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Reference-Dependent Valuations of Risk: Why Willingness-to-Accept Exceeds Willingness-to-Pay

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Why Willingness-to-Accept Exceeds Willingness-to-Pay[*]

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Abstract

The gap between willingness-to-pay (WTP) and willingness-to-accept (WTA) benefit values typifies situations in which reference points—and direction of movement from reference points—are consequential. Why WTA-WTP discrepancies arise is not well understood. We generalize models of reference dependence to identify separate reference dependence effects for increases and decreases in environmental health risk probabilities, for increases and decreases in costs, and reference dependence effects embodying the interaction of two changes. We estimate separate reference dependence effects for the four possible cost and health risk change combinations using data from our choice-based experiment for a nationally representative sample of 4,745 households. The WTA-WTP gap is due largely to the reference dependence effects related to costs. Standard models of reference dependence are not consistent with the results, as there is an interactive effect. Estimated income effects are under a penny and thus cannot account for higher values of WTA relative to WTP.

Key words: reference dependence, health risks, stated preference, willingness to pay, WTA, WTP

JEL Classification: D80, Q25, I10, H40

Reference dependence with respect to money or goods has become a prominent component of many theoretical models as well as an influential factor in empirical applications. Kahneman and Tversky's (1979) prospect theory incorporated reference dependence for utility function arguments such as income.[1] Accompanying this theoretical work has been experimental and empirical evidence on reference dependence effects, including a substantial literature on disparities between willingness-to-accept (WTA) and willingness-to-pay (WTP) values reviewed by Horowitz and McConnell (2002) and a literature on endowment effects reviewed by Knetsch and Tang (2006).[2]

The role of reference dependence effects is not limited to income levels, goods, and lottery payoffs, as there may also be reference point influences that also pertain to probabilities. In their study of willingness-to-pay and willingness-to-accept values for health risks pertaining to product safety, Viscusi, Magat, and Huber (1987) found a substantial WTA-WTP difference for valuations of consumer product risks arising from increases and decreases in the probability of an adverse health outcome. They termed this result a "reference risk effect," because the phenomenon arose in the context of probability changes rather than changes in the level of a valued utility function attribute. As with other WTA-WTP gaps, the source of the discrepancy is unclear, as WTP and WTA contexts typically are confounded by changes in both directions. Costs are increasing while risks are decreasing for WTP while costs are decreasing and risks increasing for WTA. The purpose of our study is to separate the risk and cost effects.

[1] The influence of reference dependence has been extended in subsequent versions of prospect theory such as that by Schmidt, Starmer, and Sugden (2008). A recent spate of theoretical models have articulated well-developed theories of reference dependence, as exemplified in Sugden (2003), Munro and Sugden (2003), Kőszegi and Rabin (2006), and Loomes, Orr, and Sugden (2009).
[2] Among the examples of such studies is the analysis of status quo effects in Samuelson and Zeckhauser (1988). Similar reference point effects have been suggested for health status, as in Breyer and Fuchs (1982).

To accommodate possible reference-dependent influences pertaining to probabilities that are not restricted to amounts of goods or other utility function attributes, it is necessary to generalize standard theoretical models of reference dependence. We consider two dimensions of reference points—the reference point with respect to money and the reference point with respect to health risk probabilities. Thus, individuals may experience reference dependent influences with respect to increases and decreases in monetary expenditures as well as with respect to increases and decreases in the probability of an adverse health outcome. Our model permits the WTA-WTP disparity for health risks to arise from a reference point effect for money, a reference point effect for health risk probabilities, or both. Because two reference points are affected by choices involving both changes in risk and changes in money, the existence of a WTA-WTP difference does not pin down which of these reference effects is the source of the difference. Using an experimental design that includes all four possible combinations of increases and decreases in health risk and money, we identify the causal influence and show that the reference point effect for money is more influential than is the reference point effect for probabilities. Moreover, it is possible to reject standard theoretical models in which reference point influences are dependent only on the change in one component. Conventional theoretical formulations of reference point effects are not borne out, as there is an important interaction effect in which the reference effect for health probabilities is more pronounced when the original endowment is disturbed by decreases in costs.

This article formulates a conceptual framework that forms the basis of empirical tests of reference dependence for valuation of health risks. Although the focus of our analysis is on reference dependence for money and health risks, the empirical methodology and ramifications apply more generally to reference dependence for probabilities and outcomes. After generalizing models of reference dependence to incorporate reference point effects for probabilities in Section 1, Section 2 introduces a stated preference choice experiment designed to estimate the influence of reference points to identify positive and negative changes in money and health risks. We find evidence of important reference effects for cost and health risk probabilities that account for the WTA-WTP disparity. However, as shown in Section 3, the role of these effects is not symmetric. The strongest reference point influences on risk-money tradeoff rates arise from decreases in costs, which is the influence that is largely responsible for the WTA-WTP disparity. There is a pronounced reference dependence effect for increases in risk probabilities only when costs are decreasing, as in the WTA scenario.

Multivariate analysis of our demographically representative sample provides an additional dividend. The income level differences between a WTA and WTP amount have long been hypothesized as a rational explanation for the WTA-WTP gap. We demonstrate that the reference point effects and the WTA-WTP disparity are not attributable to income effects. Using information on the income levels of the respondents, our estimates show that the role of income effects is negligible compared to the magnitude of the reference dependence influences. Section 4 concludes.

1. Reference Dependence for Money and Health Risk Probabilities

The reference dependence model developed here addresses reference dependence effects for costs and health risk probabilities. Both costs and health risks are negatively valued attributes. We assume that the reference points are well defined, as is the case in the choice experiment structure described in subsequent sections.

1.1. General Model Structure

The general formulation of the model utilizes a gain-loss utility format for reference dependence, as in Sugden (2003), Munro and Sugden (2003), and Kőszegi and Rabin (2006), which we generalize to account for reference dependence for probabilities rather than goods. The basic model assumes additive separability of the utility of cost and expected utility of health risks with a gain-loss utility for each component. We then incorporate the possibility that reference effects may be interactive.

The cost utility component of the model is analogous to standard utility functions for money except that the model is in terms of cost, which is negatively valued. Let c_0 be the reference initial cost level and c_1 be the new cost level, where all cost terms are positive. The utility function v(c) for costs has the properties $v < 0$, $v' < 0$, and $v'' \leq 0$.

The health risk considered in this article is a temporary morbidity risk similar to those that Evans and Viscusi (1991) have shown can be treated empirically as monetary equivalents using an additively separable utility function. Thus, the health outcome in our study is not a permanent disability or fatal outcome that affects the marginal utility of money. Let p_0 be the initial reference probability of the adverse health effect, p_1 be the new morbidity risk probability, r be the morbidity risk cost, and h(r) be the utility function for health. Although h(r) equals a fixed monetary loss of r that never varies in our example, in general one might expect $h < 0$, $h' < 0$, and $h'' \leq 0$ to characterize the dependence of h(r) on the severity r.

Both cost and health have reference-dependent gain-loss components that, for purpose of the empirical analysis, we treat as multiplicative constants for which we estimate their average values.[3] The reference-dependent factor for cost will be denoted by μ, where cost increases have a factor μ^+ and cost decreases have a factor μ^-, where $\mu^+ > \mu^-$, as one would expect losses from one's initial cost reference point to loom larger than gains.[4] The reference-dependent factor for the health risk is λ, where λ^+ is the factor for risk increases and λ^- is the factor for risk decreases, and $\lambda^+ > \lambda^-$ because of the relative aversion to increases in the probability of health losses. The expected utility u from moving from a situation with c_0 cost and probability of adverse health effect p_0 to a cost level c_1 and risk probability p_1 is

$$u\left(c_1 \mid c_0 ; p_1, r \mid p_0, r\right) = v(c_1) + \mu\left[v\left(c_1\right) - v\left(c_0\right)\right] + p_1 h(r) + \lambda\left[p_1 - p_0\right] h(r). \qquad (1)$$

Thus, the monetary cost portion of the expected utility function follows the familiar structure in which the valuation is the utility value of the new cost level plus the gain-loss utility value. The reference-dependent component for the health risk probability is the distinctive component, but it is formulated analogously. However, unlike other models of reference dependence, the reference dependence effect for risks is with respect to the gain-loss value of probabilities, not utilities.

The tradeoff between cost and risk can be determined by implicit differentiation of equation 1, yielding

$$\frac{-\partial c_1}{\partial p_1} = \frac{u_{p_1}}{u_{c_1}} = \frac{(1+\lambda)\, h(r)}{(1+\mu)\, v'}. \qquad (2)$$

The role of reference dependence is captured by the reference dependence factor $f(\mu, \lambda) = (1 + \lambda) / (1 + \mu)$. Given this structure, the value of $f(\mu, \lambda)$, and consequently the value of tradeoff rates, is greater for shifts from the reference point involving cost decreases, for which μ

[3] Kőszegi and Rabin (2006) develop a more general formulation but provide a shopping example similar to the treatment of costs in this model. Below we note how the approach can be generalized to include the functional dependence of μ and λ.

