Journal of Environmental Management (1999) **56**, 25–34
Article No. jema.1999.0263, available online at http://www.idealibrary.com on IDEAL®

The economic value of reducing environmental health risks: Contingent valuation estimates of the value of information

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Obtaining economically consistent values for changes in low probability health risks continues to be a challenge for contingent valuation (CV) as well as for other valuation methods. One often cited condition for economic consistency is that estimated values be sensitive to the scope (differences in quantity or quality) of a good described in a CV application. The alleged limitations of CV pose a particular problem for environmental managers who must often make decisions that affect human health risks. This paper demonstrates that a well-designed CV application can elicit scope sensitive values even for programs that provide conceptually complex goods such as risk reduction. Specifically, it finds that the amount sport anglers are willing to pay for information about chemical residues in fish varies systematically with informativeness—a relationship suggested by the theory of information value.

Keywords: contingent valuation, scope test, information value, fisheries, health risks.

Introduction

Several recent contingent valuation (CV) studies found that the amount respondents were willing to pay for a good was seemingly insensitive to differences in the quantity or quality of the good offered (Kahneman and Knetsch, 1992; Desvousges *et al.*, 1993). This insensitivity to *scope* is one element of a class of *embedding effects* that seem to produce violations of economic theory in values obtained by CV methods. Specifically, a lack of sensitivity to scope may occur if estimated values are insensitive to characteristics of a good, such as quantity or quality, that economic theory suggests should affect values. On the basis of an observed absence of scope effects in some CV studies, some researchers have stated that CV is fundamentally flawed because it produces value estimates that are 'demonstrably arbitrary' (Kahneman and Knetsch, 1992).

A recent review of CV studies rejected the notion that CV routinely produces scope insensitive values (Carson, 1997). Of 31 split-sample tests reviewed, all but four found statistically significant scope effects. The review concluded that inadequate survey design and administration procedures may have contributed to a lack of observed scope effects in these four studies. Furthermore, one of the four studies (Lin and Milon, 1995) addressed the value of reducing low probability health risks, a case where, 'it is possible to consistently obtain results that suggest insensitivity to scope in split-sample tests' (Carson, 1997; p. 1505).

This paper reports scope sensitive CV estimates of the value of information about health risks associated with environmental contamination. Specifically, it found that anglers valued alternative types of information about chemical residues in sport fish—information they could use to reduce health risks—in a manner consistent with expectations from the theory of information value. The paper adds to the evidence that the CV method is capable of estimating scope sensitive values. It also demonstrates that a

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Received 2 May 1997; accepted 22 February 1999

0301–4797/99/050025+10 $30.00/0

well-designed and administered CV questionnaire can obtain scope sensitive values for goods as complex as information that can reduce low-probability food related health risks.

The first section of this paper integrates the empirical setting and the theory of information value and develops three testable hypotheses about the value of alternative information formats. These hypotheses form the basis for tests of scope effects in the empirical results. The following section describes the process of questionnaire design and data collection. The methods used for data analysis are then presented along with tests of the scope sensitivity hypotheses. A final section discusses the implications of the research.

Michigan's 'public health advisories' and the value of information

Michigan's public health advisory program

Monitoring of sport fish in the Great Lakes region of the Unites States has found traces of a variety of potentially harmful chemical residues. The State of Michigan, which borders four of the five Great Lakes, publishes a public health advisory to inform people about the risks associated with chemical residues in fish. The advisory is printed in the booklet of fishing regulations issued by the state and is directed primarily to anglers. One element of the advisory is a list of fishing sites where monitoring uncovered fish with concentrations of chemical residues above state standards for human consumption.

The list of *unsafe*[1] sites contained in the advisory is the product of an ongoing program that monitors fish at about 30 new sites each year. By 1992, fish from 350 separate sites across the state had been monitored. Fish at 50 of these sites were found to contain unsafe levels of chemical residues and were listed in the advisory. For each listed site, the advisory gives the name and location of the site, the specific fish species found to be contaminated, suggested consumption restrictions for those species,[2] and the chemical responsible for the warning.

