Recreation

Measuring a Social Cost of Environmental Pollutants Through the Use of an Information Variable

Robert N. L Shulstad

Abstract. Avoidance costs of pollutants are estimated by introducing an information variable into the recreationist's demand model, hypothesizing a discontinuance or decrease in their activity as information concerning contamination is received. The decrease in recreationists' consumer's surplus estimates a social cost of environmental pollutants. Mercury and Oregon's pheasant hunters are examined.

Key words: economics, information, pollutants, recreation.

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The conceptual framework for determining the optimum level of pollution control by equating marginal social costs to marginal social benefits has been well established, but the conceptual and empirical questions of social evaluation still remain.

To this point in time, most efforts have been concerned with valuing the treatment and damage costs associated with environmental pollutants. Another very real and perhaps larger cost to society is the avoidance costs incurred as individuals voluntarily alter their behavior in an effort to avoid exposure to the damaging effects of pollutants. The objective of this paper is to present a methodology for valuing these avoidance costs.

Edwards, in an effort to aid public decision-makers in the choice of pesticide use policy, developed a benefit-cost model which incorporated a value for the externalities generated by the use of persistent pesticides [3]. However, in estimating the externalities generated by pesticide use in Dade County, Florida, only acute external effects were valued. Edwards argues that without an established relationship between chemical use and environmental effects, information on the suspected effects of chemicals cannot be introduced into the benefit-cost decision model.

Full information is not presently available for defining the cause and effect relationships between discharges of potential pollutants, the resulting concentrations of these in the environment and the physical effects

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of these concentrations on individual organisms and broader natural systems. Yet, decisions must be made for control of the pollutants. A primary concern must be to develop a means of evaluation which will allow for the systematic consideration of chronic and suspected effects of environmental contaminants in the determination of optimum control policy.

Castle and Stoevener argue that at least one of three technical conditions must exist to provide a necessary condition for public intervention into the market allocations of resources [2]. These conditions are the existences of technological interdependencies, indivisibilities, or public goods. In respect to the use of persistent pesticides and other environmental contaminants, technological interdependencies are suspected.

In selecting the appropriate control policy, the public decision-maker is faced with positive net private benefits arising from the use of persistent pesticides, non-private costs to society resulting from the acute effects of the pesticides, and suspected chronic effects to both man and wildlife which may result from the use of the pesticides. These suspected effects, if correct, would represent increased public costs. If a decision to restrict the use of the pesticide is made when private net benefits exceed the value of proven externalities, it can only be justified on the basis of a social value judgment in conjunction with the policy maker's estimates of expected damages. Specifically, the judgments are that 1) the use of the pesticide will automatically and inevitably affect the consumption or production of individuals not using the pesticides; 2) that the value of these effects will be greater than the net private benefit derived from the pesticide use, i.e., a portion of the suspected effects will in fact result; and 3) that public intervention will result in social benefits greater than social costs.

An important aspect in evaluating a pesticide use policy must be concerned with the effects of that policy on individuals who are not directly involved in the decision to use the pesticide. It is these individuals who bear the external costs of pesticide use. Their behavior can be altered either involuntarily through the actions of a biological relationship, as in the case of acute or chronic pesticide poisoning, or voluntarily, as they attempt to avoid exposure to such effects. Thus, the evaluation of externalities involves the valuation of behavioral changes and the costs associated with those changes; damage costs, treatment costs, and avoidance costs.

The voluntary behavioral changes of individuals which manifest themselves in treatment and avoidance costs will always be initiated by the receiving of information. Such information will often concern the harmful effects or damage costs which could be incurred if action is not taken. The extent of the behavioral changes resulting from a given amount of information will be dependent on the previous knowledge of the individual, the context in which the information was received, and the attitude of the individual.

If an individual believes the information to be true, his actions will be the same whether the information is true or not.

Evaluation of human response to information concerning environmental dangers may provide a valuable indicator of the avoidance costs associated with environmental pollutants. However, the value of this response can be used as an indicator of a social cost of the pollutant only if the information provided is not misleading.

