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Discounting Human Lives

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The future costs of regulatory programs to protect human health are routinely discounted, but the lives they save in the future are not. To shed light on the public's attitude toward the discounting of human lives, researchers at Resources for the Future asked 2,600 individuals to choose between one hypothetical program that would save lives immediately and another that would save lives in 5, 10, 25, 50, or 100 years. From the responses, they inferred the number of lives that must be saved in the future to make people as content as saving one life today, compared this implicit discount rate to the respondents' discount rate for money, and identified several factors that affect discount rates for human lives.

One of the missions of the U.S. Environmental Protection Agency (EPA) is to protect human health by reducing human exposure to pollution. Some EPA regulations—those controlling chemical plant accidents, for example—yield immediate health benefits. Others will save lives—that is, prevent premature deaths—but not for some time. Examples include the cleanup of Superfund sites to prevent groundwater contamination and the banning of asbestos in a variety of uses. Both actions reduce the public's exposure to cancer-causing substances; but because the cancer cases avoided would not have occurred until many years after exposure, the actions save lives in the future rather than today.

This creates a problem in evaluating the benefits of environmental regulations. In counting the number of lives saved by a regulation, should a life saved 25 years from now be equivalent to a life saved today? According to EPA, the answer is yes. In evaluating regulations to ban asbestos under the Toxic Substances Control Act, for example, EPA simply added up the number of lives that would be saved, regardless of when they would be saved.

However, analysts at the Office of Management and Budget and others have criticized EPA for not figuring the benefits of these regulations in the same way that it calculated costs. Instead of merely adding up the dollar costs of the ban, regardless of when they occurred, the agency valued a dollar ten years from now at the amount one would have to put in the bank today to yield $1 in ten years—the so-called present discounted value of the dollar. If money in the bank earns interest at 5 percent, this amount is only 61 cents. EPA thus discounted the costs of the asbestos ban but not the benefits.

Over the last three years, researchers at Resources for the Future (RFF) and the University of Maryland have investigated how members of the public feel about the discounting of human lives.

At the heart of this investigation was the following question: Does the public feel that a life saved in the future is equivalent to a life saved today, or does it feel that a life saved in the future counts less than a life saved today?

Far from arcane, the subject of discounting lives arose in a recent court ruling. On October 18, 1991, the U.S. Court of Appeals for the Fifth Circuit overturned EPA's regulations of a variety of asbestos-containing products. Among other reasons for its decision, the court cited the agency's unwillingness to discount the lives saved in the same way it discounted the future costs of the regulations (see *Corrosion Proof Fittings v. EPA*).

To shed light on the issue of discounting lives, the RFF and University of Maryland researchers surveyed approximately 2,600 households—1,600 in the state of Maryland and the Washington, D.C., metropolitan area, and 1,000 nationwide. In a telephone interview, each household was told that the government could fund only one pollution control program and was asked to choose between a program that would save X lives today and another program that would save Y lives in the future. From the answers to these questions, the researchers were able to infer the number of lives that must be saved in the future to make people as happy as would saving one life today. The larger this number, the more heavily people discount lives saved in the future.

Discounting lives saved in the future

As part of the Maryland Poll, a public opinion survey conducted by the University of Maryland Survey Research Center in November and December of 1990, approximately 1,000 households in Maryland were asked to choose between two hypothetical life-saving programs based on the following information:

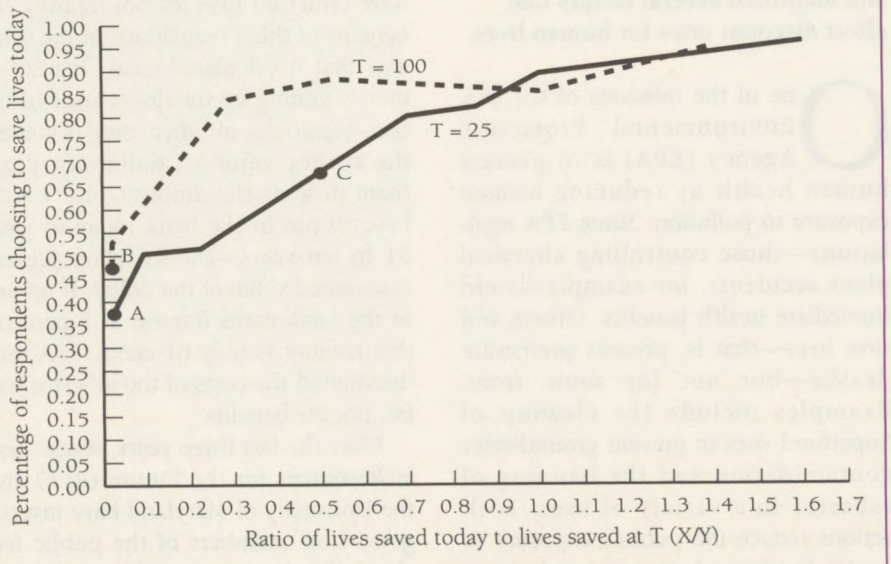
> Each year some people in the United States may die as a result of exposure to certain kinds of pollutants. Unless there are programs to control this pollution, 100 people will die this year from pollution and 200 people will die T years from now. The government has to choose between two new programs to control this pollution. The two programs cost the same, but there is only enough money for one.
>
> Program A will save 100 lives now.
>
> Program B will save Y lives T years from now.
>
> Which program would you choose?

The survey designers varied Y, the number of lives that would be saved in the future. They also varied T, the time at which future lives would be saved. Half the survey sample was told that lives would be saved 25 years in the future; the other half was told that lives would be saved 100 years in the future. After receiving an answer to the question, the interviewers asked each respondent to explain the reasons for his or her decision and gathered information on the respondent's age, race, education, income, and family status.

Because the number of lives saved in the future was varied, it is possible to examine how the percentage of people choosing the present-oriented program (Program A) changed as the number of lives saved in the future changed. This percentage can be viewed as a function of the ratio of lives saved today (X) to lives saved in the future (Y) (see figure, p. 2). For example, when told that Program A would save 100 lives and Program B would save 200 lives in 25 years (X/Y = 1/2), 68 percent of the respondents chose Program A (see point C in the figure).

For each time horizon the survey revealed that the percentage of people choosing Program A increased as that program saved more lives relative to those saved by the future-oriented program (Program B). It also revealed that, other factors being equal, the percentage of people choosing Program A increased as the time horizon for Program B increased. (In the figure this is evidenced by the fact that the curve

Responses to choices between saving lives today and saving lives in the future



Number of Lives Saved in the Future that Are Equivalent to One Life Saved Today

Time horizon	Sample size	Lives saved at T equivalent to one life saved today	Implied discount rate
T = 5	475	2	.168
T = 10	480	3	.112
T = 25	462	6	.074
T = 50	528	11	.048
T = 100	442	44	.038

Source: Data for T = 5 and T = 10 come from the national poll, data for T = 50 from the Washington Poll, and data for T = 25 and T = 100 from the Maryland Poll.

representing the 100-year time horizon lies above the curve representing the 25-year time horizon.)

One of the striking revelations of the survey was how present-oriented the respondents were. When faced with a choice between saving 100 lives today and 4,000 lives in 25 years, 38 percent of the respondents chose to save 100 lives today (see point A in the figure). When faced with a choice between saving 100 lives today and 7,000 lives in 100 years, 47 percent of the respondents chose to save 100 lives today (see point B in the figure).

