

STATISTICAL VS. IDENTIFIED LIVES IN BENEFIT-COST ANALYSIS

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Abstract

Economic evaluation of projects involving changes in mortality risk conventionally assumes that lives are statistical, i.e., that risks and policy-induced changes in risk are small and similar among a population. In reality, baseline mortality risks and policy-induced changes in risk often differ among individuals although these differences are imperfectly known. We examine the effects of information about heterogeneity of risk on economic evaluation. Although social welfare (defined as aggregate expected utility) is unaffected by information about risk heterogeneity, the economic valuation of changes in risk (the sum of individual compensating or equivalent variations) is sensitive to this information. The effect of information on economic valuation and hence the outcome of a benefit-cost analysis (BCA) depends on: i) whether information is about heterogeneity of the baseline and/or change in risk, ii) whether risk is valued using willingness to pay (WTP) or willingness to accept (WTA) measures, iii) the status quo policy, and iv) whether individuals are risk-averse or risk-neutral in wealth. We show that BCA does not systematically favor identified over statistical lives and suggest some political factors that may explain the apparent public-decision bias toward protecting identified lives.

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1. Introduction

Modern societies seem to spend more generously to save the lives of identified than anonymous victims (Viscusi, 2000a; Lamm, 2001; Richardson and McKie, 2003), a phenomenon that has been described as “statistical murder.”¹ But spending large amounts to benefit only a few may be inefficient. It may also be inequitable: the question arises why some receive particular attention and not others. The special concern toward identified lives can drive priorities in risk management including the choice between prevention and treatment of disease (Corso et al., 2002) and the allocation of efforts among risks, e.g., treating kidney-disease patients and reducing traffic crashes, building a nuclear power plant or a coal plant with more diffuse health effects. From a broader perspective, information about whom a policy affects may influence the chance that it will be adopted. This effect may be particularly important for health and safety policies and for the valuation of health and mortality risk.

The economic literature on the “value of life” has, from the beginning, clearly distinguished between identified and statistical lives. In the first paragraph of his seminal paper, Schelling (1968) writes “*It is not the worth of human life that I shall discuss, but of ‘life-saving,’ of preventing death. And it is not a particular death, but a statistical death.*” Economists have since been cautious to make clear that the standard valuation approach – purposely labeled the “value-per-statistical-life” (VSL) approach – applies only when changes in risk are small and similar among the affected population.² As Viscusi (1992: 17) states “*This need to think in terms of statistical lives as opposed to certain lives defines the main character of our choice problem.*” The focus on statistical rather than identified lives is consistent with the traditional marginal approach to the valuation of public goods (Samuelson, 1954; Bergstrom, 1982) and lessens the scope for psychological concerns in the usual case where the effects of a policy on individual mortality risks are small (Schelling, 1968).

The focus on statistical lives leaves open the question of how to evaluate a project that may save, or threaten, the lives of identified people. One may judge that the VSL approach is inappropriate because lives are not “statistical enough.” But what should one do instead? Scholars have recognized that identified and statistical lives are not the same (Schelling, 1968; Mishan, 1971; Weinstein et al., 1980; Keeney, 1995; Pratt and Zeckhauser, 1996)³ but how this affects economic valuation is less clear.

The distinction between identified and statistical lives is not sharp but a continuum characterized by available information about heterogeneity of risk. People are neither identical nor anonymous and neither baseline risks nor policy-induced changes in risk are always small or identical across people. In general, baseline risks and risk changes differ among individuals because of differences in exposure (e.g., to sources of pollution, traffic

¹ In her paper entitled “Murdering Statistical Lives ...?” Linnerooth (1982: 231) attributes the provocative term to Howard Raiffa. It was subsequently used by Graham (1995) and Viscusi (2000b). Tal (1998: 170) cites an alternative use of the term by Merrell and Van Strum (1990: 21) to describe the permitting of any activity (e.g., pesticide use) that imposes mortality risk on someone.

² Howard (1984) proposed valuing risk increments in terms of “micromorts,” i.e., risk changes of one in a million. This alternative emphasizes the focus on small risk changes.

³ In particular, Pratt and Zeckhauser (1996) examine the effects of risk and wealth on optimal public safety expenditures defined behind a Rawlsian veil of ignorance (before individuals have information about their own wealth and risk). Linnerooth (1982) and Hammitt (2002) compare VSL with effectiveness measures such as live and life years saved.

conditions) and differences in susceptibility (e.g., related to age, sex, health status, genetics, behavior). In practice, information about how risks and policy-induced changes in risk differ among individuals varies among cases. Often it is so limited that one has little choice but to treat the risks as identical. Individuals may be conceived as facing a compound lottery. In the first stage, their initial risk and policy-induced risk change are drawn from the population distribution and in the second stage the outcome of the risk is realized. Before information about the outcome of the first stage is available, risks are identical across individuals.

Societies may choose to protect individual over statistical lives to support principles of respect for individuals and compassion (Zeckhauser, 1975; Tal, 1998). Decisions that are seen to protect identified victims have the merit of endorsing social values of compassion, solidarity, and unwillingness to sacrifice the few for the benefit of the many. In making this choice, societies must determine when the gains in equity, symbolism, and other objectives outweigh the loss in efficiency (Okun, 1975; Linnerooth, 1982). Differences between *ex ante* and *ex post* identifiability may have implications for decision making. *Ex ante* identifiability may attract public attention and invoke a “rule of rescue” response (Richardson and McKie, 2003). *Ex post* identifiability may be required to attribute deaths to particular decisions and to hold decision makers accountable (Raiffa et al., 1977).

The objective of this paper is to examine how information about heterogeneity of risk and of policy-induced changes in risk influences economic valuation. This objective can be efficiently addressed in a one-period model. Specifically, we investigate how the results of benefit-cost analysis (BCA) depend on information about individual risks and risk changes in a conventional static VSL model. We compare these results with maximization of aggregate expected utility, an objective which is independent of information about risk heterogeneity when, as in our analysis, people are otherwise identical. For the sake of comparability, we consider situations in which the aggregate initial and final risks, i.e., before and after the public project is implemented, are the same. The only difference is the individual-specific information about risk heterogeneity.⁴ We find that this difference has, in many cases, a predictable and intuitive effect on the outcome of BCA. The sign of the effect depends on several factors including whether the information concerns the baseline and/or change in risk and whether willingness to pay (WTP) or willingness to accept (WTA) measures are used. In addition, we find that BCA does not provide systematic support for giving greater priority to identified than to statistical lives.

Our analysis meets a well-known conceptual issue, “Broome’s paradox.”⁵ Consider a project that is anticipated to kill one person from a population of similar individuals (e.g., the project may put construction workers at risk). It may be that if the identity of the one who would die was unknown the project would pass a net-benefit test and be adopted. Yet if this person’s identity was known he might require infinite compensation for the loss of his life and the project would fail the net-benefit test and be rejected. This is a paradox in the sense that the only difference between the two situations is knowing the identity of the person who will die,

⁴ Another critical source of individual heterogeneity is wealth. The effect of wealth heterogeneity is beyond the scope of this paper. We concentrate on the issue announced in the title, which motivates the focus on risk heterogeneity.