A Case Study: Mercury Contamination in Oregon's Pheasants

Mercury concentration in excess of the U. S. Food and Drug Administration's maximum allowable limit of 0.5 parts per million have been accumulated in some of Oregon's pheasants as the result of feeding on seed and herbage treated with mercury chemicals. Excessive concentrations of mercury can result in physiological effects in the pheasants as well as providing harmful concentrations to higher members of the food chain [1]. As other wildlife or humans feed on mercury contaminated pheasants, they too may suffer sublethal, chronic effects from the mercury ingested.

The primary use of pheasants is as a game bird for hunting and observation. Thus, the primary externalities of mercury fungicides use as it affects the pheasants of Oregon would be borne by the pheasant hunters.

There are presently no reliable data available concerning the effects of mercury on humans which would be descriptive of this situation and which would allow a direct evaluation of these kinds of costs of mercury use in agriculture. Instead, a more indirect approach had to be taken and the revealed demand technique was selected.

It was assumed that mercury effects would be limited to those individuals who would consume the pheasants after they were harvested by the hunter; that the hunter would take into account these possible harmful effects, and that the utility of pheasant hunting would hence decline. Further, it was assumed that the hunter's knowledge about the effects of mercury in pheasants would largely be the result of information flows concerning the presence and dangers of mercury available to the hunter through the mass media. It was hypothesized that hunters' behavior would change in that they would (1) cease pheasant hunting altogether, or (2) would reduce their hunting effort as they received information about the dangers of mercury in pheasants [6]. In effect, the information variable was used as an indicator of the quality of the pheasant hunting experience. 1/

An information variable was developed through the use of content analysis to reflect the amount of information which was supplied about the subject by the state's major newspaper, The Oregonian. 2/ This analysis found the articles concerning mercury contamination to be predominately one sided. Mercury was consistently recognized as a source of concern due to its cumulative nature and harmful effects. Thus, the volume of information appeared to be the appropriate measure of the level of information flows.

Four measures of the volume of information were examined; column inches of articles in year preceding the hunting season, cumulative column inches of articles in two years preceding the hunting season, number of articles in the year preceding the hunting season, and cumulative number of articles in the two years preceding the hunting season. While information is theoretically important it is difficult to predict the most effective measure of its presence.

Demand for Pheasant Hunting Days Per Hunter: Cross-Sectional and Time Series Models

An individual's demand for pheasant hunting days was hypothesized to be a function of the price per pheasant hunting day both in dollar costs and travel time costs, the prices of alternative commodities, his income, the length of the pheasant hunting season, the amount of hunter competition, the success of the hunt, and the amount of information available to the hunter concerning the presence and danger of mercury in the pheasants.

The individual's demand model for pheasant hunting days can be expressed as:

$$(1) \qquad Q = F\ (P,\ P_A,\ Y,\ T_1,\ T_2,\ H,\ S,\ I)$$

where

Q = Pheasant hunting days per hunter per season.

P = Real dollar transfer cost per pheasant hunting day (costs included; transportation, food, lodging, ammunition, and licenses).

P_A = Price of alternative commodities.

Y = Real income per capita.

T_1 = Travel time costs needed to reach the site, measured by one-way distance from the hunter's residence to the nearest border of the hunting area.

T_2 = Length of the hunting season in days.

H = Number of pheasant hunters.

S = Hunting success.

I = Index of the level of information concerning mercury in pheasants.

A cross-sectional model (2) was used to isolate the relationship between days of pheasant hunting, dollar transfer costs, travel time costs, and experience related success (S_E).

$$(2) \quad Q = f_1\ (P,\ T_1,\ S_E \mid P_A,\ Y,\ T_2,\ H,\ I)$$

A modified Clawson approach for demand estimations was used to estimate cross-sectional demand models for pheasant hunting in each of the three primary pheasant hunting areas in Oregon. 3/ Data were obtained from the 1971 Oregon State Game Commission's hunter questionnaire and represented the returns from a five percent sample of all individuals who had a hunting license in 1971.