Respondents considered 6 lives saved 25 years in the future as equivalent to 1 life saved today.

When asked the reasons for these choices, about one-third of the respondents expressed the view that the problems of today are more pressing than those of the future; but another third indicated that, because of technological progress, it would be easier to save lives in the future than in the present. The latter may feel that it is the responsibility of future generations to save themselves (and that, due to technological progress, they should have no trouble doing so), or that they need not make the choice they are being asked to make because lives in the future will be saved in some other way than through Program B.

However, not all respondents were so present-oriented. Even when fewer lives would be saved in the future than in the present (X/Y > 1), about 10 percent of the respondents preferred to save lives in the future. The reason most often cited for this response was that people have a moral responsibility toward future generations.

In subsequent surveys, the effect of three other time horizons for the future-oriented program was examined. As part of the Washington Poll, conducted by the University of Maryland Survey Research Center in March and April of 1991, approximately 600 people were confronted with the choice between a program that saves lives immediately and a program that saves lives 50 years in the future. In a national survey of 1,000 households, conducted in the fall of 1991, people were asked to choose between a present-oriented program and a program that saves lives either 5 or 10 years in the future.

The results of these surveys were compared with those of the Maryland Poll by calculating, for each time horizon, the median number of lives saved in the future (Y) that is equivalent to one life saved today (X) (see table, p. 3). (The median number is the ratio of Y to X at which half the respondents choose the present-oriented program and half choose the future-oriented program.) As expected, this number increased as the time horizon increased. Survey respondents required only 2 persons to be saved in 5 years for each person saved today, but required 6 persons to be saved in 25 years and 44 persons to be saved in 100 years for each life saved today.

Although the number of lives that must be saved in the future increased as the time horizon increased, the discount rate—that is, the interest rate applied to a life today to make it equivalent to 44 lives in 100 years—decreased. The discount rate was approximately 17 percent for a 5-year horizon, but less than 4 percent for a 100-year horizon. The discovery that the discount rate decreases as the time horizon increases is consistent with the findings of studies that measure people's discount rates for money. It reflects a tendency for people to view the time between today and 50 years from today as shorter than the time between 50 years from today and 100 years from today.

Discount rates for money compared with those for lives

In the national survey of 1,000 households, the RFF and University of Maryland researchers explored the relationship between peoples' discount rates for money and their discount rates for saving lives. Of interest was whether, on average, these two discount rates are the same and whether individuals who have high discount rates for money also have high discount rates for saving lives, reflecting, perhaps, a general orientation toward the present.

In the national survey, people were asked to choose between receiving $10,000 today and receiving a larger sum in either 5 or 10 years. Their choices implied an average monetary discount rate of 20 percent for a 5-year time horizon and 10 percent for a 10-year time horizon. These rates, while

higher than market interest rates at the time of the survey, are close to monetary discount rates inferred in other studies from purchases of energy-saving appliances and from reenlistment bonuses paid to members of the military. More important, they are approximately equal to the discount rates for saving lives (see table, p. 3).

The researchers also found that people with high monetary discount rates have high discount rates for saving lives. Those people who chose to receive $10,000 today rather than a larger sum in the future were for the most part the same people who preferred the present-oriented life-saving program to the future-oriented program.

Factors affecting discount rates

A question that arises in interpreting answers to queries about choices among life-saving programs is whether these answers reflect pure altruism or incorporate some selfish concerns. Did respondents to the above surveys discount lives saved in the future because they or their families are unlikely to benefit from future-oriented life-saving programs or because they do not feel as close a kinship with persons living in the future as they do with persons alive today?

One way of answering this question is to ask the respondents whether they considered how life-saving programs would affect them personally. In the national survey, they were asked whether, in making their choices, they had considered the effect that these programs would have on them or their families. Forty percent said they had; however, statistically, this consideration did not increase the chance that they would choose the present-oriented program.

An indirect way of investigating whether responses reflect selfish concerns is to see if the variation in responses can be explained by the respondent's age or by whether or not he or she has children. If older people are less likely to benefit from future programs, and responses are partly selfish, then older people should have higher discount rates than younger people. This should also be true of people with young children. When confronted with a choice between a program that saves lives today and a program that saves lives in 25 years, a person with young children should be more likely to choose the former—all else being equal—if he or she is more concerned about protecting his or her children when they are children than about protecting them when they are adults.

Statistical analysis of survey responses confirmed these hypotheses. The older the respondent was, the higher was his or her discount rate for saving lives. Having children who were under the age of 18 and who lived at home raised the discount rate for saving lives 25 years or more years in the future, but had no statistically significant effect on the discount rate for saving lives in 5 or 10 years. This is consistent with the hypothesis that 5 years from now a person's children will still be children and just as deserving of protection as they are now, but 25 years from now they will be adults and able to take care of themselves.

The only other demographic variable that consistently affected discount rates for saving lives was race. Blacks had significantly higher discount rates than other races, as has been found when it is money, rather than lives, that is discounted. Because the analysis controlled for—that is, held constant—education and income variables, the race variable may have reflected cultural factors or the fact that blacks have shorter life expectancies.

It is perhaps surprising that income and education had no effect on the discount rate. Further reflection, however, suggests that there is no reason why low-income persons, who have been found to discount monetary rewards more heavily than high-income persons, should discount lives at a higher rate.

Caveats

The above findings should be regarded as preliminary for several reasons. First, relatively brief telephone interviews are an imperfect vehicle for eliciting preferences with regard to choices as difficult as those presented. Second, some evidence suggests that the order in which questions are asked has a slight effect on responses and thus on the calculation of implicit discount rates. Third, as reported above, some fraction of the respondents took into consideration the fact that the present-oriented program could protect them personally while programs with time horizons of 50 years or more were unlikely to do so. Since the responses of these people reflect selfish concerns, some people might question the validity of using the discount rates inferred from the RFF study to make social decisions.

In spite of these caveats, however, the overwhelming majority of those questioned attached a lower priority—sometimes much lower—to lives saved in the future, even when the time horizon was quite short (5 or 10 years). For example, for a program that would save lives 25 years in the future to be preferred to a program that saves lives immediately, it had to save at least six times as many lives. If borne out by additional research, this finding would have important implications for the evaluation of many programs to regulate health and safety. In view of the resources being devoted to these programs, such research appears to be worth undertaking.

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Incentive-based Approaches to Regulating Toxic Substances

Molly K. Macauley and Karen L. Palmer

Applying incentive-based strategies to toxic substance regulation can be complicated. Potential risks to health and the environment can occur at many stages in the life cycle of a toxic substance, and the risks vary among different products and uses of products containing toxic substances. Thus researchers at Resources for the Future recommend that regulatory intervention be focused on specific stages in the life cycle of toxic substances, but warn that intervention must be broad enough to mitigate incentives to adopt production processes and products that could pose greater risks than the processes and products they replace. Despite this and other potential pitfalls, they find that incentive-based strategies such as product labeling and deposit-refund schemes may be desirable for regulating certain stages of the life cycle of some chemicals.