The CV component of this study estimated the value to anglers of two specific alternatives to the current advisory program. First, monitoring fish at a site generates two possible information outcomes, either fish at the site are safe to eat or they are not. The 1992 advisory published only the latter information. It did not tell anglers about the 300 sites that had been monitored where fish contained no residues or residues below state standards. The advisory program can therefore be characterised as a *partial disclosure* program in that it only partially disclosed test results. One of the information alternatives valued by this study was a *full disclosure* advisory program. A full disclosure advisory includes a list of sites in the advisory that have been monitored and found to be safe.[3] Second, the study estimated the value of monitoring fish at a greater number of sites each year. The value of monitoring more sites was estimated for both partial and full disclosure advisory programs.

To test for scope effects, the analysis compares the ordering of estimated values for alternative advisories with the ordering suggested by the theory of information value. The remainder of this section derives an ordering of advisory alternatives based on the theory of information value and develops hypotheses about their relative value.

The value of information

In the absence of information, anglers do not know whether the fish they seek contain unsafe levels of chemical residues or not. They are also uncertain about the health consequences of consuming contaminated fish. The following discussion of information value therefore models angling choice as a problem of maximising expected utility. Anglers' utility is taken to be a function of specific

[1] The remainder of the paper refers to sites where fish contain concentrations of chemical residues above state standards as *unsafe sites*. Sites where chemical residues in fish do not exist or are below state standards are referred to as *safe*.

[2] Specific consumption advice includes: (1) consumption not to exceed one meal per week and (2) no consumption.

[3] In the Great Lakes region, the State of Minnesota and the Province of Ontario issue full disclosure advisories.

fishing behaviors such as characteristics of a fishing site and the size, species and quantity of fish to pursue and to consume. The vector q represents these behavioral choices. Anglers' health also enters into the utility function. The advisory suggests that health may be a function of the unknown state of chemical residues and the choices the angler makes about site and species selection and consumption.

Anglers are uncertain about which of K states of chemical residues, denoted by $S = \{s_1, s_2, \ldots, s_K\}$, are present in fish at a particular site. Given available information, they form beliefs about the probability of each state, $P(s_k)$. Define q^* as the expected utility maximising set of actions based on these prior beliefs. The maximal expected utility based on prior beliefs is therefore:

$$u_p = \sum_{k=1}^{K} u[q^*, h(q^*, s_k)]\, P(s_k) \qquad (1)$$

where $u(\cdot)$ is the utility function and $h(\cdot)$ is the function that relates behavioral choices and states of contamination to health.

Now suppose the angler has access to additional information about the state of chemical residues. Information consists of a set of signals, $Y = \{y_1, y_2 \ldots y_I\}$, about the state of chemical residues (Hirshleifer and Riley, 1992). Anglers interpret these signal by assigning them *likelihood probabilities*. The set of likelihood probabilities $P(y_i \mid s_k)$, $\forall s_k$ associated with each signal reflect the perceived information content of the signal. Anglers combine their prior beliefs with these likelihood probabilities to form informed, posterior beliefs about the state of contamination.

Signals have value because of their potential to help anglers avoid mistakes. A mistake is an action taken in ignorance that differs from the action an angler would choose if informed. If an angler forms Bayesian posterior beliefs $P(s_k \mid y_i)$ upon receipt of signal y_i, then the maximal expected utility associated with the angler's prior optimal action, q^*, is:

$$u_m = \sum_{k=1}^{K} u[q^*, h(q^*, s_k)]\, P(s_k \mid y_i) \qquad (2)$$

The action q^* may be a mistake because it may not be the optimal choice associated with informed, posterior beliefs.

Define the expected utility maximising choice given posterior beliefs $P(s_k \mid y_i)$ as q^{y_i}. The value of the signal y_i in utility terms is the addition to expected utility the signal makes possible relative to the utility associated with the mistake, or:

$$v_{y_i} = \sum_{k=1}^{K} u[q^{y_i}, h(q^{y_i}, s_k)]P(s_k \mid y_i) - \sum_{k=1}^{K} u[q^*, h(q^*, s_k)]P(s_k \mid y_i) \qquad (3)$$