⁵ Broome’s (1978) provocative paper raises a number of issues for BCA. Many of these issues are addressed in a set of critical papers (Buchanan and Faith, 1979; Jones-Lee, 1979; Williams, 1979). On the issue of interest to this paper, Ulph (1982) suggests that Broome’s paradox arises due to an inappropriate social welfare function, i.e., a utilitarian framework. Our discussion differs from Ulph’s since we work within a utilitarian framework.

and this it may be argued (Broome, 1978) should not ultimately affect the social decision rule.⁶ Broome's paradox is a useful starting point for our analysis.

The remainder of the paper is organized as follows. In Section 2, we present a simple example based on Broome's paradox which highlights the effect of information about heterogeneity of policy-induced changes in mortality risk on BCA. In Section 3, we review the standard model of value per statistical life. Using that model, we examine in Section 4 how information about heterogeneity of policy-induced changes in mortality risk affects each of the four measures of economic valuation: compensating and equivalent variations for reductions and increases in mortality risk. In Section 5, we examine the effects of information about heterogeneity in baseline risk. We show in Section 6 that altruism (concern for others' well-being) does not in general justify a special concern with identified lives. In Section 7, we conclude with a discussion of policy implications and of other factors that may help to explain the special concern with identified lives observed in public decisions.

2. A Paradox of Benefit-Cost Analysis?

We begin with a simple example that illustrates how the outcome of a BCA depends on information about heterogeneity of a policy-induced change in risk. Consider an economy with two people, H and L. Each has initial wealth w and probability p of surviving the single period we consider. Each is risk-neutral in wealth and has no bequest motive. Hence each individual has expected utility (EU)

$$EU = pw. \quad (1)$$

Consider a project that will impose mortality risk on both people. The average incremental mortality risk is e . The monetary benefit of the project to each person is s .

If people do not know their individual incremental risks (or if the incremental risks are identical) then each has expected utility

$$EU/\text{no info} = (p - e)(w + s). \quad (2)$$

Defining social welfare as the sum of the two individuals' expected utilities, average social welfare is given by eqn. (2). Moreover, if the two individuals face different incremental risks but the total risk in the economy is fixed (i.e., the expected number of lives lost is fixed) then eqn. (2) also describes per-capita social welfare.

Now consider the effect of information about individual risks. For simplicity, assume H (high) faces incremental risk $2e$ and L (low) faces no incremental risk. Average social welfare given information is

$$EU/\text{info} = 0.5(p - 2e)(w + s) + 0.5p(w + s) = (p - e)(w + s). \quad (3)$$

⁶ Broome (1978) presents another version of the paradox based on the timing of decisions that we sum up as follows: Suppose information about who will die is not available today but will be available tomorrow. If the project is up for consideration today, it may be acceptable, but tomorrow it will be deemed unacceptable by an infinite margin. Thus re-evaluating the project one day later would lead to rejecting it as "infinitely wrong." Cf. Heinzerling (2000) who argues that the evaluation of projects that affect mortality risks should not depend on whether the lives at risk are identifiable.

Social welfare with information is the same as in the no-information case. In this example, information about individual changes in risk does not affect social welfare, as Broome (1978) suggests. Moreover, observe that the project will enhance social welfare if and only if

$$(p - e)(w + s) > pw. \quad (4)$$

Now examine how BCA would handle the situation. BCA involves comparing the monetary values of social benefits and costs. The per-capita benefit is s . The costs are the total compensation required to induce the people to accept the mortality risks. The compensating variation to accept a risk x , $C(x)$, is defined by⁷

$$(p - x)[w + C(x)] = pw \quad (5)$$

which implies

$$C(x) = xw/(p - x). \quad (6)$$

In the case without information about individual risks, the per-capita cost is

$$C/\text{no info} = ew/(p - e). \quad (7)$$

With information about individual risks the per-capita cost is

$$C/\text{info} = 0.5[2ew/(p - 2e)] + 0.5[0] = ew/(p - 2e). \quad (8)$$

Since $C/\text{info} > C/\text{no info}$, the decision recommended by BCA may depend on whether or not the individual risks are known.⁸ Specifically, if

$$C/\text{no info} < s < C/\text{info}, \text{ i.e., } ew/(p - e) < s < ew/(p - 2e), \quad (9)$$

then BCA will suggest the project should proceed if there is no information about individual risks but should be rejected if individual risks are known.

Another approach to BCA is to ask if there is any lump-sum transfer y such that the project with transfer is Pareto superior to rejection of the project. In the present case with information, the question is whether there is an amount y that could be transferred from L to H such that H prefers to adopt the project, i.e.,

$$(p - 2e)(w + s + y) > pw, \quad (10)$$

and L prefers to adopt the project, i.e.,

$$p(w + s - y) > pw. \quad (11)$$

⁷ Alternatively, we could consider terminal wealth with the project, $w + s$, and obtain net compensating variation, $C(x) - s$.

⁸ Eqn. (7) demonstrates that the required compensation could be infinite for $e = p$, as Broome (1978) suggests. The example will show that this extreme case is not required to induce the type of paradox proposed by Broome.

Eqn. (11) implies that $y < s$, i.e., L cannot provide compensation greater than s if he is to prefer the project with transfer to its absence. So the maximum expected utility of H cannot exceed that obtained when $y = s$. It is clear that eqn. (10) may not be satisfied since the survival probability $(p - 2e)$ can be arbitrarily close (or even equal) to zero and so with finite s the inequality is violated.⁹

How is it possible that information about individual risk has no effect on social welfare but may change the adoption rule of the project? The BCA criterion aggregates welfare gains and losses across people in monetary terms. The relationship between survival probability and the monetary value of utility increments can be highly non-linear. In our example, as survival probability approaches zero the monetary value of a unit of utility approaches infinity. In contrast, the expected-utility criterion adds increments of expected utility that are linear in probability. Measuring in utility units, changes in individual risk (holding population risk constant) and information about individual risk have no effect on social welfare. Measuring in monetary units, information may have a large effect since the monetary value of the harm increases more rapidly for the person whose risk is increased than it decreases for the person whose risk is decreased (i.e., the indifference curve for wealth and risk and the compensation function for risk are both convex, as will be shown below).

This example illustrates a well-known point: adding compensation is not the same as adding utility.¹⁰ If one wants to use monetary compensation as an accurate proxy for adding utility, one needs to adjust compensation for differences in the marginal utility of consumption between people. It is well-known that adding unweighted compensation is valid in a first-best economy in which a social planner is able to implement lump-sum transfers to equalize marginal utility of consumption across people (Samuelson, 1954). But it is also well-known that implementing optimal lump-sum transfers, or weighting compensation by the inverse of the marginal utility of consumption, confronts the problem of non-observability of utility which BCA avoids by seeking to determine only whether a proposed change is a potential Pareto improvement (i.e., satisfies a Kaldor-Hicks compensation test).