More than 60,000 chemicals enter into the multitude of products and services that contribute to today's lifestyle. Taken together, these chemicals comprise a huge industry. In the United States alone, sales of chemicals earn more than $200 billion a year. The sheer variety, ubiquity, and economic importance of chemicals make efforts to guard against their possible undesirable health or environmental effects a challenge. Traditionally, regulation to create safeguards has taken some form of command and control—most frequently product bans or other mandated restrictions such as product reformulation. But are there incentive-based approaches to environmental regulation that might serve as desirable alternatives to command and control?

A lengthy and expanding economics literature has argued for the general superiority of incentive-based strategies over command-and-control (CAC) regulation, primarily because of the cost savings expected from these strategies. This literature has been further expanded by a recent study by researchers at Resources for the Future (RFF) that considers the advantages and disadvantages of several incentive-based approaches for regulating toxic substances. One approach is to tax toxic emissions or to issue tradable permits for them. Both taxes and tradable permits are aimed at governing chemical production or use. Another approach would employ a system of deposits and refunds aimed at controlling disposal of chemicals, and a deposit-refund scheme in the form of a performance bond on new chemicals aimed at mitigating the toxic effects of chemicals. Yet another approach would use product labeling to provide information on the safe use of chemicals. The RFF study considered these approaches in case studies of four toxic substances that have been the focus of current regulatory concern: chlorinated solvents, which are principally used in dry cleaning, metal degreasing, aerosols, and paint removers; formaldehyde, which is used mainly in pressed woods and plastics; cadmium, which is used in batteries and paints; and brominated flame retardants (BFRs), which are used in plastics and textiles to reduce their flammability.

The RFF study assumed that the goal of regulatory intervention is to cost-effectively capture (internalize) the health and environmental impacts of chemical production and use. Without attempting to draw conclusions about the benefits arising from such intervention, the RFF study presumed that policymakers would regulate the above substances; the researchers' task was to explore alternatives to CAC regulation. The study did not estimate the magnitude of the potential cost savings of incentive-based approaches as compared with CAC regulation (an important topic for future research), but it did suggest some of the key factors that will affect the size of the savings.

Characteristics of toxic substances

The existing literature on incentive-based strategies for controlling pollution generally assumes a fairly homogeneous pollutant associated with one stage of production at an identifiable source—the canonical example might be sulfur dioxide emissions from electric utility plants. Only some aspects of this literature address specific issues, discussed below, that arise in considering regulation of toxic substances.

The RFF study further explored these issues, taking into account three characteristics of toxic substances that complicate a straightforward application of incentive-based strategies for environmental regulation. The first characteristic is the multiple-stage life cycle of chemicals. The potential for risks to health and the environment may occur at many stages in this life cycle—at the minemouth or during production of the feedstock, during production of intermediate products that use chemicals as an input, during use by industry or households, and upon disposal. Thus regulatory intervention to safeguard against risk may be necessary at more than one stage of a chemical's life cycle and may have to take different forms. For example, it might be beneficial to tax intermediate production of a chemical to mitigate air or water pollution and to label the final product in which

the chemical is an input in order to inform end users about the potential hazards and proper handling of the product.

The second characteristic of toxic substances considered by the RFF study is the marked variation in the distribution of risk of harmful exposure across heterogeneous products and uses. Not all products or uses of a chemical may pose potential risks; nor is the nature of the risk always the same. A product or its use may be harmful to people or to the environment; it may be harmful to society as a whole or merely to the end user; or it may harm one or several environmental media (for example, it may harm air but not water or soil). Thus regulatory intervention may have to be highly product- or use-specific to safeguard against risk without unduly restricting relatively harmless applications of toxic substances.

Because a toxic substance may pose risks to human health and the environment at many stages in its life cycle, regulatory intervention may be necessary at more than one stage and may have to take different forms.

The third characteristic considered by the RFF study is the generally wide scope of substitute products or production processes. Regulating a substance (or one of its products or uses) is likely to induce substitution of another product or production process. Generally speaking, small modifications in the makeup of many chemicals can lead to a substitute product. Although substitution possibilities are an intended consequence of regulatory intervention, the existence of potentially more harmful substitutes for a particular toxic substance or class of substances implies that toxic substance regulation, if too narrow in scope, could unintentionally result in increased levels of environmental and health risk.

Regulation of toxic substances

The above characteristics lead to several observations regarding the regulation of toxic substances. The first is that focusing intervention on specific life-cycle stages is likely to be desirable. A tax targeted at intermediate stages of production or at certain end uses during which risk of exposure is concentrated would better ensure that risks are mitigated than would a tax on all production of a substance. However, a tax targeted at specific production stages or end uses may entail significant administrative and enforcement costs. In contrast, a blunt instrument—such as a tax on all production of a chemical—may be easier, thus less costly, to administer. This is because typically there are fewer producers of chemicals upstream in the production process—at the minemouth or feedstock level—than there are downstream at the level of intermediate production of products containing chemicals, and because there are fewer producers than end users of products. However, such blunt intervention would reduce use of chemicals in those applications for which there are more substitutes rather than in those applications for which risks of human or environmental exposure are greatest.

A second observation regarding regulation of toxic substances is that the most desirable intervention strategies are self-enforcing. The property of self-enforcement is clearly advisable for all types of regulation (whether of the command-and-control variety or incentive-based) and in all circumstances (whether a single source, homogeneous pollutant or a multisource, multimedia pollutant is involved). However, this property is probably of particular importance in the case of toxic substances, given their ubiquity and heterogeneity. Opportunities for eluding the purchase of a permit for or evading a tax on a toxic substance may be easy to exploit. For example, the large numbers of intermediate producers may make it easy to resell a substance ostensibly intended for benign uses—a substance for which no tax would be levied or permit would be purchased—to a producer who uses it in a production process or a final product that poses great risks. Consider, for instance, the possible response to a tax on formaldehyde used in the production of resins that are found in wood furniture and the absence of a tax on formaldehyde used in the production of household cleaning products. This tax, which would reflect the fact that formaldehyde in wood furniture poses more health risks than formaldehyde in household cleaning products, could be evaded if cleaning product manufacturers resold the untaxed formaldehyde to furniture manufacturers as a substitute for the taxed formaldehyde. Opportunities also arise to undermine deposit-refund schemes. For example, some chemicals may be readily and relatively undetectably diluted in order to increase refunds.

For these reasons, the RFF study suggested the use of intervention strategies that might be self-enforcing. These strategies include deposit-refund schemes that are modified to reduce opportunities for diluting chemicals, as well as taxes and permits that allow cost-effective monitoring. Strategies that increase the probability that violators will be monitored in the future might also prove useful.