Equation (3) defines the ex post value of signal y_i (Hirshleifer and Riley, 1992). The value is ex post in the sense that it is contingent on the receipt of a particular signal. In an ex ante valuation of alternative information systems, the particular signal that will be received is not known. The ex ante value of an information system, prior to knowing which signal it will produce, is the expected value of ex post signal values with respect to the probability of receiving each possible signal (Hirshleifer and Riley, 1992). The ex ante value of an information system Y is therefore:

$$v_Y = \sum_{i=1}^{I} \{ \sum_{k=1}^{K} u[q^{y_i}, h(q^{y_i}, s_k)]P(s_k \mid y_i) - \sum_{k=1}^{K} u[q^*, h(q^*, s_k)]P(s_k \mid y_i) \}\, P(y_i) \qquad (4)$$

where $P(y_i)$ is the probability of receiving signal y_i.

Since q^{yi} rather than q^* is the expected utility maximising choice given posterior beliefs $P(s_k \mid y_i)$, the expressions in Equations (3) and (4) must be non-negative. Thus, the value of information about contaminants in sport fish is non-negative ex ante or ex post. Ex post, receiving information in the form of a particular signal y_i cannot make a person worse off. It either confirms prior beliefs about the state of nature and leaves behavior unchanged or it changes prior beliefs and prevents a mistake. Similarly, since receipt of any particular signal cannot make a person worse off, the ex ante expected value of a set of possible signals before a particular signal is issued is also non-negative.

Information value

The concepts of *informativeness* and *fineness* can be used to order signals by value. A signal is informative if its receipt is more likely

when one state exists than if other states exist. An informative signal thus provides an indication of which of the possible unknown states is most likely. A signal increases in informativeness as the likelihood probability associated with one state increases relative to the likelihood probabilities associated with other states. At the extremes, a signal is perfectly informative if there is only one non-zero likelihood probability associated with it. The likelihoods associated with an uninformative signal are all equal. An uninformative signal is thus equally likely regardless of the true state. The value of an information system is non-decreasing in the informativeness of its component signals (Blackwell and Girshick, 1954; Marschak and Miyasawa, 1968).

Fineness is a special case of informativeness (Marschak and Radner, 1972). An information system Y is *finer* than a system X if at least two signals in Y are subsets of at least one signal in X. Information value is non-decreasing in the fineness of signals that identify states that are relevant to decision making. The concept of fineness implies that an information system that splits an existing signal into two or more decision relevant signals is finer—and therefore no less valuable—than the original system (Marschak and Miyasawa, 1968).

The relative value of alternative advisory information

Equations (3) and (4) suggest that there are two ways to increase the expected value of information. The first is to increase the informativeness (value) of a signal. The second is to increase the probability of receiving a more informative (more valuable) signal relative to the probability of receiving a less informative (less valuable) signal.

The alternative advisory programs considered in this study affect the informativeness and fineness of signals and the relative probability of receiving different signals. Consider first the value of monitoring a greater number of sites with partial disclosure. The partial disclosure format issues two signals. First, it issues a signal to *restrict consumption* (RC) of fish at unsafe sites. The RC signal is informative to the extent that anglers believe it is most often issued when fish at a site are actually not safe to eat. The informativeness of the RC signal depends on anglers' perceptions of the accuracy of both tests for contaminants and the reporting of test results. These perceptions are not affected by the number of sites monitored. Monitoring a greater number of sites therefore does not affect the informativeness of the RC signal. It does, however, increase the probability that any particular unsafe site will be identified as such. It therefore increases the probability of receiving the RC signal.

Second, the partial disclosure advisory issues an implicit signal of *no report* (NR) for sites that are not explicitly included in the list of unsafe sites. These sites include (1) sites that have been monitored and found to be safe, (2) sites that have not been monitored but are safe, and (3) sites that have not been monitored and are unsafe. As more sites are monitored, more of the unsafe sites in the third category are identified. The partial disclosure advisory issues a RC signal for these sites and removes them from the pool of sites for which a NR signal is issued. The proportion of safe sites in the pool thus increases relative to the number of unsafe sites. Monitoring a greater number of sites therefore increases the likelihood that a NR site is actually safe. Monitoring a greater number of sites and partially disclosing test results thus increases the informativeness of the NR signal. Since more sites are identified as unsafe, monitoring a greater number of sites also reduces the probability that the advisory will issue the NR signal.