[4] The factor μ- for cost decreases is also consistent with the possibility of a house money effect, as in Thaler and Johnson (1990).

is given by μ^-, and for risk increases, for which λ is given by λ^+. Each of these changes will boost $f(\mu, \lambda)$.

1.2. Possible Reference Point Effects

Although our focus is on marginal risk-cost tradeoff rates rather than exchanges of goods, it is useful to characterize the four gain-loss combinations in conventional terminology pertaining to such directions of influence. Figure 1 summarizes the four possibilities.[5] Quadrant 1 is the WTP factor $f(\mu^+, \lambda^-)$ in which a cost increase is incurred to purchase a risk probability reduction. This value is expected to be smaller than the WTA value in Quadrant 3 since the factor $f(\mu^-, \lambda^+)$ for WTA embodies a diminished valuation of cost in the denominator and a higher valuation of risk in the numerator than does WTP. Because a WTA-WTP disparity can arise from either of these influences, observation of WTA-WTP discrepancy does not pinpoint the source of the difference. The situation in Quadrant 2 in which both cost and risk are increasing is labeled tradeoff among losses (TL), where TL has a factor of $f(\mu^+, \lambda^+)$ that should yield a higher tradeoff rate than WTP. Both Quadrant 2 and WTP in Quadrant 1 include μ^+ in the denominator of the reference dependence factor, but the TL value in Quadrant 2 also includes an increase in the risk probability, which raises the numerator of f because $\lambda^+ > \lambda^-$. We designate the situation in which both risk and cost are decreasing in Quadrant 4 as the tradeoff among gains (TG). The TG case in Quadrant 4 should exhibit a lower tradeoff rate than for the WTA value in Quadrant 3 because of the decrease in risk level, producing a lower value in the numerator of the reference dependence factor f. Thus, of the four cases shown in Figure 1, WTA should have the highest value, and WTP should have the lowest value.

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[5] Because costs and risks are both negatively valued, the arrangement of the quadrants differs from that in other treatments, such as Knetsch and Tang (2006) for which the tradeoff among losses and tradeoffs among gains quadrants are reversed from the order in Figure 1. The WTP and WTA quadrants are standard.

Formulating comparisons in terms of ratios leads to additional relationships. Thus,

$$\frac{TL}{WTA} = \frac{f(\mu^+, \lambda^+)}{f(\mu^-, \lambda^+)} = \frac{WTP}{TG} = \frac{f(\mu^+, \lambda^-)}{f(\mu^-, \lambda^-)} = \frac{1+\mu^-}{1+\mu^+} < 1, \tag{3}$$

and

$$\frac{WTP}{TL} = \frac{f(\mu^+, \lambda^-)}{f(\mu^+, \lambda^{+)}} = \frac{TG}{WTA} = \frac{f(\mu^-, \lambda^-)}{f(\mu^-, \lambda^+)} = \frac{1+\lambda^-}{1+\lambda^+} < 1. \tag{4}$$

While the empirical analysis treats λ and μ in terms of average values that affect the gain-loss utility components for this particular risk context, one would expect these values to be different for other choice situations. In the simplest case, each of the parameters depends only on one particular component of the tradeoff. Thus, the cost parameter μ is a function of the level of costs, or $\mu(c_0, c_1)$, and the reference risk parameter λ is a function of the risks and their severity, or $\lambda(p_0, p_1, r)$. This separability facilitates both the modeling and estimation of reference dependence effects.

However, while the formulation above has the advantage of simplicity, there is no theoretical basis for ruling out the possibility that the reference dependence contextual effects interact in some fashion. Thus, the valuations of shifts in the risk level could depend on the changes that are occurring in the financial gain or loss domain. The most general formulation of the reference dependence factors would be $\mu(c_0, c_1, p_0, p_1, r)$ and $\lambda(c_0, c_1, p_0, p_1, r)$.

A more structured variant of this interdependence that is examined below is that in which the reference dependence effect for risk hinges on whether one is in the financial gain or loss domain. In particular, suppose that reference dependence for risks is only observed when the individual is in the cost decrease domain so that financial loss aversion is the dominant factor when costs are increasing. Such a formulation leads to a generalization of equation 1. Let $\delta = 1$

if costs are in the decrease domain μ^-, and $\delta = 0$ if costs are in the cost increasing domain μ^+. Then equation 1 can be rewritten as

$$u(c_1 | c_0 ; p_1, r | p_0, r) = v(c_1) + \mu[v(c_1) - v(c_0)] + p_1 h(r) + \delta\lambda[p_1 - p_0]h(r). \qquad (5)$$

While a term such as δ may not enter in all applications, it will be pertinent when there is a clear asymmetry in which risk reference dependence is only manifested when costs are decreasing, and available resources are consequently increasing. Thus, when costs are increasing, the focus on the cost increase may be so great that the salient financial concerns swamp other reference point influences. We find that equation 5 is a more appropriate characterization of reference point effects in our study than is equation 1, which is patterned on more standard frameworks.

2. Survey Structure and Sample

The data used to test for the different reference dependence effects are based on a stated preference experiment that elicited individual tradeoffs between health risks and cost. As indicated in the critical survey by Horowitz and McConnell (2002), the WTA/WTP ratios for hypothetical experiments are not significantly different from those in experiments with actual stakes. Their review also found that the main WTA/WTP ratio outliers involved unfamiliar goods, which may not be a major factor for this study as the survey focuses on the tradeoff between water bill expenses and personal morbidity risks from drinking water for a nationally representative adult sample. The familiar nature of the goods and the payment mechanism offer an advantage over some other experimental contexts as well, in that the subjects have experience with both the good and the payment mechanism. Although people generally are not asked to consider purchasing tap water at different levels of safety, the health outcome is quite common, and consumers commonly make safety-related choices such as the purchase of water filters.

The stated preference survey approach has several strengths. It is possible to elicit preferences in a survey with respect to health risks that could not actually be inflicted on subjects in an experiment. This format also makes it possible to analyze the responses from a representative population rather than a convenience sample. In particular, the sample used for this study is a nationally representative sample of 4,745 adults. The survey was administered by Knowledge Networks using a Web-based sample, where the panel was drawn using a probability sampling approach for the entire U.S. population.[6] People who did not have computers were provided with internet access to generate a highly representative sample. The excellent performance of this sample on a wide variety of criteria is documented in Bell, Huber, and Viscusi (2011). Further details regarding the data appear in Appendix A. Appendix Table A.1 shows that the sample drawn closely parallels the characteristics of the adult U.S. population. The diversity of this nationally representative sample makes it possible to examine the effect of sample characteristics on the risk tradeoff rates, including estimating the income elasticity of such tradeoffs. Our analysis of the income elasticity effect enables us to test the hypothesis that the WTA-WTP discrepancy arises from income effects.

Stated preference studies involve elicitations of willingness to pay for hypothetical commodities. The stated preference methodology has evolved considerably over the last two decades and now meets demanding standards to ensure the consistency and overall validity of the responses. The approach used here does not involve a single valuation question but is a choice-based experiment involving the use of a series of iterative questions that progressively approach the individual's risk-cost tradeoff rate. To ensure the validity of the technique, we report the results of a series of scope tests as detailed by Heberlein et al. (2005). In addition, the survey

[6] Our use of the Knowledge Networks panel for EPA-funded water benefit studies has been specifically approved by the Office of Information and Regulatory Affairs, U.S. Office of Management and Budget. Viscusi, Huber, and Bell (2011) provide a detailed analysis of the properties of the survey for the WTP case.

structure incorporates an internal rationality test to ensure that responses pass a scope test and to identify and eliminate inconsistent respondents who exhibit intransitive preferences. The empirical analysis also includes explicit controls to account for starting point biases and uses the same starting points across the different treatments.

2.1. Characterization of the Risk

The survey focuses on the morbidity risk of gastrointestinal (GI) illness from drinking water, described as follows:

> The most common sickness caused by drinking water contamination is called Gastrointestinal (GI) Illness. Contaminants in water can cause nausea and vomiting, diarrhea, stomach pain, and sometimes a fever. Such illnesses usually last from 2 to 14 days, but average about a week before all symptoms end.

Notice that GI illness may be aversive but was designed to not be life threatening, so people would be willing to trade it off against money. The survey follows the GI illness description with questions that encouraged reflection on the harm. These questions address whether the respondent had experienced such illnesses from food or drink, the length of such illnesses, and whether they believed that contaminated water caused their illness. The survey also identified groups with higher risk of getting the illness: children under the age of 10, the elderly, and those with compromised immune systems. The average U.S. population risk for GI illness from drinking water is about 5/100, which is conveyed to respondents using a risk ladder with probability anchors.[7] In addition, the survey presents subjects with a grid consisting of 1,000

[7] This overall risk estimate is between the estimate of the GI illness incidence rates in the literature, as it is a bit lower than the estimate in Messner et al. (2006) and higher than the estimate in Colford et al. (2002). The other risk estimates presented to subjects using the risk ladder were the annual risk of being bitten by a dog, the risk of being

squares, of which 50 were colored to indicate the average U.S. population risk. All subsequent presentations of risk levels in the context of the iterative choice process included the pertinent grid and used different colors of squares to indicate any increases or decreases in risk associated with the cost-risk options being presented.

