Journal of Benefit-Cost Analysis

Volume 3, *Issue* 4 2012 *Article* 4

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Recommended Citation:

Farrow, Scott and Larson, Douglas M. (2012) "News and Social Cost: The Case of Oil Spills and Distant Viewers," *Journal of Benefit-Cost Analysis*: Vol. 3: Iss. 4, Article 4.
DOI: 10.1515/2152-2812.1074

News and Social Cost: The Case of Oil Spills and Distant Viewers

Scott Farrow and Douglas M. Larson

Abstract

Although contingent valuation methods are now frequently used to assess the total value of even distant events, benefit-cost analysis could also be informed by observed behavior that links distant events and consumers. It is typically the news media which connect passive consumers to distant events about which they may or may not take action. The information and adaptation costs incurred by the news consumer are privately beneficial, but additionally are shown to be a lower bound to social welfare losses from a socially defined "bad" event under plausible circumstances. The recent Deepwater Horizon well blow-out in the U.S. Gulf of Mexico is a current example which we seek to inform by study of the oil spill from the Valdez, Alaska spill in 1989. We identify an incremental willingness to pay for news about the Exxon Valdez spill above a standard news broadcast and an increased probability of viewing a broadcast related to the spill. We develop and explain how this private value associated with media consumption can be interpreted as a partial measure of social costs for passive viewers who take no further action beyond news viewing and likely represent the majority of affected citizens (though not necessarily the majority of social costs). Though the per-person values of passive users may be modest in magnitude in the present application, some passive use values appear to be measurable, and that it may well be worth pursuing further the search for the faint but observable links between behavior and distant events through the news media.

KEYWORDS: information, adaptation, passive use, media, oil spill, television

Author Notes: We have greatly benefited from discussions with Don Bieniewicz, Nancy Bockstael, Ambarish Chandra, Greg Duncan, Bob Hahn, Arnold Harberger, Paul Jakus, Jim Kahn, V. Kerry Smith, Andrew Solow, David Weimer, Richard Zerbe and the comments of two anonymous referees. All errors remain our own.

1. Introduction

We investigate the case of a news event that is legally defined as "bad" and derive the links between individually beneficial action and the resulting social cost, much like individual investments in personal security. New information is the typical triggering action for a standard event study where news is announced, such as the merger of two companies or a pollution advisory, and the existence of an impact is evaluated in the affected market (Campbell, Lo, and MacKinlay, 1997; Lamdin, 2001; Eckhout, Gollier and Schlesinger, 2005). Less well established is the economic analysis of the intermediary between the event and the consumer, the news media. In many cases media news coverage may be the only link between the consumer and the event, whereas in other cases there may be additional consumer activities in response to the information.

Before developing the theory of social cost measurement, we motivate the study with two broadly similar events, the 2010 *Deepwater Horizon* well blowout in the Gulf of Mexico that resulted in considerable news coverage and will no doubt cause litigation and policy changes for years to come, and the 1989 Valdez, Alaska tanker oil spill. Our central question is "How might economists value the impact on individuals whose only exposure to the event is through the news media"? One approach is through contingent valuation studies. Another approach to understanding distant behavior is to pursue what faint behavioral trails may exist that link consumers to distant events, a phrase related to the review of contingent valuation studies following the *Exxon Valdez* event (Arrow et al., 1993). In order to pursue one trail we use data from the Valdez, Alaska oil spill in 1989 to develop new tools for the estimation of value and social cost for those who sit and watch.

We investigate two monetized welfare measures of a news event study. The first evaluates the incremental, positive, compensating variation to consumers of news based on their access to information and the increase in its value due to the event. There are extensive and intensive margins to this compensating variation, in the form of an increase in the probability of news consumption and an increase in the value of that consumption compared to an expected broadcast. These effects are combined and may be termed as private (or personal) value to consumers, although such values may also feed back into advertising decisions and the revenue of media firms. The second, more complex, question we investigate is to what extent these personally optimal and incremental choices may be viewed as an element of, or bound for, social costs or benefits associated with a distant event.

But exactly what is "news" and its link to economic constructs is little studied. Media analysts offer a variety of definitions of news including "what is significant" and "what are by definition new" (Bignell and Orelbar, 2005). More

https://doi.org/10.1515/2152-2812.1074 Published online by Cambridge University Press

complex treatments of news in the media refer to a broad "surveillance function" and defining what is newsworthy as involving deviance or social significance, each with several potentially quantifiable dimensions (Shoemaker and Cohen, 2006). By contrast, economic or decision analysis research tends to discuss information as an input into an optimal decision in which acquiring more information, either actively or passively by waiting, is related to its value in the primary decision (Clemen, 1996; Hirshleifer and Riley, 1997; Morgan and Henrion, 2004; Eckhout, Gollier, and Schlesinger, 2005). Hirshleifer and Riley (1997, pp. 167–177) explicitly link information and news as they define increments to information as news or messages. They also identify a message service as the activity, such as television news watching, that delivers the news (information). Optimal decision making under uncertainty then involves paying, or waiting for, a message service to deliver news in order to make an optimal decision such as a consumer or investment choice in the face of uncertainty.

Consequently, we take the consumption of news from the media as an activity in which the reporting of extreme events makes sense both as surveillance of the external environment and as a potential element of decision making under uncertainty. We posit that news viewing can, but need not, lead to behavioral adaptation that directly affects individual welfare. For instance, consumers may view television news and learn of contaminated food products or of an increase in crime. Consumers may as a consequence adapt, by shifting food purchases in the first case and altering public behavior or purchasing steel doors or other defensive devices in the second. News of more distant events may lead to changes in behavior such as changing the company or country from which one buys goods, or to alter donations to charitable or other organizations as has happened in large amounts following recent natural disasters. Consumers may also choose not to change their behavior, based on their preferences and budget. We do not investigate what specific adaptive steps are taken; we focus on the initiating step of acquisition of information and the personal value and social cost associated with that activity.

