	1	1	1	1	1	2	0	0	450.00	0	5	5	1	4	1	1
4	3	4	5															
9	27	0.167	.5	1	2	1	1	9	0	0	350.00	1	7	7	1	3	0	1
2	2	2	2															
9	28	0.167	9	1	1	1	1	2	1	1	400.00	1	1	3	1	12	0	1
1	2	2	2															
9	29	0.167	2	1	2	1	1	2	0	1	1000.00	0	7	5	1	1	1	1

```
1   4   4   2
9   30  0.000 20   777 3   1   1   8   0   0   777     1   777 777 777 777 1  1
4   2   3   2
9   31  0.000 20   0   1   1   1   9   1   0   500.00 1   4   7   1   15  1  1
4   2   3   5
9   32  0.000 .5   0   1   1   1   1   1   1   300.00 1   3   2   0   777 1  1
4   2   1   5
9   33  0.000 5    0   1   1   1   2   1   1   1000.00 0  2   2   1   24  0  1
1   2   3   2
9   34  0.000 7    1   1   1   1   3   1   1   550.00 1   2   777 0   777 1  1
3   2   2   5
9   35  0.000 5    1   2   0   1   2   0   0   400.00 1   5   7   1   13  1  1
4   2   2   5
9   36  0.000 1.5  1   2   1   1   7   1   0   370.00 1   2   4   1   1   1  1
1   1   4   5
9   37  0.000 20   1   2   1   1   1   0   0   600.00 1   1   1   1   192 1  1
4   4   777 4
9   38  0.000 2    1   1   1   1   2   0   1   1200.00 1  4   7   1   1   0  0
1   2   2   2
9   39  0.000 2    1   1   1   0   12  1   1   700.00 1   5   7   0   777 1  1
4   3   2   2
9   40  0.083 5    0   1   1   0   777 0   1   700.00 0   7   7   0   777 1  1
2   2   2   5
9   41  0.083 1    0   1   0   1   9   0   1   250.00 0   5   4   0   777 1  0
1   2   777 5
9   42  0.167 20   0   1   1   1   1   0   0   500.00 1   5   7   1   36  1  1
1   2   3   5
9   43  0.083 3    0   1   0   1   1   1   1   175.00 0   4   4   1   2   1  1
1   2   2   5
9   44  0.083 1    0   2   0   1   9   0   1   500.00 0   4   2   0   777 1  1
2   2   2   5
10  1   0.000 7    0   1   0   1   1   0   1   350.00 1   7   5   0   777 1  1
2   2   2   5
10  2   0.000 7    0   2   1   1   4   0   0   800.00 0   2   5   1   .03 1  1
4   2   2   5
10  3   0.000 10   0   1   1   1   2   0   0   777     1   5   3   1   .5  1  1
1   2   2   5
10  4   0.167 1    0   1   1   1   1   1   1   200.00 1   4   5   0   777 1  1
4   2   2   5
10  5   0.000 12   0   1   0   1   8   0   1   200.00 1   2   3   0   777 1  1
1   3   3   2
10  6   0.167 1.5  0   2   0   1   1   0   1   60000.0 0  5   5   1   4   0  1
4   2   2   2
10  7   0.167 1.5  1   1   1   1   4   0   0   1100.00 0  2   2   1   6   0  0
1   1   1   2
10  8   0.000 5    1   1   1   1   3   1   1   400.00 0   2   2   1   12  0  1
1   2   2   2
10  9   0.000 10   1   2   1   1   5   1   0   350.00 1   2   7   0   777 1  1
4   2   2   5
10  10  0.167 5    1   2   1   1   5   0   0   3000.00 1  5   5   1   1   1  1
4   2   3   5