The logical point conveyed by the example is that without information individuals are identical and there is no need to weight their compensation for any difference in marginal utilities. In this case, the unweighted sum of compensation is a correct indicator of social welfare. This is not true with information about differences in individual risks. Indeed, with information the situation is asymmetrical and marginal utilities may differ between

⁹ Note that if one wants to maximize social welfare (SW), defined as the sum of the two individuals' expected utilities, it is optimal to transfer all the benefits of the project to the person with higher survival probability. That is, the maximum of $SW = (p - 2e)(w + s + y) + p(w + s - y)$ is obtained for $y = -s$. Since there is assumed to be no bequest motive, any wealth given to a person who dies contributes no well-being to the society. This shows that SW can be made higher under information about individual risks than under no information. In contrast, BCA can lead to the recommendation to adopt the welfare-enhancing project only in the no-information case. This example also suggests that information may have a negative value for the society. Suppose the condition in eqn. (9) holds. Then if society evaluates the project using BCA, information would lead it to reject the project. Without information, the project would be accepted and SW would increase.

¹⁰ See, e.g., Blackorby and Donaldson (1990), Johansson (1998), and in the context of mortality risk, Armantier and Treich (2004). Linerooth (1982) suggests that the higher VSL of individuals facing larger mortality risk is not sufficient justification for disproportionately allocating public resources to protect them. Although the private opportunity cost of spending is low for such individuals (by the dead-anyway effect described in Section 3), the social opportunity cost is not. Pratt and Zeckhauser (1996) propose adjusting empirical estimates of VSL to account for differences between private and social marginal utilities of wealth associated with heterogeneity of total mortality risk.

individuals. Hence, whether lives are statistical or identified may matter for economic valuation. In the remainder of the paper, we study the effects of individual-specific information about risks on the outcome of BCA, i.e., on the sum of unweighted individual compensation.

3. The Value-per-Statistical-Life Model

In the standard single-period value-of-statistical-life (VSL) model, the individual maximizes his (state-dependent) expected indirect utility given by

$$V = pu(w) + (1-p)v(w) \quad (12)$$

where p is the probability of surviving the period, $u(\cdot)$ is the utility of wealth if he survives the period, and $v(\cdot)$ is the utility of wealth if he dies (e.g., the utility of a bequest). This model was introduced by Drèze (1962) and Jones-Lee (1974) and has been commonly used in the VSL literature (e.g., Hammitt, 2000; Viscusi and Aldy, 2003).

We adopt the standard assumptions that:

$$u \text{ and } v \text{ are twice differentiable with } u > v, u' > v' \geq 0, u'' \leq 0 \text{ and } v'' \leq 0. \quad (13)$$

That is, state-dependent utilities are increasing and weakly concave. At any wealth level both utility and marginal utility are larger if alive than dead. Under the standard assumptions (13), indifference curves over (w, p) are decreasing and strictly convex as illustrated in Figure 1.

VSL is the marginal rate of substitution between wealth and survival probability, i.e., (the negative of) the slope of the indifference curve at (w, p) . It is defined by

$$\text{VSL} = -\frac{dw}{dp} = \frac{u(w) - v(w)}{pu'(w) + (1-p)v'(w)} > 0. \quad (14)$$

VSL may vary across individuals since it depends on w , p , and on the shape of the utility function through u and v . Since VSL is a marginal rate of substitution it does not capture heterogeneity in the risk change. VSL provides a good approximation to an individual's monetary compensation for a given change in risk only when the change dp is sufficiently small. At the population level average VSL provides a good approximation to the social value of a change in population risk if all risk changes in the population are small. A formally equivalent situation is that of a few individuals facing a large change in risk when these individuals are anonymous (to themselves and to others).¹¹

¹¹ It is important to acknowledge that identifiability may impair rational decision-making when the threat of death is present. This is recognized by Schelling (1968): "*The avoidance of a particular death – the death of a named individual – cannot be treated straightforwardly as a consumer choice. It involves anxiety and sentiment, guilt and awe, responsibility and religion. If the individuals are identified, there are many of us who cannot even answer whether one should die that two may live.*" In the following, we abstract from this issue that may play an important role for practical BCA, e.g. for the elicitation of individual WTP in surveys. Observe however that opposite arguments may be used with statistical lives due to the small probabilities involved, like the insensitivity of WTP to probabilities (Hammitt and Graham, 1999).

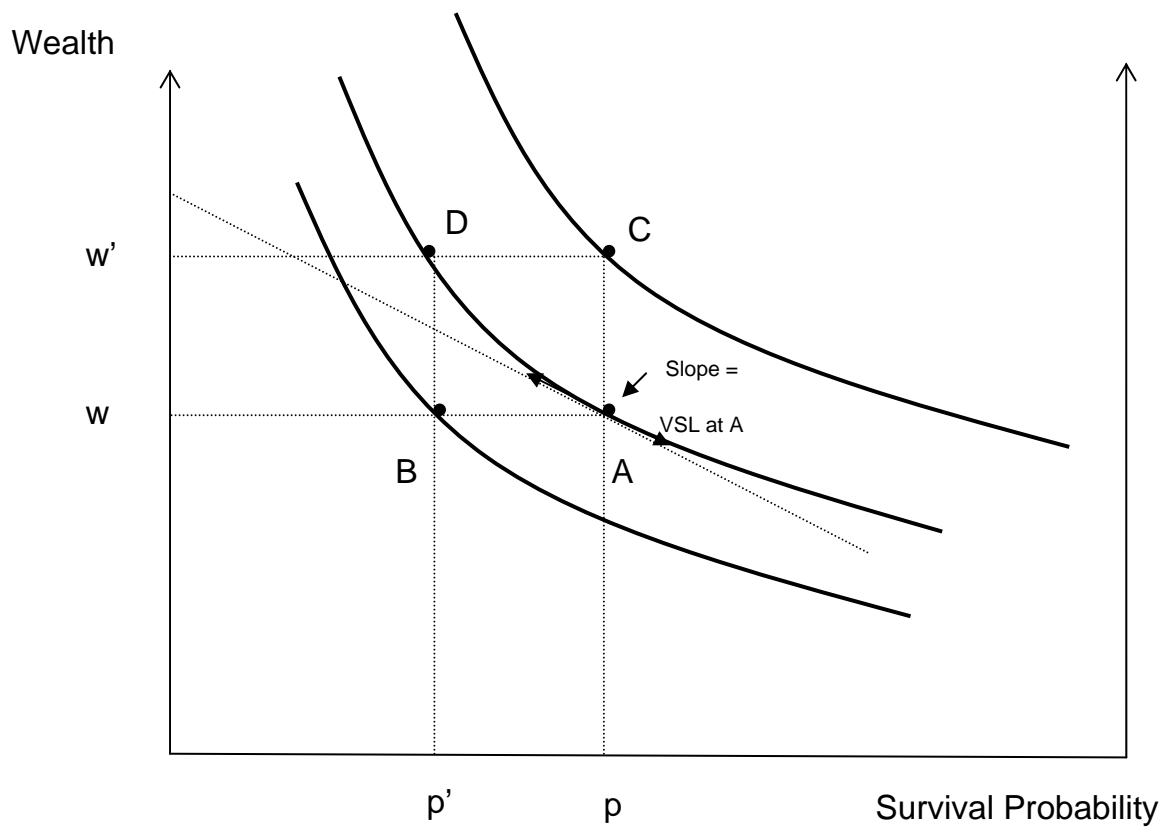


Figure 1: Indifference curves, VSL, the dead-anyway and the wealth effect.