A third observation regarding the regulation of toxic substances is that such regulation must be broad enough in scope to mitigate incentives to adopt potentially more harmful substitutes. In the state of California, the regulation of select chlorinated solvents without regard to the harmful effects of possible substitutes has led to higher emissions from the substitute solvents and in-

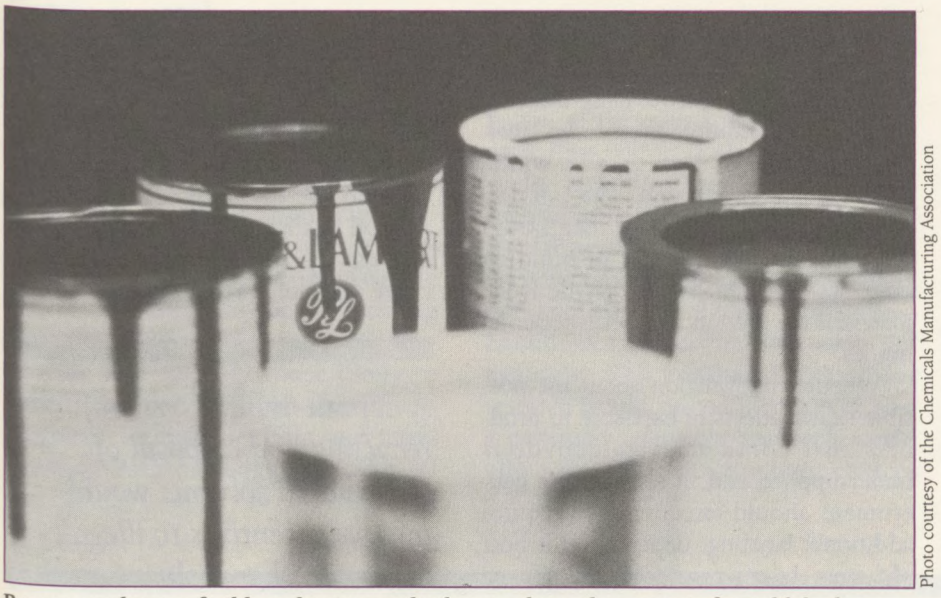

Photo courtesy of the Chemicals Manufacturing Association

Because end uses of oil-based paints and other products that contain formaldehyde are associated with few third-party health effects, the most appropriate way to regulate them may be product labeling.

creased risks of exposure to the toxic effects of these emissions. Regulation of brominated flame retardants presents similar possibilities for risk-increasing substitution. The posting of a performance bond or other insurance might be considered to guard against products that pose greater risks than the products they are substitutes for—or to allow compensation to those harmed by these substitutes. Such risk sharing by producers may reduce the large amounts of information that regulators presently must obtain in overseeing new and existing chemicals.

Regulatory intervention at various stages of the life cycle of a toxic substance must be approached with caution. In its examination of incentive-based strategies for regulating formaldehyde, the RFF study illustrated the potential for such intervention to increase risks of harmful exposure to the substance at another stage of the life cycle. It suggested that product labels and product standards might reduce consumers' potential exposure to formaldehyde vapors from various household products. However, the study considered the possibility that producers of these products would reduce such exposure by retaining the products in warehouses and delivering them to retailers only when vapors had dissipated to the point that the products would meet emissions standards for acceptable levels of formaldehyde in households. Thus an unintended effect of intervention at the end-use level might be that warehouse workers would be exposed to levels of vapors higher than those prior to intervention. Similarly, incentives to encourage recycling of chlorinated solvents and cadmium could have unintended consequences by reducing society's exposure to these chemicals during disposal, but increasing emissions of the chemicals during recycling.

Another consideration that arises with regard to regulatory intervention at various stages of a chemical's life cycle is the need to coordinate such intervention with existing regulations that affect the production, distribution, use, and disposal of toxic substances—for example, limits on emissions of toxic substances into the air and water, rules for transport of these substances, and standards for occupational health and safety. Intervention to mitigate the public's risk of harmful exposure to brominated flame retardants at the disposal stage of the BFR life cycle and existing fire safety regulations that induce the use of BFRs illustrate this need. The former would have to be coordinated with the latter in such a way that the health risks arising from the disposal of BFRs are balanced with the benefits of using products in which BFRs are an input. The RFF study noted but did not explicitly consider the combined effects of existing regulation and regulations outlined in its case studies. Instead, it assumed that the effects of each were separable.

The preceding discussion suggests that it is inappropriate to recommend a single regulatory approach for all toxic substances. Although two or more such substances may have similar characteristics, it is generally necessary to conduct a case study of each substance to determine the stage or stages of the life cycle at which intervention might be desirable. This is so even when the risk of harmful exposure occurs at the same stage or stages of the life cycle of two or more substances with similar characteristics.

Regulation aimed at a specific stage in the life cycle of a toxic substance must be coordinated with existing regulation so as to balance health risks with the benefits of using products containing the substance.

As already noted, among the incentive-based approaches to regulating toxic substances analyzed in the RFF study are product labeling and deposit-refund schemes. The former may be desirable for regulating end uses of formaldehyde, while the latter may be desirable for regulating the recycling and disposal of chlorinated solvents.

Product labeling for formaldehyde

In many applications of the substances considered by the RFF study, third-party effects are negligible—that is, risk of harmful exposure is limited to the end user rather than extending to society as a whole. This is generally the case with products containing formaldehyde.

Exposure to formaldehyde arises principally through the emission of vapors from products. Because it is product users who are primarily exposed, few third-party health effects are associated with consumption of the products. The near absence of such effects suggests that the most appropriate form of regulatory intervention may be one that increases the supply of information to consumers about both the possible health effects of formaldehyde and the actions that consumers can take to mitigate these effects. One way to increase this supply is to label products that contain formaldehyde with facts about health effects and mitigating actions. Although the benefits to consumers from access to information about the possible health effects of formaldehyde may differ markedly from one individual to the next, anecdotal evidence suggests that, in general, the gains are likely to be large. If so, labeling may be preferred to bans or other restrictions on products containing formaldehyde.

Consumers of products that contain formaldehyde risk the greatest exposure to formaldehyde; thus product labeling appears to be the most appropriate way to regulate this substance.

In some instances, industry has already voluntarily undertaken labeling of products containing formaldehyde. The Consumer Product Safety Commission has been encouraging industry to undertake additional voluntary labeling of particular products in which formaldehyde is an input. The U.S. Department of Housing and Urban Development requires labeling of building materials that emit formaldehyde if the materials are used in the construction of homes.

Whether information about the possible health effects of exposure to products that contain formaldehyde is undersupplied and, if so, whether government should encourage or require additional labeling, depends on a host of factors. In any case, when consumers are informed about actions to mitigate harmful exposure to a product through product labeling, they can choose to continue use of the product or find a substitute for it. Thus labeling is one way to preserve consumer choice and at the same time safeguard against health risks.

Deposit-refunds for chlorinated solvents

Hazardous exposure to chlorinated solvents can arise through improper disposal of these solvents, which may lead to groundwater contamination. Existing regulations under the Resource Conservation and Recovery Act are designed to eliminate this exposure by restricting land disposal of spent solvents and sludges that remain after chlorinated solvents are recycled. These regulations require solvent waste to be incinerated at a licensed hazardous waste incinerator or treated and disposed of at a hazardous waste landfill. They also call for a system of manifests for tracking transport of this waste. The regulations have raised the cost of proper solvent disposal, perhaps giving recyclers an incentive to illegally dump solvent waste.

To remove the incentive for illegal disposal and thus reduce the social costs of such disposal, a deposit-refund system might be imposed on all parties that accept spent solvent for recycling and disposal. Such a system would encourage recyclers of chlorinated solvents to use the most socially efficient method of disposal by raising the costs of illegal disposal and rewarding appropriate disposal practices.

A deposit-refund system for recycling and disposal of chlorinated solvents would remove incentives to illegally dispose of these solvents and would encourage a reduction in solvent emissions during recycling.