10  11  0.167 7    1   1   1   1   4   0   0   250.00 0   5   7   1   777 1  1
2   2   2   5
10  12  0.000 10   0   3   0   1   8   1   0   1500.00 0  2   2   1   4   1  1
4   1   1   5
10  13  0.000 .5   1   1   0   1   6   1   1   777     0   3   2   0   777 1  1
1   2   2   5
10  14  0.167 3    0   1   1   1   2   0   1   7000.00 0  4   6   1   36  0  1
4   2   2   2
10  15  0.000 5    1   1   0   1   6   0   1   400.00 0   7   5   1   3   1  1
1   3   3   5
10  16  0.167 3    777 1   1   1   9   1   0   550.00 1   2   2   777 777 7  7
777 777 777 777
10  17  0.167 12   0   1   0   1   2   0   1   2000.00 1  2   2   0   777 0  1
1   2   2   2
10  18  0.167 10   0   1   1   1   2   0   0   777     1   5   4   1   1   1  1
1   2   2   5
10  19  0.167 5    0   1   1   1   1   1   1   600.00 0   7   2   0   777 1  0
```

```
3   2   3   5
10  20  0.167 2   0  3  0  1  2   1  0  1000.00 0  5   5   1  60  1  1
1   2   3   2
10  21  0.167 5   0  1  0  1  6   1  1  600.00  0  3   3   0  777 1  1
1   2   2   5
10  22  0.000 10  1  2  1  1  2   0  0  300.00  1  5   6   0  777 1  1
3   2   2   5
10  23  0.000 9   0  1  0  1  2   1  0  450.00  0  7   7   1  1   1  1
3   2   2   5
10  24  0.000 20  1  1  0  1  2   0  1  777     0  777 777 1  .5  1  1
1   777 777 1
10  25  0.000 10  0  1  1  0  777 0  1  777     0  5   3   1  .5  1  1
1   1   777 5
10  26  0.000 12  0  1  1  1  1   1  0  400.00  0  4   3   1  1   1  1
4   2   2   5
10  27  0.167 9   1  1  0  1  2   1  0  777     1  5   4   1  1   1  1
2   2   1   5
10  28  0.167 5   1  2  1  1  4   1  0  700.00  1  3   5   1  12  1  1
4   2   2   5
10  29  0.000 10  0  1  0  1  2   0  1  777     0  7   7   0  777 1  1
1   2   2   5
10  30  0.167 10  0  1  0  1  1   1  0  777     1  5   5   0  777 1  1
2   2   2   5
10  31  0.000 12  1  2  1  1  2   0  0  700.00  1  2   4   1  .5  1  1
4   2   2   5
10  32  0.000 .5  1  2  1  0  10  0  0  300.00  0  4   5   1  12  1  1
4   2   2   5
10  33  0.167 20  1  2  1  1  3   0  1  250.00  0  1   1   1  1   7  1
4   2   2   777
10  34  0.000 5   0  2  1  0  777 1  1  700.00  1  777 777 1  9   0  1
3   1   1   2
10  35  0.167 1.5 0  2  1  1  10  1  1  600.00  1  2   1   1  6   1  1
4   1   2   5
10  36  0.167 10  0  1  0  1  2   0  0  400.00  1  2   2   1  777 1  1
2   1   1   5
10  37  0.167 12  0  2  1  1  4   1  0  777     0  5   4   1  .5  1  1
1   2   1   5
10  38  0.167 9   0  2  0  1  6   0  0  280.00  0  3   3   1  1   1  1
2   2   3   2
10  39  0.167 10  0  1  1  1  2   0  0  2000.00 1  6   6   1  1   1  1
4   2   2   5
10  40  0.167 10  0  2  1  1  4   1  0  700.00  1  2   7   1  777 1  1
4   2   3   5
