Working Papers Series

Working Paper WP93/09 September 1993

COSTLY INFORMATION AND ESTIMATING EXISTENCE VALUES

by

Daniel Rondeau
Kimberly S. Rollins
Patrick Martin

UNIVERSITY of GUELPH

Department of Agricultural Economics and Business

University of Guelph
Guelph, Ontario
Canada
N1G 2W1

COSTLY INFORMATION AND ESTIMATING EXISTENCE VALUES

by

Daniel Rondeau*
Kimberly S. Rollins**
and
Patrick Martin***

WORKING PAPER WP93/09
Department of Agricultural Economics and Business
University of Guelph

September 1993

Paper presented at the joint Association of Environmental and Resource Economists/American Agricultural Economics Association summer meetings, Orlando, Florida, August 3, 1993.

* Research Coordination Branch, Canadian Parks Service, Hull, Quebec, Canada, K1A 0H3;
** Department of Agricultural Economics and Business, University of Guelph, Ontario, Canada, N1G 2W1;
*** Department of Economics, University of Guelph, Ontario, Canada, N1G 2W1.

Correspondence should be address to: Daniel Rondeau, Economic Analyst
Canadian Parks Service
6th Floor - 25 Eddy Street
Hull, Quebec K1A 0H3

COSTLY INFORMATION and ESTIMATING EXISTENCE VALUES

ABSTRACT

The theoretical and empirical implications of information effects on estimates of existence values (EV) are analyzed using a Household Production model. If households operate in perfect information markets, current practices of providing "policy relevant" or "complete" information to respondents to Contingent Valuation (CV) surveys may produce larger benefit estimates than should be used in damage assessment and benefit-cost analysis. However, the probable failure of information markets provides a rationale for the provision of information. An empirically applicable rule is derived that determines the optimal level of information use when estimating existence values. Adopting this methodology would provide an improved decision rule, reinforce the validity and credibility of CVM results, and promote the acceptance of EV and other nonuse values as a desirable component of benefit-cost analysis.

COSTLY INFORMATION and ESTIMATING EXISTENCE VALUES

by Daniel RONDEAU, Kimberly S. ROLLINS and Patrick MARTIN

Introduction

The general population is seldom aware of the characteristics and functions of environmental goods, such as natural spaces and species, for which existence values (EV) are measured. This lack of knowledge imposes that survey instruments used in applications of the Contingent Valuation Method (CVM) provide respondents with new information about the characteristics and functions of the good being valued. As Bishop and Welsh (1992) note, "generalizing such values from samples to population does raise concerns because such values are <u>conditional</u> existence values in the sense that they would exist only if the population as a whole were fully informed". While survey design protocols advocate the use of "policy relevant" or "complete" information in order to stimulate an appropriate cognitive consideration of the scenario by respondents, little attention has been devoted to analysing the welfare implications of information provision.

This paper explores the effects of explicitly recognizing costly acquisition and public provision of information in theoretical modelling of existence values, and on the measures of welfare change estimated using the Contingent Valuation Method. After a review of existing evidence on the effects of information in Contingent Markets, a model is developed to analyze how information and its cost of acquisition may impact the definition and estimation of EV as measured by the CVM. This analysis is performed first under the assumption of a competitive information market, and second, under the assumption of market failure. Exploratory results of the model when substitutes are recognized are presented as a direction for future research and followed by concluding remarks.

Evidence of Information Effects

In general, theoretical representations and empirical studies of EV do not explicitly consider the knowledge of individuals about the resource being valued other than to qualify study results. Bishop and Welsh (1992) succinctly state that the goal of CVM studies "should be to obtain the values that the population as a whole would express if it were more fully informed". They also dismiss the necessity of measuring informational effects on valuation estimates, writing:

> "because respondents do not have full knowledge...does not necessarily mean that they have no preference with respect to that resource. Rather, it may simply reflect the fact that no choice problem involving that particular resource have yet been encountered; they (respondents) may have felt little need to acquire specific information about it... Lack of knowledge can not be taken as evidence that the existence of such resource lacks the ability to satisfy preferences. It could simply indicate the lack of past choice opportunities to motivate information gathering." [p.407]

This approach provides little insights into the reasons why individuals do not inform themselves about goods and circumstances, knowledge of which may improve their well-being. It also leaves unanswered the question of how much more information should respondents to CV surveys be provided with. The survey literature stresses that "policy relevant", or, "all relevant" information about the good being valued must be provided to respondents in order to ensure the proper elicitation of "true value".[1] Hence, any change in information that affects reported value in a significant manner is deemed to be a bias.

This interpretation contradicts Randall and Stoll's (R&S)(1983) observation of wide fluctuations in the existence demand for the snail darter.[2] They note:

> "starting from an initial state of little or no information, small increments to the information base may produce large shifts in existence value, in total or at the margin. Existence value is, therefore, quite volatile in the face of new information. It is important to realize that this volatility has nothing to do with measurement error or bias. It is not that the "estimates" are volatile; the problem is that the perceived <u>reality</u> of existence value is volatile..." [p.270].

Randall, Hoehn & Brookshire (1983) also challenge the notion of information bias noting that changes in market structure, including modifications in information, should be expected to influence market behaviour. Just like a catalog description might affect the demand for a private good, Kopp (1992a) considers the effect of information on EV to be a desirable feature of nonuse values and contingent markets, a feature required by neoclassical consumer theory. Freeman (1986) also implicitly recognized the role of information when he proposed that survey results be reported as "the value of the environmental good *as described* in the CVM instrument is $X". [p.154, emphasis added].

Bergstrom, Stoll and Randall (BSR)(1990) focus their attention on the effects of information on the WTP for the conservation of a Louisiana wetland. They presented various amounts of information to different groups of respondents, about the various services provided by coastal wetland and elicited their WTP. BSR were not able to reject the hypothesis of a positive effect of information on WTP. Their findings support the hypothesis that "information [about the services provided by wetland] affects the perceived marginal utility of a given rationed quantity of wetland" [p.620]. What BSR illustrate is actually that information has the effect of shifting the expenditure and Hicksian demand curves for the protection of the resource.

This result is supported by Samples, Dixon & Gowen (SDG) (1986) who found a positive relationship between the willingness to pay (WTP) of respondents to preserve humpback whales and the provision of information about its physical characteristics, behaviour and endangered status. However, Boyle (1989) later argued that this evidence was inappropriately making use of "gross" changes in information rather than marginal changes. His own research on the impact of small increments in information does not support SDG's claim.

Whitehead and Blomquist (1991a) express the view that:

> "a necessary condition for existence value is that information about a natural resource (knowledge of resource existence) has been acquired in some way. Without information about a natural resource, no existence values are plausible for that natural resource." [p.98],

and empirically tested a household production function (HPF) model developed by R&S (1983). By linking observable behaviour to respondents prior knowledge about the wetland, and linking this level of information to stated WTP for its continued existence, they obtained results suggesting strongly that the formation of EV is the consequence of observable individual behaviour. They conclude that:

> "households become environmental group members, travel to wetland and obtain information about them. Households trade off something of value for the knowledge of the existence of wetland resources" [p. 105].

More recently, Hoevenagel and Linden (1993) report results consistent with these previous studies. They conclude that "the provision of extra information on the ecological good has a significant effect on WTP values, i.e. providing additional attributes resulted in higher values" [p.235]. However, they also note, like Boyle, that "small refinements in information may have no impact".

While this body of research suggests the presence of informational effects and that knowledge acquisition by household is deliberate and costly, none of the authors cited above have investigated the welfare implications ensuing from these findings[3]. The following sections are devoted to this task.