The original endowment for risk-cost combinations is the person's current water bill and a risk level of 50 GI illnesses per 1,000. As indicated by the four quadrants in Figure 2, respondents consider situations involving one of the four combinations of changes in the number of GI illnesses and the size of their water bill.

There were four general variants of the iterative choice structure administered to different survey participants. The data analyzed below consequently pertain to only a single observation for each participant. In each case, the survey endows respondents with the same initial levels for cost and risk—the household's annual water bill and the 5% individual risk of contracting GI illness in a given year. Figure 3 gives the case in which respondents are asked to accept either a greater risk at no increase in cost or a greater cost but with no increase in risk. Appendix B details the other three conditions. In all cases, the survey text leading to the risk and cost changes is adjusted to be appropriate for those on municipal water supplies differently from those on wells. For example, the following mechanism characterizes how a decrease in the risk for those on municipal water supplies is accomplished through improved treatment methods: "More expensive methods, using additional rounds of filtering or disinfecting, employing more expensive filter material, or employing new technologies might remove more contaminants." The counterpart source of improvement for those on wells is based on well-specific technologies and is the following: "Carbon filters can be used to remove contaminants, a process called

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involved in a traffic accident, and the chance of catching the flu. Economic studies of water quality include Innes and Cory (2001) and Hensher, Shore, and Train (2005).

reverse osmosis can be used to remove impurities, and even ultraviolet light can be used to destroy harmful organisms in water." The intent here is to make the four tradeoff conditions reasonable to a broad variety of people. To adjust for any differences, the analysis includes a variable for well users, which in this case did not approach statistical significance.

2.2. Cost-Risk Tradeoffs

The example shown in Figure 3 reflects the tradeoff among losses case in which respondents are asked to accept either a greater risk at no increase in cost or a greater cost but with no increase in risk. Characterizing tradeoffs among losses is less straightforward than characterizing tradeoffs between cost increases for risk decreases as in the WTP situation. Respondents are first given a rationale for the change in their baseline situation. In this case, aging water supply systems lead to an increase in risks, but this risk increase could be reduced by incurring greater costs imposed by the respondent's water utility. The grid following this description offers respondents the choice of returning to their initial risk level of 50 per 1,000 for a cost of $100 per year, or incurring a risk increase to 70 GI cases per 1,000 at no additional cost. Respondents who express indifference to this initial choice exhibit a tradeoff rate of $100/[(70/1,000)-(50/1,000)], or $5 per 1/1,000 risk of GI illness.

The survey focuses on health risks that are small and can be viewed as monetary equivalents, or h(r) = r, and for the small amounts of money involved we will assume that v(c) = – c. Letting $\Delta c = c_1 - c_0$ and $\Delta p = p_1 - p_0$, the survey condition becomes

$$-c_0 - p_0 r = -(c_0 + \Delta c) - \mu(\Delta c) - (p_0 + \Delta p)r - \lambda \Delta p r, \qquad (6)$$

or

$$\frac{-\Delta c}{\Delta p} = \frac{1+\lambda}{1+\mu} r = f(\mu, \lambda) r. \tag{7}$$

The initial baseline situation and the associated risk-cost tradeoff is varied across respondents in the survey design. To avoid anchoring effects of the initial baseline information, the survey options are structured to yield an approximately equal split in the WTP context between those opting for the new treatment option and those preferring the current treatment.[8] The starting ratios used for the other three survey variants are the same as in the WTP case to avoid the influence of possible starting point effects on the differences across the four experimental treatments. Respondents may differ in terms of the initial tradeoff ratio presented. The empirical analysis explicitly includes a starting point tradeoff ratio variable to account for starting point effects.

The survey proceeds in an iterative fashion after respondents indicate their initial choice. If the subject indicates indifference between the old and new treatment, this portion of the survey ends. If the subject indicates a preference for one of the two options, the survey presents the subject with a succession of choices that diminish the relative attractiveness of the preferred alternative or increase the attractiveness of the less preferred alternative. The respondents do not see subsequent stages of the tree before completing the choice at a prior stage. Figure 4 indicates a sample iterative structure decision tree. For respondents who reverse their preference and do not reach indifference, the two adjacent tradeoff values bound the tradeoff rate for the empirical analysis.

The survey also incorporates an internal rationality test. Subjects move along the decision tree in a manner that assumes preferences are consistently ordered so that within-subject

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[8] In particular, subjects chose the new treatment option 52% of the time in the WTP survey context. For discussion of the rationale for the equitable tradeoff approach, see Huber, Viscusi, and Bell (2008).

responses necessarily pass a scope test. However, the end points of the decision tree reflect individuals who continue to prefer a particular option even when it is dominated by the other option. If the person, for example, indicates a preference for the new treatment even though the new treatment provided the same yearly GI risk but at a higher cost, then that person is given an opportunity to reconsider their selection of a dominated option. But responses of those who persist in making a dominated choice are labeled as inconsistent. Overall, 90% of the sample did not violate this test of rationality in their choice pattern. The valuations analyzed below are restricted to those who answered the questions in a consistent manner.

The results of the survey can be used to calculate estimates of the tradeoff rates for all four quadrants in Figure 1. Thus, it is possible to evaluate the relationship among the different reference dependent influences and to determine which effects are most influential. It is not feasible to estimate the absolute values of the reference dependence parameters.

3. Empirical Results

3.1. Raw Survey Responses

Because valuations can be censored at both the high and low ends, as well as between two bounded choices, the appropriate statistical analysis is to examine the predicted values based on interval regression models. However, a useful starting point to explore the pattern of responses is to examine the raw values in Table 1. When calculating these raw values, we assigned responses at the edge of the decision tree the tradeoff value at that point. Respondents who reached a point of indifference received that value, while respondents who indicated a reversal of preferences without indicating a preference received the midpoint tradeoff rate for the interval in which they switched. The mean WTA values in the cost decrease, risk increase case

$f(\mu^-, \lambda^+)$ are just over double the value of the WTP values in the cost increase, risk decrease case $f(\mu^+, \lambda^-)$. The WTA amount is also above the cost decrease, risk decrease tradeoff among gains TG value for $f(\mu^-, \lambda^-)$. The TG value result is only moderately greater than the cost increase, risk increase tradeoff losses TL value for $f(\mu^+, \lambda^+)$. The combination of these results suggests that the WTA-WTP gap is mainly due to the influence of a small value of μ^- in the denominator of $f(\mu^-, \lambda^+)$ rather than a high value of λ^+ in the numerator of the reference dependence tradeoff factor. Thus, it is the influence of being in the decrease domain for cost rather than the increase domain for risk that is largely responsible for the WTA-WTP differences.

3.2. Interval Regression Estimates

To analyze these results more precisely, we rely on estimates based on interval regressions of the data. The survey structure generates several possible structures for the tradeoff rate that is elicited. Suppose that the individual indicates a point of indifference t_{12} in the range $[t_1, t_2]$. Then from the standpoint of the interval regression, the observation is a point estimate of the tradeoff rate in the interval $[t_{12}, t_{12}]$. Another set of interval responses consists of people who indicate a switch in their preferences, such as switching from the pro-environmental option to the less costly option. These respondents do not indicate an explicit tradeoff rate, but rather reveal through their switching behavior that the tradeoff rate lies somewhere in the interval $[t_1, t_2]$. The final set of respondents consists of censored observations. Because the highest permitted tradeoff is t_u and the lowest permitted tradeoff is t_l, the data also include right-censored observations $[t_u, +\infty)$, and left-censored observations $(-\infty, t_l]$. The survey decision tree specifies the overall structure.

The interval regression generalizes the Tobit estimates so that it can accommodate both censoring and interval responses. The interval regression provides maximum likelihood estimates where the likelihood contribution of the tradeoff rate t_i for person i in interval $[t_1, t_2]$ is $Pr(t_1 \leq t_i \leq t_2)$. The predicted values discussed are based on the individual post-estimation values, which are then averaged across all respondents.

Table 2 presents two sets of models of the tradeoff rate in terms of the log valuations per 1/1,000 illness risk. The first equation includes only an intercept and indicator variables for three of the four question variants, with the omitted category being WTA, which is the cost decrease, risk increase group $f(\mu^-, \lambda^+)$. Relative to this highest valuation group, all other cost-risk change combinations have significantly lower values. The lowest value among all choice options is for the WTP cost increase, risk decrease choice question $f(\mu^+, \lambda^-)$, but this value has an almost identical coefficient that is not significantly different from the estimate for the cost increase, risk increase $f(\mu^+, \lambda^+)$ value for the tradeoff among losses TL case in Quadrant 2 of Figure 1. The cost increase aspect of the choice structure is the dominant influence and depresses valuations. The intermediate cost decrease, risk decrease $f(\mu^-, \lambda^-)$ case for tradeoff among gains TG in Quadrant 4 generates a lower value than the WTA amount, but a higher value than the other two choice questions.