10  41  0.000 10  1  1  0  1  2   1  0  350.00  0  4   5   1  1   1  1
1   2   2   5
10  42  0.167 1   0  1  0  1  6   1  0  400.00  1  1   2   1  .63 1  1
2   2   2   5
10  43  0.167 9   0  1  0  1  2   0  1  777     0  7   7   1  .5  1  1
1   2   3   5
10  44  0.167 12  0  1  1  1  4   0  1  2000.00 1  1   1   1  1   0  1
1   3   2   2
10  45  0.000 7   0  1  1  1  4   1  0  600.00  0  7   7   1  1   1  1
2   2   1   5
10  46  0.000 12  0  1  1  1  3   0  1  450.00  0  4   3   1  1.5 1  1
1   777 3   5
10  47  0.167 5   0  1  1  1  2   0  0  200.00  0  4   2   1  777 1  1
1   2   2   5
10  48  0.000 10  0  2  0  1  6   0  0  1000.00 0  1   7   0  777 1  1
4   2   1   5
10  49  0.167 5   0  1  0  1  2   0  0  650.00  0  2   4   0  777 1  1
4   2   2   5
10  50  0.000 5   0  1  1  1  2   0  1  1000.00 0  7   7   0  777 1  1
2   2   2   5
10  51  0.000 7   1  2  0  1  1   0  1  20000.0 1  2   2   0  777 1  1
1   2   2   1
10  52  0.167 5   0  1  0  1  2   1  0  400.00  1  2   6   1  6   1  1
1   3   2   5
10  53  0.167 12  0  1  0  1  6   1  1  450.00  0  3   2   1  .5  1  1
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2	2	2	5															
10	54	0.167	7	0	1	0	1	2	1	0	777	1	3	2	1	.03	1	1
1	2	2	5															
10	55	0.167	20	0	1	0	1	2	777	1	777	0	4	2	1	1.5	1	1
3	2	2	5															
10	56	0.000	2	0	2	1	1	4	1	1	400.00	0	3	3	0	777	1	1
1	1	1	5															
10	57	0.167	20	0	1	0	1	7	0	0	100.00	1	4	4	1	1	1	1
1	2	3	5															
10	58	0.000	9	0	2	0	1	6	1	0	300.00	1	5	7	1	5	1	1
2	2	2	5															
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1	2	2	5															
11	2	0.167	3	0	2	1	1	2	1	0	400.00	0	3	6	1	2.5	1	1
2	2	2	5															
11	3	0.167	10	1	1	1	1	2	0	1	1000.00	1	7	6	1	777	0	1
1	2	1	2															
11	4	0.167	2	0	1	1	1	1	1	0	90000.0	1	7	4	1	1	1	1
4	2	2	5															
11	5	0.167	.5	1	2	1	1	10	0	0	800.00	1	2	2	0	777	1	1
2	2	3	5															
11	6	0.167	10	1	1	1	1	10	0	0	1000.00	1	5	5	1	1	0	1
2	2	3	2															
11	7	0.167	3	0	2	1	1	1	1	0	350.00	1	5	7	1	.5	1	1
4	2	2	5															
11	8	0.167	2	0	3	0	1	10	1	1	700.00	0	2	2	1	48	0	1
1	3	3	2															
11	9	0.167	3	1	1	1	1	10	0	1	500.00	1	5	5	1	125	1	1
1	2	2	2															
11	10	0.167	7	1	2	1	1	1	0	0	600.00	0	5	7	1	10	0	1
1	2	2	5															
11	11	0.167	10	0	2	1	1	2	0	1	700.00	0	5	4	1	32	0	1
1	2	1	2															
11	12	0.167	10	1	1	1	1	10	0	0	600.00	1	3	3	1	36	0	1
3	3	3	5															
11	13	0.000	12	0	1	1	1	2	1	1	600.00	0	2	2	1	.5	1	1
1	1	1	5															
11	14	0.000	2	1	3	1	1	14	0	0	1300.00	0	1	3	1	48	0	1
4	2	2	777															
11	15	0.000	12	0	2	1	1	10	0	1	1000.00	0	4	777	1	10	1	1
3	2	2	5															