The Model

The following model is built on the premise that informational effects are desirable features of contingent markets, consistent with economic theory. Households gain utility from the mere knowledge that a resource or environmental amenity exists in a state that they value. A representative household faces the following constrained utility maximization problem:

$$\max_{X,I} \; U = u(X,Z) \tag{1}$$

subject to:

$$Z = z(Q|I) \tag{2}$$

$$M \geq P \cdot X + C(I) \tag{3}$$

Where U ≡ utility of a representative household

X ≡ a vector of market goods

Z ≡ existence commodity produced by the household

Q|I ≡ exogenously determined quantity or quality level of an environmental amenity. The production of Z is said to be conditional (|) on a certain amount of I being held by the household

I ≡ index of the amount of information about Q, held by the household

M ≡ household initial full income

P ≡ price vector of market goods

C(I) ≡ total cost of acquiring I units of information.

While the model does not explicitly recognize the attributes of, or the time spent by household members, it could easily be extended to a full HPF representation.

I is an index of the amount of information acquired by, or provided to the household. It is defined over the entire set of existing and potential information about the resource. In the case of wilderness areas, this information may include geographic location and characteristics, size, species, biological and geomorphological phenomena it encompasses, ecosystem functions, environmental services it provides to humans, etc. In the case of animal or plant species, the information set may include physical and biological characteristics, population status, location, role in the food chain or ecosystem, and all other existing and potential knowledge about it.

The costs of information acquisition are explicitly recognized in the budget constraint. $C(\mathrm{I})$ is postulated to be twice continuously differentiable, with positive increasing (or constant) marginal costs: $\partial C/\partial \mathrm{I} \geq 0$, $\partial^2 C/\partial \mathrm{I}^2 \geq 0$. Faced with equally beneficial sources of information, optimizing households will first choose the cheapest source of information and then move on to more expensive ones. This cost structure for information is consistent with a scenario in which basic information on a wide array of conservation issues, species and places is easily accessible at relatively low costs from magazines, television programs and other similar sources. As each source of information becomes "depleted", locating new sources and obtaining additional information becomes an increasingly costly task in terms of expenditure and time. Consumers purchase more specialized literature, become contributing members of environmental groups, and request information from public agencies. At the limit, when all currently available information has been acquired, any new knowledge about a given resource has to be obtained through elaborate and expensive scientific research.

The household maximizes utility, subject to its full income constraint M. It faces a competitively determined price vector, P, and the total cost of information $C(\mathrm{I})$. The utility function is twice continuously differentiable with $\partial U/\partial X > 0$, $\partial U/\partial Z > 0$; $\partial^2 U/\partial X^2 \leq 0$, and $\partial^2 U/\partial Z^2 \leq 0$. X and Z are normal goods. The utility function is assumed to be separable in Z and X, and in Q and X. The existence commodity Z is produced from a combination of weakly complementary inputs Q and I where both inputs are essential. Q is valued only if I is consumed. It is also assumed that $\partial z(Q \geq 0 | I > 0)/\partial Q \geq 0$ and $\partial^2 z(Q \geq 0 | I > 0)/\partial Q^2 \leq 0$.[4] This assumption denotes that the current analysis is restricted to positively valued amenities. In addition, $\partial z(Q > 0 | I \geq 0)/\partial I \geq 0$ and $\partial^2 z(Q \geq 0 | I > 0)/\partial I^2 \leq 0$, which states that for any positive level of Q, the marginal product of information is no less than zero and decreasing in I. This follows from the restriction that the analysis applies only to amenities with positive EV. It is a testable hypothesis consistent with the findings of SDG (1986), BSR (1990a), W&B (1991a) and Hoavenagel and van der Linden (1993).

Together, the assumptions on the marginal product of Q and I ensure that their marginal utility is decreasing. While it seems reasonable that the marginal product of Q be decreasing over its entire range, I could possibly exhibit increasing marginal product over part of its range (e.g. at low levels). This is a matter left to be confirmed by empirical testing. Postulating monotonically decreasing marginal products will later eliminate the possibility of non-unique solutions.

Finally, the assumption that $\partial U/\partial Q$ (at Q=0) $< \infty$ and $\partial U/\partial I$ (at Q=0) $< \infty$ make the existence good non-essential, ensuring that the household will not spend its entire income on information as the resource diminishes to zero.

In contrast to R&S (1983) and W&B (1991a), the model postulated in this paper does not explicitly recognize the passage of time. In this study, the WTP of the household for Q can be interpreted as the present value of a stream of annual payments. For the purpose of generating EV, past information gathering activities are taken as given in the period valuation takes place and entirely captured by I. The model departs from the view, implicit in R&S and W&B's models, that direct or indirect use of the resource cannot produce both, direct or indirect benefits, and EV in the same time period. There are no justifiable grounds on which to reject that users of a resource can receive existence and other direct and indirect benefits simultaneously.

It is also implicit to the model that information does not deteriorate in quantity or quality. This strong assumption eliminates the need for updating information and the difficulty of tracing the resulting movements along the marginal utility and cost functions. The measures of value that will be derived are equivalent to those obtained when the post-payment level of the resource is assured with certainty for the lifetime of the household. The assumption that no existence commodity is produced without a positive amount of Q is a related phenomenon. It causes information to be objective and disallows fraud. While it is conceivable that utility could be generated by transmitting false information to households, this possibility is ignored.

Results

Deriving a solution to the maximization problem provides the indirect utility function

$$V = v(P, C_{I^*}, Q, M) \tag{4}$$

where C_I denotes the derivative of $C(I)$ with respect to I and I^* is the optimal level of information purchased by the household. Separability in X and Z allows the specification of the indirect utility function as an explicit function of I:

$$V = v(P, C_{I^*}, Q|I^*, M) \tag{5}$$

Making use of duality, the expenditure function

$$M = m\big(P, C_{I^*}, Q, v(P, Q|I^*, M)\big) \tag{6}$$

provides the basis necessary to define the compensating surplus (CS) measures of welfare change. Let Q° and M° be the initial levels of the resource and household income, and V° be the resulting maximized utility. The CS associated with an increase in resource from Q° to Q'' is the amount the household would be willing to pay (WTP) in order to obtain the increase in Q and remain as well off (no better off) as at level V° (Mitchell and Carson, 1990). Following BSR, the compensating surplus can be expressed as:

$$\text{WTP} = \text{CS} = m(P, C_{I^*}, Q'', V'') - m[P, C_{I^*}, Q'', V^\circ) \tag{7}$$

$$= m\big(P, C_{I^*}, Q'', v(P, Q'' \mid I^*, M^\circ)\big) - m\big(P, C_{I^*}, Q'', v(P, Q^\circ \mid I^*, M^\circ)\big) \tag{8}$$

$$= M^\circ - M'' > 0 \tag{9}$$

where $\qquad V'' = v(P, C_{I^*}, Q'', M^\circ)$

If the change in Q was a reduction, CS<0 would be interpreted as the minimum amount the household would be willing to accept (WTA) in compensation for the loss of Q. These measures of welfare change, are illustrated in Figure 1.[5]