Economic values can typically be measured for direct market based actions using standard procedures. But what is the value for those who make their decisions to sit and listen or watch or read? We first develop a utility based structure for the personal benefits of news consumption. Whether these personal benefits are equivalent to social benefits, or instead represent social costs, is a matter of debate. Various terms have been linked with a possible social cost interpretation such as non-use value (Hausman, 1993; Carson et al., 1994), passive use value (Carson et al., 2001), and distant use value (Turner et al., 2001). Some economists have argued that the welfare implications of such users can never be measured using observed behavior, but is only measured using surveys about hypothetical economic behavior.

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We develop a framework that identifies the information acquisition and further adaptive behavior as mitigation activity responding to an original decrease in welfare from the event. Information acquisition will be shown, under plausible and even likely circumstances, to represent a lower bound on the original change, here a loss, in welfare. This implies that observable behavior exists for some aspects of distant or passive use and that such behavior is measurable using methods formally equivalent to those developed for direct users.

We have found a continuum of cases that may reflect a social cost. For instance, consider first the case of local news about criminal events. The model to be developed assumes an initial loss in welfare from the event to which a person might choose to adapt. A consumer may incur costs in obtaining the information and decide to engage in some defensive activity such as fences, alarms, different driving patterns, and so on. Few analysts would dispute that a policy that reduces crime could include as benefits the reductions in the cost of incremental information gathering and defensive expenditures even though those expenditures are optimal (benefit enhancing) for the individual in the state of the world with more crime.

The situation is a bit different with the kind of incident, and induced behavior, that we analyze here. Rather than counting the private benefits of policy-induced actions as part of the social benefit of the policy, we use the private benefits of incident-induced actions to "bound" the person's contribution to social costs of the incident. We focus on a distant event identified as illegal such that a social definition of "bad" exists (Zerbe, 2001). The requirements for our bounding approach to work are (a) that the person is made worse off by the incident, and (b) that the person not be made fully whole by the private actions s/he takes in response.

A natural objection is to ask about "rubberneckers," i.e., those who take vicarious pleasure from accidents or spectacles. Indeed, our approach would not work for those who truly gain pleasure from awful incidents, because they directly gain rather than lose from the incident. But for the type of event we are analyzing, this stereotype of behavior seems to be in a relatively small minority, if it occurs at all. Recent opinion polls about peoples' responses to the Gulf oil spill make clear that the vast majority of the public feels both that the spill is a major problem and that they are harmed directly or indirectly by it.

For example, in the ABC News/Washington Post Poll of July 7–11, 2010, 68% said they thought the spill was a "major disaster," whereas 28% said it was a "serious problem." Only 3% said it was "not too serious." The same respondents also described their feelings about the spill, with 35% indicating they were "angry," 29% saying they were "upset," and 33% feeling "concerned." Only 2% said they were "not concerned" and the question is not even asked whether someone feels better as a result of the event. This was their state of mind after

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having consumed considerable media coverage of the incident: 47% said they were following the news about the oil spill "very closely," and 40% said they were following the news "closely" (USA Today/Gallup Poll of May 24–25, 2010).

These sentiments are echoed in various ways in related polls. A majority of people feel they are and will be affected adversely, with harm to the economy and rising prices for fuel and food mentioned in addition to their environmental concerns. They have been consuming media coverage of the incident, yet remain of the opinion that they are less well off than they were for the spill. These are the conditions under which it is the private benefits of their media consumption are a lower bound for the economic loss that distant viewers suffer from the spill, as we show later.

The consumption of information, and more specifically the television news, is likely to be the initiating activity for a passive user. Changes in the consumption of other goods or services as a result of the news are not analyzed here. However, because television viewing was the largest source of national news during the era of our case study event, the 1989 *Exxon Valdez* oil spill in Prince William Sound (Iyengar and Kinder, 1987), if the proposed approach is valid it should be applicable to television viewing of this event.

2. Theory

Information might be consumed for a variety of reasons, including "entertainment, consumption decisions, production activities, and political actions," as Hamilton (1995, 2004) suggests following Downs (1952). We assume information gathering is the result of utility maximizing activity that may include any of these elements, subject to one or more budget constraints. Our approach investigates whether specific content changes viewing behavior, but we do not answer specifically why a person may be interested in that content. The related normative issue, noted above and taken up more fully later, is the extent to which privately beneficial personal choices can be interpreted as social welfare changes, given attitudes such consumers express and social norms on the nature of the event. We first create a discrete consumer surplus measure based on the difference between the implicit price of, or marginal willingness to pay for, media consumption and the viewer's opportunity cost. The change in television viewing behavior will be shown to depend on two parts, the change in probability of viewing and the change in the implicit price per minute of viewing. Consumers will be observed to have a (net) willingness to pay for observing the event over the baseline of a standard news item.

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Consistent with the viewership data we have available, we focus on the conditions under which a broadcast segment containing a particular news story is viewed.[1] To motivate the analysis, a model of consumer choice subject to both money and time constraints is needed. Broadly, we, follow the approach pioneered by Becker (1965). Although the choice problem that leads to our estimating conditions can be set up in more than one way, it is sensible to frame it with two time constraints: the overall time constraint within which all activities must fit, and a constraint on the length of the story being viewed each day. We assume that the consumer's overall time constraint binds, consistent with time playing an important role in determining choices,[2] although the story length constraint may or may not bind, depending on the viewer's interest in it.[3] With a joint choice of labor supply (hours worked, h) and a focus on media viewing, v, the primal version of the consumer's choice problem with both money and time constraints is:

$$\max_{q,v,h} u(q,v,z,x) + \lambda \cdot (E + w \cdot h - t \cdot q) + \mu \cdot (T - h - v - q) + \phi \cdot (\overline{v} - v) \ ,$$

where q is aggregate consumption of market goods at unit price, v is media viewing, z is an indicator of environmental amenities associated with the news story (those in Prince William Sound in our application); x measures long-run viewer characteristics and viewing patterns, h is hours worked at wage w, E is transfer payments, $\overline{v}$ is (broadcaster-determined) quantity of media available, t is the time required for market goods consumption, and T is total time available.[4]

The (first order) conditions for optimal viewing and labor supply are useful in interpreting the econometric estimates in our empirical application.