11	16	0.000	7	0	2	1	1	10	0	1	900.00	1	3	5	1	12	0	1
4	3	2	2															
11	17	0.000	9	0	1	1	1	10	0	0	777	1	3	5	0	777	1	1
1	2	2	5															
11	18	0.000	3	0	2	1	1	10	777	1	325.00	0	5	7	0	777	1	1
1	2	2	5															
11	19	0.000	1.5	1	1	1	1	2	0	0	900.00	1	2	5	1	1	1	1
1	2	2	5															
11	20	0.000	5	0	1	1	1	10	1	0	400.00	0	4	4	1	.5	1	1
2	2	2	5															
11	21	0.000	7	0	1	0	1	1	0	0	350.00	1	5	7	1	.25	1	1
3	1	1	5															
11	22	0.000	7	0	2	1	1	1	1	0	800.00	0	2	7	0	777	1	1
1	2	777	5															
11	23	0.000	10	1	2	0	1	1	1	1	700.00	1	5	5	0	777	1	1
4	2	2	5															
11	24	0.000	2	0	2	1	1	10	1	0	650.00	0	7	6	0	777	1	1
2	2	2	5															
11	25	0.000	9	0	3	1	1	2	1	0	500.00	0	4	5	1	1	1	1
5	2	2	2															
11	26	0.000	1.5	0	2	1	1	14	0	1	600.00	0	1	1	1	12	0	1
1	2	2	5															
11	27	0.000	7	0	2	1	777	10	1	1	450.00	0	3	3	1	1	1	1
4	2	2	1															
11	28	0.000	9	0	2	1	1	4	0	1	500.00	0	2	1	0	777	1	1
2	2	2	2															

11	29	0.000	7	1	3	1	1	1	0	0	1500.00	0	5	5	1	12	0	1
4	1	1	5															
11	30	0.000	2	0	1	0	1	10	0	0	400.00	1	4	7	1	1	1	1
2	3	2	5															
11	31	0.000	2	0	2	1	1	10	1	0	1000.00	1	2	1	1	3	1	1
4	2	2	5															
12	1	0.167	1.5	0	2	1	1	10	0	0	400.00	0	2	5	1	.25	1	1
1	1	2	5															
12	2	0.167	1.5	0	2	0	1	2	1	0	777	1	5	5	1	9	0	1
1	2	2	2															
12	3	0.000	0.5	0	2	1	1	10	1	0	777	1	6	6	1	1	1	1
4	3	4	5															
12	4	0.000	20	0	2	1	1	10	0	0	900	1	2	2	1	1	1	1
2	1	1	5															
12	5	0.167	1.5	1	2	1	1	10	0	0	350	0	3	4	1	1	1	1
3	2	3	4															
12	6	0.000	0.5	1	1	2	1	2	0	0	777	0	2	2	1	6	0	1
1	2	2	2															
12	7	0.000	1	1	1	1	1	2	0	1	1000	1	1	2	1	84	0	1
1	2	2	2															
12	8	0.167	1.5	1	2	1	777	2	0	1	700.00	0	2	2	1	3	0	1
1	3	2	2															
12	9	0.000	5	0	2	1	1	10	1	1	800.00	1	1	1	1	40	0	1
3	2	3	2															
12	10	0.000	20	0	2	1	1	10	0	0	500	1	2	7	1	25	0	1
1	2	2	2															
12	11	0.000	1	1	2	0	1	10	1	0	1200	0	3	5	0	0	1	0
4	2	2	5															
12	12	0.167	1.5	1	2	1	1	10	0	0	800	0	5	7	1	1	0	1
1	1	1	2															
12	13	0.000	1.5	0	2	1	1	10	1	0	1000	0	2	2	1	2	1	0
3	2	2	5															
12	14	0.000	12	1	2	1	1	2	0	0	1000	0	3	3	1	12	0	1
1	2	2	2															
12	15	0.000	0.5	0	2	1	1	2	0	0	500	1	2	7	1	120	1	1
4	2	3	5															
12	16	0.000	20	0	2	1	1	2	1	1	200	0	777	777	777	777	7	7
777	777	777	777															
12	17	0.000	20	0	2	1	1	10	1	0	700	1	3	7	1	1	0	1
1	2	2	2															
12	18	0.000	1.5	1	2	0	1	10	0	1	350	1	2	5	1	36	0	1
1	2	2	2															
12	19	0.000	2	1	1	0	1	2	0	1	1000	1	1	4	1	48	0	1
1	3	2	2															
12	20	0.000	1.5	1	3	1	1	1	1	0	1500	0	1	1	1	48	0	1
1	2	2	5															