The expression for VSL in eqn. (14) is useful for identifying two effects that will be important for our analysis. First, the dead-anyway effect (Pratt and Zechauser, 1996) describes how VSL increases with risk, i.e., decreases with survival probability p ($\partial \text{VSL} / \partial p < 0$). In Figure 1, the indifference curve is steeper at B than at A. Intuitively, an individual facing a large total probability of death has little incentive to limit his spending on risk reduction since he is unlikely to survive and have other opportunities for consumption.¹² In eqn. (14) the value of the numerator is independent of p and a decrease in p reduces the value of the denominator (since $u' > v'$). Second, the wealth effect describes how VSL increases with wealth w , i.e., $\partial \text{VSL} / \partial w > 0$ and the indifference curve in Figure 1 is steeper at C than at A. The intuition for the wealth effect is two-fold. First, wealthier people have more to lose if they die (i.e., the numerator in eqn. (14) increases with w because $u' > v'$). Second, the utility cost of spending is smaller (or no larger) due to weakly diminishing marginal utility (risk aversion) with respect to wealth (i.e., the denominator in eqn. (14) does not increase because $u'' \leq 0$ and $v'' \leq 0$). As a consequence, VSL increases as one moves upward and leftward along an indifference curve and the indifference curves are convex. In Figure 1, VSL at D is greater than VSL at A because of both the dead-anyway and the wealth effects.

4. Information about Heterogeneous Changes in Risk

The example in Section 2 showed that information about risk heterogeneity can matter if the policy decision is based on BCA. The strength of this effect depends on the non-linearity of the compensation function $C(x) = xw/(p-x)$ (eqn. (6)). The crucial property is the convexity of this function, which we now demonstrate.

Consider two individual-specific risk increments, x_1 and x_2 . In the absence of information about individual-specific risk, each individual faces an expected risk increment of $\bar{x} = 0.5x_1 + 0.5x_2$ and requires compensation $C(\bar{x})$ (see Figure 2). Under perfect information, each knows his specific incremental risk and average compensation is $0.5C(x_1) + 0.5C(x_2)$. Information increases average compensation iff $0.5C(x_1) + 0.5C(x_2) \geq C(\bar{x})$, i.e., when $C(x)$ is convex. Clearly, convexity of the compensation function is a necessary and sufficient condition for information about individual-specific risks to increase average compensation for any distribution of individual-specific risks in the economy (holding average risk fixed). Moreover, convexity of the indifference curves over (w, p) implies that $C(x)$ is convex.

Analyzing the convexity of C is equivalent to comparing the compensation required for successive risk increments. Compare the compensation required for an incremental risk increase of x to the compensation required for a second equal increment x once the first has been made. Convexity implies that compensation for the second increment is larger than for the first. There are two differences in the compensation for the second unit compared with the first: i) survival probability is lower, $p-x$ compared with p ; and ii) wealth is higher, $w + C(x)$ compared with w . The first difference increases compensation through the dead-anyway effect and the second increases compensation through the wealth effect.

¹² For the same reason, he also has little incentive to limit his expenditures on other goods.

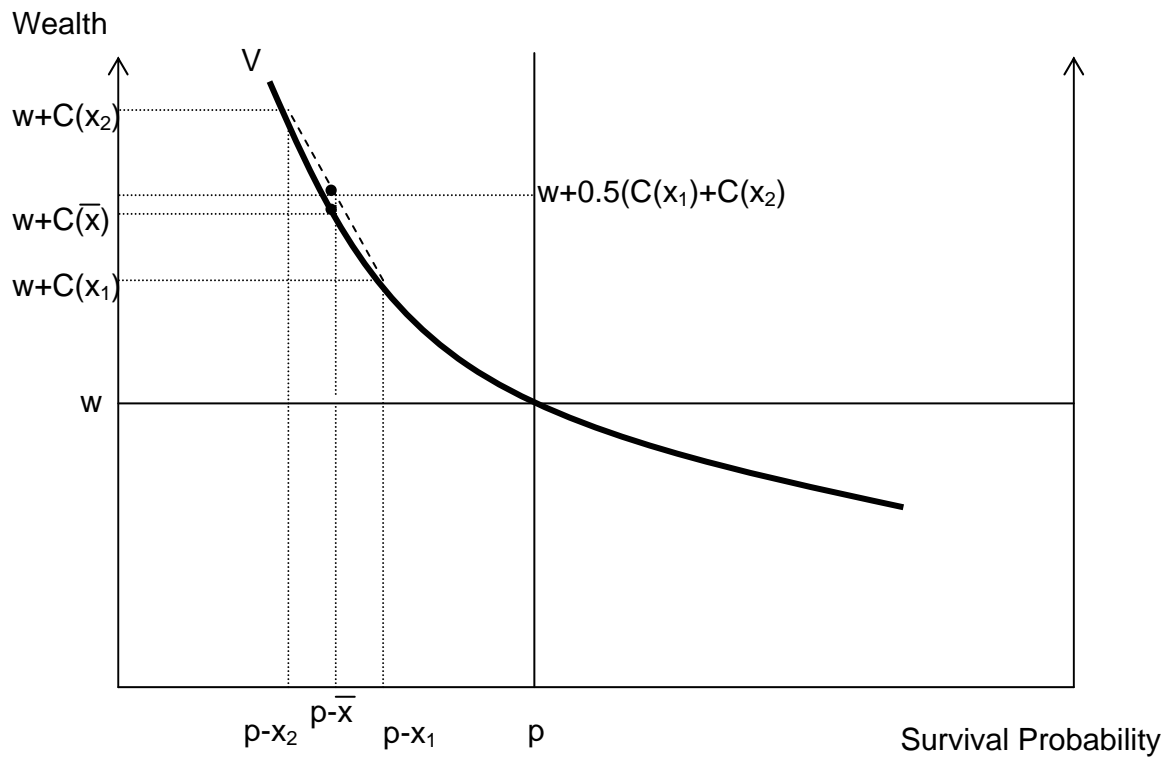


Figure 2: Individual-specific information about risk change increases the average WTA.

In the remainder of this section we use the standard VSL model (14) to study how information affects the valuation of changes in risk. As we have just seen, this amounts to studying the convexity of the compensation functions for changes in risk. We consider the valuation of both increases and decreases in risk, using both WTA and WTP. We find that the conclusions differ in each of the four cases.