Free Information and Households' WTP

I^* is the respondent's level of knowledge about a resource that a researcher would observe prior to conducting a contingent valuation survey. As Bishop and Welsh (1992) report for Wisconsin's striped shiner, the level of knowledge of respondents prior to the administration of a survey can be very low. In order to elicit a value for the resource, CV survey instruments must provide respondents with additional information, prior to the actual valuation question. This procedure raises the level of information held by households from the private optimum, I^*, to a higher level, say $\ddot{I}$. From the household's perspective, this information comes free of charge. Using equation 8, we note that the empirical findings that WTP and I are positively correlated is formalized in the model's construction. Keeping in mind that the provision of information in CVM experiments is perceived to be free by respondents,

$$\partial \text{WTP}/\partial I = \partial m\big(P, C_{I^*}, Q'', v(P, Q'' \mid I^*, M^\circ)\big)/\partial I - \partial m\big(P, C_{I^*}, Q'', v(P, Q^\circ \mid I^*, M^\circ)\big)/\partial I \tag{10}$$

$$= \partial M/\partial V'' \cdot \partial V''/\partial I - \partial M/\partial V^\circ \cdot \partial V^\circ/\partial I > 0 \tag{11}$$

The first and third terms in equation 11 represent the marginal cost of utility at V^{*} and V° respectively, where $V^{\circ}<V^{*}$. As BSR point out, the marginal cost of utility is the inverse of the marginal utility of income (λ). Positive non-decreasing marginal costs for I, and X held constant, combined with positive marginal utility of Q result in $\partial M/\partial V^{*} \geq \partial M/\partial V^{\circ}$, since the reference level of utility V° is smaller than V^{*}. Terms two and four represent the effect of a marginal increase in I on utility. As a result of the weak complementarity between I and Q, $\partial V/\partial I$ increases with the level of resource it is associated with. The direct implication is that $\partial V^{*}/\partial I > \partial V^{\circ}/\partial I$ and $\partial WTP/\partial I > 0$. As illustrated in figure 2, the provision of free information shifts the expenditure function downward and rotates its lower part inward to produce an increase in WTP.

The dependence of resource values on information casts doubts on the validity of the CVM and the results it provides. If various levels of information yield different values for a resource, there is room for diverging and conflicting results, or even for their manipulation by researchers or interested parties. Rosenthal & Nelson (1992) express this concern noting that the survey itself becomes a potentially important medium of communication, one that may create the stage for changing consumer perceptions. More troublesome is the idea that conflicting and diverging measures of the value of a resource may all be valid estimates. These and other research results suggest that there is not a unique measure of existence benefits from a resource. There is rather a set of possible values, each corresponding to a specific level of information, from which one estimate must be chosen.

The procedure consisting of providing policy relevant or full information to respondents only provide one possible measure of resource benefits. This approach was developed from the need to design questionnaires that satisfy the conditions for an acceptable cognitive evaluation of the CV scenario and to avoid biases. Unfortunately, it does not guide the selection of the theoretically appropriate level of information to be provided to respondents when valid information effects are acknowledged.

Welfare Effect of Information in a Competitive Market

In fact, under the assumption that information markets are competitive, the provision of information to households (in CVM studies or otherwise) results in a loss of social welfare. Two key conditions assure this result. 1) a competitive market corresponds to a situation where the marginal cost of public provision of information is equal to the private marginal cost; and 2)information is perceived to be free by households, so that equation 11 holds.

Prior to the administration of a CVM survey, the rational household faced with a competitive price of information has already chosen the optimal level of information (I^*). At that level of I, the marginal cost of providing an additional unit of information to the household must therefore exceed the marginal benefits derived from it. Stated otherwise, the value of the additional utility is worth less than the cost of providing the information to the respondents. The net welfare change associated with the provision of information is therefore negative. This strongly suggests that the practice of providing information in CVM studies, though it induces a higher WTP for the resource, results in an overall loss of welfare if the cost of distributing information is accounted for and identical or higher than the market price of I.

We can make a comparison with the estimation of use values using travel cost models (TCM). Providing free information to respondents in a CVM study of EV is analogous to offering a household a free trip to a park, over and above its private optimal number of visits. In a travel cost study of the park, a researcher who ignored that one of the trips taken was free to the household would mistakenly derive a demand function for the site that exceeds true demand, and consequently overestimates recreational benefits. Like a free trip, providing information generates positive existence benefits to the household. The relevant question however, is whether providing information enhances or reduces social welfare.

In both the TCM example and the model introduced above, households have a positive WTP for the means by which utility is gained (information or trip). The reason they do not take the additional trip on their own, or purchase more information privately, is that the utility cost of foregone consumption of X is greater than the additional benefits they would get from Q. Just as they would use the privately chosen number of trips to measure the true recreational demand for a site, researchers should base their estimation of EV on the level of information privately purchased by households.

Market Failure, Efficiency Gains and Public Provision of Information

Information is non-rival in consumption, allowing many households to derive benefits from the same information. Markets may therefore fail to efficiently supply households for their production of existence goods (Z). Furthermore, the purchase of information by private parties may be sub-optimal if scientific information is not presented in a format readily understandable by laymen. The personal cost to individual households of translating scientific knowledge into meaningful, welfare-enhancing information is added to the costs of acquisition and may prevent its wide use or distribution.[6]

It is also well known and accepted that the market place fails to provide the socially optimal level of conservation. In particular, responsibility for the protection and management of natural resources has been entrusted upon public management agencies such as the Canadian Parks Service, Canadian Wildlife Service, U.S. National Parks, Forest, Fish and Wildlife Services and other provincial and state organizations. Understanding scientific information about the resources they manage is a vital part of their duty, and the task of gathering information also rests with them, a direct consequence of the lack of commercial interests in the resources involved. The public good aspects of environmental amenities makes both their management, and the necessary collection of information about them, public goods as well.

In addition to market imperfections, public agencies may face a different cost function than private households, enabling them to realize efficiency gains in the delivery of information. Efficiency gains could be the result of scale effects in the translation and distribution of information. Each household on its own must understand the scientific information obtained from various sources. A central agency can go through the process of translating the information into a language and presentation more readily accessible, and widely distribute that information at a cost presumably lower than that faced by individual households. Market failure and potential efficiency gains can therefore be represented by a downward shift of the marginal cost function, over the entire range of I.

The model shows than an exogenous increase (decrease) in the marginal cost of information curve results in a decrease (increase) in the WTP for a positive change in the level of the resource. Using the conventional representation of the CS and holding the reference level of utility constant at V° provides a measure of the effect of shifting the cost schedule on the compensating surplus for a change in Q:

$$\partial WTP/\partial C_I = \partial m(P,C_I,Q^{\circ},V^{\circ})/\partial C_I - \partial m(P,C_I,Q^{\prime\prime},V^{\circ})/\partial C_I < 0 \qquad (12)$$

In order to establish this result, we note that $\partial M/\partial C_I > 0$ for any Q and a given constant level of utility. The higher the price of information (this would also apply to any normal good X) the larger the amount of expenditure necessary to reach this level of utility. This translates into an upward shift of the expenditure function. From weak complementarity, the increase in costs induces a decrease in information purchased which results in a larger loss of utility when the level of resource is high than when it is low. It follows that the additional amount of expenditure necessary to regain the initial level of utility V° increases with Q. Consequently, an exogenous increase in the marginal cost curve results in a decrease in the WTP for an increase in Q.

Assuming that information transfers are financed through non-distortionary lump-sum taxation, public agencies wanting to choose the optimal level of information to distribute would optimize the agent's utility using equations 1 to 3, but using a modified information cost schedule $C^P(I)$ where the marginal cost of public information is everywhere smaller than the private marginal gathering cost ($C_I^P < C_I$). The resulting optimum is consistent with previous results and with equation 12 and ensure that reduced costs of information increase the WTP for Q. This is accomplished through an increase in the amount of information detained by the household. It follows that, under conditions that ensure efficiency gains in the distribution of I, public agencies could increase social welfare by providing a greater amount of information than the market allocates. However, a valid measure of welfare change must subtract the costs of providing the information from the increased WTP for the resource.