12	21	0.000	1.5	1	2	1	1	10	1	1	1000	0	1	1	1	36	1	1
3	1	2	2															
12	22	0.000	2	1	2	1	1	10	1	0	800	0	4	7	1	36	0	1
1	2	2	2															
12	23	0.000	9	1	2	1	1	2	0	1	1200	0	4	5	0	0	1	1
2	1	1	5															
13	1	0.000	1	1	1	0	1	2	1	0	350	0	2	2	1	3	1	1
1	1	2	5															
13	2	0.000	20	0	2	1	1	3	0	1	550	0	2	1	0	0	1	1
1	2	2	1															
13	3	0.000	5	0	2	1	1	2	0	0	1000	1	7	7	1	102	1	1
4	2	2	5															
13	4	0.000	12	0	3	1	1	4	1	0	1000	1	7	2	1	15	1	1
4	1	2	5															
13	5	0.000	7	0	2	0	1	2	0	0	300	1	4	2	0	0	1	1
1	1	1	5															
13	6	0.000	1	0	3	1	1	4	1	1	5000	0	7	7	0	0	1	1
4	4	4	2															
13	7	0.000	7	0	3	0	1	6	1	0	800	1	2	2	1	.25	1	1
4	2	2	5															
13	8	0.000	9	0	2	0	1	10	0	0	700	1	6	5	1	1	1	1
4	2	2	5															

```
13   9    0.000 9     1    2    0    1    6    1    0     600    0    3    3    0    0    1    0
1    2    2     5
13   10   0.000 3     1    2    1    1    3    0    0     500    1    2    3    0    0    1    1
1    3    3     5
13   11   0.000 5     0    2    1    1    2    0    1     400    0    7    2    1    2    1    1
1    3    2     5
13   12   0.000 1     0    3    0    1    14   0    0     500    0    7    6    1    .5   1    1
4    3    2     5
13   13   0.000 5     1    2    0    1    2    0    0     300    0    1    2    1    777  0    1
4    1    1     2
13   14   0.000 9     0    2    0    1    6    0    0     250    0    7    7    1    36   1    1
4    3    2     5
13   15   0.000 1     1    1    0    1    10   1    0     800    0    6    4    0    0    1    1
1    2    2     5
13   16   0.000 1.5   1    1    1    1    2    0    0     1000   1    1    4    0    0    1    0
1    3    3     5
13   17   0.000 1.5   1    2    0    1    6    1    0     600    0    3    3    0    0    1    0
1    3    3     5
13   18   0.000 10    777  1    2    0    2    1    1     1100   0    2    3    1    28   0    1
3    1    1     2
genr sz=51
* where sz equals the class size
if(cls.eq.2)sz=34
if(cls.eq.3)sz=35
if(cls.eq.4)sz=20
if(cls.eq.5)sz=16
if(cls.eq.6)sz=36
if(cls.eq.7)sz=61
if(cls.eq.8)sz=41
if(cls.eq.9)sz=44
if(cls.eq.10)sz=58
if(cls.eq.11)sz=31
if(cls.eq.12)sz=23
if(cls.eq.13)sz=18
genr pie=0.0615
* where pie is the probability, calculated from class rosters, that the sum of last four
*digits of social security number is between 0-10.
if(cls.eq.2)pie=0.0704
if(cls.eq.3)pie=0.0704
if(cls.eq.4)pie=0.0367
if(cls.eq.5)pie=0.1111
if(cls.eq.6)pie=0.0578
if(cls.eq.7)pie=0.12
if(cls.eq.8)pie=0.0714
if(cls.eq.9)pie=0.125
if(cls.eq.10)pie=0.0948
if(cls.eq.11)pie=0.086
if(cls.eq.12)pie=0.00
if(cls.eq.13)pie=0.286
stop
```