Due to data limitations or lack of cross-sectional variability, the effects of prices of alternative commodities, income, hunter competition, biologically induced success changes (S_B), the length of the hunting season, and the level of information on the demand for pheasant hunting days were estimated using time series analysis (3).

$$(3) \quad Q_t = f_2 \, (P_{A_t}, Y_t, H_t, I_t, S_{B_t}, T_{2_t} \mid P, T_1, S_E)$$

The estimated effect of the information variable was to be used as a shifter of the cross-section demand function to provide the basis for the evaluation of the impact of mercury use on the recreational value derived per hunter from pheasant hunting.

Ordinary least squares regression was used to estimate the time-series days per hunter relationship. Yearly data over the period 1950 through 1971 were used. Due to a high degree of multicollinearity between real per capita income and the price of alternative commodities, which was a characteristic of the time series data, income was dropped from the model. The remaining data were corrected for autocorrelation and equation (4) was estimated.

$$
\begin{aligned}
(4) \quad \hat{Q}_t = \; & -0.7272^{**} \quad + 0.0238 \, (D)_t^{*} \\
& \;(2.29)^{4/} \qquad\quad (3.77) \\
& + 0.0085 \, (P_A)_t + 0.7549 \, (S)_t \\
& \quad (0.83) \qquad\qquad (1.52) \\
& - 0.000008 \, (H)_t - 0.00006 \, (I)_t \\
& \quad (-1.25) \qquad\qquad (0.29)
\end{aligned}
$$

* Significant at $\alpha = .01$
** Significant at $\alpha = .05$

$$
\begin{aligned}
^{**}R^2 &= 0.572^{4/} \\
\bar{R}^2 &= 0.438 \\
\text{D-W} &= 1.97 \\
n &= 22
\end{aligned}
$$

where

Q_t = Average number of pheasant hunting days per hunter per season.

D_t = Length in days of the pheasant hunting season in year t.

P_{A_t} = Price of alternative commodities measured by the consumer's price index for year t.

Y_t = Average per capita real income for Oregon in year t.

S_t = Average success measured in birds bagged per day for year t.

H_t = Hunter pressure measured in number of pheasant hunters in year t.

I_t = Index of information on the presence and dangers of mercury in pheasants measured by the number of column inches of articles appearing in The Oregonian during the 12 months preceding the hunting season of year t.

Based on equation (4) the hypothesis that knowledge of the presence and dangers of mercury in pheasant would decrease the demand for pheasant hunting days by hunters who remain in the pheasant hunting population was rejected. That is, information concerning mercury did not significantly affect the number of pheasant hunting days demanded by hunters who continued to hunt.

The Number of Hunters Relationship

The primary effect of mercury on the behavior of pheasant hunters was expected to be reflected in the number of hunters who discontinue hunting entirely in an attempt to avoid exposure to the mercury. To determine the magnitude of this effect, yearly data were used to estimate the number of hunters relationship.

The number of pheasant hunters was assumed to be a function of Oregon's population (Pop_t), real per capita income (Y_t), the level of expected success $(S)_{t-1}$, the degree of accessibility to private lands ($L.A.D._t$) and the level of information concerning mercury in pheasants (I_t).

$$(5) \quad H_t = H(Pop_t, Y_t, S_{t-1}, I_t, L.A.D._t)$$

Least squares regression of the yearly data resulted in the following number of hunters relationship (6).

$$(6) \quad \hat{H}_t = \underset{(0.63)}{16{,}677} + \underset{(5.44)}{0.1300}\,(Pop)_t^{*} - \underset{(-5.60)}{69.851}\,(Y)_t^{*}$$

$$- \underset{(-3.33)}{233.73}\,(I_{\#c})_t^{*} + \underset{(1.78)}{23{,}964}\,(S)_{t-1}^{**}$$

$$- \underset{(-2.76)}{10{,}386}\,\binom{\text{Land Access}}{\text{Dummy}}_t^{*}$$

$*\ \alpha = .01$
$**\ \alpha = .05$

$*R^2 = 0.8945$

$\bar{R}^2 = 0.861$

$D\text{-}W = 2.1535$

$n = 22$

where

H_t = Number of individuals hunting pheasant in Oregon in the t^{th} year.

