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MEASURING THE BENEFITS OF RISK REDUCTION IN PROGRAM EVALUATIONS AND REGULATORY IMPACT ASSESSMENTS

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Abstract — The risk of death is affected by a wide variety of public policies and regulations. This paper argues that societal willingness to pay for risk reduction should be used in a consistent manner when evaluating programs and regulations affecting the risk of death. We review the conceptual basis for using estimates of willingness to pay for risk reduction and provide new empirical estimates of these magnitudes based on Canadian data. The explicit and consistent measure that we propose can promote both efficiency and equity in the use of society's resources.

Résumé — Le risque de mort est un facteur sur lequel influent de nombreux règlements et politiques publics. Dans cette étude, les auteurs soutiennent que l'attitude favorable du public, qui se montre prêt à payer pour la réduction des risques, doit faire l'object d'un traitement consistant dans les études portant sur les programmes et les règlementations qui influent sur le risque de mort. Les auteurs examinent la base conceptuelle sur laquelle reposent les estimations de l'empressement à payer pour la réduction des risques et fournissent de nouveaux chiffres estimatifs empiriques portant sur les données canadiennes. La mesure explicite et consistante proposée peut déboucher sur l'accroissement du rendement et de l'équité en ce qui a trait à l'utilisation des ressources dont dispose la société.

MANY GOVERNMENT PROGRAMS AND regulations affect the risk of death in Canadian society. Programs to train air traffic controllers, improve public health, or improve highway safety all fall into this category. Government regulations to restrict the use of hazardous chemicals in the workplace and hazardous products in the home or to protect the ozone layer also have potential impacts on the risk of death. In this article we assess the ways in which evaluators of programs or regulations that affect the risk of death can deal with this difficult issue. In particular, we provide empirical estimates, based on

Canadian data, of the benefits that evaluators should attach to programs and regulations that lower the risk of death.

In its issue of October/November of 1987, *The Canadian Journal of Program Evaluation* published a listing of federal government program evaluation studies completed between April 1985 and March 1987. At least seven of these evaluation studies were relevant to risks of the kind that we analyze, and at least one evaluation did specifically assess the value of lives saved. These evaluations included an Agriculture Canada study of the benefits of meat hygiene, a Public Works study of fire protection, a Health and Welfare study of environmental hazards, and a Consumer and Corporate Affairs assessment of proposed tent flammability regulations that did assess the value of lives saved.An updated list would include a Consumer and Corporate Affairs study of the risks of hydrofluoric acid in consumer products, and an Environment Canada study of deaths prevented by regulations to reduce the consumption of substances that destroy the ozone layer. The risks of death are, in other words, ubiquitous, and a standard approach should be adopted for dealing with them.

This article argues that statistical estimates of societal willingness to pay for risk reduction should be a standard component of program evaluations and regulatory impact assessments. In the section that follows, we provide the conceptual basis for assessments of willingness to pay for risk reduction and for the use of this concept in evaluation studies. The next section describes the methodology we use to measure social valuations of risk and outlines our empirical findings for Canada. In the following section we discuss the applicability of these results to evaluations and related assessments, relative to cost-effectiveness analysis. In the final section, we provide a summary and conclusions.

MEASURING THE BENEFITS OF REDUCED DEATH RISKS

The central points of this article are that individuals' valuations of how much risk they are willing to accept should determine how public sector resources are allocated to reduce serious risks, and that a consistent measure should be used in evaluation studies. The difficulty lies in implementing this concept. We assume that in most areas, lower risks can be achieved by spending more money. At some point, the benefits from risk reduction will decline sufficiently that fully informed taxpayer-voters would not choose to commit more funds to this area. How can we measure this trade-off between risk and the costs of risk reduction?

The fundamental contribution of the economic approach to this issue is to emphasize that the public sector should base risk assessments on the preferences of individuals who will be affected by these risks. Individuals face a variety of risks in many different circumstances and, as a result, there will be many different individual valuations of risk. To establish a standard format for discussing these valuations, economists calculate estimate of what is referred to as the "value of life".

The term is an unfortunate one because it conveys a picture of decision makers allowing specific and predictable accidents to occur if prevention costs exceed some threshold. The reasons for the misleading nature of this term are revealed through an analysis of different possible measures of the value of life.

For instance, a simple and often-encountered approach to the valuation of program or regulatory effects that may save lives is to calculate direct measures of benefits that focus on potential loss of production or wages. For example, if a consumer is burned in a tent fire and is absent from work for three months, one approach would be to measure benefits in terms of reductions in lost wages as a result of regulations reducing tent flammability.