Two distinct welfare changes are being measured: one for an increase in information, and one for a change in Q. However, the households' valuation process is dependent on the purchase of information as an input requirement to the production of Z. Information is not valued in itself, but rather for its contribution to Z. Though there exists a Hicksian demand curve for I, in the absence of indirect use value from the means I is obtained, information's only role is to shift the demand curve for Q. By analogy, a similar phenomenon occurs in the travel cost model where a trip is a necessary input to the generation of recreation benefits. In estimating the "net" benefits provided by a resource, the costs of travel are subtracted from gross benefits. In the case of nonuse values, the costs of producing the existence commodity (here the cost of I only) must be substracted from the area under the Hicksian demand curve for Z in order to yield the net value of the resource.

This model, available empirical data on the effect of information on WTP, and the presumption of market failure in the distribution of information provide the theoretical foundations on which to justify the provision of information in CVM experiments and to interpret conditional population estimates of EV. By extension, the results show that providing public information about protected or endangered places and species is a Pareto-improving public policy option for which the costs and benefits must be weighted against other program options. Resource management agencies generally devote very few dollars on outreach education programs. Park agencies in particular, spend comparatively large sums of money in infrastructure and labour in order to provide services to visitors, and education programs aimed at nonusers may have suffered from the difficulties of demonstrating the benefits they generate. The model developed here can be used to analyze the value of information and education programs and reinforces the argument that nonuse values need to be considered when allocating resources among various conservation and education components of resource management programs.

Optimal Level of Information: The Contingent Valuation Method and Information Effects

It has already been shown that when CVM researchers (or the public agency) face a lower information cost schedule than private individuals, the marginal provision of information has the effect of increasing both the WTP for a resource (gross EV) and net social welfare (net EV). This allows for the development of a natural and consistent rule for choosing one estimate of EV amongst the set of admissible values. For any given reference level and change in Q being analyzed, it can be shown that there exists an optimal level of information that determines the optimal EV of the change in the resource.

Let $\hat{I}$ be the optimal level of information falling from the model using the lower cost function $C^p(I)$.[7] $\hat{I}$ is the optimal level of information that households should have when assessing the value of a change in the resource from Q° to Q''. From equation 12, we know that $\hat{I} > I^*$. However, since households have already purchased I^* amount of information at a total cost of $C(I^*)$, the public agency (or CV researcher) only needs to provide the information above I^* up to $\hat{I}$, at a total cost $C^p(\hat{I}) - C^p(I^*)$. It follows that the maximum attainable existence value, $\hat{EV}$, net of information costs, is given by:

$$\begin{aligned}\hat{EV} = \; & \{m(P,C_{I^*},Q'',v(P,Q''|I^*,M^\circ)) - m(P,C_{I^*},Q'',v(P,Q^\circ|I^*,M^\circ))\} + \\ & \{m(P,C_{I^*},Q'',v(P,Q''|\hat{I},M^\circ)) - m(P,C_{I^*},Q'',v(P,Q^\circ|\hat{I},M^\circ))\} - \\ & \{m(P,C_{I^*},Q'',v(P,Q''|I^*,M^\circ)) - m(P,C_{I^*},Q'',v(P,Q^\circ|I^*,M^\circ))\} - \\ & \{C^p(\hat{I}) - C^p(I^*)\} \qquad (13)\end{aligned}$$

$$\begin{aligned}= \; & \{m(P,C_{I^*},Q'',v(P,Q''|\hat{I},M^\circ)) - m(P,C_{I^*},Q'',v(P,Q^\circ|\hat{I},M^\circ))\} - \\ & \{C^p(\hat{I}) - C^p(I^*)\} \qquad (14)\end{aligned}$$

The first line of equation 13 is identical to equation 8 and is the WTP to pay for the increase in the resource at the privately obtained level of information. This corresponds to area a of figure 4, which shows a graphic representation of the optimality condition in terms of marginal WTP and marginal information costs. Line 2 minus line 3 is the increase in WTP generated by the provision of information to the household, when the new information is perceived to be free of charge (it is the non-marginal equivalent of $\partial WTP/\partial I^*$). This is represented by area b+c in figure 4. Finally, line 4 represents the cost of publicly providing the increment in information from I^* to $\hat{I}$, and corresponds to area c.

Noting that lines 1 and 3 of equation 13 are identical, simplification yields Equation 14. It is a simple rule to apply since the first line of equation 14 is the contingent valuation response (WTP) to a scenario bringing the respondent to a level of knowledge $\hat{I}$. The optimal EV of the resource is given by subtracting the cost of distributing the new information from the household's expressed WTP. The maximum net EV corresponding to the optimal level of information is therefore the sum of area a and b of figure 4, and the net welfare gain associated with the public distribution of information is equivalent to area b alone. Area d is the deadweight loss resulting from market imperfections.

Application of this new rule in CVM experiments requires that I^*, $\hat{I}$, and the public information cost function be known. The public cost function is presumably relatively easy to estimate; respondents knowledge about the resource can be tested prior to the administration of CV surveys to determine I^*; but knowing $\hat{I}$ is an unlikely prospect.

Fortunately, the CVM can be used to determine the optimal level of information, $\hat{I}$, and to subsequently estimate the net EV of the resource. Using equation 14, replacing $\hat{I}$ with the generic variable I, EV can be maximized with respect to I, for any $I>I^*$. This provides the first order condition:

$$\partial WTP/\partial I = \partial C^P(I)/\partial I \tag{15}$$

which yield the optimal level of information $\hat{I}$. Assuming that the public information cost function is known, this level of information can be empirically estimated by repeating the CVM experiment for various levels of information, and comparing the marginal benefits and costs of additional amounts of I, as prescribed by equation 15. Given earlier restrictions on the model's functions, $\hat{I}$ and $\hat{EV}$ are unique solutions as long as Q is not a choice variable.

The approach outlined here is similar to conducting a number of contingent markets, each defining a Hicksian demand curve for Q|I, where I varies between markets[8]. Knowing the set of demand curves for Q|I would allow the selection of the socially optimal level of information. Adopting this methodology could reinforce the validity of CVM results. It would provide an improved decision rule, based on economic theory, that effectively discriminates amongst the set of possible and acceptable estimates of EV that were shown to exist for any given variation in Q. By narrowing the number of possible value estimates, it would promote the acceptance of nonuse values and increase the credibility of the method by which they are measured.

Extension and Direction for Future Research - Information and Substitute Resources

In general, if two environmental amenities are good substitutes for one another, the loss of one area should not cause an important loss of utility, and the WTP of the household to avoid the loss should be relatively low. On the other hand, if the consumer considered each area to be absolutely unique and without possible substitutes, her valuation of any of them should reflect this uniqueness. It follows that if substitutes enter the utility function and if respondents fail to appropriately consider them when faced with contingent market decisions, appropriate welfare measures must be derived from CVM markets that include these substitutes. Modifying equations 2 and 3 allows for an exploratory investigation of information effects when a substitute is available:

$$Z = \omega(Q^1|I^1, Q^2|I^2) \tag{16}$$

$$M \geq PX + C(I^1) + C(I^2) \tag{17}$$

The superscript 1 and 2 respectively identify the resource and information about it; and a substitute resource and its relevant information. The two cost functions are assumed to be identical and have the properties postulated earlier. These new production function and constraint define the expenditure function:

$$M = m(P, C_I^1, Q^1, C_I^2, Q^2, V) \tag{18}$$

or alternatively

$$M = m\big(P, C_I^1, Q^1, C_I^2, Q^2, v(P, Q^1|I^1, Q^2|I^2, M)\big) \tag{19}$$

and the Hicksian measures of welfare change defined above with the appropriate addition of the second resource and marginal cost arguments.