Under the deposit-refund system, the solvent waste handler would be required to pay a deposit to the government for every pound of spent solvent accepted for recycling and disposal. This deposit would be exchanged for proof of recycling or proof of legal disposal at a licensed hazardous waste facility. The deposit-refund would be set equal to the difference between the social marginal cost of illegal disposal and the private marginal cost of illegal disposal, and the deposit would be refunded on all solvents that are either recycled or properly disposed of at a licensed hazardous waste disposal facility. Since recyclers would not receive a refund on any solvents emitted during recycling, the deposit-refund system would give them an incentive to reduce emissions into the air. Because some emissions will always occur during recycling, the deposit-refund system, which is self-financing, should yield some net revenue to the government. This revenue could be used to cover some of the administrative costs of the deposit-refund program.

Future research

The RFF study suggested several directions for future research on incentive-based approaches to regulating toxic substances. One is analysis of the costs and benefits of these approaches and of alternative command-and-control approaches. This would indicate the size of the savings to society accruing from incentive-based regulatory intervention and identify those likely to benefit or suffer (through loss of employment, for example) from such intervention. Another suggested area of research is exploration of the interactive effects of multiple layers of regulation of a substance. This would include examination of the effects of intervention at more than one stage of a substance's life cycle, as well as the consequences of such intervention for different environmental media (air, water, and soil) and for activities related to the production, use, and disposal of toxic substances—hazardous materials transportation, for example. Still another direction for research would be consideration of how a particular regulatory approach would affect the future technology choices made by firms, particularly with regard to the relative health and environmental effects of substitute production processes and products.

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Recent Trends in Major Natural Disasters and Industrial Accidents

Theodore S. Glickman and Dominic Golding

Are natural disasters and industrial accidents that involve hazardous substances becoming more frequent and severe? This is one of the questions researchers at Resources for the Future attempted to answer by developing a database on natural disasters and industrial accidents that occurred worldwide during the years 1945 to 1986. Trends evidenced by the database have implications for policies and resource allocations to prevent, prepare, and respond to these events.

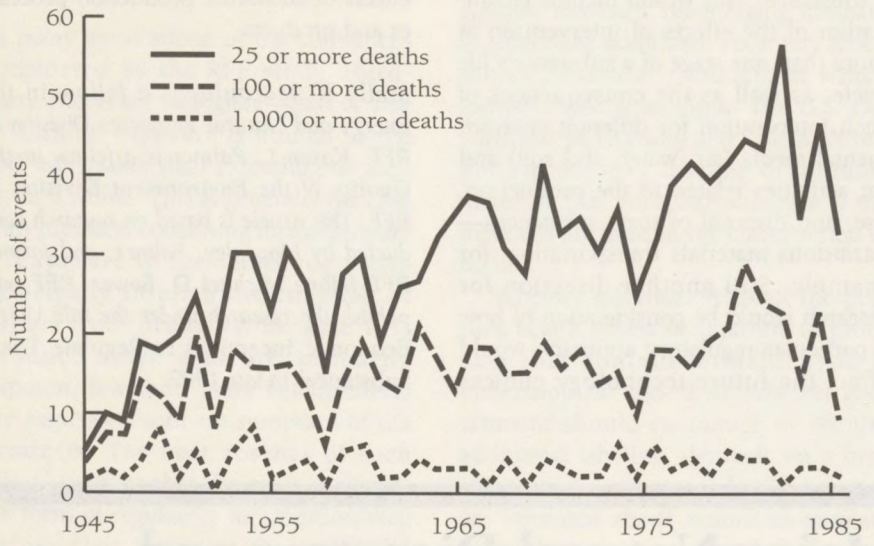
During the years 1945 to 1986, more than 1,200 natural disasters, each with 25 or more associated fatalities, occurred worldwide. These disasters resulted in more than 2.3 million deaths. During the same period, industrial accidents, each with 5 or more fatalities, that involved the release of hazardous materials were much less frequent and claimed far fewer lives. Nearly 300 of these accidents occurred worldwide, resulting in the deaths of almost 15,000 people.

These statistics were derived from a database recently developed by researchers at Resources for the Future (RFF). The database makes it possible to discern whether the natural disasters and industrial accidents noted above became more frequent, or severe, or both over the years 1945 to 1986; to discover which regions of the world suffered most as a result of their occurrence; and to determine which types of these events were most common and which were most devastating. All this information has implications for the development of policies to prevent, prepare for, or respond to natural disasters and industrial accidents and for the targeting of resources to efforts that will garner the greatest life-saving benefits.

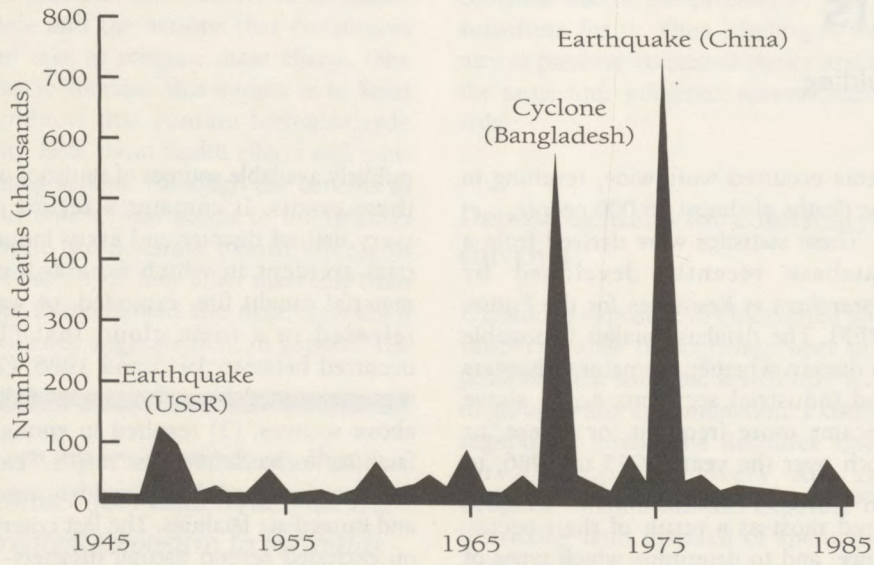
The RFF database improves on previous surveys and compilations of data on natural disasters and industrial accidents by providing a compendium of information drawn from two dozen publicly available sources of statistics on these events. It contains a record of every natural disaster and every industrial accident in which a hazardous material caught fire, exploded, or was released in a toxic cloud that (1) occurred between 1945 and 1986, (2) was mentioned by at least one of the above sources, (3) resulted in enough fatalities to be defined as "major," and (4) was characterized by sudden onset and immediate fatalities. The last criterion excluded certain natural disasters—namely, droughts, epidemics, and famines—and certain industrial catastrophes of a chronic nature—such as the long-term discharge of hazardous substances into the environment.

The setting of a lower fatality threshold for industrial accidents—that is, a minimum of only 5 fatalities as opposed to 25 fatalities—reflects two facts. First, individual industrial accidents generally claim fewer lives than individual natural disasters, although death tolls alone do not indicate the severity of the social

Number of major natural disasters worldwide



Worldwide fatalities due to major natural disasters



and economic repercussions of these accidents. Second, risks due to technological hazards are perceived by the public to be higher than risks due to natural hazards.