The interval regression equation that we use to estimate the individual values includes a detailed set of explanatory variables that appear in column 2 of Table 2. In the expanded regression, the indicator variables for the question versions follow the same pattern and have magnitudes very similar to those in column 1 of Table 2.

Consistent with the literature on the income elasticity of good health, as in Viscusi and Evans (1990), reducing health risks is a normal good, as there is a positive income elasticity for valuations of reductions in morbidity risks from water. A long-standing issue in the endowment effect literature and the companion literature on the WTA-WTP gap is whether income effects account for the discrepancy. Because our equation in Table 2 includes a significant income variable, it is possible to calculate the effect of income changes on valuation amounts. The greatest annual cost change associated with any of the choices is only $120, which is 0.2% of the average annual household income in the sample. Based on the estimated relationship between income and valuations, if the average respondent's income were reduced prior to taking the survey by this $120 cost, the effect on valuations would be less than a penny. This effect is far too small to be captured in valuations expressed in whole dollar terms. Thus, any income effects are dwarfed by the observed WTA-WTP discrepancy.

A related economic factor that could contribute to a WTA-WTP disparity is the lack of close substitutes, which affects the curvature of indifference curves. However, the survey did not consider the elimination of tap water, which could create potential substitutability concerns, but rather specified marginal changes in water quality that can readily be addressed through use of a filter and use of bottled water if the changes were of major concern. Moreover, it is noteworthy that the most influential reference dependence effects are not related to tap water risks but rather to shifts in monetary resources. It is the cost-related reference dependent effect for money that largely accounts for the WTA-WTP disparity, not the reference dependence effect for health risks.

Other variables in the equation in Table 2 also perform in the expected manner and, as with the income variable, are consistent with a behavioral scope test along the lines outlined in Herberlein et al. (2005). Education serves as a measure of lifetime wealth and is positively related to valuations as well. Older respondents—who face greater health risks from contaminated water and are also at a different stage of their life cycle with greater wealth levels—have greater values. There are also higher values for women, whom some studies have suggested may exhibit greater degrees of risk aversion. People who consider themselves to be environmentalists and who consequently should have a greater valuation of safety also express greater valuations. Likewise those who have revealed themselves to place a high value on water safety by using a water filter system also have greater valuations. People who are heavy tap water users as reflected in the number of glasses of tap water drunk per day have greater valuations. This pattern for heavy tap water users is consistent with individual responsiveness to the presence of a dose-response relationship for risk exposures. Black respondents also had greater valuations, which is consistent with their greater exposure to risks from their primary water source.[9]

The valuations also are consistent with individual responsiveness to costs. Thus, people who receive a water bill directly and who should be more concerned with costs have a somewhat lower valuation. Other variables included in equation 2, which are not statistically significant and are not reported, include a detailed set of indicators for region and household composition.

Higher values of the starting tradeoff ratio increase the tradeoff rate that respondents express. Thus, the regression results in column 2 of Table 2 control for the anchoring influence of the initial tradeoff choice. In addition to accounting for the effect empirically, we control for this influence across the four experimental groups by not altering the starting values for different groups. In addition, we set the starting values to approximate a 50-50 split in the WTP context between respondents who have a higher tradeoff rate or a lower tradeoff rate than that specified

[9] U.S. Department of Housing and Urban Development (2011) reports that Blacks and Hispanics have greater exposure to unsafe water.

in the initial choice. This set of starting points is held constant and is not altered to produce a 50-50 split in the other three scenarios so as to avoid any potential bias.

Accounting for the influence of interval responses and censoring based on the interval regression yields the predicted values shown in Table 3. The mean valuation per 1/1,000 risk of illness has high value of $57.10 for the cost decrease, risk increase WTA $f(\mu^-, \lambda^+)$ choice set, which is 4.6 times the magnitude of the cost increase, risk decrease WTP $f(\mu^+, \lambda^-)$ value of $12.50.[10] This WTA/WTP ratio is well within the range of estimates found by Horowitz and McConnell (2002), who report an average mean WTA/mean WTP of 7.2. Whether the risk level is increasing or decreasing is influential in the cost decrease domain, as the value for the tradeoff among gains case involving cost decreases and risk decreases with reference dependence factor $f(\mu^-, \lambda^-)$ is $22.80. This TG tradeoff value is 40% of the tradeoff value for the cost decrease, risk increase WTA $f(\mu^-, \lambda^+)$ choice set. Thus, this set of responses provides evidence consistent with a value of μ^- for cost down that satisfies $\mu^- < \mu^+$, and a value of λ^+ for risk that satisfies $\lambda^+ > \lambda^-$.

The outlier in the pattern of tradeoff values is the tradeoff value for the tradeoff among losses involving cost increases, risk increases, with the reference dependence factor $f(\mu^+, \lambda^+)$. This TL tradeoff value is $12.52. Although the inequalities in equation 4 are satisfied, the WTP/TL ratio of 0.998 is very close to 1.0 so that there is no evidence of any reference dependence effect for TL when both cost and risk are increasing rather than just cost alone. The effect of the health risk probability increase on the tradeoff rate in the cost increase situation does not accord with what would be expected based on the cost decrease results. In particular, when costs are decreasing, the marginal effect on valuations for risks to be increasing rather than decreasing is to boost these values by $34.30. These findings suggest an interactive effect

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[10] Calculation of the mean estimates is based on the procedure in Train (2003). If a logged distribution has a mean M and a variance S, then the mean of the unlogged distribution is $e^{(M+S/2)}$. In this application M is the mean predicted logged value across respondents, and S is the variance of those predictions.

between the reference dependence parameters as modeled in equation 5. The risk increase effect is influential when in the cost decrease domain, but not in the cost increase domain when financial concerns are more pressing and, in fact, the exclusive concern.

Much the same pattern as shown in the mean effects is borne out by the median values. For example, the median for the WTA value for cost decrease, risk increase $f(\mu^-, \lambda^+)$ is 4.6 times the size of the WTP value for cost increase, risk decrease case $f(\mu^+, \lambda^-)$. The value for the tradeoff among gains case with a cost decrease, risk decrease $f(\mu^-, \lambda^-)$ is in the intermediate range, and there is negligible difference between the valuations for the cost increase domain irrespective of whether the risk level is increasing or decreasing.

3.3. Parallels with the Literature

The risk tradeoff results exhibit remarkable parallels with experimental results in the literature and consequently may illuminate reference dependent mechanisms of general importance. Three of the four cases considered here parallel those in the mug-money experiment analysis in Knetsch and Tang (2006), who consider three of the four quadrant variants and report results similar to our findings.[11] The upper left and lower right quadrants in Figure 1 reflect respectively the classic WTP and WTA questions and are included in their experimental analysis. Knetsch and Tang's findings imply a WTA/WTP ratio of 3.5 compared to our estimate of 4.6. In addition, the ratio of the WTA to their equivalent gains case for mugs is 2.0, which parallels our tradeoff among gains TG case involving risk decreases and cost decreases in Quadrant 4, as the estimated mean values in Table 3 imply a ratio of WTA to TG equal to 2.5.

Experimental evidence for tradeoffs between money and Coke reported in Bateman et al. (1997) address all four gain-loss possibilities as in our study, but the focus is not on tradeoff rates

[11] The mug experiments were first reported in Kahneman, Knetsch, and Thaler (1990).

but on the percent of participants who are willing to make money trades for Coke.[12] Overall, 3.75 times as many people were willing to make the trade in the WTP scenario as compared to the WTA variant, which is the familiar WTA-WTP gap. What is noteworthy is that 50% were willing to make the trade in their equivalent loss quadrant, which is close to their 60% figure for WTP. This similarity parallels our tradeoff among losses TL cell in Quadrant 2 for tradeoffs involving cost increases and risk increases. These loss tradeoff estimates are very similar to the WTP cell estimates. Thus, for Table 2 and in the empirical analysis in Table 3, there is no statistically significant difference between the WTP and the TL values when both cost and risk are increasing. Similarly, 26% of the respondents are willing to make the money for Coke trade in the equivalent gains variant, which is between the percentages for WTA and WTP. Likewise, in our case the mean tradeoff rate in Table 3 for Quadrant 4, in which cost and risk are decreasing, is $22.80, which is between the WTA and WTP values.

4. Conclusion

Examination of all four possible combinations of cost and risk probability changes indicate that reference dependence effects are not restricted to commodities, money, and similar attributes of utility functions. Probabilities with respect to adverse health outcomes could generate an analogous source of reference dependence if one varies the severity of the health outcome in either direction. That parallel case was not, however, the focus of our analysis as it could be addressed using existing models. In our study, the severity of the outcome is held constant, but the probability of the outcome is varied. To accommodate possible reference dependent effects with respect to probabilities, we generalized the gain-loss models of reference

[12] The specific comparisons below are for the Bateman et al. (1997) results for those preferring £0.80 to four cans of Coke, as summarized by Knetsch and Tang (2006).

dependence to incorporate such possible reference dependence. The structure of this model has strong parallels with existing reference dependence frameworks and suggests that economic models of reference dependence can accommodate a wide variety of reference dependence effects.