It must first be noted that if it is optimal for the household to purchase information on either of the resources, it will in fact purchase some of both since I^1 and I^2 produce similar marginally decreasing utility and are purchased on marginally increasing cost schedules. With the same initial income ($M°$) as before, $I^1 + I^2 < I^*$. However, the additional private good, I^2, provides new opportunities to purchase units of information with high utility yields, and so, the optimal level of utility will be greater than was previously achievable: $V^{12} > V°$.[9] From duality, cost minimization subject to the original utility level ($V°$) would yield a lower optimal level of expenditure $M^{12} < M°$. As before, the WTP for an increase (or to avoid a decrease) in Q^1 will be valued positively. Substitution possibilities and a lower marginal cost of utility assure, however, that WTP will be lower than in the absence of a substitutes.

Let the privately optimal levels of information be denoted by $\bar{I}^1$ and $\bar{I}^2$. Providing households with a marginal amount of new, free information about resource 1 produces different changes in the valuation of Q^1 and Q^2. If Q^1 and Q^2 are not perfect substitutes, the effect of increasing I^1 on the WTP for Q^1 is positive and given by:

$$\partial WTP^1/\partial \bar{I}^1 = \partial m\big(P, C_I^1, Q^{1\prime}, C_I^2, Q^{2\circ}, v(P, Q^{1\prime}|\bar{I}^1, Q^{2\circ}|\bar{I}^2, M°)\big)/\partial \bar{I}^1$$
$$- \partial m\big(P, C_I^1, Q^{1\prime}, C_I^2, Q^{2\circ}, v(P, Q^{1\circ}|\bar{I}^1, Q^{2\circ}|\bar{I}^2, M°)\big)/\partial \bar{I}^1 > 0 \tag{20}$$

while the effect on Q^2 is indeterminate and given by:

$$\partial WTP^2/\partial \bar{I}^1 = \partial m\big(P, C_I^1, Q^{1\circ}, C_I^2, Q^{2\prime}, v(P, Q^{1\circ}|\bar{I}^1, Q^{2\prime}|\bar{I}^2, M°)\big)/\partial \bar{I}^1$$

$$- \partial m\left(P, C_I^1, Q^{1o}, C_I^2, Q^{2\prime}, v(P, Q^{1o}|\bar{I}^1, Q^{2o}|\bar{I}^2, M^o)\right) / \partial \bar{I}^1 : \text{indeterminate} \tag{21}$$

The effect of increasing I^1 on the utility level increases with the level of resource it is associated with. The magnitude of the change in WTP for Q^1 decreases as Q^2 becomes a better substitute. At the limit, if Q^2 was a perfect substitute, $WTP^1=0$ and $\partial WTP^1/\partial \bar{I}^1 = 0$, since the household's utility is not affected by the loss of only one of them.

The indeterminate effect of a change in I^1 on the WTP^2 for an increase in Q^2 comes from the fact that the marginal utility of I^1, $\partial V/\partial \bar{I}^1$, decreases with the level of Q^2 while the cost of marginal utility, $\partial m/\partial V$, increases with Q^2. However, the lower the importance of $Q^2|\bar{I}^2$ in the production of Z, the higher is the relative importance of $Q^1|\bar{I}^1$ and the higher the marginal effect of $\bar{I}^1$ on utility. If an increase in I^1 augments the degree of substitutability of Q^1 for Q^2, we would expect equation 21 to take on a negative sign. By making Q^1 a better substitute, it reduces the amount the consumer is willing to pay for an increase, or to avoid a decrease in Q^2, and still maintain her original level of utility.

Whitehead and Blomquist (1991b) empirically confirm that designing surveys with information about substitute resources significantly reduces the WTP for the wetland. CVM studies that omit to control for substitutes generate erroneous results (Bishop and Welsh, 1992). Leaving out substitutes also implies ignoring the welfare effects of new information on the value of these substitutes and further confuses the link between the results of CVM studies and the appropriate welfare measures they attempt to estimate.

Information partly defines the capacity of one resource to replace another, affecting the marginal rate of substitution between the two resources entering the utility function. A passage by Talhelm (1983) expresses a similar idea:

> "consumer's classification in demand may be based on a different set of attributes [than those on which biological and physical classification systems are based]. ... Public values are determined more by the uniqueness from the consumer's perspective than by the biophysical uniqueness, though the former is sometimes overlooked". [p.278]

Such phenomena occur in the markets for some private goods. A typical example come from the automobile industry where each car model is commonly marketed under two or more brand names. The same type of practice occurs in the food retail sectors where well-known food producers package the same product under their brand name, a chain label and as a no name product. While some products may be identical in their objective characteristics, they may not be considered perfect substitutes and the demand for them may differ. Therefore, the fact that information modifies the perceived substitutability of different environmental goods may be considered a desirable feature of contingent markets.

However, much additional research is necessary in order to develop a more complete analysis of substitution possibilities in a world with costly information effects. A particular emphasis should be put on developing a precise understanding of how information alters or defines the degree of substitutability between public goods.

Concluding Remarks

Building on existing empirical evidence suggesting that the willingness of nonusers to pay for valuable environmental amenities is positively correlated with their level of knowledge about that resource, this paper has established a basis on which to analyze the role of costly information in the valuation of environmental goods. The development of a simplified HPF model has shown that if markets efficiently supply information to households, current CVM practices may promote the supply of an excessive amount of information to respondents. Consequently, current measures of EV may be larger than should be used in damage assessment and cost-benefit analyses. However, the probable failure of markets to efficiently allocate information provide a strong argument in favour of public dissemination of information about environmental goods, and rationalizes the necessity to raise the knowledge of CVM respondents.

From the potential cost savings resulting from public distribution of information follows a rule that can be used to determine the optimal level of information to be provided to respondents of CV surveys. This finding offers the possibility of replacing the estimate of EV falling from the ill-defined "policy-relevant", or, "all relevant" information rule by an optimality condition that can be estimated using the CVM. The empirical implementation of the rule can be done using the CVM, which confer additional appeal to the approach, and make it subject to future empirical testing.

Admitting information and its cost of acquisition as a valid base to define and measure EV could provide an improved decision rule that effectively discriminates amongst the set of possible and acceptable estimates of EV, reinforce the validity and credibility of CVM results, and promote the acceptance of EV and other nonuse values as a desirable component of damage assessment and benefit-cost analysis.