To show the geographical distribution of the frequency and severity (as measured in fatalities) of major natural disasters and industrial accidents, the Resources for the Future database divided the world into regions. With respect to natural disasters, it was divided into seven regions: North America, Latin America and the Caribbean, Europe and the former Soviet Union, sub-Saharan Africa, the Middle East and North Africa, Southern Asia, and East Asia and the Pacific. With respect to industrial accidents, it was divided into three regions: the United States and Canada, Europe and the former Soviet Union, and all other countries.

In the RFF database, natural disasters were divided into three types and industrial accidents into four types. Natural disasters were broadly classified as meteorological, geological, and other. Meteorological disasters were further divided into floods, tropical cyclones (including hurricanes, cyclones, and typhoons), other storms (including tornadoes), and heat and cold waves. When the majority of deaths that data sources attributed to a tropical cyclone or other storm was caused by a flood, the event was classified as a flood. Geological disasters were divided into earthquakes, volcanic eruptions, and tsunamis (tidal waves produced by submarine earth movements or volcanic eruptions). Other disasters included landslides and naturally occurring fires. The RFF database classified industrial accidents as being transportation-related, occurring at a fixed facility, involving a pipeline, or unknown. It did not include accidents that occurred during mining and demolition activities because these activities involve hazards of a highly specific nature.

Major natural disasters, 1945–1986

The database reveals that, during the years 1945 to 1986, the annual number of natural disasters that resulted in 25 or more deaths generally increased until the 1980s. There is a similar though less pronounced upward trend in the annual number of disasters that resulted in 100 or more deaths. The annual number of disasters that resulted in 1,000 or more deaths remained relatively constant (see top figure, p. 10).

One possible explanation for the upward trend in those disasters that resulted in at least 25 fatalities is increasingly better reporting by news sources and government agencies of events of this kind happening in more remote regions of the world. However, the most likely explanation is the substantial rise in world population and the

increasing vulnerability of economically disadvantaged people. Population growth, increasing urbanization, land shortages, and economic hardships often force people in less developed countries to migrate to locations having geological and meteorological hazards, while endemic poverty limits emergency preparedness and response and the ability of individuals to cope with natural disasters.

During the years 1945 to 1986, East Asia and the Pacific suffered the greatest number of major natural disasters and the greatest number of associated deaths.

On average, 30 natural disasters killed 56,000 people per year and 1,850 people per disaster during the years 1945 to 1986. These figures may be misleading, however. The average number of fatalities per year and per disaster was vastly inflated by a few disasters resulting in unusually high death tolls. The three deadliest disasters—the 1948 earthquake in the former Soviet Union (110,000 deaths), the 1970 cyclone in Bangladesh (500,000 deaths) and the 1976 earthquake in China (700,000 deaths)—accounted for more fatalities than all the other natural disasters combined (see bottom figure, p. 10). If the deaths due to these three events are excluded, the average number of fatalities per year and per disaster would drop to about 25,000 and 800, respectively.

The frequency and severity of major natural disasters were unevenly distributed across the globe. During the years 1945 to 1986, three regions bore the brunt of these disasters: East Asia and the Pacific, Latin America and the Caribbean, and Southern Asia. East Asia and the Pacific suffered both the largest number of natural disasters (401) and the most deaths (977,000). The number of deaths, however, is inflated by the earthquake that occurred in China in 1976. When the fatalities from this and the USSR and Bangladesh disasters noted above are excluded from the total death toll of each region, Southern Asia is found to have the highest total number of deaths and the highest number of deaths per disaster.

During the same time period, North America had a relatively large number of natural disasters (149) that resulted in relatively few deaths, both in total (15,000) and on average per disaster (104). Europe and the former Soviet Union had slightly fewer disasters (127). Of all the regions of the world, sub-Saharan Africa had the smallest number of disasters (45) and the smallest number of deaths (9,000); these numbers would have been much higher if epidemics, droughts, and famines had been included in the RFF database. Although the remaining region, the Middle East and North Africa, had the second smallest number of disasters (86), it had the highest number of deaths per capita.

These seven regions vary considerably in size. Although it might be expected that the largest regions would experience the most disasters, size appears to be of less importance than location in relation to the principal areas of geological and meteorological activity. For instance, Southern Asia comprises only 4 percent of the world's land area but suffered 18 percent of the disasters between 1945 and 1986.

The annual number of deaths due to natural disasters was more variable than the annual number of natural disasters. The substantial drop in the number of these deaths regionally and worldwide from 1980 to 1986 is contrary to expectations, given the increase in the number of disasters during this period. The drop may have resulted from the normal fluctuations in the magnitude of natural disasters, or it may reflect improved abilities to prepare for and respond to these events.

During the years 1945 to 1986, 917 meterological disasters killed about 1,072,000 people. Although less frequent, geological disasters, which numbered 225, claimed approximately 1,240,000 lives—about 168,000 more than meteorological disasters. The number of meteorological disasters increased dramatically over time, but the number of associated deaths did not. In contrast, the number of geological disasters remained relatively stable while the number of associated deaths grew substantially. Other types of natural disasters were much less common and claimed far fewer lives than either meteorological or geological disasters.

The most common types of natural disasters were floods, tropical cyclones, earthquakes, and other storms. Floods accounted for nearly one-third (395) of the total number of disasters (1,267). Compared with floods, tropical cyclones claimed a larger number of lives in total (791,000) and per disaster (2,907). Earthquakes caused about half the deaths attributable to natural disasters (1,198,000) and resulted in the most deaths per disaster (6,272).

Major industrial accidents, 1945–1986

During the years 1945 to 1986, there were 293 major industrial accidents worldwide, or an average of 7 per year. The number of these accidents that resulted in 25 or more deaths was consistently smaller than the number that resulted in 5 or more deaths (see top figure, p. 12).

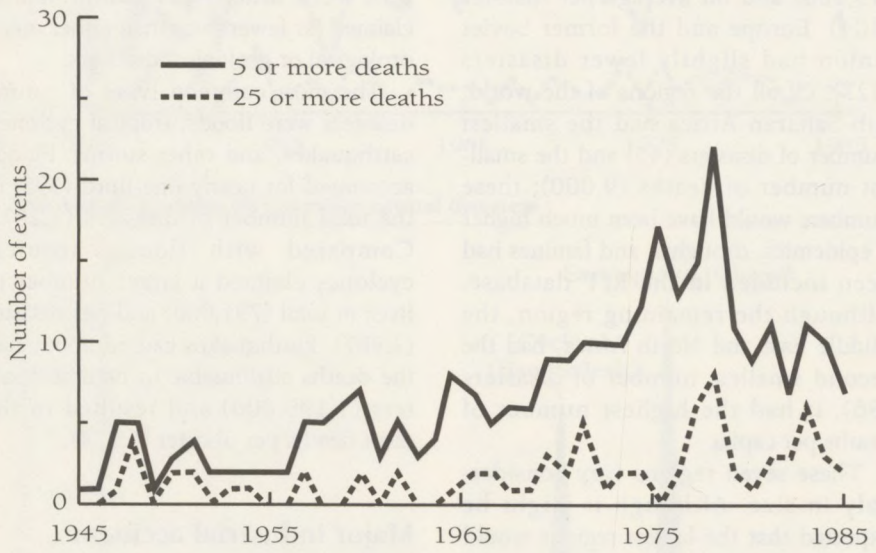
The RFF database reveals an upward trend in the number of these accidents through 1979—the year in which the greatest number of them occurred—and a steep downward trend thereafter. The extent to which these trends are related to the level of industrial activity is unclear, given the difficulty of measuring such activity worldwide; but the level of industrial activity certainly did not fall off dramatically after 1979. The

explanation could be that the rising number of accidents throughout the 1960s and 1970s led to organizational, operational, and regulatory changes that reduced the potential for accidents to occur.