[1] We do not take up the interesting question of how the choice of what to watch is made in a household, which is not essential for our purposes. Households vary in both the number of viewers and television sets, and in some cases the chooser is an individual and in others it is a group within the household. Although we describe the conditions that must hold for an individual to watch television news, if the analysis were reframed so that the choice of what is viewed is joint within the household, each individual within the household nonetheless would compare the implicit benefit of viewing the program chosen against her opportunity cost of time in deciding whether to participate in the viewing experience.

[2] If the overall time constraint were not binding, the problem would simply reduce to the standard problem of consumer choice with a single (money) budget constraint, which would be uninteresting for present purposes.

[3] Were they able to choose how long they watched the media story, viewers with a keen interest would choose a longer viewing time, but would be constrained by the actual segment length. Those with less interest would not be restricted by this constraint and would not watch the entire story.

[4] To emphasize the time costliness of activities such as media viewing, we have assumed that there is no money cost of viewing, but this simplification does not affect the nature of our results.

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Converted to money terms by dividing both sides by the marginal utility of money (λ), the condition for optional viewing (given that the program is watched) is:

$$\frac{\phi}{\lambda} = \frac{u_v}{\lambda} - \frac{\mu}{\lambda}, \tag{1}$$

where ϕ / λ is the marginal net benefit of an additional minute of viewing, which is the difference between the marginal value of viewing (u_v / λ) and the marginal cost of viewing (μ / λ, the opportunity cost of time). From the first order condition for labor supply $(\lambda \cdot w - \mu = 0)$, this can be written as:

MNB of viewing = *MB* of viewing – *w*.

The *MNB* is a per-minute private net benefit of viewing the story, i.e., the difference between the marginal benefit (*MB*) of a minute viewed and the wage per minute, and is strictly positive when the story length constraint binds (i.e., when $\phi > 0$) and the viewer watches the entire story, and is zero otherwise. In both cases, however, because the segment viewed is of discrete length, the per-minute welfare measure of interest is the average net benefit (i.e., total net benefit of the segment divided by minutes watched), which will typically be positive.[5]

In setting up an estimation model (welfare implications will follow), it is more convenient to work from the dual perspective, reframing the consumer choice problem in terms of distance function minimization,[6] because the choice variables which solve this problem are the virtual prices or marginal willingness to pay for goods. The virtual prices provide a direct way of econometrically modeling consumer decisions in terms of willingness to pay for a good relative to alternative benefits or prices. To operationalize this, suppose the marginal willingness to pay or inverse Hicksian demand for television news viewing $\upsilon_{id}(x_d, z_d, \varepsilon_{id})$ by individual *i* on day *d* [i.e., u_v / λ in Eq. (1) above as it varies across people and time] is parameterized as:

$$\upsilon_{id}(x_d, z_d, \varepsilon_{id}) = x_d \cdot \beta + z_d \cdot \alpha + \sigma \cdot \varepsilon_{id}, \tag{2}$$

[5] Declining marginal benefit of viewing time with increases in minutes viewed would be sufficient for this, for example.

[6] This is subject, in this case, to the time constraints along with the usual utility constraint. The distance function optimization statement is not written explicitly, as it contains the same information as the utility maximization problem.

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where x_d is the vector of viewing patterns and viewer characteristics with corresponding parameter vector β;[7] z_d is the vector of story characteristics relating to Prince William Sound as predetermined by the broadcaster, with corresponding vector α; ε_{id} is a symmetric random variable with zero mean and unit variance; and σ is a scale parameter.[8] Because network news is broadcast over the airwaves free of charge, the money price of viewing is zero, so the full price of viewing is the person's opportunity cost of time[9], the wage rate w_i scaled to be commensurate with the time units of consumption[10].

We assume consumers act rationally to choose the quantity of television news by comparing its implicit value to the opportunity cost of their time. The probability of a representative consumer watching a minute of television news can therefore be characterized in terms of the marginal benefit $[\upsilon_{id}(x_d, z_d, \varepsilon_{id})]$ and the marginal opportunity cost of viewing (w_i); that is, for individual *i* on day *d*,

$$\begin{aligned} \text{Prob } (i \text{ viewing on day } d) &= \text{Prob}\{\upsilon_{id}(x_d, z_d, \varepsilon_{id}) > w_i\} \\ &= \text{Prob}\{x_d \cdot \beta + z_d \cdot \alpha + \sigma \cdot \varepsilon_{id} > w_i\} \\ &= \text{Prob}\{\varepsilon_{id} < -w_i / \sigma + (x_d \cdot \beta + z_d \cdot \alpha)/\sigma\}, \end{aligned} \qquad (3)$$

where the last probability statement follows from the symmetry of the error distribution, which is invoked to reverse the inequality in order to derive a statement about the cumulative distribution function of the error.

[7]The vector x_d includes the column vector e = (1,…,1)′, segment length, and any desired viewer demographics that are invariant with respect to day; the utility index can be thought of as imbedded in the intercept term. Because the data available to us contain segment length and number of viewers by day, we assume that the segment length constraint is binding. The daily subscript is made explicit here because the consumer model identifies changes in viewing patterns over time.

[8]A supply model where story length, t^b, is chosen by the news organization to maximize profit based on story characteristics and long run viewer and advertiser characteristics is available from the authors. The story length is then predetermined to a viewer of the specific program.

[9] This is likely to be the major determinant of the full price even when the news is viewed on a cable or satellite channel.

[10] The relatively extensive literature on the value of time in transportation, household production, and non-market valuation settings often includes a variety of potential adjustments (typically downward) to the wage rate to reflect the effects of taxation, benefits, institutional limitations on the equilibrium number of hours worked, and elements of consumption mixed with pure opportunity costs. In our view, the value of leisure time devoted to information market activities is worthy of more detailed investigation, although here we use a mean before tax wage due to the nature of the data available for empirical analysis. This is a conservative approach to valuing information because overstating the opportunity cost of leisure time will, all else equal, understate the marginal net benefit of viewing, as Eq. (1) indicates.