The results of the stated preference choice experiment indicate a very strong influence of reference dependence on cost-risk tradeoffs. Cost-related reference dependence is manifested regardless of the reference domain for risk. Based on an empirical analysis of all four cost and risk directions of change, it is clear that the reference dependence effect for cost is largely responsible for generating the well-known WTA-WTP discrepancy. Thus, the empirical analysis successfully disentangled the respective influence of the presence of two component reference point effects that could be responsible for the WTA-WTP gap.

The empirical results also provided evidence of a reference dependence effect for risk in the cost decrease domain. The failure of risk increases to produce a reference effect when costs are increasing is consistent with an interactive effect of the reference dependent influences. It is only when respondents are shifted from their initial endowment by decreasing costs that reference risk effects come into play. Standard models of reference dependence that ignore potential interaction are not borne out.

Although our focus is on tradeoffs between health risk probabilities and money rather than commodities and money, the pattern of findings exhibits very strong parallels with the findings of experimental studies. As a result, the pattern of reference dependence parameters may illuminate the source of reference dependence effects in other situations as well. For contexts involving money, being in a situation where financial resources have increased rather than decreased makes the role of reference dependent influences much more pronounced.

Because of the use of a large national sample with detailed demographic information, it is also possible to rule out potential economic influences that could account for the WTA-WTP discrepancy. None of these effects are attributable to income effects, which we estimate and find to be extremely small. Rather, there is a fundamental concern with reference points that can have a major influence on people's tradeoffs between cost and health risks.

Appendix A. Description of the Sample

The survey was administered by Knowledge Networks (KN) to members of the KN panel over the 2008-2009 period. The KN panel is a probability sample of the U.S. population. People who do not have internet access are provided with computers or internet service to generate a representative sample. The total survey length of this Web-based survey was under 25 minutes. The survey response rate was 69%.

Table A.1 presents the demographic characteristics of the sample of 4,745 consistent respondents. The second column of statistics presents the U.S. population counterparts. As the data indicate, the sample mix tracks the U.S. population averages quite closely in terms of gender, age, race, education, marital status, and household income.

Table A.2 presents the sample characteristics of the variables used in the empirical analysis.

Appendix A. Sample Characteristics
Appendix Table A.1
Comparison of Sample to the National Adult Population[a]

Demographic Variable	Sample (n=4,745) Percent	US Adult Population Percent
Gender		
Male	47.5	48.4
Female	52.5	51.6
Age		
18 - 24 years old	8.2	12.6
25 - 34 years old	14.0	17.9
35 - 44 years old	19.4	18.8
45 - 54 years old	21.0	19.6
55 - 64 years old	20.2	14.8
64 - 74 years old	11.6	8.7
75 years old or older	5.6	7.7
Race / Ethnicity		
White	81.9	81.3
Black/African-American	9.8	11.7
American Indian or Alaska Native	1.3	2.4
Asian/Pacific Islander/Other	6.7	4.6
Hispanic	9.7	13.5
Educational Attainment		
Less than High School diploma	10.8	14.2
High School Diploma or higher	59.9	58.8
Bachelor's Degree or higher	29.4	26.9
Marital Status		
Married	58.2	55.0
Single (never married)	21.8	26.0
Divorced	12.4	10.4
Widowed	5.4	6.4
Household Income		
Less than $15,000	11.2	13.3
$15,000 to $24,999	9.6	11.6
$25,000 to $34,999	10.4	10.7
$35,000 to $49,999	16.6	14.2
$50,000 to $74,999	21.1	18.2
$75,000 or more	31.1	32.0

[a] *U. S. Census Bureau (http://www.census.gov/).* 2008 adult population (18 years+).

Appendix Table A.2
Variables Used in the Analysis

Variable	Mean	Std. Dev.
Value for Reducing 1/1,000 GI Risk	11.32	15.05
Log(Value for Reducing 1/1,000 GI Risk)	1.71	1.24
Starting Cost Difference ($/year)	93.46	21.55
Starting Risk Difference (X/1,000)	23.79	9.57
Starting Cost to Risk Ratio	4.38	1.44
Fraction of Respondents with Value Censored Low	0.16	0.36
Fraction of Respondents with Value Censored High	0.07	0.25
Household Income	61098.04	41839.70
Log (Household Income)	10.73	0.85
Years of Education	13.80	2.59
Age	48.43	16.23
Gender: Female	0.53	0.50
Race: White	0.82	0.38
Race: Black	0.10	0.30
Race: Other	0.08	0.27
Hispanic	0.10	0.30
Household Size	2.54	1.43
Considers Self Environmentalist	0.42	0.49
Homeowner	0.77	0.42
Well User	0.18	0.38
Receives a Water Bill	0.69	0.46
Glasses of Tap Water per Day	2.85	2.42
Filter Use	0.40	0.49
Live in Metropolitan Statistical Area	0.84	0.37
Region: Northeast	0.18	0.39
Region: South	0.35	0.48
Region: West	0.22	0.42
Region: Midwest	0.24	0.43

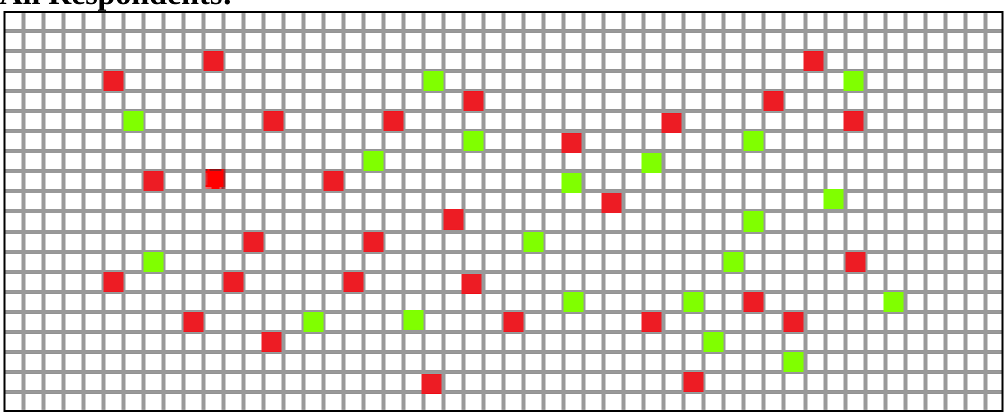
Appendix B

Sample Survey Text
Appendix B.1
Sample Survey Text for the First Question Set (Cost Up, Risk Down)
Willingness to Pay

Municipal Water Users:
Imagine that your water utility is considering a new treatment for the water that comes to your home faucet. This treatment would increase the yearly cost of your water bill and also reduce the risk of GI illness.

Well Users:
Imagine that you could purchase a new treatment for the water that comes to your home faucet. This treatment would increase the yearly cost for your tap water and also reduce the risk of GI illness.

All Respondents:



The image above shows that with the new treatment, 20 fewer people would get GI illness every year. The green squares are the people who would not become ill with the new treatment.

Remember the national average for GI illness is about 50 of every 1,000 people each year.

Which alternative would you prefer?

	New Treatment	No New Treatment	
Yearly Risk of GI Illness	30 of every 1,000 people	50 of every 1,000 people	
Additional Yearly Cost of (Water Bill or Tap Water)	+ $ 100 Additional Cost	$0 Additional Cost	
Your Choice	New Treatment	No New Treatment	No Preference

Appendix B.2
Sample Survey Text for the Second Question Set (Cost Down, Risk Down)
Tradeoff among Gains

Municipal Water Users:

Municipal water treatment facilities are always interested in finding cheaper, more effective methods for removing contaminants from drinking water.

In the next series of questions, we will ask you to imagine that your water utility is considering two new treatments for the water that comes to your home faucet.

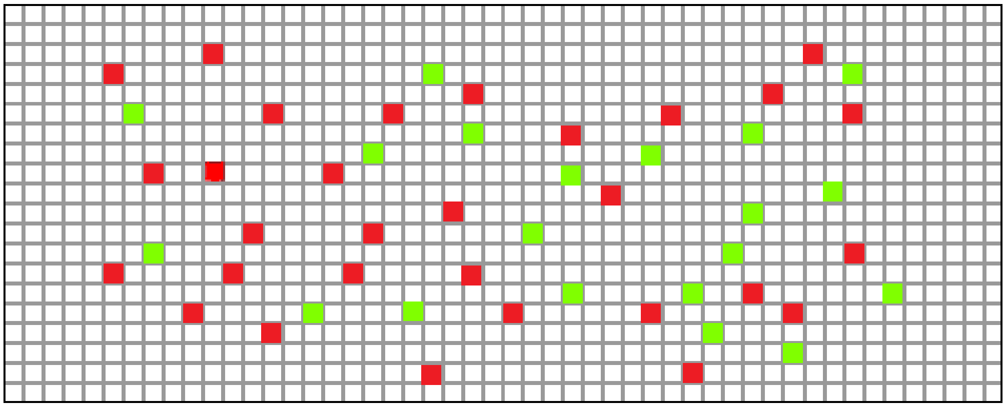
Imagine that your water utility has developed new technologies for treating the water that comes to your home faucet.