Monitoring more sites affects the value of the partial disclosure advisory in two ways. First, it increases the informativeness of the NR signal while leaving the informativeness of the RC signal unchanged. Second, it increases the probability of receiving the RC signal relative to the probability of receiving the NR signal. If the RC signal is more informative than the NR signal, a greater probability of its receipt cannot decrease the value of the advisory. Focus groups with anglers suggested that few question the RC signal, they considered it very informative and many used it to guide their choice of fishing sites. The NR signal, on the other hand, is not based on monitoring and contains no solid information. Anglers are unlikely to consider

it a more informative indicator of the presence or absence of chemical residues than the RC signal. These results yield the first hypothesis regarding scope sensitive values for advisory alternatives: *the value of a partial disclosure advisory should be non-decreasing in the number of sites monitored annually.*

The full disclosure advisory issues three signals. Like the partial disclosure advisory, it issues a RC signal if a monitored site is unsafe. The full disclosure advisory also implicitly issues a NR signal when a site has not been monitored. For sites that have been monitored and found to be safe, the full disclosure advisory issues a *no consumption restriction* (NCR) signal. The NR and NCR signals of the full disclosure advisory are subsets of the NR signal from the partial disclosure advisory. The full disclosure advisory is therefore finer—and no less valuable—than the partial disclosure advisory for a given level of monitoring. This gives rise to the second scope sensitivity hypothesis: *for a given level of monitoring, a full disclosure advisory should be at least as valuable as a partial disclosure advisory.*

The RC signal with full disclosure is identical to the RC signal with partial disclosure. As is the case with partial disclosure, monitoring a greater number of sites does not affect the informativeness of the full disclosure RC signal. By the same logic, monitoring more sites does not affect the informativeness of the full disclosure NCR signal. The informativeness of the NR signal with full disclosure is also unlikely to be affected by increased monitoring. With full disclosure, all monitored sites, both safe and unsafe, are removed from the pool of sites for which an NR signal is issued. Removal of these sites is unlikely to significantly affect the proportion of safe and unsafe sites for which the NR signal is issued. The informativeness of the NR signal is therefore unlikely to change significantly.

Monitoring a greater number of sites with full disclosure likely has little, if any, affect on the informativeness of signals. It does, however, substantially increase the chance of receiving the relatively informative RC or NCR signals. As more sites are monitored, the chance that anglers learn whether particular sites are safe or unsafe increases. A final scope sensitivity hypothesis is thus: *the value of a full disclosure advisory should be non-decreasing in the number of sites monitored annually.*

The remainder of the paper focuses on testing the three hypotheses developed in this section. The following section describes the process of questionnaire design and data collection. The analysis section then tests the hypotheses on the collected data.

Questionnaire design and data collection

A series of focus groups, one-on-one interviews, and pretests were used to design the CV questionnaire. Three focus groups explored anglers' beliefs about chemical residues in fish, the language they used to talk about it, and their perceptions of and responses to advisory information. The focus group findings were then incorporated into a draft questionnaire. Sixteen one-on-one interviews refined the draft questionnaire. The interviews identified questions that were unclear or ambiguous and helped assess the adequacy of response choices. The interviews included probing and debriefing questions to determine whether respondents understood and accepted the choice the valuation scenario asked them to make.

A small-scale pretest served as a field test of the survey instrument and administration procedures. It also provided an initial estimate of the distribution of values for the advisory alternatives of interest. This information was used to select the range of program costs used in the final referendum style valuation question.

The final CV questionnaire contained questions about respondents' fishing behavior, their use of the advisory information, a valuation scenario and socio-economic characteristics. The CV valuation scenario contained three parts. The scenario first described the contamination and monitoring situation, the information content of the current advisory, and characteristics of possible alternative advisory programs (see Figure 1). The second part of the scenario described a specific alternative advisory and contrasted it with the current program (see Figure 2). The scenario then presented a referendum choice setting that asked respondents

Michigan's Public Health Advisory

There are more than 5800 public fishing sites in Michigan. These include 2200 sites on rivers and streams, 3600 inland lakes, and the Great Lakes. The state has tested 350 of these sites for chemical residues in fish. About 30 new sites are tested each year.
The current public health advisory tells you:

- That you should not eat too much fish from *any* inland lake because of widespread mercury contamination, and;
- It lists 50 sites where fish contain chemical residues *above* state limits.