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Because our data are aggregated over demographic groups, we estimate an aggregate version of Eq. (3) where viewing characteristics will change by age and gender. Story characteristics in the broadcast do not vary by individual. The aggregate version of the model explains the number of viewers from each demographic group on each day; because one would not expect errors to be correlated across people, this variable is distributed asymptotically normally with mean $N_j \cdot P_{id}$ and variance $N_j \cdot \sigma^2$, where P_{id} is the individual probability of viewing on day *d* given in Eq. (3), N_j is the number of viewers in group *j*, and σ is the scale factor for the individual probability model. Thus, the aggregate version of the probability model can be written with a group mean marginal benefit:

$$\upsilon_{jd} = x_d \cdot \beta + z_d \cdot \alpha + (\sigma / \sqrt{N_j}) \cdot \varepsilon_{jd}, \tag{4}$$

where $\varepsilon_{jd} \sim N(0,1)$. The corresponding probability statement for this aggregated model is:

$$\begin{aligned} &\text{Prob}\,(N_{jd} \text{ viewing from group } j \text{ viewing on day } d) \\ &\quad = \text{Prob}\{\varepsilon_{jd} < (-1/\sigma) \cdot w_j \cdot \sqrt{N_j} + (\beta/\sigma) \cdot x_d \cdot \sqrt{N_j} + (\alpha/\sigma) \cdot z_d \cdot \sqrt{N_j}\}, \end{aligned} \tag{5}$$

where w_j is the mean wage for group *j*. The model in Eq. (5) is a standard dichotomous choice model with heteroskedasticity, which can be estimated by probit or logit methods. The coefficient on the heteroskedasticity-transformed wage identifies the scale of the willingness to pay, Eq. (2), and is used to identify the other coefficients of Eq. (2) from the estimates of Eq. (5). That is, if the probit or logit model estimates are $\hat{\gamma} \equiv (\hat{\gamma}_1, \hat{\gamma}_x, \hat{\gamma}_z)$ corresponding to the covariate vector $v_{jd} \equiv (w_j \cdot \sqrt{N_j},\ x_d \cdot \sqrt{N_j},\ z_d \cdot \sqrt{N_j})$ of exogenous variables, then coefficients of Eq. (2) can be identified as $\hat{\sigma} = -1/\hat{\gamma}_1$, $\hat{\beta} = -\hat{\gamma}_x / \hat{\gamma}_1$, and $\hat{\alpha} = -\hat{\gamma}_z / \hat{\gamma}_1$.

The observable linkage between news coverage and viewing behavior is given by the coefficient vector $\hat{\alpha}$ linked to the impact of the story attributes. If there is no change in viewing behavior due to increased coverage induced by the spill, the elements of $\hat{\alpha}$ will be statistically indistinguishable from zero. Conversely, rejection of this null hypothesis implies an observable change in behavior with measurable welfare impacts due to the spill.

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2.1. Individual Welfare Measurement

The structure of the model in Eq. (2) implies that the effect of an oil spill story is a constant shift upward or downward in implicit price for the duration of the story. It yields estimates of the implicit price of a minute of the newscast with the oil spill story $(\upsilon^1 : z_d \cdot \alpha \neq 0)$ and without $(\upsilon^0 : z_d \cdot \alpha = 0)$, where superscripts indicate the with/without condition.

As discussed earlier, the difference between implicit price and opportunity cost is the compensating variation measure of (net) willingness to pay (*wtp*) per minute; that is, for an individual in demographic class *j*,

$$wtp_{ijd} = \upsilon_{ijd} - w_{ij} \tag{6}$$

and the total compensating variation for all the N_j individuals in demographic group *j* on day *d* is:

$$wtp_{jd} = \sum_i wtp_{ijd} = N_j \cdot (\upsilon_{jd} - w_j),$$

where υ_{jd} is predicted from Eq. (4) using the estimates obtained from maximizing the likelihood function built up from Eq. (5), and w_j is mean wage for group *j*.

The daily welfare calculation of interest under the demand interdependency assumption then is obtained by summing net welfare change over all the demographic groups (Small and Rosen, 1981), as:

$$\begin{aligned}\Delta WF_d &= \overline{v}_d \cdot \sum_j \{E(wtp^1_{jd}) - E(wtp^0_{jd})\} \\ &= \overline{v}_d \cdot \sum_j \{\Pr ob(wtp^1_{jd} > 0) \cdot E(wtp^1_{jd} \mid wtp^1_{jd} > 0) \\ &\qquad - \Pr ob(wtp^0_{jd} > 0) \cdot E(wtp^0_{jd} \mid wtp^0_{jd} > 0)\},\end{aligned}$$

where $\overline{v}_d$ is the time devoted to the oil spill story on day *d*. By adding and subtracting a common term, the difference in welfare can be written as:

$$\Delta WF_d = \overline{v}_d \cdot \sum_j \{\Pr ob^1 \cdot (wtp^{1+}_{jd} - wtp^{0+}_{jd}) + (\Pr ob^1 - \Pr ob^0) \cdot wtp^{0+}_{jd}, \tag{7}$$

where $\Pr ob^k \equiv \Pr ob \cdot (wtp^k_{jd} > 0)$ and $wtp^{k+}_{jd} \equiv E(wtp^k_{jd} \mid wtp^k_{jd} > 0)$, for $k = 0,1$.

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Eq. (7) identifies two expected effects as the oil spill story is aired in lieu of the alternative which would otherwise have been shown: (i) an intensive margin effect, in which the willingness to pay for a minute of news coverage may change for those who are already media viewers, which is driven by the change in implicit price; and (ii) an extensive margin effect, namely a change in the probability of watching and in viewership as new people watch for the first time. If the probability of watching increases, perhaps influenced by other sources of information, a fraction of the audience has an increase in welfare given by the net value of the broadcast times the change in probability. Note that these welfare effects are additional to the viewer's baseline willingness to pay for (and probability of consuming) media in the absence of the oil spill.