4.1 WTA for implementing a risk-increasing project

Generalizing the introductory example, we first consider WTA for a risk-increasing project. Let $C(x)$ be the WTA (compensating variation) defined by

$$(p-x)u(w+C(x))+(1-p+x)v(w+C(x))=pu(w)+(1-p)v(w) \quad (15)$$

with $0 \leq x \leq p$. Differentiating with respect to x gives

$$C'(x) = \frac{u(w+C(x)) - v(w+C(x))}{(p-x)u'(w+C(x)) + (1-p+x)v'(w+C(x))} > 0. \quad (16)$$

Differentiating once again with respect to x gives, under our assumptions on u and v , $C'' > 0$. As noted above, the convexity of C is immediate from the convexity of the indifference curve. Indeed, we have $C(\bar{x}) < 0.5[C(x_1) + C(x_2)]$ (see Figures 2 and 3). Since WTA is convex in risk increments it increases with information about individual risk changes. This is due to the dead-anyway effect and the wealth effect, both of which are positive in this case, as shown above.

This case shows that information about individual risk changes increases the cost of the risk-increasing project and induces a bias in favor of the status quo. With more information, a project that would have been accepted may be rejected, preventing an increase in mortality risks in the economy. This is the case illustrated by Broome's (1978) paradox.

4.2 WTP for implementing a risk-decreasing project

Let $P(x)$ be the WTP (compensating variation) for implementing a risk-decreasing project defined by

$$(p+x)u(w-P(x))+(1-p-x)v(w-P(x))=pu(w)+(1-p)v(w) \quad (17)$$

with $0 \leq x \leq 1-p$. Differentiating with respect to x gives

$$P'(x) = \frac{u(w-P(x)) - v(w-P(x))}{(p+x)u'(w-P(x)) + (1-p-x)v'(w-P(x))} > 0. \quad (18)$$

Differentiating once again with respect to x gives $P'' < 0$. Observe from Figure 3 that this result is immediate from the convexity of the indifference curve, i.e., $P(\bar{x}) > 0.5[P(x_1) + P(x_2)]$. WTP is concave in risk reductions and thus decreases with information about individual risk changes. Note that both the dead-anyway and wealth effects are negative in this case.

This case shows that more information decreases the benefit of the risk-decreasing project and, like the previous case, induces a bias in favor of the status quo. More information may lead to rejecting a project that would have been accepted, forgoing an opportunity to reduce mortality risks in the economy.

Combining the results for the WTP and the WTA cases indicates that a project that would induce an increase in risk for some persons and a decrease for others is less likely to be adopted with more information about risk heterogeneity.¹³

4.3 WTA for not implementing a risk-decreasing project

Let $C_n(x)$ be the WTA (equivalent variation) for forgoing a risk-decreasing project defined by

$$pu(w + C_n(x)) + (1 - p)v(w + C_n(x)) = (p + x)u(w) + (1 - p - x)v(w) \quad (19)$$

with $0 \leq x \leq 1 - p$. Differentiating with respect to x gives

$$C_n'(x) = \frac{u(w) - v(w)}{pu'(w + C_n(x)) + (1 - p)v'(w + C_n(x))} > 0. \quad (20)$$

Differentiating once again with respect to x gives

$$C_n''(x) = -\frac{(C_n'(x))^2 [pu''(w + C_n(x)) + (1 - p)v''(w + C_n(x))]}{pu'(w + C_n(x)) + (1 - p)v'(w + C_n(x))}. \quad (21)$$

Under our assumptions on u and v , $C_n'' \geq 0$. WTA is convex and thus increases with information. In Figure 3, $C_n(\bar{x}) \leq 0.5[C_n(x_1) + C_n(x_2)]$. Observe that under risk neutrality (i.e., $u'' = v'' = 0$), C_n is linear and there is no effect of information. Under strict risk aversion (i.e., $u'' < 0$ and $v'' < 0$), the dead-anyway effect is negative and the wealth effect is positive, suggesting that the latter effect dominates. Note that it is not possible *a priori* to determine the convexity of C_n from Figure 3.

This case shows that more information increases the benefit of the risk-decreasing project and induces a bias in favor of the status quo (implementing the project). In this case, more information may lead to adopting a project that would have been rejected, reducing mortality risks in the economy.

4.4 WTP for not implementing a risk-increasing project

Let $P_n(x)$ be the WTP (equivalent variation) to prevent implementing a risk-increasing project defined by

¹³ Note that the results rely only on the convexity of the indifference curves and that the conditions exhibited in (13) are sufficient, but not necessary, for this convexity property to hold. This suggests broader applications of the results than to pure mortality risks.