The advisory does not tell you about:

- The 300 tested sites where chemical residues *do not* exist or are *below* state limits.

The advisory program could be changed.

- In addition to the list of sites where chemical residues are *above* state limits, the advisory could list tested sites where chemical residues *do not* exist or are below state limits.
- More than 30 new sites could be tested each year.

These changes would increase the amount of information in the current advisory but they would also cost more money.

Figure 1. Final Valuation Scenario, Page 1.

Your Vote on Advisory Programs

The Table below shows two advisory programs. The 'Current Advisory' is Michigan's current advisory program. 'Program A' is a different program that could be put in place.

Program options	Current Advisory	Program A
Lists tested sites where chemical residues are *above* state limits?	Yes	Yes
Lists tested sites where chemical residues do not exist of are *below* state limits?	No	Yes
Number of new sites tested each year.	30	1240
Cost to you in higher license fees.	$0·00	$0·40

Suppose the Michigan Department of Natural Resources (DNR) sent you a ballot to vote 'for' or 'against' Program A. If a majority of anglers vote 'for' Program A, it will replace the Current Advisory. If a majority vote 'against' Program A, the Current Advisory will be continued.

1. Would you vote for Program A if it permanently increased your yearly license cost by $0·40, or vote against it and keep the Current Advisory at no additional license cost?

1 Vote for Program A
2 Vote against Program A and keep Current Advisory
3 Don't know or no opinion

Figure 2. Final Valuation Scenario, Page 2.

whether they would: (1) vote for the alternative program funded by a permanent increase in the annual fishing license cost or (2) vote against the alternative and continue the current advisory program at no additional cost.

Alternative advisory programs were differentiated by three characteristics. First, the 1992 advisory was a partial disclosure advisory. The alternative was either a partial or full disclosure advisory. Second, the 1992 advisory program monitored 30 previously

unmonitored sites each year. The alternative monitored either 110,620 or 1240 new sites annually. Finally, the alternative program was offered at one of 10 different costs.[4] A full factorial design over these characteristics defined 60 unique alternatives. Each respondent was asked to vote on one randomly assigned alternative.

The final questionnaire was administered by mail to 1578 people randomly selected from among the approximately 1·2 million Michigan residents who were licensed to fish in 1991. The survey was administered in three stages as described by the total design method (Dillman, 1978). Of the original sample, 230 questionnaires were returned as undeliverable. The final sample therefore consisted of 1348 accessible individuals. A total of 990 questionnaires were returned for a return rate of 73·4%. The survey produced 951 useable responses to the CV valuation scenario, 70% of the accessible sample.

Analysis

The theory of information value suggests that information value is non-decreasing in informativeness. In the context of the advisory alternatives considered in this study, this implies that anglers should be willing to pay at least as much for an advisory that monitors more sites or fully discloses monitoring results as for an advisory that monitors fewer sites or partially discloses results. The following analysis tests these relationships in a PROBIT regression framework that estimates the value of alternative advisory formats as a function of the number of sites monitored, the level of disclosure, and characteristics of the respondent. The analysis employs a form of the PROBIT model developed by Cameron and James (1987) to directly estimate coefficients that represent mean values for the advisory alternatives.

Table 1 reports the estimated PROBIT mean values for advisory alternatives. The variables PSITES, FSITES and FULLD represent the characteristics of the alternative advisory programs offered in the CV scenario. The variable PSITES equals the number of additional sites monitored annually for respondents for whom the CV scenario offered a partial disclosure advisory. For respondents offered a full disclosure advisory, PSITES equals zero. The variable FSITES equals the number of sites monitored annually for respondents for whom the CV scenario offered a full disclosure advisory. Otherwise, FSITES equals zero. The variable FULLD is an indicator variable for a full disclosure advisory. The non-program variables (READ through COLLEGE) were entered in the regression as differences from their mean values. The coefficients of the program variables thus represent mean values for the average respondent.