2.2. Social Welfare Measurement

Consider the compensating variation measure for an individual in more detail. We specify that a "bad" event has occurred, which appears to be the case for the vast majority of distant viewers given the attitudes noted in the Introduction section. The event is illegal in the case at hand, or it may be identified as bad by some other social norm[11]. The event is a public bad, B, that directly enters consumers' welfare and hence is reflected in their consumption choices. In the context of our use of an environmental quality index z, the bad event is defined as $B \equiv z^0 - z^1$. We isolate this effect from the original level of utility from private goods, $y^0 \equiv [v^0, q^0]$, but allow for the fact that there may be adapting behavior by the consumer to acquire information and possibly to alter consumption activity, to $y^1 \equiv [v(z^1), q(z^1)]$. Consequently, we define the compensating variation (CV) as the difference in minimum (money) expenditure (to maintain constant utility), with and without the bad effect and the associated change in consumption activities y. The change in CV for the consumer is taken to be negative, which is the operating assumption behind our analysis, and which seems reasonable for most passive users. The change in welfare can be decomposed into an initial effect of the environmental event, and the adaptive response by the consumer. To see this, write the overall welfare effect as:

$$CV = e(B^0, w, u^0; y^0) - e(B^1, w, u^0; y^1), \tag{8}$$

[11] This framing is related to the long-standing issue of the analytical "standing" of the benefits to a thief in benefit-cost analysis. Here we use the approach of Zerbe (2001) who, in evaluating the welfare impacts of a given law, does not assign the thief standing, but if the law itself is being analyzed, one may wish to grant the thief standing. Here we take the illegality of oil spills as given as it was at the time.

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where $e(B,w,u^0)$ is the minimum expenditure function dual to the utility maximization problem defined earlier, and the terminology $e(B^k,w,u^0;y^k)$, for $k=0,1,$ simply emphasizes that when the consumer may not always be able to adjust optimally to exogenous changes in B by varying private consumption y.

To obtain a useful interpretation, add and subtract the restricted expenditure function $e(B^1,w,u^0;y^0)$ [12] in Eq. (8), and group terms, to obtain:

$$CV=[e(B^0,w,u^0;y^0)-e(B^1,w,u^0;y^0)]+[e(B^1,w,u^0;y^0)-e(B^1,w,u^0;y^1)]. \quad (9)$$

This can be interpreted as:

Net Welfare Cost = Welfare Cost$|_{\text{no private actions}}$
+ Value of Adaptive Consumption$|_{\text{private actions}}$.

The left-hand side and the first term on the right-hand side (RHS) are negative by construction in this setting. The second term on the RHS is positive (or else it would not be undertaken) and includes the value of adaptive behavior such as viewing television and any further altered consumption decisions. Their net effect is the net welfare cost after positive adaptation taken by the consumer. With the assumption that the consumer is not made whole by adaptation, then the (negative of the) value of adaptive activity is a lower bound on this loss. For instance, if adaptive activity fully compensated for the initial loss (the first term on the RHS) such that the net welfare cost were zero, then the value of the adaptive actions would equal the initial welfare loss. In all other cases, the total set of adaptive actions, including the initiating act of information acquisition, represents a lower bound to the initial loss.

This pair of effects is illustrated in Figure 1, using the money expenditure function and the levels of the environmental amenity affected by the incident. Suppressing the price vector in the expenditure for simplicity, the initial level of money expenditure is the level of income, $M\equiv e(z^0,u^0)\equiv e(z^0,u^0;y^0),$ where y^0 represents private actions the consumer takes, including media viewing. The initial event prompts a change in utility which can equivalently be expressed as the money expenditure to maintain original utility level $u^0,$ before the consumer has an opportunity to react; this level of expenditure is $e(z^1,u^0;y^0).$ Thus, the initial welfare cost to the consumer is $CV^0\equiv M-e(z^1,u^0;y^0)<0.$ Adaptive

[12]The restricted expenditure function explains the cost of achieving u^0 when private goods consumption cannot be varied, and is held fixed at y^0.

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actions $y^1(z^1)$ reduce expenditure to maintain utility to $e(z^1,u^0)=e(z^1,u^0;y^1)$, so that the net welfare effect (loss) is $CV^1 \equiv M - e(z^1,u^0) \leq 0$. The private value of adaptive actions, $e(z^1,u^0;y^0)-e(z^1,u^0)$; is less than or equal to the initial welfare effect if the consumer is not made whole by the adaptive actions.