Pop_t = Oregon's population in t^{th} year.

Y_t = Per capita real income in Oregon in t^{th} year.

$I_{\#c}$ = Cumulative number of The Oregonian articles concerning the presence and danger of mercury in pheasants appearing in the two years preceding the t^{th} hunting season.

S_{t-1} = Expected success of the t^{th} hunting season as measured by the actual success of the $t-1^{th}$ hunting season.

Based on the estimated number of hunters relationship, a loss of 17,602 hunters from the 1971 pheasant hunter population could be attributed to the knowledge of the presence and dangers of mercury in pheasants. This represents 92 percent of the actual decrease in hunter numbers from the 1970 season to the 1971 season.

The effect of mercury on the behavior of pheasant hunters was examined through the use of time series models. The effect of mercury on the behavior of hunters who remain in the hunting population after information concerning mercury became available was found to be insignificant. A significant reduction in the number of pheasant hunters was found to be related to the presence and dangers of mercury in pheasants. This cause and effect relationship must be assigned with caution, however, because of the limited data base used in its estimation.

Valuing the Avoidance Costs

The economic value of the avoidance costs was determined utilizing the cross-sectional demand models for the three primary pheasant hunting areas of Oregon. Four variations of the modified Clawson method were used in estimating these demand models.

The first and second variations used a composite variable representing both the dollar transfer costs (P) and the travel time costs (T_1) of the pheasant hunting experience. The relative effects of each were then estimated by use of a trade-off function developed from a previous recreation study. 5/

A traditional distance-based transfer cost model was then developed to serve as a check on the trade-off method.

An estimate of the loss of consumer's surplus to those hunters who discontinued hunting was developed using a weighted average of the consumer's surplus estimates developed for each area. The weights for each area were equal to the number of hunters lost from that area divided by the total number of hunters who quit hunting.

The weighted upper bound of the loss of consumer's surplus per hunter was estimated to equal $278.31 per season. The weighted lower bound equaled $222.57 per hunter per season. On a daily basis the loss in net economic value per hunter had an upper bound of $58.81 and a lower bound of $48.70. Thus, the net loss in the value of Oregon pheasant hunting, which could be attributed to the use of mercury fungicides in Oregon had an upper bound of 4.7 million dollars and a lower bound of 3.8 million dollars. This value is a measure of the avoidance costs associated with mercury fungicide use.

The actual dollar estimates are not of primary importance. Their development hinged on the use of many limiting assumptions and a scant amount of data. Likewise, the use of column inches of articles and the cumulative number of articles as proxies for the level of information flows and making inferences about the knowledge of pheasant hunters from these proxies can only be considered a first approximation.

While a significant information effect on pheasant hunting effort was estimated, cause and effect relationships must be assigned with caution because of the limited data base of the estimates. More important is the rationale for the use of the information variable itself. Human response to information about environmental dangers associated with agricultural technology, or stemming from any other source, can be used as an indication of the social costs of environmental contaminants. But, the value of these behavioral changes will be a valid measure of avoidance costs of the pollutant only if such information is not misleading. In the area of agricultural technology where environmental effects are often complex and incompletely understood, it is especially important that through continued research, information flows be improved so that behavioral responses by both private and public decision-makers are as well based as possible. As information flows improve, their measurement will be helpful in generating improved measures of avoidance costs.

Footnotes

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1/ The use of a quality characteristic in the demand model for estimating recreational benefits was introduced by Stevens in an effort to measure the effects of water pollution on the direct benefits derived from fishing in Yaquina Bay [7].

2/ Content analysis is a phase of information-processing in which communication content is transformed, through objective and systematic application of categorization rules, into data that can be summarized and compared [5].

3/ This method was chosen due to the characteristics of the empirical problem recognizing the difficulties associated with this technique, i.e., in specification of the model and interpretation of results.

4/ Due to the use of a new iterative process to correct for autocorrelation, developed by Hammonds, the R^2 and the t-statistics are not reliable, however, they are probably a better indicator than those of an uncorrected model [3].

5/ See [6] for an elaboration on how the composite variable and trade-off function were used.

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