The coefficients of the variables PSITES and FSITES are both positive with one-tailed levels of significance of at least $\alpha = 0{\cdot}10$ and $\alpha = 0{\cdot}05$ respectively. The marginal value of monitoring an additional site with either partial or full disclosure is thus positive, a finding that supports the first and third scope sensitivity hypotheses. It is somewhat surprising that the marginal value of monitoring with the more informative full disclosure advisory is essentially equal to that for partial disclosure. Note, however, that sensitivity to scope implies only that the marginal value of monitoring with full disclosure be no less than the marginal value of monitoring with partial disclosure.

While the marginal value of additional monitoring is essentially equal for partial or full disclosure, the large positive coefficient of FULLD suggests that anglers place a significant premium on full disclosure over partial disclosure at any level of monitoring. This finding supports the second scope sensitivity hypothesis—that a full disclosure advisory should be at least as valuable as a partial disclosure advisory at any level of monitoring.

Estimated coefficients of several non-program variables also support the correspondence of the regression results with the theory of information value. First, the value of information is strictly positive ex ante only if anglers anticipate changing their behavior in response to the information. The variables USELIST and BCHANGE provide two measures of anticipated behavioral change. The variable BCHANGE relates primarily to response to a partial disclosure advisory and does not appear to significantly

[4] The 10 program costs used in the study were \$0·40, \$0·95, \$1·45, \$1·90, \$2·85, \$4·10, \$5·55, \$8·75, \$14·50 and \$41·00.

Table 1. Value of advisory alternatives in 1993 dollars

Variable name	Variable definition	Estimated coefficients and standard errors[b]
Constant	Constant term.	0·3457 (2·202)
FSITES	Number of sites monitored with proposed full-disclosure program.	0·0046** (0·0027)
PSITES	Number of additional sites monitored with proposed partial-disclosure program.	0·0045* (0·0028)
FULLD	Respondent offered full-disclosure program.	5·643* (3·151)
READ[a]	Respondent had read the current advisory.	2·658 (2·777)
CHANGE[a]	Changed behavior in response to the current advisory.	0·3652 (2·645)
USELIST[a]	Would base site choice on proposed list of safe sites.	15·612*** (2·979)
BCHANGE[a]	Would change behavior if favorite site listed as unsafe.	1·702 (1·847)
FATAL[a]	Believes illness from contaminated fish likely fatal.	7·245*** (2·120)
SCIENCE[a]	Believes scientists understand health risks associated with residues in fish.	2·688 (1·901)
COLLEGE[a]	Completed college degree.	6·836*** (1·866)
Log likelihood	−436·02	
McFadden's R^2	0·18	
Percent correct predictions	72%	

[a] Non-program variables are entered as deviations from mean values.
[b] Asterisks indicate significance at $\alpha = 0{\cdot}10$*, 0·05** and 0·01***.

affect advisory value. The variable USELIST corresponds to anticipated use of a full disclosure advisory and has a large impact on advisory value. These results are consistent with the finding that the value of a full disclosure advisory exceeds that of a partial disclosure advisory.

Second, the analysis also suggests that both the magnitude and severity of risk were relevant to respondents. In general, respondents viewed their personal risk associated with contaminated fish to be small. The median reported chance that a respondent would, 'someday have health problems because of chemical residues in Michigan's sport fish' was 1 in 100 000. The perceived baseline risk measured in this manner did not significantly influence the value of advisory alternatives. The positive and significant coefficient of the variable FATAL, however, suggests that the perceived severity of the risk is a significant determinant of advisory value.

Finally, respondents who had completed a college education placed a significantly higher value on information than did respondents who had not completed college. This may imply that college educated anglers were better able to understand the complex advisory alternatives and comprehend the implications for their personal risk exposure.