Figure 1

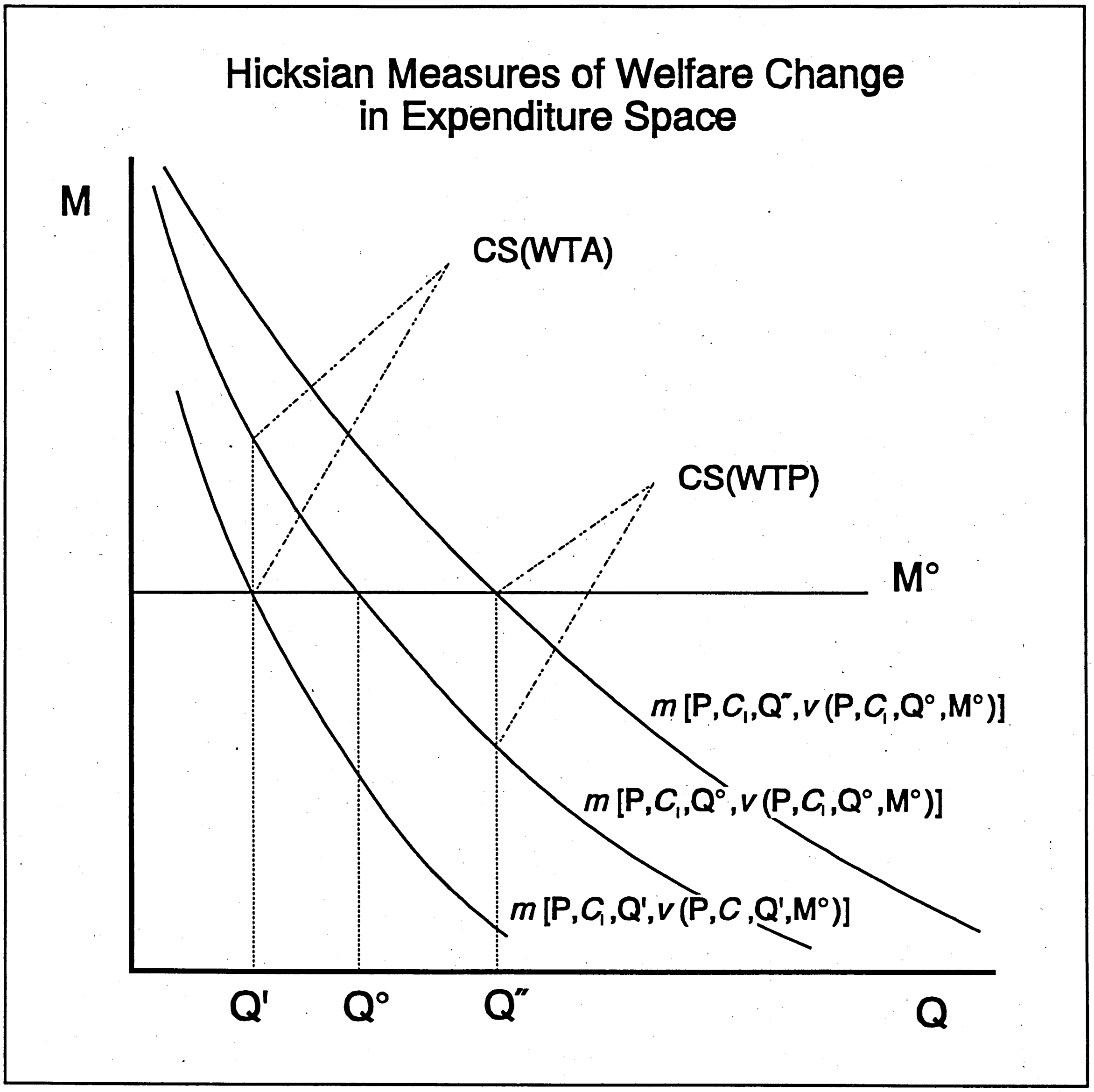
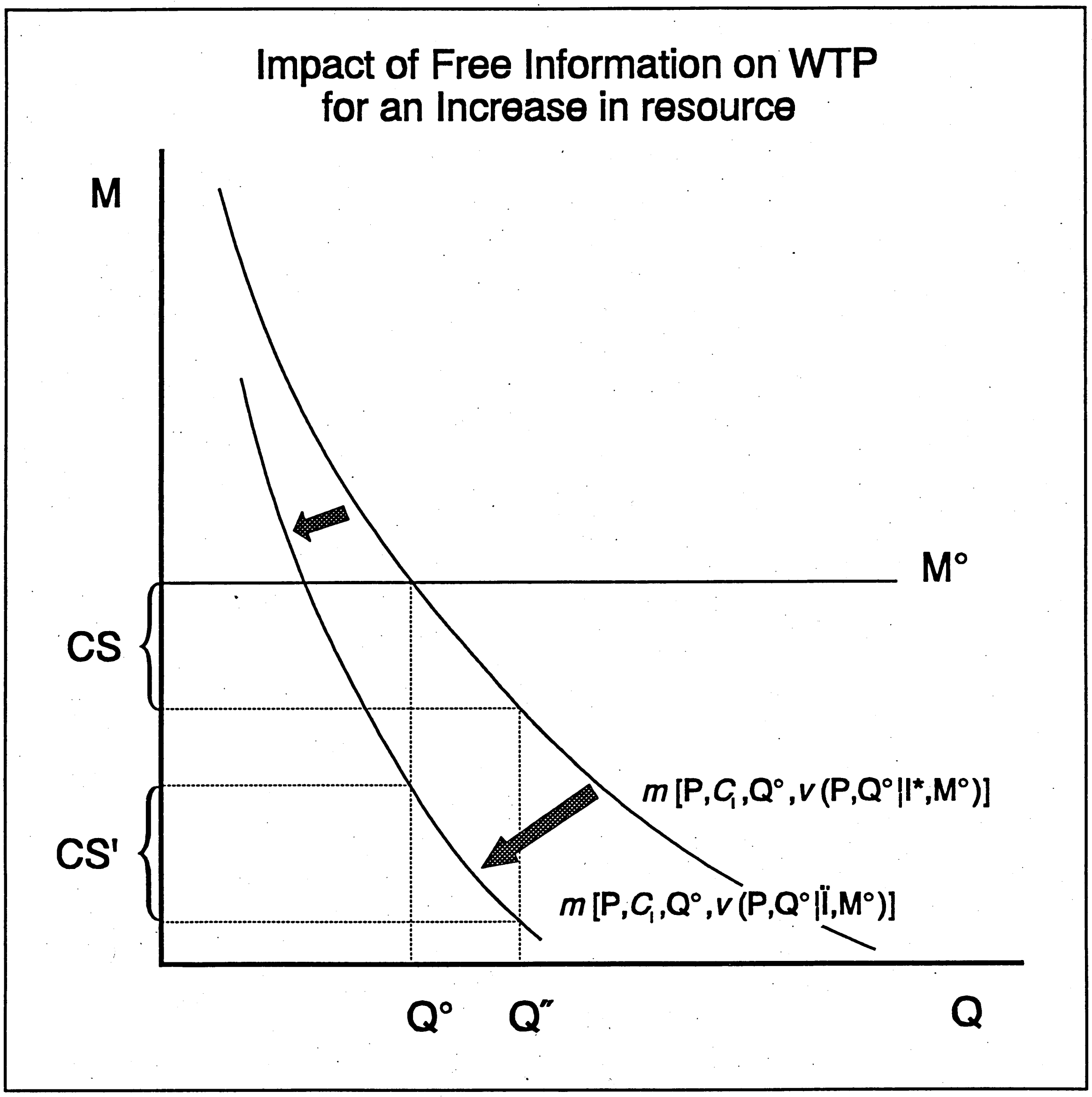
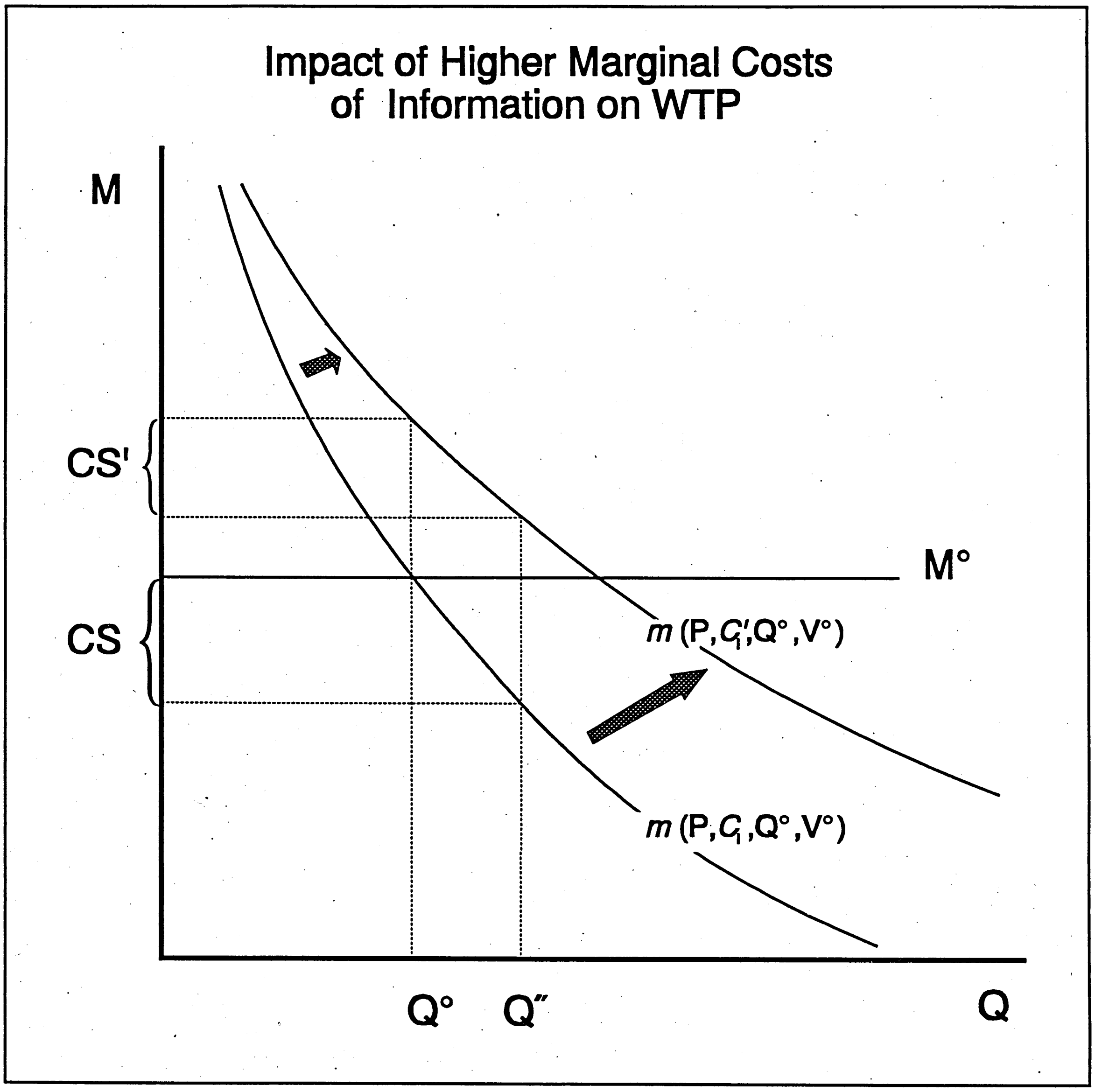