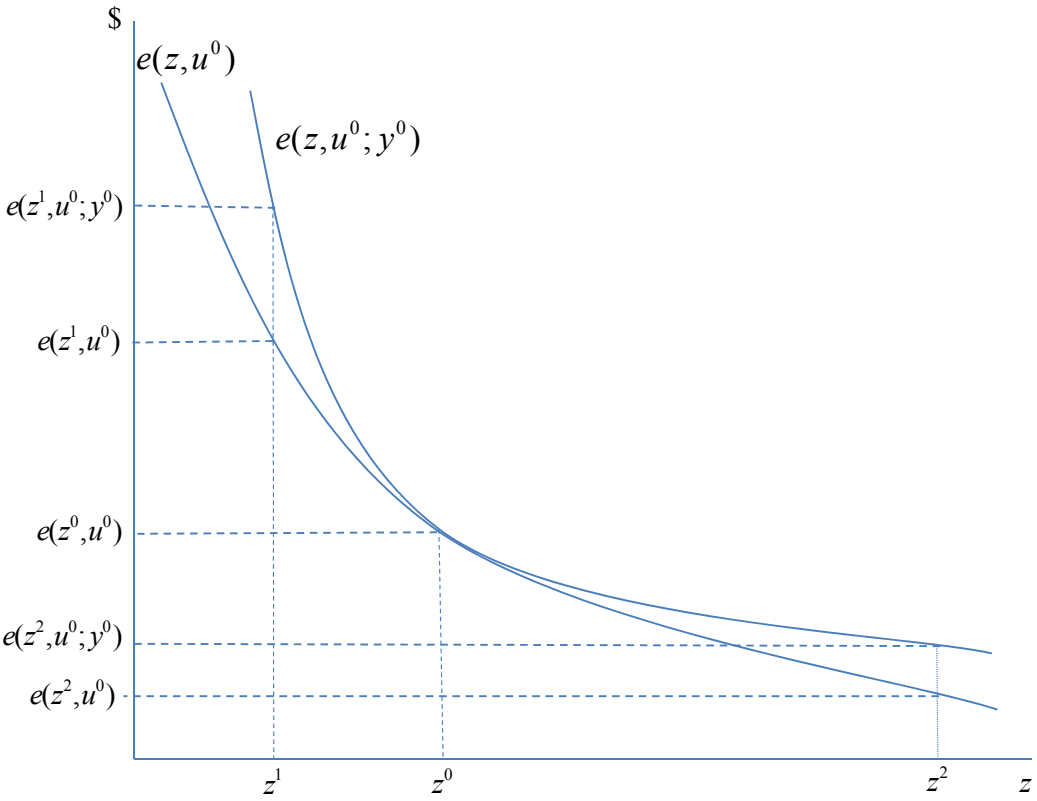

Figure 1: The Welfare Effects of Exogenous Environmental Change and Personal Adaptation.

Consequently, the value of information viewing to the consumer represents one element of their adaptive behavior and is a lower bound on the initial welfare loss. For some, perhaps many viewers who take no further action, the information acquisition will be the only adaptive activity and the only social measure of loss observable from private actions. For others who take further adaptive action that we do not measure, the estimates from television viewing are an even more conservative lower bound. The presence of substantial passive use value not associated with adaptive behavior is an additional reason why welfare loss estimates from adaptive behavior can be considered a lower bound.

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One can also frame the private gain from information acquisition as a bound on the final, rather than initial, welfare loss. If the value of private actions is no more than half the initial welfare loss, this measure of welfare change is no larger than the consumer's loss due to reduction in the public good, and thus represents a valid lower bound estimate on the passive viewer's loss due to the environmental event.

It is worth noting that this type of decomposition of welfare effects in Eq. (9) is common practice in the literature on the values of environmental improvements. For an improvement from z^0 to z^2, the expenditure function change from $e(z^0,u^0)$ to $e(z^2,u^0;y^0)$ is passive use value, whereas the change from $e(z^2,u^0;y^0)$ to $e(z^2,u^0)$ is use value.[13] In this literature, it is common to interpret use value (which is positive) as a lower bound on the total welfare change, because passive use value is also positive. The approach can, in principle, be used equally well to provide lower bounds for welfare change of other positive events, such as a space shot or royal wedding.

3. Data and Empirical Results

Translation of the theoretical structure into an empirical model depends on the actual data available. We have data on the daily coverage related to the oil spill from the *Exxon Valdez* by each of the three evening news programs dominant in 1989. We also have daily estimates of the viewership for each program and grouped data on the demographics of the viewers. The question of interest is how the implicit price, or willingness to pay for a minute of television viewing, was shifted as a result of the coverage of Prince William Sound following the oil spill and the change in viewership. Because we wish to develop measures relating to the value of information about environmental quality at Prince William Sound, the focus is on stories about Prince William Sound only, not the whole newscast.

News of the *Exxon Valdez* event reached the national television news on March 24, 1989. The daily time spent on *Exxon Valdez* coverage throughout 1989 for each major network and whether the coverage was the lead story are some of the data reported in the Vanderbilt Television News Archives (1989–1990). Aggregate coverage in 1989 for each of the three networks are reported in Table 1, with ABC providing the most coverage at 96.2 minutes, and CBS the least with 72.8 minutes. Stories ranged in length from 10 seconds to over 9 minutes, with network means ranging from 2.2 to 2.4 minutes. As presented in Table 1, the Prince William Sound cumulative coverage by all three networks averaged 4.4

[13] Although path independence of compensating variation assures that the sum of use and passive use value is always the same, the amount of the total welfare change that is attributed to each may vary depending on whether *z* or *y* changes first.

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minutes of an approximate 90 minutes of broadcast time on nights when the story was covered, with total time devoted to the story ranging from 10 seconds to 19 minutes immediately following the spill reflecting situations where multiple networks covered the topic on the same day.

Table 1: Coverage of the *Exxon Valdez* Incident by Major Broadcast Networks, 1989.

			Coverage Time in Minutes			
Network	Weekdays in Database	Days of Coverage	Total	Mean	Min.	Max.
ABC	255	40	96.2	2.4	0.17	9.2
CBS	255	30	72.8	2.4	0.33	5.0
NBC	255	37	82.2	2.2	0.17	5.3
All Networks	255	57	251.2	4.4	0.17	19.3

Source: Vanderbilt Television News Archives (1989–1990).

Table 2 provides a comparison of the total coverage of the event compared with other major media within a few years of the spill. It can be seen that in aggregate, the technical opportunities for cumulative viewing cover a wide time span from a few seconds on one night to tens of hours.

Table 2: Hours of Network News Broadcast Time for Major Events in the 1980s.

	Hours
1984 Elections	80.5
TWA Flight 847 Hijacking/ Hostage Incident	14.5
Grenada Invasion	12.0
Exxon Valdez Oil Spill (1989 only)	4.2
Bhopal industrial accident	2.0

Source: Vanderbilt Television News Archives (1989–1990).

The second type of information available to us are Nielsen data which include daily television news ratings, the number of households per rating point, and a quarterly report on the demographics of the evenings television news audience. The Nielsen data used here are based on electronic monitoring of the program being watched and those viewing among a 4000 household daily sample across the country.[14] Although information on such detail as "attentiveness" is not measured, this sample is both large and repeated over time in comparison to the

[14] We are not able to analyze weekend viewing because the Nielsen data only include weekday information.