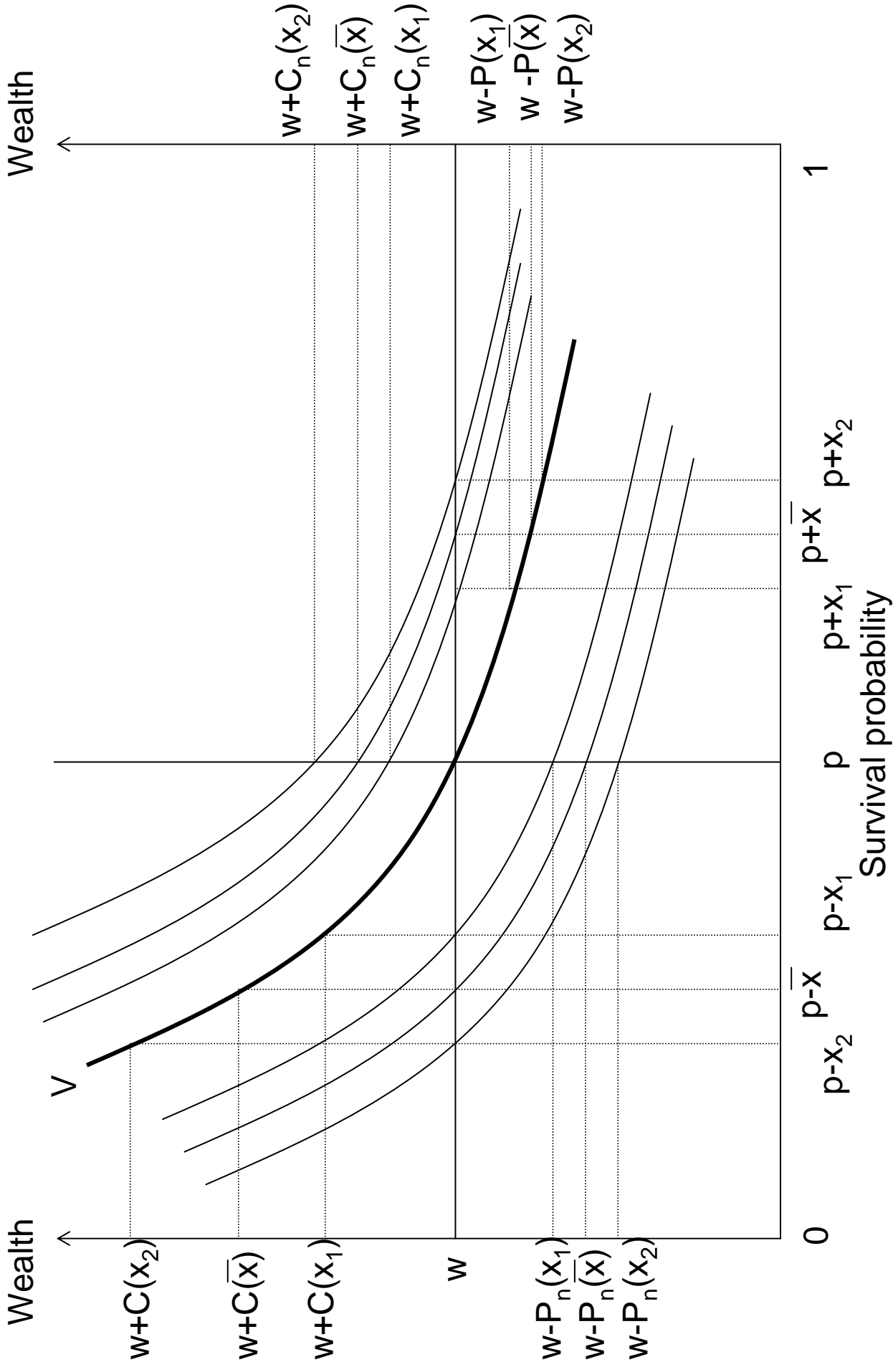


Figure 3: Four measures of value of risk change.

$$pu(w - P_n(x)) + (1 - p)v(w - P_n(x)) = (p - x)u(w) + (1 - p + x)v(w) \quad (22)$$

with $0 \leq x \leq p$. Differentiating with respect to x gives

$$P_n'(x) = \frac{u(w) - v(w)}{pu'(w - P_n(x)) + (1 - p)v'(w - P_n(x))} > 0. \quad (23)$$

Differentiating once again with respect to x gives

$$P_n''(x) = \frac{(P_n'(x))^2 [pu''(w - P_n(x)) + (1 - p)v''(w - P_n(x))]}{pu'(w - P_n(x)) + (1 - p)v'(w - P_n(x))}. \quad (24)$$

Under our assumptions on u and v , $P_n'' \leq 0$. WTP is concave and decreases with information. In Figure 3, $P_n(\bar{x}) \geq 0.5[P_n(x_1) + P_n(x_2)]$. Note that, as for the previous case, there is no effect under risk neutrality and under strict risk aversion the wealth effect (which is negative) dominates the dead-anyway effect (which is positive). Note again that it is not possible *a priori* to infer the sign of the second derivative of P_n from Figure 3.

This case shows that more information decreases the cost of the risk-increasing project and induces a bias in favor of the status quo (implementing the policy). More information may lead to adopting a project that would have been rejected and thus increase mortality risks in the economy.

5. Information about Heterogeneous Baseline Risks

In Section 4 the initial risk is common across individuals although the risk changes can differ. In this section we consider how information about heterogeneity of baseline risk can affect valuation. We begin with a problem first analyzed by Pratt and Zeckhauser (1996) on the concentration of risk in a community, in which the baseline risk and risk change are perfectly correlated in the population. We then consider a simpler problem in which baseline risk is heterogeneous but the policy-induced risk change is common across the population. We restrict our analysis to compensating variation (WTP for a risk reduction, WTA for a risk increase) and find that the effect of information is generally ambiguous when individuals are risk averse.

5.1 Heterogeneity in both change and baseline risk

Suppose there are N people in the economy each with initial wealth w . Only $R \leq N$ people are at risk and of these R people $d \leq R$ will die. None of the $N - R$ others will die. A reduction in R may be interpreted as both a change in the concentration of risk in the population and as a change in individual-specific information in the economy.

We return to the simplest possible assumptions as in our initial example, i.e., $u(z) = z$ and $v(z) = 0$, which we loosely describe as the risk-neutral case. Social welfare in this economy equals

$$SW = (N - R)w + R \frac{R - d}{R} w = (N - d)w. \quad (25)$$

Observe that social welfare is independent of R . Suppose that a risk-reducing project will save n lives ($n \leq d$) for a given per-capita cost F . The net effect of the project on social welfare is also independent of R .

Let us now look at how BCA would handle the situation. Let $P(R)$ be the WTP (compensating variation) for the project of each of the R people who benefit, defined by

$$\frac{R - d + n}{R} [w - P(R)] = \frac{R - d}{R} w, \quad (26)$$

which yields

$$P(R) = \frac{n}{R - d + n} w. \quad (27)$$

Both individual WTP $P(R)$ and total benefits $RP(R)$ are decreasing in R . Information about risk heterogeneity affects the outcome of BCA but not social welfare.

Note the direction of the bias: the monetary value of the benefit of the project is larger when the number of people who are identified as at risk is smaller, i.e., a “benefit-concentration” effect. This result is opposite the one obtained in Section 4.2 where aggregate WTP decreases with information about individual risk reductions. Here information about which people face larger risk reductions increases aggregate WTP. Better information about individual-specific risks may lead to adopting a project that would otherwise be rejected, decreasing mortality risk in the economy.

Alternatively, we can evaluate WTA (compensating variation) for a risk-increasing project. Suppose that a risk-increasing project will kill r people in this economy ($r \leq R - d$) for some social benefit. Let $C(R)$ be defined by

$$\frac{R - d - r}{R} [w + C(R)] = \frac{R - d}{R} w \quad (28)$$

which gives

$$C(R) = \frac{r}{R - d - r} w. \quad (29)$$

Individual WTA denoted $C(R)$ decreases with R as does the total social cost $RC(R)$. In this case, better information as to which people face additional risk increases aggregate WTA. Better information may lead to rejecting a project that would otherwise be accepted, preventing an increase in mortality risk as in Broome’s (1978) paradox.

To summarize, under risk neutrality with respect to wealth, more information about the concentration of risk and risk change can lead to lower mortality risks in the economy. This can occur through either of two pathways: adopting risk-reducing projects that would be

rejected and rejecting risk-increasing projects that would be adopted with poorer information about the concentration of risks and benefits.

What is the effect of a change in R in a model with risk aversion? Consider the following example. Take the utility function

$$u(z) = \sqrt{z} \text{ and } v(z) = 0 \quad (30)$$

together with the following set of parameter values: $w = 1$, $d = 50$, and $n = 20$. It is straightforward to obtain

$$P(R) = w \left[1 - \left(\frac{R-d}{R-d+n} \right)^2 \right] = \frac{40(R-40)}{(R-30)^2} \quad (31)$$

so that $RP(R)$ is increasing over $R \in [50, 60]$ and decreasing over $R > 60$. In this case information about how many people are at risk has an ambiguous effect on aggregate WTP.

The non-monotonicity of $RP(R)$ emphasizes the presence of two effects: when R decreases fewer people will pay but each is willing to pay more. This example proves that is not possible *a priori* to determine which effect dominates under risk-averse preferences, as previously shown by Pratt and Zeckhauser (1996: 753).

5.2 Heterogeneity in baseline risk

The previous results suggest that the effect of information about the concentration of risk in an economy is more difficult to sign than the effect of information about differences in risk changes from a common baseline analyzed in Section 4. This can be easily understood. In the case of information about which people are at risk there are not one but two sources of individual-specific risks: risk over the baseline probability and risk over the change in probability. In the cases considered in Section 5.1, these risks are perfectly positively correlated.