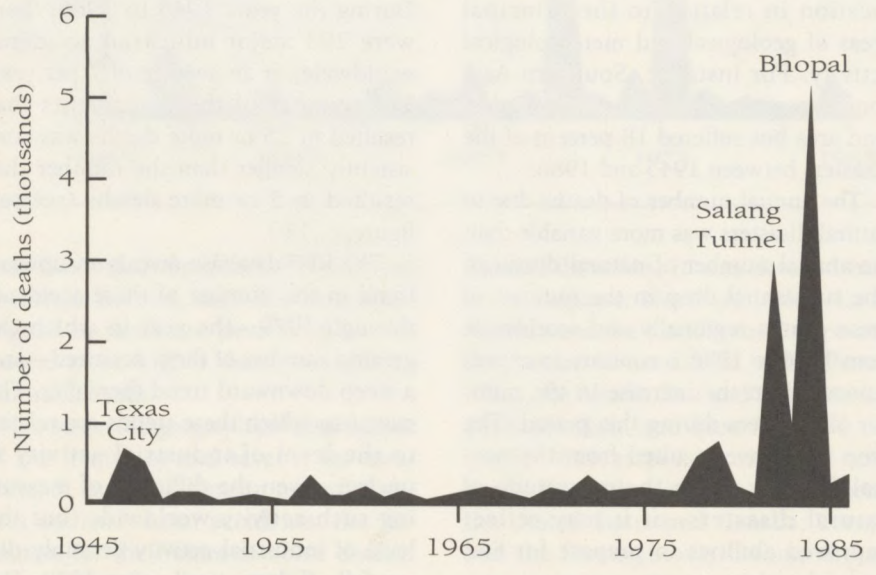
Despite the decline in the number of disasters between 1980 and 1986, there was a substantial increase in the number of deaths during that period. This increase is primarily attributable to two accidents that resulted in very high fatalities: a fuel truck crash in the Salang Tunnel in Afghanistan in 1982 that killed 2,700 people, and a chemical plant accident in Bhopal, India, in 1984 that killed 3,849 people (see bottom figure, p. 12). On average, there were 350 deaths per year and 50 deaths per accident.

As was the case with major natural disasters, the frequency and severity of major industrial accidents were unevenly distributed across the globe. During the years 1945 to 1986, the United States and Canada together suffered the largest number of major industrial accidents. However, the greatest number of fatalities due to these accidents occurred in countries outside North America (excluding Mexico) and Europe (including the former Soviet Union) in the period 1980–1986.

Number of major industrial accidents worldwide



Worldwide fatalities due to major industrial accidents



The number of major industrial accidents peaked in the period 1973–1979. Many of the accidents during this period occurred in the southern United States and may be attributed to increased oil drilling and other industrial activities associated with the 1973 oil embargo. Until 1980, however, the total number of deaths due to major industrial accidents increased only marginally compared with the substantial increase in the number of these accidents.

During the years 1945 to 1986, there were 124 major industrial accidents in the United States and Canada, 86 in Europe and the former Soviet Union, and 83 in all other nations. Associated fatalities numbered 2,016, 2,680, and 10,280, respectively. Thus, the average number of deaths per major industrial accident was approximately 16 for the United States and Canada, 31 for Europe and the former USSR, and 124 for all other nations.

Accidents of all four types classified in the RFF database increased throughout most of the years from 1945 to 1979. Although they decreased from 1980 to 1986, the number of associated deaths during that period rose dramatically due to two fixed-facility accidents (in Bhopal and Mexico City), one transportation accident (in Afghanistan), and one pipeline accident (in Sao Paulo, Brazil), each of which had a very high number of fatalities.

During the years 1945–1986, the number of transportation-related accidents roughly equalled that of fixed-facility accidents; the number of

fatalities associated with each of these types of accidents was also roughly the same. Transportation accidents accounted for 4,108 (46 percent) of the major industrial accidents and 31 (45 percent) of the resulting deaths during this period. Fixed-facility accidents accounted for 118 (40 percent) of the accidents and 7,063 (47 percent) of the deaths. If not for the accidents in Afghanistan and Bhopal, transportation accidents would have surpassed fixed-facility accidents in number of total deaths and deaths per accident.

The United States and Canada suffered the largest number of major natural disasters between 1945 and 1986; but the largest number of deaths due to these accidents occurred outside North America and Europe.

The RFF database reveals that 35 percent of the major industrial accidents at fixed facilities and 68 percent of the associated fatalities occurred in the chemical industry. If not for the Bhopal accident, however, the chemical industry would have been responsible for fewer deaths than the petroleum refining industry, which accounted for 27 percent of the accidents at fixed facilities and 15 percent of the resulting deaths. The manufacturing industry accounted for 20 percent of all the fixed-facility accidents but less than 3 percent of the total fatalities. The remaining fixed-facility accidents were attributed to other industries or to unidentified industries.

The database shows that maritime accidents accounted for 47 percent of all the major industrial accidents that occurred during the transport of hazardous materials and 33 percent of the fatalities due to industrial accidents. However, roadway accidents, which accounted for 29 percent of the transportation-related accidents, were responsible for 53 percent of the deaths. If not for the Salang Tunnel accident in Afghanistan, maritime accidents would have been responsible for a greater number of deaths than roadway accidents. Railway accidents accounted for 16 percent of the transportation-related accidents and 10 percent of the resulting deaths. Road/rail accidents—that is, accidents involving the collision of road vehicles with trains—and accidents involving unidentified means of transport accounted for the remaining transportation-related accidents.

Pipeline accidents accounted for 33 (11 percent) of all major industrial accidents and 860 (6 percent) of all the deaths due to these accidents. With the exception of the oil pipeline explosion that killed 508 people in Sao Paulo in 1984, most of the pipeline accidents resulted in relatively few deaths. Overall, gas pipeline accidents were almost five times more common than liquid pipeline accidents, but the latter killed almost twice as many people (557 deaths compared with 303).

Comparative impacts of disasters and accidents

During the years 1945 to 1986, major natural disasters were more frequent and severe than major industrial accidents. The RFF database reveals that natural disasters occurred four times more often than industrial accidents and claimed more than 150 times as many lives each year. It also shows that each natural disaster resulted in more than 30 times as many deaths as each industrial accident.

The majority of deaths were caused by a relatively small number of disasters and accidents with particularly high numbers of fatalities. The ten worst natural disasters (in terms of fatalities) accounted for 66 percent of all deaths attributable to natural disasters, and the ten worst industrial accidents accounted for 63 percent of all deaths due to industrial accidents.

The annual number of deaths worldwide due to major natural disasters and industrial accidents was approximately 56,000. This number is slightly greater than the annual number of deaths due to highway accidents in the United States.