Hicksian Measures of Welfare Change
in Expenditure Space
M
CS(WTA)
CS(WTP)
M°
m [P,C1,Q″,v (P,C1,Q°,M°)]
m [P,C1,Q°,v (P,C1,Q°,M°)]
m [P,C1,Q',v (P,C ,Q',M°)]
Q'
Q°
Q″
Q

Figure 2



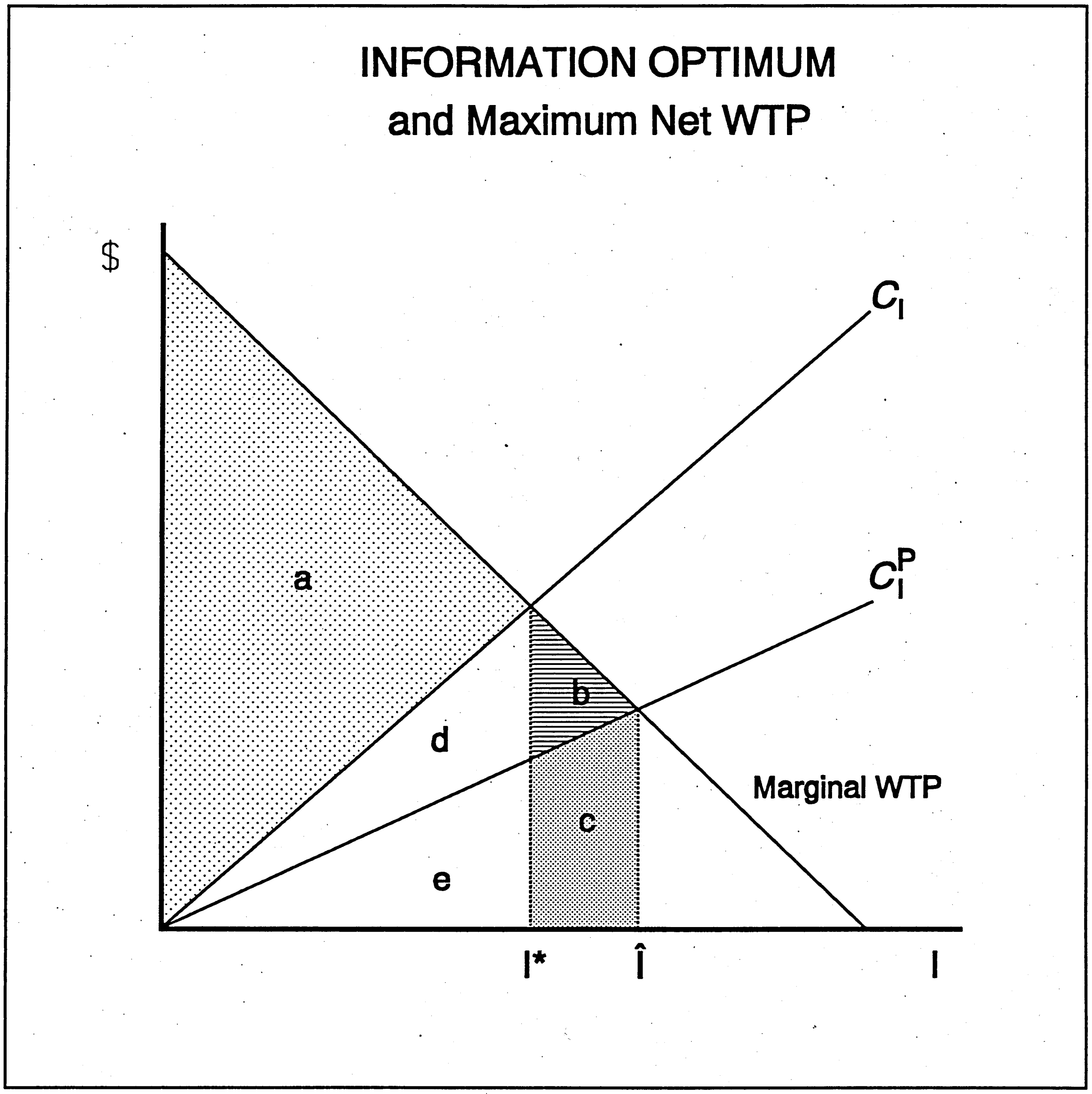
Impact of Free Information on WTP
for an Increase in resource
M
M°
CS
CS'
m [P,C1,Q°,v (P,Q°|I*,M°)]
m [P,C1,Q°,v (P,Q°|Ï,M°)]
Q°
Q″
Q

Figure 3



Impact of Higher Marginal Costs of Information on WTP
M
CS'
CS
M°
m (P,C'ᵢ,Q°,V°)
m (P,Cᵢ,Q°,V°)
Q°
Q″
Q

Figure 4



INFORMATION OPTIMUM
and Maximum Net WTP
$
C_I
C_I^P
a
b
d
c
e
Marginal WTP
I*
Î
I

BIBLIOGRAPHY

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

Bergstrom, J.C., Stoll, J.R. and Randall, A. 1989. "Information Effects in Contingent Markets". *American J. of Agricultural Economics*, Vol. 71:685-691.