The first treatment option would reduce GI illness risk at the same cost you are paying now.

The second treatment option would reduce the cost of your water bill with no change in the risk of GI illness.

Even if the proposed reduction is greater than the total cost of your water bill, try to imagine that you would receive the reduced cost anyway, either through lower local taxes or lower costs for other goods.

Remember the national average for GI illness is about 50 of every 1,000 people each year.



The image above shows that with the first treatment, you would have a 20 out of 1,000 lower chance of getting GI illness each year. The green squares show the reduction in your risk of becoming ill with the first treatment.

Which treatment would you prefer?

	Treatment 1	Treatment 2	
Yearly Risk of GI Illness	30 of every 1,000 people	50 of every 1,000 people	
Reduction in Yearly Cost of Wells or Water Bill	$ 0 Reduced Cost	- $ 100 Reduced Cost	
Your Choice	Treatment 1	Treatment 2	No Preference

Appendix B.3
Sample Survey Text for the Second Question Set (Cost Down, Risk Up)
Willingness to Accept

Well Users:

Well users were not asked this set of questions.

Municipal Water Users:

Water utilities try to use the most cost effective treatments available to ensure that the water delivered to your home faucet is safe for drinking.

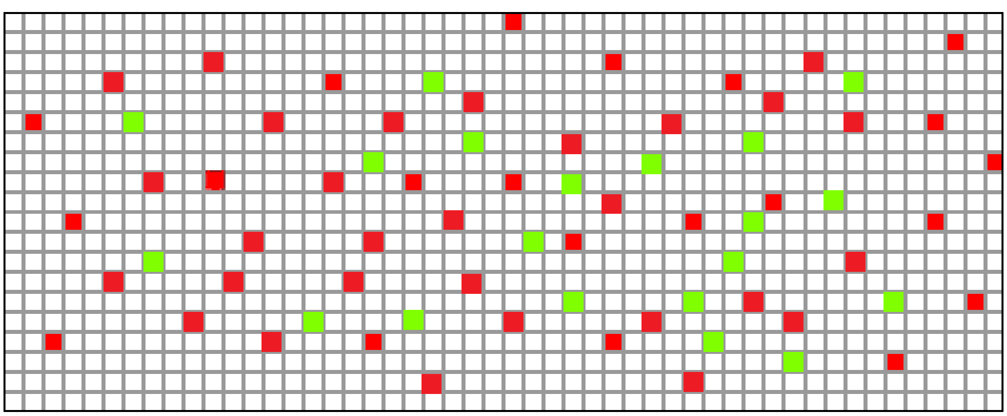
For the next set of questions, we would like for you to imagine that your local water utility is considering a new treatment for the water that comes to your home faucet. This treatment would be less expensive than what is done currently but would be less effective.

This treatment would decrease the yearly cost of your water bill but would increase the risk of GI illness.

Imagine that your water utility is considering a new treatment for the water that comes to your home faucet. This treatment is less expensive but less effective. It would decrease the yearly cost of your water bill but would increase the risk of GI illness.

Even if the proposed reduction is greater than the total cost of your water bill, try to imagine that you would receive the reduced cost anyway, either through lower local taxes or lower costs for other goods.

Remember the national average for GI illness is about 50 of every 1,000 people each year.



The image above shows that with the new treatment, 20 more people would get GI illness every year. The green squares are the additional people who would become ill if the new treatment were used.

Which treatment would you prefer?

	Current Treatment	New Treatment	
Yearly Risk of GI Illness	50 of every 1,000 people	70 of every 1,000 people	
Change in Yearly Cost of Wells or Water Bill	$0 Reduced Cost	- $ 100 Reduced Cost	
Your Choice	Current Treatment	New Treatment	No Preference

Appendix B.4
Sample Survey Text for the Third Question Set (Cost Up, Risk Up)
Tradeoff among Losses

Municipal Water Users:

[#1]
Experts believe that the nation's water utilities will face increased costs in the future to maintain water treatment infrastructure and to ensure that water supplies stay safe. Many facilities are quite old and in need of maintenance, upgrade, or repair.

Though the exact amount of these costs is not certain, if these costs are not paid, GI illness risks from drinking water are likely to increase.

[#2]
An increasing population means increasing demand for clean water. This requires water utilities to find additional sources for drinking water. New sources are more expensive to reach or require more treatment than existing water sources.

If these costs are not paid, water might be delivered with insufficient treatment to completely disinfect it, increasing the risk of GI illness.

[#3]
Increasing levels of pollution from upstream homes and businesses requires water utilities to treat water longer or perform additional kinds of treatments to ensure that it is safe to use.

If these costs are not paid, water might be delivered with insufficient treatment to completely disinfect it, increasing the risk of GI illness.

Well Users:

[#4]
Increasing levels of pollution from upstream homes and businesses sometimes threatens drinking water supplies for well users.

All Respondents:

Such risks could require additional treatment to ensure that it is safe to use. If these costs are not paid, the water could have an increased risk of causing GI illness.

The next questions will ask what increased costs you would be willing to accept to prevent increases in risk of GI illness in drinking water.

Municipal Water Users:

Suppose that your water utility is proposing a rate increase for the water that comes into your home.

If the rate increase is accepted, your yearly water bill would increase by $100.

If the rate increase is rejected, the risk of GI illness would increase by 20 illnesses per 1,000 people each year.

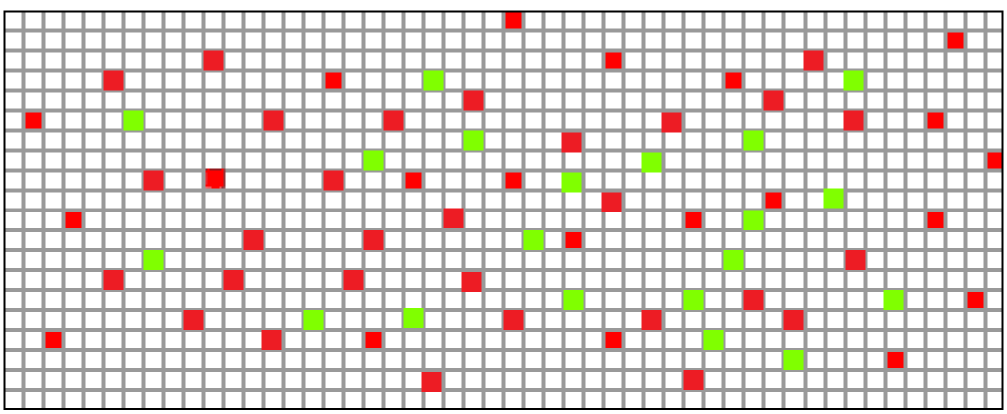
Well Users:

Suppose that pollution in your area is threatening the safety of your well water. Additional treatment would be required to maintain your tap water's current level of safety.

If the new treatment is accepted, the yearly cost of your tap water would increase by $100.

If the new treatment is rejected, your risk of GI illness would increase by 20 out of 1,000 each year.

All Respondents:



Municipal Water Users:

The image above shows that without the new treatment, 20 out of 1,000 more people would get GI illness every year. The green squares are the additional people who would become ill without the new treatment.

Well Users:

The image above shows that without the new treatment, 20 out of 1,000 higher risk of GI illness every year. The green squares are the additional chances of becoming ill without the new treatment.

All Respondents:

Would you be in favor of accepting or rejecting this treatment?

	With New (Rate Increase or Treatment)	Without New (Rate Increase or Treatment)	
Yearly Risk of GI Illness	50 of every 1,000 people	70 of every 1,000 people	
Additional Yearly Cost of (Water Bill or Tap Water)	+ $ 100 Additional Cost	$0 Additional Cost	
Your Choice	Accept. I am in favor of this (Rate Increase or Treatment)	Reject. I am opposed to this (Rate Increase or Treatment)	I have no preference for whether this (Rate Increase or Treatment) happens or not

References

Bateman, I., Munro, A., Rhodes, B., Starmer, C., & Sugden, R. (1997). A test of the theory of reference-dependent preferences. *Quarterly Journal of Economics*, 112(2), 479–505.

Bell, J., Huber, J., & Viscusi, W. K. (2011). Survey mode effects on valuation of environmental goods. *International Journal of Environmental Research and Public Health*, 8, 1222–1243.

Breyer, F., & Fuchs, V. R. (1982). *Risk attitudes in health: An exploratory study*. NBER Working Paper Series No. 875.

Colford, J. M., Jr., Roy, S., Beach, M. J., Hightower, A., Shaw, S. E., & Wade, T. J. (2002). A review of household drinking water intervention trials and an approach to the estimation of endemic waterborne gastroenteritis in the United States. *Journal of Water and Health*, 4(Suppl. 2), 71–88.

Evans, W. N., & Viscusi, W. K. (1991). Estimation of state-dependent utility functions using survey data. *Review of Economics and Statistics*, 73(1), 94–104.

Heberlein, T. A., Wilson, M. A., Bishop, R. C., & Schaeffer, N. C. (2005). Rethinking the scope test as a criterion for validity in contingent valuation. *Journal of Environmental Economics and Management*, 50(1), 1–22.