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much more limited sampling typical of contingent valuation surveys. The final type of information is national average wage and salary rates associated with age and gender (US Bureau of Labor Statistics, 1989). When expanded to the total population, the daily Nielsen ratings data provide estimates of the number of US households watching the three major broadcast networks. The quarterly ratings and share summary also provides estimates of the number of viewers represented by each ratings point in six major demographic categories: females of ages 18–34 years, 35–49 years, and 50+ years, with similar categories for male viewers. They are indexed by j=1,…,6 in that order in this study. From these estimates the number of viewers in each demographic group was calculated by network and day of 1989. These viewer totals were used in conjunction with census data for 1989 on the number of persons and mean annual household income in each of the six demographic categories, to compute viewer shares by network, day, and demographic group, along with the opportunity cost (foregone wage) of a minute of viewing time. The total number of persons in each demographic category and the opportunity cost of a minute of viewing time are given in Table 3.

Table 3: Potential Viewers and Opportunity Cost of Time, 1989.

	Female		Male	
Age	Viewers (millions)	Wage ($/min.)	Viewers (millions)	Wage ($/min.)
18–34	34.589	0.126	33.810	0.156
35–49	26.655	0.152	25.659	0.230
50+	33.539	0.135	27.218	0.207

Although our focus is on the effect of the *Exxon Valdez* news, there are other stories offered at the same time but our viewing data are recorded for the entire program. Decisions to view the program until the *Exxon Valdez* coverage may be influenced by introductions at the top of the broadcast, but our maintained hypothesis given the data available is that coverage of other subjects and their placement are uncorrelated with the many variations in time and days of coverage of the *Exxon Valdez*. Furthermore, as part of the estimation procedure, we include a decay term to assess whether the *Exxon Valdez* effect is attenuated over time and that the effect is likely specific to the *Exxon Valdez* coverage.

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3.1. Estimation

Two versions of Eq. (5) were estimated using the daily records on the proportion of each demographic group viewing the nightly network news in 1989. The first model uses the total audience share for all three commercial networks as the endogenous variable modeled as a function of the total coverage of the spill (minutes) on a given night (and other conditioning variables), whereas the second uses per-network share of audience as a function of each network's own nightly coverage of the incident. The time of coverage of the spill is parallel to the "event" in some other event analysis. Here periods of time with and without "events" are included in the estimation while also allowing for a decay effect of an event. Given the six demographic groups and 255 weeknights in 1989, the total number of observations was 1530 for the aggregate network model and 4590 for the individual network model. The variables in the vector x_d included *WAGE*, the per-minute opportunity cost of time, and *DAY* and DAY^2 which were used to control for trends in viewership unrelated to the coverage of Prince William Sound. DAY is defined as the day of the year on which the broadcasts took place and was included when visual inspection of the data indicated that seasonal patterns are likely to exist.[15]

The variables in the coverage vector z_d were based on the expectation that *Exxon Valdez* coverage would increase willingness to pay and viewership, with a possible decay effect to reflect reduced impact of a given level of coverage with the passage of time. This diminishing marginal impact of information is anticipated in much of the literature on information acquisition. To maintain a simple linear-in-parameters estimation specification, we chose z_d based on a slightly modified version of Eq. (5), where we write:

$$\Pr\text{ob}(\text{Viewing}_{jd}) = \Pr ob\{\varepsilon_{jd} < [-w_j + x_d \cdot \beta + \gamma \cdot \ln(\overline{v}_d / (DAY - 82)^{\phi})] / (\sigma / \sqrt{N_j})\}, \qquad (5')$$

where $\overline{v}_d$ is the number of minutes' coverage[16] of Prince William Sound on day *d*, and *(DAY*-82*)* is a count variable measuring the number of days after the spill (which occurred on day 82 of the year). From Eq. (5′) it can be seen that with $\gamma > 0$ and $\phi > 0$, the effect on viewing probability (and willingness to pay) of an increase in Prince William Sound story length on a given day is positive

[15] An alternative way to address seasonality would be to compare viewership on days in 1989 to those from the same day a year earlier. Although this could be a useful way to account for seasonality in viewership, without a sufficiently large time series on comparable day viewership (which we do not have) that such an approach might end up reflecting idiosyncrasies in the timing of news events as much as controlling for seasonality patterns.

[16] "One", 1, was added to all time values so the variable would be non-negative when there were zero minutes of broadcast time.

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$[\partial \text{Prob}(\text{Viewing}_{jd})/\partial \overline{v}_d > 0]$, whereas the passage of time diminishes the probability of viewing and willingness to pay for a given story length $[\partial Prob(Viewing_{jd})/\partial DAY < 0]$. Given the specification in Eq. (5′), the vector z_d is $z_d \equiv [\ln(\overline{v}_d), \ln(DAY - 82)]$ and the corresponding parameter vector is $\alpha = [\alpha_1, \alpha_2] = [\gamma, -\gamma \cdot \phi]$. This is linear in the estimated parameters $\hat{\alpha}_1$ and $\hat{\alpha}_2$, from which one can identify $\hat{\gamma} = \hat{\alpha}_1$ and $\hat{\phi} = -\hat{\alpha}_2 / \hat{\alpha}_1$.

Results of probit estimation of the aggregate and individual network models are given in Table 4. The Prince William Sound variables for both coverage in minutes and the decay effect were significant in the decision whether to watch the news, with signs as expected (*t*-statistics are in parentheses). The combined effect of these two variables is that the probability of viewing increased the most immediately after the spill, with a fairly rapid decay effect. In the aggregate model, after 16 days the increased probability of viewing due to Prince William Sound coverage had decayed to zero. In the individual network model, most of the welfare impact had occurred by this time, but long stories presented later in the year continued to have a positive impact on probability of viewing.

Also highly significant were the mean wage rate and the time trend variables. As noted earlier, in addition to signaling a negative relationship between opportunity cost of time and the probability of viewing, the coefficient on wage gives an estimate of the reciprocal of the standard error of willingness to pay. The highly significant time trend variables indicate the larger temporal pattern of viewership, with lowest viewing probabilities in the summer months. It is also interesting to note the differential viewing patterns by age and gender in which relatively younger people watch less and older people and females watch more than middle-aged males.