In the extreme cases of death or permanent disability, it is possible to calculate the discounted future earnings (DFE) of the individual in question. The DFE approach does use market data, but this method is widely regarded as inadequate and should not be used by itself in evaluation studies (Mishan, 1976; Schelling, 1968). In the case of loss of life, the DFE approach deals only with earnings. It thereby implies that no benefits are generated by reducing accidents involving retired persons. This result is unacceptable and illustrates the inherent weakness of the method: The discounted future earnings of individuals do not measure the compensation that they would require to accept specific risks voluntarily.

In considering the utility of value-of-life estimates, it is important to understand precisely what is being measured. We are not measuring the benefits of saving the life of an identifiable individual. Value-of-life estimates are useful only for considering the extent to which resources should be devoted to achieving small reductions in the risk of death. For example, consider the risk of death due to air traffic congestion at Pearson International Airport in Toronto. A regulation to restrict incoming and outgoing flights to one per hour would essentially reduce this risk to zero. From this, with some admitted uncertainty, we could estimate lives saved. It would also be possible to estimate the economic costs associated with this drastic curtailment of flights. The example is extreme in that we know the public would prefer less safety than that associated with such a severe restriction. Given this willingness to accept greater risk because of the high cost of further reducing risk, it is possible to calculate, at least hypothetically, an estimate of the trade-off between risk of death and the economic costs that the public is willing to accept.

In this hypothetical example of airport safety, actual data on preferences for risk reduction do not exist. The task of the analyst, in evaluating a program involving social risks, is to find estimates from areas where data are available and are applicable to the program in question. One set of relevant and accessible data to use for this purpose comes from the labor market, where workers regularly accept jobs with measurable differences in risk in return for compensation.

Imagine, for example, that jobs with a risk of death of one per 1,000 workers per year pay $10,000 more than otherwise identical jobs with no risk of death. We assume freedom of choice between jobs, and complete information about potential risks. A group of 1,000 workers opting for greater compensation in the riskier job receive additional compensation of $10 million for accepting this risk. We also know that, on average, this group of workers will experience one fatality. As a group, they have revealed that they prefer to accept the risk of one additional death for compensation of $10 million. Government can use this statistical value of life as a minimum estimate of the value of life; within this group of workers there would be support for any program or regulation that can eliminate death risks of comparable magnitude for amounts up to $10 million.

It is important to emphasize that a measure of this kind is useful only when measuring small changes in the probability of death where the identity of victims is unknown. This approach has limitations, but we believe that it is likely to provide the best available information on the risk preferences of the Canadian population. The alternatives to this measure are almost certain to be ad hoc and inconsistent. The approach that we suggest seems to guarantee that public-sector expenditures and regulations do not put an excessively low value on risk reduction. In the following section, we describe our approach to calculating a statistical value of life for use in evaluation studies, based on Canadian data.

EMPIRICAL VALUATIONS OF RISK

The economics literature on risk valuation shows that there are a number of ways of calculating or inferring risk preferences. The most straightforward approach surveys individuals and asks them directly about their willingness to pay for reduced risks (Jones-Lee, 1976). This method has the advantage of focusing directly on affected individuals, but will be too costly to use in most cases. It is also possible to infer such valuations from housing and travel choices where differential risks are faced (Blomquist, 1979). Our approach is to calculate wage premiums for risky occupations and to infer from these the willingness to pay for risk reduction.

The focus of our empirical analysis is on differences in annual earnings across occupations. These occupations differ in many ways, including the education and training required, the type of work involved, the geographic location, the degree of risk, and many other factors. Our objective is to hold constant all impacts on annual earnings other than risk, to provide a statistically valid measure of the compensation that is required for workers to accept such risks voluntarily.

The data used in our empirical estimates were collected as part of the 1984 Canadian National Election Study. The primary purpose of the study was to assess the results of that election, but its advantage for our purpose is that it provides very detailed information about respondents and the characteristics of their jobs. We used data on 777 male and female workers in the blue-collar and service sectors of the Canadian economy. The four-digit Standard Occupational Classification codes for these individuals were linked with unpublished occupational fatality data obtained from Labor Canada and the Quebec Occupational Health and Safety Board. From these data, we constructed a death-risk variable that is the fatality rate for each occupation for 1981–1983.

The data just described were then used in a multiple regression equation to determine the independent impact of risk of death on earnings. The implicit value-of-life estimates calculated from this framework vary somewhat, depending on the precise specification of the equation.

Table 1 illustrates our approach. This table is derived from a multiple regression equation relating earnings and occupational risk. It holds constant a series of other variables described in the table and shows the extent to which workers receive more compensation in return for accepting greater job risks. In our approach, these data are used to infer required compensation for exposure to risk. It is clear from this table that the risks faced by different workers vary considerably and that their compensation reflects this systematically.