We next consider the simpler problem of analyzing only the effect of information about heterogeneous baseline risks. Assume that people have different survival probabilities p but the risk reduction x is the same for everyone. We can show that information about baseline risks has an ambiguous effect in this case as well. Take the same risk-averse utility function as in (30). Compute WTP to reduce risk by x (now denoted $P(p)$) as in eqn. (17) to obtain

$$P(p) = \frac{wx(2p+x)}{(p+x)^2}. \quad (32)$$

From Section 4.2 it is easy to understand that the convexity of $P(p)$ in p determines the effect of information about baseline probability on aggregate WTP. Yet from eqn. (32) the sign of this effect is ambiguous as the sign of $P''(p)$ depends on the sign of $p - x/2$. Consequently the effect of more information about heterogeneous baseline risk depends on the values of p and x . Again, it is easy to see that this ambiguity disappears under risk-neutrality, in the sense that more information about baseline probabilities increases aggregate WTP and aggregate WTA for all values of p, x and w .

In contrast to the effects of information about heterogeneity of risk reduction analyzed in Section 4, this section shows that the effects of information about heterogeneity in baseline risk on the value of risk changes are in general ambiguous. This ambiguity results when differences in risk changes are perfectly correlated with differences in baseline risk and also when the risk changes are common across individuals (equivalently, when there is no information about heterogeneity of risk changes). An exception occurs for the case of risk neutrality with respect to wealth where information about either risk concentration or heterogeneous baseline risks increases both aggregate WTP for a risk-reducing program and aggregate WTA for a risk-increasing program.

6. Altruism and the Identifiable Victim Effect

In this section, we briefly discuss the effect of altruism. Concern for others' well being is an important and natural concern in the matter of saving lives. Moreover, it is widely believed that there is an "identifiable victim effect": people are willing to pay more to save the lives of others when these lives are easily identifiable than when they are statistical (see, e.g., Jenni and Loewenstein, 1997; Heinzerling, 2000; Small and Loewenstein, 2003). Typically, there is an empathic response to rescuing identified people (or animals) in precarious circumstances. There is little hope of capturing all the channels underlying such empathic responses in a simple economic model (recall the quote from Schelling (1968) in footnote 10). In any case, our previous model did not have a chance to do so since there was no consideration of altruism.¹⁴

We consider only the case of pure altruism.¹⁵ It has been shown that pure altruism may be ignored in BCA. The sum of private compensating variations is indeed an adequate estimate of the benefits of the project in the sense that if this sum exceeds the sum of the private costs of the project, then the project is a potential Pareto improvement for altruistic people. This point was first stressed by Bergstrom (1982), elaborated by Jones-Lee (1992), and generalized by Bergstrom (2006). The argument is simple. A pure altruist benefits when the project reduces another person's risk but is harmed when the project imposes costs on the other person. The sign of one person's altruistic valuation for another is the same as the sign of the net private benefits to the other and so pure altruism cannot alter the sign of the social net benefits.

The implication of this observation is that pure altruism should not affect the valuation of lives in BCA, no matter how much information is available about risk heterogeneity, and hence the identifiable victim effect should be ignored.

7. Policy Implications

A standard economic result is that public projects with positive expected value should be adopted (Arrow and Lind, 1970). This conclusion assumes an economy with either complete markets or a large number of individuals who can share risks. In this economy, the sum of individual compensating variations for a project is consistent with the maximization of social

¹⁴ In model (12), a natural interpretation of the utility function $v(\cdot)$ is as a bequest function. This may be viewed as a form of altruism, e.g., toward one's children. But this is not the form of altruism that is important here. We study altruistic preferences over other people's mortality risks.

¹⁵ See Jones-Lee (1992) for an analysis of the implications of both pure (i.e., benevolent, non-paternalistic) and paternalistic altruism (e.g., safety-focused altruism) for the valuation of life.

welfare, with or without information on the distribution of the project's effects among individuals, because complete markets for risk-sharing yield an efficient outcome at which individuals equate their marginal utilities. When risk-sharing opportunities are limited, the rule of acceptance for public projects is less clear and the adequacy of BCA as a method for identifying gains in social welfare is not guaranteed.

An important case of limited risk-sharing is when a bad outcome decreases marginal utility, a property of the standard state-dependent model for valuing mortality risk described in expressions (12) and (13). In this case, it may be that some individuals could never be compensated for their loss, as suggested by Broome (1978). Marginal utilities may differ among people and BCA may not be a correct indicator of social welfare. Individual-specific information about mortality risks – whether lives are statistical or identified – may affect the result of BCA.

We have studied some theoretical determinants of this difference. Let us summarize some results:

1. The effects of information about interpersonal differences in the risk change due to a project depend on whether one evaluates the project using WTP or WTA measures.
 - a. WTA, whether compensating variation for a risk increase (Section 4.1) or equivalent variation to forgo a risk decrease (Section 4.3), is larger with more information about heterogeneity of the risk change. Information about how the project affects individuals' risks may lead to rejecting a risk-increasing project that would have been accepted (as in Broome's paradox) or accepting a risk-decreasing project that would have been rejected with less information. In both cases, information about heterogeneity leads toward lower aggregate risk in the economy.
 - b. WTP, whether compensating variation for a risk decrease (Section 4.2) or equivalent variation to prevent a risk increase (Section 4.4), is smaller with more information about heterogeneity of the risk change. Information about how the project affects individuals' risks may lead to rejecting a risk-decreasing project that would have been accepted and accepting a risk-increasing project that would have been rejected with less information. In both cases, information about heterogeneity leads toward higher aggregate risk in the economy.
 - c. As a corollary, there is no necessary relationship between the extent to which risk changes are statistical or identifiable and the degree of protection endorsed by BCA.
2. When baseline risks are heterogeneous the effect of information on BCA is in general ambiguous. When individuals are risk neutral with respect to wealth more information about baseline risk can lead to increases in both types of compensating variation, i.e., WTP for a risk-decreasing policy and WTA for a risk-increasing policy, and can therefore lead to more protective decisions, yielding smaller aggregate risk.
3. BCA does not explain the identifiable victim effect, even with pure altruism. This is a consequence of a more general result that pure altruism need not be considered in BCA (Bergstrom, 2006).

It is interesting to compare BCA with cost-effectiveness analysis (CEA). In CEA, changes in health risk are often evaluated by the expected change in quality-adjusted life years (QALYs)

in the economy.¹⁶ Evaluation of the effects of a program on mortality risk is unaffected by whether lives are statistical or identified or by information about heterogeneity of baseline risks or risk changes (holding constant population risk and risk change as measured by aggregate expected QALYs). This result is immediate since the expected change in QALYs is linear in the probabilities. Hence if individuals' preferences for survival are consistent with QALYs, CEA may be consistent with social welfare maximization (Hammit, 2002).¹⁷ This observation supports Adler's (2006) argument that QALYs may be a better measure than WTP of social welfare under certain circumstances, here when risks are strongly heterogeneous. Hadorn (1996) reports that the insensitivity of the QALY approach to heterogeneity was criticized in the famous Oregon priority-setting exercise. The approach was perceived as yielding an ordering that undermined treatments for people facing life-threatening conditions, thus violating a preference for giving priority to identified victims.¹⁸

Overall, neither BCA nor CEA provide general support for prioritizing identified over anonymous people in life-saving policies. Political factors are, however, natural candidates to explain such a prioritization.