We found that logit model results were qualitatively similar and thus do not report them here. We also explored nested discrete choice models to explain the choice of station watched given the individual had decided to view the news, but none of the variables in our data set had any appreciable effect in explaining this lower level decision. This is consistent with expectations that the major impact of a news story is to change the decision whether or not to view the news, not to affect the choice of which station to watch. Viewers may develop loyalties to local stations, which are carefully cultivated by the stations themselves, over a period of time. The fact that any newsworthy event will be covered by each station means that viewers can turn to the station with which they identify most closely for coverage. But the fact that something of potential importance has occurred causes people to watch, or not watch, in greater numbers than before, with more or less satisfaction from watching. It is this commitment of resources to media consumption that constitutes the faint behavioral trail on which to base

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estimates of the change in individual welfare associated with the change in environmental quality at Prince William Sound.

Table 4: Estimation Results for the Network News Viewing Models (*t*-statistics are in parentheses; all variables significant at least at the 5% level).

	Individual Network Model	**Aggregate Network Model**
Constant	–1.28	–0.633
	(–72.0)	(–21.2)
Elderly	0.055	0.071
	(199.2)	(139.5)
Youth	–0.147	–0.29
	(–33.7)	(–39.0)
Female	0.049	0.067
	(10.3)	(9.1)
Ln Valdez	**0.005**	**0.006**
	(2.2)	**(2.0)**
Ln Decay	**–0.003**	**–0.005**
	(–4.2)	**(–3.5)**
Wage	–1.989	–1.666
	(–24.6)	(–12.4)
Day	–0.002	–0.003
	(–51.4)	(–38.8)
Day^2	5.09E–06	7.37E–06
	(50.3)	(38.0)
Log-L	–1055	–690.2
Restr. Log-L	–1113.8	–760.1
Chi-squared (df)	117.7 (8)	139.8 (8)
No. of Obs.	4590	1530

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Table 5 presents the welfare associated with the coverage effects identified in the viewing models and welfare measurements computed from Eq. (7). In addition to the total welfare change, the impacts on mean probability of viewing and expected willingness to pay are presented. In each model, both mean probability of viewing and expected net willingness to pay per minute increased slightly. The individual welfare impact on the change in television news viewing was estimated to be $12.7 to $17.2 million in 1989 and from $22.5 to $30.3 million in 2010 based on an adjustment using the Consumer Price Index.

Table 5: Probability Change and Welfare Estimates

		Individual		**Aggregate**
		Network Model		**Network Model**
Per Viewer Estimates				
$Prob^0$		0.0621		0.1947
$Prob^1$		0.0625		0.1956
wtp^0 ($/minute)		0.2143		0.3301
wtp^1 ($/minute)		0.2146		0.3305
Aggregate Estimates		Million		Million
Total 1989 Value		**$17.20**		**$12.80**
Total 2010 value		**$30.30**		**$22.50**

The social welfare impact is the same value reversed in sign but with a more limited interpretation. That interpretation according to the discussion in section 2 is that these personal benefit values are a lower bound on the loss in welfare. To these values could be added the value of additional adaptation actions which, even when taken together, would still be a lower bound on the total loss in welfare unless complete welfare adaptation was possible. Although the values we find may be considered relatively small, it is likely that many people may take no additional adaptive actions other than obtaining the news. For these individuals, the information based values may be the primary observable impact.

4. Conclusions

Event studies may be formally applied to news broadcasts and private welfare effects estimated from them. More controversial is the link between the individually optimal action and a social cost associated with news coverage of a

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distant event. However, we show the conditions needed for this and they appear to be satisfied by the available evidence on consumer sentiment about the recent Gulf of Mexico oil spill and by extension to the Valdez, Alaska spill. To demonstrate methods for assessing the welfare losses of passive viewers of major environmental incidents, this study estimated the personal welfare impact of television news gathering from the *Exxon Valdez*, for which there are data on media coverage and viewer response. The personally optimal media consumption activities are then viewed as an adaptation activity with the potential to reduce the original welfare loss from an environmental calamity, the resulting private gain from which is a lower bound on the original welfare loss from the incident.

This micro-level approach is most relevant to assessing the change in welfare of individuals whose only contact with the environmental incident is through television coverage, which in our study is measured by changes in consumption of network news coverage caused by the *Exxon Valdez* spill. Our estimates imply increases in probability of viewing (amounting to approximately 1% of audience size) and in the willingness to pay per minute of news consumed. Our individual welfare estimates range from $13 to $17 million in 1989 or from $23 to $30 million in 2010 based on weekday coverage in 1989. Under reasonable assumptions that recent polling of consumer sentiment confirms (that the viewers are harmed by the event in question, and not fully made whole by their private actions), the gains from these private actions are interpretable as lower bounds for their loss of welfare from the environmental event, and are the start of an observable trail of behavior that links distant events to personal decisions that are distinct from direct use of the harmed environment.

There are several reasons to believe that our estimates provide a conservative lower bound on the welfare loss. Some people may engage in additional consumption that we do not measure (consumption of print or online media, for example), and there may be passive use value that is not traceable through markets. Studies that have examined passive use value from the *Exxon Valdez* spill using stated preference, rather than behavior-based, approaches have estimated this passive use value to be billions of dollars (Carson et al., 2003), although the stated preference approach is not without controversy (e.g., Hausman, 1993). In addition, the opportunity cost of leisure time we use (the person's wage) is likely to be on the high side, which as shown earlier results in a smaller welfare loss estimate.

A number of extensions and refinements are possible. Other observable effects of the *Exxon Valdez* event can be pursued by including print media, local media, and the recursive, follow-on effects of donations to interest groups and political activity or changes in purchases, all of which may contribute to the adaptation of the individual. More data, believed to be available to paying Nielsen customers, could also improve estimation by incorporating placement in the

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program and information on other stories in broadcasts as well as longer time periods.

The results of this paper suggest that, even though modest in magnitude in the present application, some passive use values appear to be measurable, and that it may well be worth pursuing further the search for the faint but observable links between behavior and distant events through the news media. Household activities, already firmly established in the methodology of economics, may reveal much of what has been interpreted as passive value in the past to be a part of the adaptive behavior to welfare-changing events.

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