Another way to view the advisory alternatives is in terms of the quantity of information they provide. The correspondence between the quantity of information provided and estimated value further reinforces the regression results. Monitoring more sites increases advisory informativeness in part by increasing the probability of receiving the relatively informative RC or NCR signals. The full disclosure advisory issues both the RC and NCR signals while the partial disclosure advisory issues only one (RC). The number of relatively informative RC and NCR signals issued by alternative advisories

Table 2. Ranking of advisory programs by number of restrict consumption (RC) and no consumption restriction (NCR) signals and by value

Advisory program	Sites with RC or NCR signals			Ranking by value[a]	
	Number of sites	Proportion of total sites[b]	Ranking	Estimated value	Ranking
Partial 110	14	0·002	1	0·84	1
Partial 620	89	0·015	2	3·14	2
Partial 1240	177	0·030	4	5·92	3
Full 110	110	0·019	3	6·49	4
Full 620	620	0·107	5	8·84	5
Full 1240	1240	0·214	6	11·69	6

[a] The ranks by value do not necessarily reflect statistically significant differences in value between alternative programs.
[b] The percent of total sites is based on a total of 5800 sites as described in the contingent valuation (CV) scenario.

is one measure of the quantity of information.

Table 2 illustrates that the ranking of advisory alternatives by the number of relatively informative RC and NCR signals is generally consistent with the ranking by value implied by the regression results. The third column of the table lists the proportion of total sites for which the relatively informative RC and NCR signals would be issued under the six alternative advisory programs listed in the first column of the table. The fifth column lists the values of the advisory alternative implied by the regression results. Columns four and six rank the advisory alternatives by the proportion of RC and NCR signals and by estimated advisory value respectively. The rankings differ only in the relative rank of the partial disclosure advisory that monitors 1240 sites and the full disclosure advisory that monitors 110 sites—the most informative partial disclosure alternative and the least informative full disclosure alternative.

Discussion

This paper provides evidence that a well-designed CV questionnaire can elicit scope-sensitive values even for a good as complex as changes in low probability health risks. The analysis strongly suggests that responses were sensitive to the informativeness of advisories, a result consistent with the theory of information value. Scope sensitivity was also evident in that values were generally less sensitive to small differences in informativeness than to larger differences. The CV questionnaire used in this research seemed capable of eliciting scope-sensitive values for a conceptually complex good.

Two factors may have contributed to the scope effects observed in the value estimates. First, focus groups, one-on-one interviews, and pretests ensured that (1) the valuation scenario described a good in terms that were relevant to respondents' decisions and (2) respondents comprehended the complex differences between alternative advisory programs. In future research it may be revealing to quantify the effect of revisions to the CV scenario on respondents' understanding of key concepts. One would expect that the more clearly respondents comprehended the differences between alternative levels of provision of a good, the more likely they would be to be sensitive to those differences.

Second, the magnitude of the differences in information content between alternative scenarios may have contributed to the significance of results. To illustrate, the valuation scenarios used in the pretest described monitoring levels of 30, 100 and 300 sites per year with partial disclosure and either 200 or 600 sites per year with full disclosure. These might appear to be substantial differences. However, the pretest scenarios also implied that there were as many as 47 000 fishing sites. Monitoring more sites, therefore, produced very small increases in informativeness. In the pretest scenarios, the proportion of sites for which a relatively informative RC or NCR signal would be issued each year ranged from 0·0001 to 0·0138. There was no significant difference between estimated values for any of the pretest programs. Respondents may have viewed the

differences between these programs as insignificant. Scope effects must be evaluated on the basis of factors that matter to respondents (e.g. informativeness) rather than factors that seem relevant to the researcher (e.g. number of sites monitored).

This work illustrates that CV can be a useful tool for environmental management professionals. First, it illustrates that a relatively modest, well-designed CV study can contribute substantially to the types of information relevant to many environmental management decisions. The qualitative focus group and pretest work associated with CV questionnaire design provides valuable general information about public perceptions of environmental problems and current or proposed management activities/solutions. Despite the strengths of the CV approach, however, the study also emphasises the importance of careful design and application in obtaining meaningful results.

More specifically, the paper illustrates that the CV method can elicit economically meaningful values for changes in low probability health risks when these changes are associated with a specific program designed to reduce risk. Unlike previous studies, this study did not ask respondents to value a change in health risk directly. Instead it elicited the perceived baseline risk level and asked respondents to value information that would permit them to reduce that risk. The design left it to respondents to assess their personal level of risk, the change in risk additional information may make possible, and how much that information was worth to them.

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