Hensher, D., Shore, N., and Train, K. (2005). Households' willingness to pay for water service attributes. *Environmental and Resource Economics*, 32(4), 509–531.

Horowitz, J. K., & McConnell, K. E. (2002). A review of WTA/WTP studies. *Journal of Environmental Economics and Management*, 44(3), 426–447.

Huber, J., Viscusi, W. K., & Bell, J. (2008). Reference dependence in iterative choices. *Organizational Behavior and Human Decision Processes*, 106(2), 143–152.

Innes, R., & Cory, D. (2001). The economics of safe drinking water. *Land Economics*, 77(1), 94–117.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy*, 98(6), 1325–1348.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk." *Econometrica*, 47(2), 263–291.

Knetsch, J. L., & Tang, F-F. (2006). The context, or reference, dependence of economic values. In M. Altman (Ed.), *Handbook of Contemporary Behavioral Economics: Foundations and Developments* (423–440). New York, NY: M.E. Sharpe, Inc.

Kőszegi, B., & Rabin, M. (2006). A model of reference-dependent preferences. *Quarterly Journal of Economics*, 121(4), 1133–1165.

Loomes, G., Orr, S., & Sugden, R. (2009). Taste uncertainty and status quo effects in consumer choice. *Journal of Risk and Uncertainty*, 39(2), 113–135.

Messner, M., Shaw, S., Regli, S., Rotert, K., Blank, V., & Soller, J. (2006). An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. *Journal of Water and Health*, 4(Suppl.2), 201–240.

Munro, A., & Sugden, R. (2003). On the theory of reference-dependent preferences. *Journal of Economic Behavior and Organization*, 50(4), 407–428.

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, 1(1), 7–59.

Schmidt, U., Starmer, C., & Sugden, R. (2008). Third-generation prospect theory. *Journal of Risk and Uncertainty*, 36(3), 203–223.

Sugden, R. (2003). Reference-dependent subjective expected utility. *Journal of Economic Theory*, 111(2), 172–191.

Thaler, R. H., & Johnson, E. J. (1990). Gambling with the house money and trying to break even: The effects of prior outcomes on risky choice. *Management Science*, 36(6), 643–660.

Train, K. E. (2003). *Discrete choice methods with simulation*. Cambridge, UK: Cambridge University Press.

U.S. Department of Housing and Urban Development. (2011). *American Housing Survey for the United States, 2009, Series H-150/09*. Current Housing Reports. Washington, DC: U.S. Government Printing Office.

Viscusi, W. K., & Evans, W. (1990). Utility functions that depend on health status: Estimates and economic implications. *American Economic Review*, 80(3), 353–374.

Viscusi, W. K., Huber, J., & Bell, J. (2011). Heterogeneity in values of morbidity risks from drinking water. SSRN Working Paper Number 11-37. Forthcoming in *Environmental and Resource Economics*, doi: 10.1007/s10640-011-9517-3.

Viscusi, W. K., Magat, W., & Huber, J. (1987). An investigation of the rationality of consumer valuations of multiple health risks. *RAND Journal of Economics*, 18(4), 465–479.

Figure 1
Taxonomy of Possible Cost-Risk Reference Point Effects

		Risk	
		Decrease (λ^-)	Increase (λ^+)
Cost	Increase (μ^+)	Quadrant 1 Willingness to Pay (WTP) $f(\mu^+, \lambda^-) = (1 + \lambda^-) / (1 + \mu^+)$	Quadrant 2 Tradeoff among Losses (TL) $f(\mu^+, \lambda^+) = (1 + \lambda^+) / (1 + \mu^+)$
	Decrease (μ^-)	Quadrant 4 Tradeoff among Gains (TG) $f(\mu^-, \lambda^-) = (1 + \lambda^-) / (1 + \mu^-)$	Quadrant 3 Willingness to Accept (WTA) $f(\mu^-, \lambda^+) = (1 + \lambda^+) / 1 + \mu^-)$

Figure 2
Experimental Structure

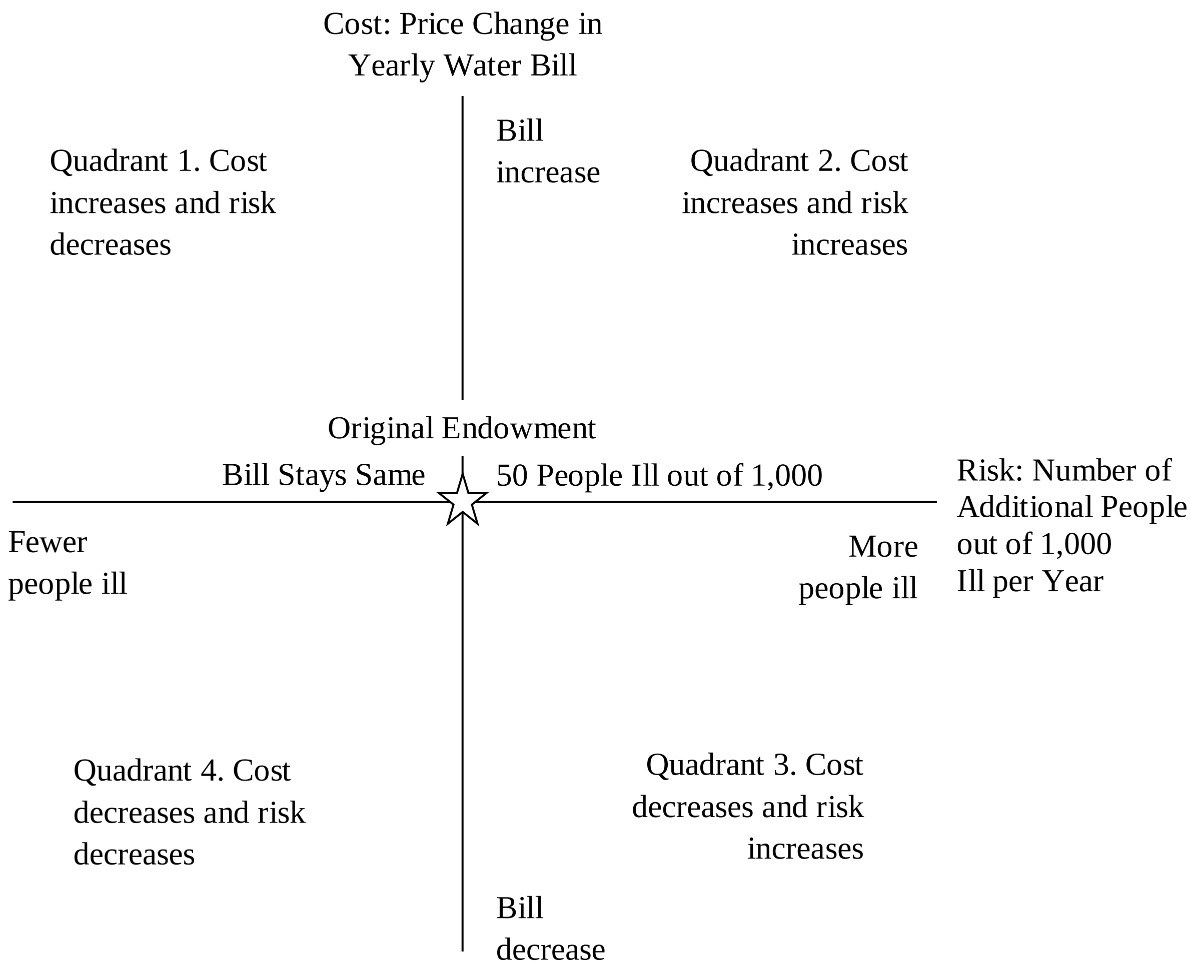


Figure 3
Sample Survey Text for the Cost Increase, Risk Increase Treatment Choice Question
Tradeoff among Losses

Increasing levels of pollution from upstream homes and businesses requires water utilities to treat water longer or perform additional kinds of treatments to ensure that it is safe to use.

If these costs are not paid, water might be delivered with insufficient treatment to completely disinfect it, increasing the risk of GI illness.

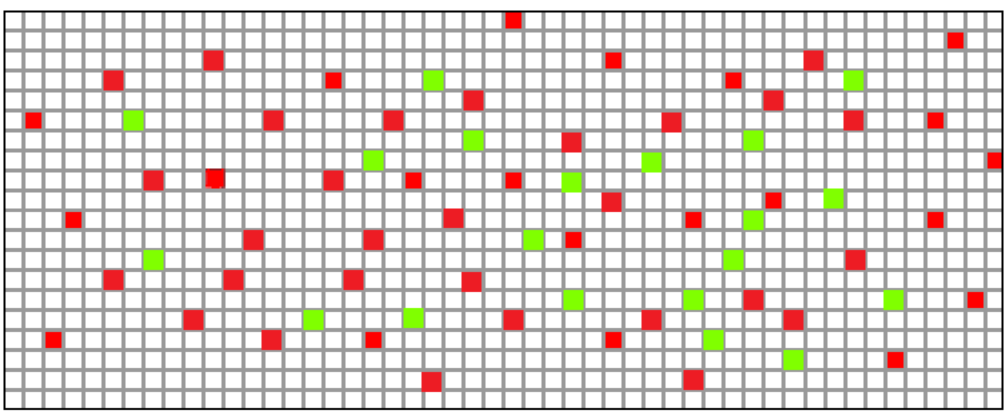
Such risks could require additional treatment to ensure that it is safe to use. If these costs are not paid, the water could have an increased risk of causing GI illness.