7.1 Political factors

We discuss four political factors that may explain why statistical and identified lives are treated differently: responsibility, empathy, lobbying, and demagoguery.¹⁹

First, it is important to recognize that persons with authority for safety decisions may have a responsibility to help identified people. In particular, there may be a legal responsibility.²⁰ By definition, the death of an *ex post* identified victim will be known and blame may be easily attributed to decision makers whereas the deaths of *ex post* anonymous individuals may go unnoticed or be more difficult to attribute to particular decisions (Raiffa et al., 1977). Risk managers routinely set limits on the risks to which individuals may be exposed, often focusing on absolute risk levels (e.g., safety norms or standards). This practice may lead to protecting only highly exposed individuals and thus toward *ex ante* identifiable individuals. Notice that *ex ante* identification need not be restricted to those exposed to high risk. Providing greater

¹⁶ A QALY represents a year of life adjusted by an index of quality of life or health (Gold et al., 1996; see Zeckhauser and Shepard (1976), Broome (1993), and Hammit (2002) for economic discussions). Simpler forms of CEA evaluate changes in mortality risk by the expected number of lives or life years saved. The US Office of Management and Budget (2003) requires federal agencies to evaluate major regulations using CEA as well as BCA and an Institute of Medicine panel recommended that QALYs be used as the measure of effectiveness in this context (Miller et al., 2006).

¹⁷ Empirical evidence suggests that QALYs are not consistent with individual preferences. See, e.g., Pliskin et al. (1980), McNeil et al. (1981), and Bleichrodt and Johannesson (1994).

¹⁸ Richardson and McKie (2003) give as an example that “*dental caps for pulp or near pulp exposure were assigned a higher priority than surgical treatment for ectopic pregnancy.*” Miller et al. (2006) evaluate the implications of QALYs for allocating risk reduction in a population.

¹⁹ Fernandez and Rodrik (1991) show that individual-specific uncertainty may change the identity of the median voter and hence the projects that will be selected by majority vote. We do not address how this effect might be influenced by information about heterogeneity of risk.

²⁰ Richardson and McKie (2003), quoting Fried (1969: 1418), indicate that the director of a mining company refusing to spend money to save a trapped man may be civilly and criminally liable even if she has invested large sums of money to prevent such a catastrophe. Similar legal responsibilities may exist in hospitals, e.g., to care for terminally ill patients.

protection to members of a minority or low-income group is a way to compensate them for other disadvantages,²¹ consistent with environmental justice (Tietenberg, 1996).

Second, decision makers may believe they have a special duty to help identified groups. Almost by definition, identified persons will be more salient to a decision maker who must target a specific policy objective. Empathy and vividness may also contribute. In contrast, decision makers may not appreciate that preoccupation with identified lives may contribute to “statistical murder.” They may prefer to base their policies on intuitive or emotional criteria rather than on BCA or CEA. They may be more willing to endorse perceived humane and caring policies and less willing to adopt policies that they perceive as unfair or unethical toward particular groups. This posture may be part of their education or their political agenda.

Third, one may view society as composed of different groups of people, or lobbies, sharing common interests. Participants in small lobbies may have more intense interests and free riding may be less pronounced, yielding disproportionate political influence (Olson, 1971). A policy that favors concentrated interests may be more likely to be adopted than a policy that profits the mass but adversely affects a few. Similarly, the existence of a group that is particularly visible, e.g., through media exposure, may constitute a threat to politicians or firms with concerns about reputation. Visibility of a group may also be used to inform or manipulate the public. This practice may exert an indirect pressure on decision makers through ensuing changes in public beliefs (Kuran and Sunstein, 1999).

The last remark leads us to a fourth political factor, demagoguery of politicians. Politicians might adopt policies that the public *believes* are good even when those policies are not necessarily good for the public. The public may prefer to reduce risk to identified victims because these induce a stronger emotional response (Jenni and Lowenstein, 1997). Identifying victims of a particular risk may also make that risk more salient and increase concern about one’s own exposure to it through the availability heuristic (Tversky and Kahneman, 1974), increasing demand for mitigation (Sunstein, 2005). This aspect may be aggravated if individuals misperceive the (marginal) costs of government services support government allocations based on ethical principles like equality (Kemp, 2003).

7.2 Policy use of benefit-cost analysis

We conclude by summarizing some remarks and raising additional concerns about the use of benefit-cost analysis (BCA) for policy decisions.

BCA using the standard VSL approach for valuing changes in mortality risk may not yield the same results as maximization of social welfare, defined as the summation of individual expected utilities. In particular, whereas social welfare may be unaffected by information about heterogeneity of baseline risk and of the magnitudes of policy-induced changes in risk, monetary measures of the risk change depend on baseline risk and risk change and so the value of a policy-induced risk change may depend on information about risk heterogeneity. In contrast, the results of a cost-effectiveness analysis (CEA), which quantifies the effects of

²¹ This practice is critically discussed by Viscusi (2000b). Notice that a simple model of public provision of safety would actually predict quite an opposite result. According to this model, it is optimal to devote more resources to prevent risks faced by the sub-population of, say, richer people. Such a practice is efficient since it rests on the assumption that the government is also able to implement lump-sum transfers to redistribute income and finance the safety provision across the population. Richer people will be taxed more heavily to compensate poorer people so that, at the optimum, marginal utilities are equal.

changes in mortality risk using quality-adjusted life years, lives saved, or other metrics, may be unaffected by information about risk heterogeneity. Hence if the effectiveness measure used in CEA is consistent with individuals' preferences, the results of the analysis may be consistent with social welfare maximization.

Our results suggest there may be more opportunity for discretion and strategy in applying BCA as a policy tool when there is greater risk heterogeneity. Suppose that some actors concerned about a project possess information about risk heterogeneity. One can imagine that they may wish to release this information strategically so that the adoption rule matches their policy interest. The strategic value of information also provides incentives to obtain it. Similarly, when information is public and arrives exogenously, opportunistic actors may wish to accelerate or delay the decision-making process. Our finding that information about heterogeneity of risk change usually favors the status quo suggests that early decisions about whether to implement a project are unlikely to be reversed by a subsequent BCA conducted when more information is available. This inertia, although reducing the possibility of Scitovsky switchings over time, may be socially inefficient. CEA, which is usually unaffected by information about risk heterogeneity, may be less susceptible to such socially inefficient manipulations.

A systematic premium for identified lives is not consistent with either BCA or CEA but may be explained by political and other factors such as symbolic support for individuals. Whether disproportionate allocation of resources toward programs that save identified lives is socially desirable depends in part on the moral legitimacy of these factors and on the magnitudes of the efficiency costs and other benefits.

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