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

Boyle, K. 1989. "Commodity Specification and the Framing of Contingent-Valuation Questions". *Land Economics,* Vol. 65:57-63.

Brookshire, D.S., d'Arge, R.C., Schulze, W.D. and Thayer, M. 1981. "Experiments in Valuing Public Goods". in V.L. Smith ed. Advances in Applied Microeconomics Vol.1. Greenwich, CT. JAI Press.

Cummings, R.G., Brookshire, D.S. and Schulze, W.D. 1986. Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Totowa, N.J. Rowan and Allenheld.

Fischhoff, B. and Furby, L. 1988. "Measuring Values: A Conceptual Framework for Interpreting Transactions wit Special Reference to Contingent Valuation of Visibility". *Journal of Risk and Uncertainty,* Vol. 1:147-184.

Freeman III, A.M. 1986. "On Assessing the State of the Art of the Contingent Valuation Method of Valuing Environmental Changes". in R.G. Cummings, D.S. Brookshire, and W.D. Schulze eds. Valuing Environmental Goods: An Assessment of the Contingent Valuation Method. Totowa, N.J. Rowman and Allenfeld.

Hoevenagel, R. and van der Linden, J.W. 1993. "Effects of Different Descriptions of the Ecological Good on Willingness To Pay Values". *Ecological Economics* Vol. 7:223-238.

Kellert, S.R. 1984. "Assessing Wildlife and Environmental Values in Cost-Benefit Analysis". *J. of Environmental Management*, Vol. 18:355-363.

Kopp, R.J. 1992a. "Why Existence Value *Should* Be Used in Cost-Benefit Analysis". *J. of Policy Analysis and Management,* Vol. 11:123-130.

Lazo, J.K., Schulze, D.S., McClelland, G.H. and Doyle, J.K. 1992. "Can Contingent Valuation Measure Nonuse Values?". *American J. of Agricultural Economics,* Vol.74:1126-1132.

Mitchell, R.C. and Carson, R.T. 1990. Using Surveys to Value Public Goods: the Contingent Valuation Method. Washington, Resources For the Future.

Randall, A., Hoehn, J.P. and Brookshire, D.S. 1983. Contingent Valuation Surveys for Evaluating Environmental Assets". *Natural Resources J.,* Vol. 23:635-648.

Randall, A. and Stoll, J.R. 1983. "Existence Value in a Total Valuation Framework". in R.D. Rowe and L.G. Chestnut eds., Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Boulder CO. Westview Press. pp. 265-274.

Rosenthal, D.H. and Nelson, R.H. 1992. "Why Existence Value Should *Not* Be Used in Cost-Benefit Analysis". *J. of Policy Analysis and Management,* Vol. 11:116-122.

Rowe, R.D. and Chestnut, L.G. 1983. "Valuing Environmental Commodities: Revisited". *Land Economics,* Vol. 59:404-410.

Samples, K.C., Dixon, J.A. and Gowen, M.M. 1986. "Information Disclosure and Endangered Species Valuation". *Land Economics,* Vol. 62:306-312.

Talhelm, D.R. 1983. "Unrevealed Extramarket Values: Values Outside the Normal Range of Consumer Choice". in R.D. Rowe and L.G. Chestnut eds., Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Boulder CO. Westview Press. pp.275-286.

Whitehead, J.C. and Blomquist, G.C. 1991a. "A Link Between Behaviour, Information, and Existence Value". *Leisure Science* Vol. 13:97-109.

Whitehead, J.C. and Blomquist, G.C. 1991b. "Measuring Contingent Values for Wetland: Effect of Information Disclosure About Related Environmental Goods." *Water Resources Research,* Vol. 27:2523-2531.

ENDNOTES

1. See for instance Lazo, Schulze, McClelland and Doyle (1992); Mitchell and Carson (1990); Fischhoff and Furby (1988); Rowe and Chestnut (1983); Brookshsire and Al. (1981).

2. The snail darter was a small fish thought to live only in a Tennessee river, downstream from the proposed Telico Dam in the early 70's. It was at the centre of an important controversy on the faith of endangered species and led to modifications to the U.S. Endangered Species Act. (See Kellert, 1984).

3. In the reduced form of the model, W&B replace the costs of activities which provide information about the resource (membership to environmental organization, buying nature magazines, watching a documentary) by binary dummy variables taking the value 1 if the activity was engaged in by the household, and 0 otherwise.

4. This notation states that $\partial z/\partial Q \geq 0$ conditional on some given level of I being greater than 0.

5. The Equivalent Surplus (ES) associated with a decrease in the resource from Q° to Q' is the amount the consumer would be willing to pay (WTP) in order to avoid the decrease and be as well off as if the decrease had happened. The expressions are

$$\begin{aligned} WTP = ES &= m(P, C_{I^*}, Q°, V°) - m(P, C_{I^*}, Q°, V') \\ &= m\big(P, C_{I^*}, Q°, v(P, Q°|I^*, M°)\big) - m\big(P, C_{I^*}, Q°, v(P, Q'|I^*, M°)\big) \\ &= M° - M' > 0 \end{aligned}$$

In this case, if an increase in Q was being valued, rather than a reduction, the ES would be interpreted as the minimum amount the consumer would be willing to accept (WTA) in order to forego an equivalent decrease but valued from the post change utility level.

6. Reformated scientific information appears in nature, outdoor and other such specialized magazines and programs, or end up in the newsletters and educational material published by environmental groups and other similar organizations. From an information dissemination perspective, however, this strategy is not fully effective since information is partly non-rival and the primary objective of some of these media might be to provide entertainment. They may therefore contain sub-optimal levels of information about natural resources. The household seeking information, as opposed to entertainment, will not purchase the optimal amount of information because of the

added costs for a product, entertainment, that they do not seek.

7. The function $C^P(I)$, introduced earlier, is the cost of information function faced by the public agency.

8. In actual applications of the CVM, researchers are confronted to a sample of households with heterogenous characteristics and varying prior knowledge and existence demand functions. Further research must be carried out on the most effetive strategy to obtain aggregate estimates of net EV using the optimality condition just introduce. Using mean values for prior knowledge and stated WTP may provide an easy solution, but may not be acurate, given heterogenous elasticity of WTP with respect to I.

9. For ease of comparison, the superscript ^{12} denotes results (V^{12}) and variables (M^{12}) related to the current model with substitutes. The superscripts $^{\circ}$ and * refer to previous levels of the variables defined in the single resource model.