The next questions will ask what increased costs you would be willing to accept to prevent increases in risk of GI illness in drinking water.

Suppose that your water utility is proposing a rate increase for the water that comes into your home.

If the rate increase is accepted, your yearly water bill would increase by $100.

If the rate increase is rejected, the risk of GI illness would increase by 20 illnesses per 1,000 people each year.



The image above shows that without the new treatment, 20 out of 1,000 more people would get GI illness every year. The green squares are the additional people who would become ill without the new treatment.

Would you be in favor of accepting or rejecting this treatment?

	With New Rate Increase	Without New Rate Increase	
Yearly Risk of GI Illness	50 of every 1,000 people	70 of every 1,000 people	
Additional Yearly Cost of (Water Bill or Tap Water)	+ $ 100 Additional Cost	$0 Additional Cost	
Your Choice	Accept. I am in favor of this Rate Increase	Reject. I am opposed to this Rate Increase	I have no preference for whether this Rate Increase happens or not

Figure 4
Survey Decision Tree
(Starting Cost Difference of $100, Starting Risk Difference of 20/1,000)

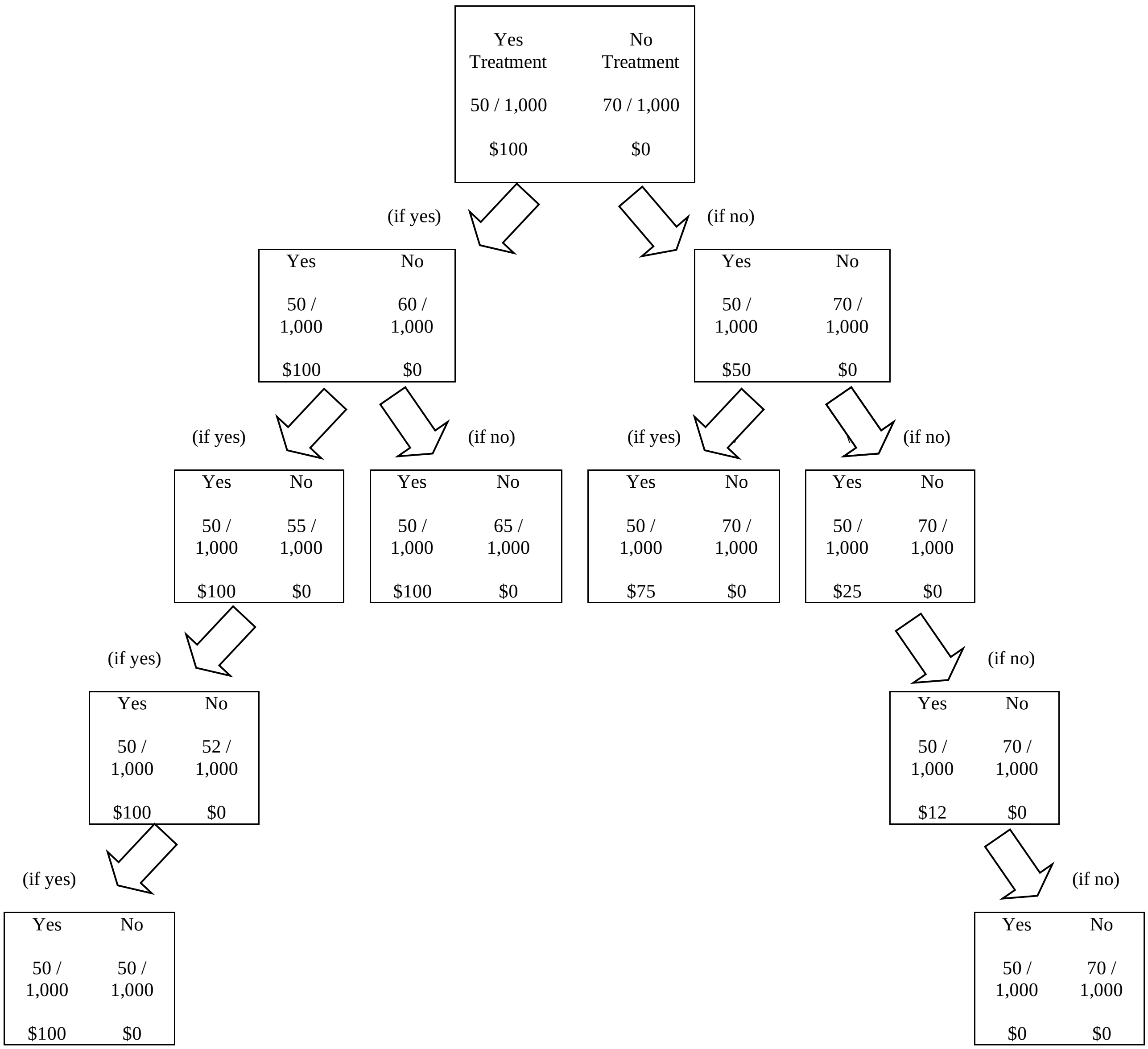


Table 1
Actual Dollar Tradeoff Rates between Cost and Health Risk
Value of a 1/1,000 Change in Risk

	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
	Cost Increase, Risk Decrease $f(\mu^+, \lambda^-)$	Cost Increase, Risk Increase $f(\mu^+, \lambda^+)$	Cost Decrease, Risk Increase $f(\mu^-, \lambda^+)$	Cost Decrease, Risk Decrease $f(\mu^-, \lambda^-)$
	Willingness to Pay (WTP)	Tradeoff among Losses (TL)	Willingness to Accept (WTA)	Tradeoff among Gains (TG)
Raw Values[a]				
Mean	8.30	8.25	17.38	13.13
(Std. Dev.)	12.51	11.81	19.44	14.13
25th percentile	2.25	2.50	4.00	3.43
Median	4.00	4.00	10.67	6.40
75th percentile	8.00	8.00	20.00	22.86
N	1,677	1,057	1,097	914

[a] Raw values are the point estimates for those indicating a tradeoff rate, the midpoint of the range for those who switch within a range but do not indicate a tradeoff rate, and the upper or lower bound for the censored observations.

Table 2
Interval Regression Results of Log Value per 1/1,000 Risk[a]

	Coefficient (Std. Error)	
	1	2
Cost Increase, Risk Decrease	-1.533***	-1.520***
	(0.061)	(0.060)
Cost Decrease, Risk Decrease	-0.891***	-0.793***
	(0.070)	(0.069)
Cost Increase, Risk Increase	-1.522***	-1.482***
	(0.067)	(0.067)
Log (Household Income)		0.105***
		(0.031)
Years of Education		0.020**
		(0.009)
Age		0.005***
		(0.002)
Gender: Female		0.145***
		(0.043)
Race: Black		0.127*
		(0.076)
Considers Self Environmentalist		0.192***
		(0.045)
Well User		-0.062
		(0.072)
Receives a Water Bill		-0.159***
		(0.062)
Glasses of Tap Water per Day		0.019**
		(0.009)
Filter Use		0.108**
		(0.045)
Starting Tradeoff Ratio		0.183***
		(0.016)
Intercept	2.944***	0.358
	(0.048)	(0.324)
Log likelihood	-9160.3	-9029.8

[a]Sample size is 4,745, including 1,971 interval observations, 1,706 uncensored tradeoffs, 328 left censored, and 740 right censored observations. Asterisks denote statistical significance at the 0.10 level*, 0.05 level**, and 0.01 level***. Other variables included in equation 2 are race: other, Hispanic, household size, homeowner, live in metropolitan statistical area, region: northeast, region: south, region: west, and missing value indicators for considers self environmentalist, race, receives a water bill, glasses of tap water per day, and filter use.

Table 3
Predicted Dollar Tradeoff Rates between Cost and Health Risk
Value of a 1/1,000 Change in Risk[a]

	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
	Cost Increase, Risk Decrease $f(\mu^{+}, \lambda^{-})$	Cost Increase, Risk Increase $f(\mu^{+}, \lambda^{+})$	Cost Decrease, Risk Increase $f(\mu^{-}, \lambda^{+})$	Cost Decrease, Risk Decrease $f(\mu^{-}, \lambda^{-})$
	Willingness to Pay (WTP)	Tradeoff among Losses (TL)	Willingness to Accept (WTA)	Tradeoff among Gains (TG)
Estimated Values				
Mean	12.50	12.52	57.10	22.80
(Std. Dev.)	4.68	4.56	22.06	6.10
Median	4.10	4.12	19.03	7.75

[a] These estimates are based on the predicted values from equation 2 in Table 2.