The average statistical value of life calculated from this methodology is \$4.6 million in 1983 dollars. We regard this as a useful lower bound estimate of the value of life to use in evaluation studies. We refer to this as a *lower bound* because it is derived from occupational earnings data. Workers may be willing to accept more risk on the job than they would accept off the job, where their families may also be involved. In cases of involuntary exposure to risks, even larger values may be appropriate. For remote and involuntarily accepted risks, the work of Viscusi (1986) implies that appropriate values may be as large as $10 million.

Table 1
Required Compensation for Exposure to Risk[1]

Deaths per 1,000 Workers per Year	Risk Percentile	Annual Earnings (1984)
.000	0 –25	$20,328
.010	33.3	20,398
.024	50.0	20,497
.054	60.0	20,780
.090	66.7	20,961
.122	75	21,185
.158	80	21,436
.295	90	22,381
.571	95	24,217

RELATIONSHIP TO COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis (CEA) is the major alternative procedure for dealing analytically with the valuation issues under discussion. In some circumstances, CEA may be necessary because the underlying data to calculate benefits are unavailable. In most circumstances, however, the procedure we suggest for quantification of benefits provides superior results.

CEA is useful in circumstances in which the analyst must provide an analytical comparison of different ways of achieving a defined objective. In most evaluation studies, however, part of the problem is to determine whether the objective in question should be pursued in preference to other potential uses of social resources.

The value-of-life calculations described in this article allow analysts to employ cost-benefit analysis rather than CEA. They do this by providing a method for attaching dollar values to programs or regulations that result in lowered risk of death for an identifiable group of individuals. Costs and benefits are then directly comparable because both are measured in dollars.

The outcome measure of CEA is a combination of physical units from the defined objective and dollars from the cost side. The outcome measure might be, for example, dollars per life saved or dollars relative to a proportion of the population immunized in a public health program. A decision to use CEA exclusively increases the potential for underfunding of programs with large beneficial effects, because CEA cannot highlight imbalances between benefits and costs. In addition, it is possible that the most cost effective of several alternatives still has costs that exceed benefits.

The final advantage of cost-benefit analysis using value-of-life estimates relates to program consistency. If CEA is used, there is always an implicit value of life that could be calculated. Since benefits are not measured directly, this implicit value of life will almost certainly vary across all of the CEA studies that are undertaken. If this is the case, there is a potential gain in reallocating expenditures to equate this value, to reduce risks in the globally most cost-effective manner. The use of value-of-life estimates in cost-benefit analysis does not guarantee that the public sector will achieve this desired consistency, but the use of CEA ensures that deviations from this ideal are not even apparent.

SUMMARY AND CONCLUSIONS

This article described the rationale for using estimates of willingness to pay for risk reduction in evaluation studies and assessments of regulatory impacts. One barrier to the widespread adoption of this approach has been the absence of estimates based on Canadian data. The results described in this paper are based on earnings equations using Canadian data and can be used in a wide range of applications where risk valuations are required. The major alternative to the benefit approach advocated here is cost-effectiveness analysis. This is a valid approach if benefits are unknown but benefit-cost rankings are not known, nor is it known whether the resources in question could be more effectively used elsewhere.

Governments at all levels decide how to allocate limited resources to competing programs. For example, should regulations be enacted to improve ventilation systems in mines, should resources for programs to train air traffic controllers be increased, or should additional safety features be required on automobiles? Society can be best served only if benefits and costs of such choices are assessed quantitatively. Periodic program evaluations provide one opportunity to make such assessments in the case of programs that affect the risks to which the Canadian population is exposed.

In response to those who offer philosophical objections to the use of such valuations, we reply that all public-sector decisions use some much measure, if only implicitly. Implicit measures often show that an excessively low value of life is being used. An explicitly calculated value can bring consistency, and hence greater equity, to the process of risk reduction. If choices are made in an ad hoc manner instead of consistently, we expect that those with the greatest access to the political system will be most successful in arguing for risk reduction programs that benefit them directly. Both equity and efficiency objectives would then be best served by the use of the consistent standard advocated in this paper.

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NOTES

1. The values in Table 1 are calculated from a regression equation of the form

$$Y_i = b_iX_i + cR_i + dR^2_i + eUR + f$$

In this equation, Y is the natural log of annual earnings, Xi is a set of individual and job-related variables, Ri is the occupational fatality rate per 1,000 workers and UR is a dichotomous union status variable. The terms b, c, d, and e are regression coefficients, and f is a random error. (The complete regression equation is available from the authors.) In computing earnings in the third column, the mean value of each Xi is substituted into the regression equation. If the model is accurate, earnings differ only because of different levels of risk.