Information needs

The development of the RFF database revealed serious shortcomings in the reporting of data on major natural disasters and industrial accidents, ranging from omissions to errors and ambiguities. None of the sources used in the database had a complete record of reports on either natural disasters or industrial accidents, and there were often gaps in the information that was given. Moreover, reports of the same event sometimes differed so much from one source to another that it was difficult to determine whether a disaster or accident described by one source was the same disaster or accident described by another source.

Practices for recording the dates, locations, conditions, contributing factors, and consequences of major natural disasters and industrial accidents all need to be standardized. More complete and consistent information is also needed about how and why these events occur, and about the consequences (other than fatalities) of these events—such as the number of people injured and the magnitude of damages to property and the environment. The fulfillment of these needs is critical to the improved understanding and management of natural disasters and industrial accidents.

Theodore S. Glickman is a senior fellow in the Center for Risk Management at RFF. Dominic Golding is a fellow in the center.

INSIDE RFF NEWS AND PUBLICATIONS

RFF Council discusses voluntary pollution reduction by industry

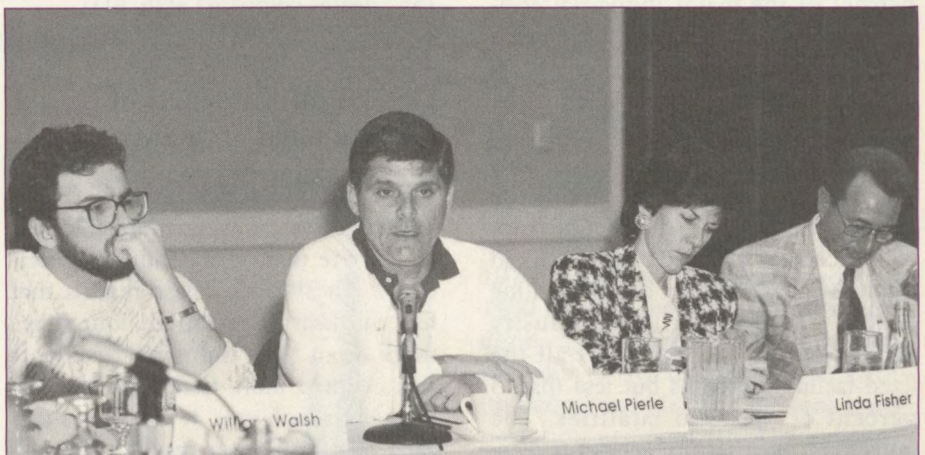
On April 2, 1992, the RFF Council—a group of individual, foundation, and corporate supporters of Resources for the Future—met at Kiawah Island, South Carolina, to discuss corporate responsibility and voluntary pollution reduction. Among the featured speakers were an assistant administrator from the U.S. Environmental Protection Agency (EPA), representatives of two U.S. companies, and a consultant to the international environmental advocacy organization Greenpeace. They each addressed topics pertinent to voluntary pollution reduction by U.S. corporations—that is, the practice of some corporations of reducing their emissions of regulated pollutants below permitted levels, or of voluntarily reducing emissions of other pollutants for which no regulatory limits have been established, or both.

At a luncheon before the council meeting, James Post, professor of management and public policy at Boston University, said there are three ways to motivate environmentally benign actions by corporations. The first is for Congress to establish a law that mandates what the environmental performance of corporations ought to be. The second is for the public to pressure corporations to act in an environmentally responsible manner. The third is for corporations to investigate how their interests might be served by voluntary pollution control and prevention. Chemical companies, said Post, have demonstrated that there is money to be saved in pollution prevention. However, he noted that the enlightened self-interest that might lead anyone to take voluntary action is embedded in what the law requires, what the public expects, and how risk is viewed.

Post also touched on what has been learned about the internal process of companies for responding to social issues such as environmental protection. He said the first stage in this process is a company's awareness of an issue—an awareness to which legal requirements contribute. The second stage is commitment to the issue, which is connected with the values of a company. The third is an effective way of implementing a company program to deal with the issue. Post said that he knew of no companies that had mounted an effective environmental program without a champion—someone in the company who maintained a personal commitment to environmental protection. However, he said, championship of such protection must be incorporated into the planning, evaluation, and reward processes of a company.

Post concluded his remarks with observations about the challenges surrounding voluntary actions in the environmental area. He said it is difficult for companies to take the financial risks involved in implementing these actions when there is scientific uncertainty about many environmental matters and when changes in technologies may revolutionize an industry over a short time. When the science is not clear, said Post, corporate managers do not know whether investments in voluntary actions can be justified. They are also concerned that these investments make sense from the perspective of technological progress in their industry.

Other challenges, said Post, are the capital requirements of voluntary programs, which limit how far companies can and should go with these programs, and the consequences of voluntary actions for domestic and international competitiveness. Post noted that U.S. firms are competing with companies and, in some instances, governments that are not playing by the same set of



Kirk Prouty Photography

Featured speakers at the RFF Council meeting included William Walsh, a consultant to Greenpeace, Michael Pierle, corporate vice president for environment, safety, and health at the Monsanto Company, and Linda J. Fisher, assistant administrator for the U.S. Environmental Protection Agency's Office of Pesticides and Toxic Substances.

environmental rules. Although voluntary actions may stimulate innovation, promote development, and create "first-mover" advantages, said Post, U.S. firms that undertake them may still be at a competitive disadvantage in an international context.

Linda J. Fisher, an assistant administrator for EPA's Office of Pesticides and Toxic Substances, commented on the advantages of EPA's voluntary pollution reduction programs and the problems these programs pose to government and industry. Among the advantages, she said, are pledges by companies to conduct business in a totally new manner—that is, from an environmental perspective—and a commitment to extend their pollution prevention efforts to their overseas operations. An additional advantage of voluntary programs is that they often produce greater benefits than originally anticipated. As an example, Fisher cited EPA's "Green Lights" program, which tries to get corporations, among others, to install energy-efficient lighting. According to the agency's estimates, if all companies participated in this program where it was financially wise for them to do so, U.S. energy consumption could be reduced by about 10 percent. Fisher notes that this reduction is probably greater than the reduction that could be achieved by a number of regulatory programs.

According to Fisher, there are several reasons why corporate America is voluntarily undertaking pollution reduction programs in the 1990s. First, communities are playing a larger role in the daily lives of corporations as a result of a 1986 law that requires companies to report their emissions of a variety of pollutants on a plant-by-plant basis in locations throughout the United States. Communities' knowledge of pollutant emissions, said Fisher, has made voluntary programs more desirable as corporations strive to show communities that they are good citizens. Second, the costs of complying with environmental laws are skyrocketing. Voluntary programs are often a less costly way for corporations to deal with environmental protection. Third, consumers are concerned about the environmental implications of the products they buy and the facilities that produce them. This concern must be taken into account as corporations try to sell their products.

Kirk Prouty Photography

At the RFF Council meeting, Linda J. Fisher of the U. S. Environmental Protection Agency's Office of Pesticides and Toxic Substances spoke about some of the advantages of corporations' voluntary pollution reduction programs and some of the barriers to their success.

Fisher outlined what EPA believes are some of the advantages of voluntary programs. One advantage, she said, is that such programs can often be more comprehensive in their approach than EPA programs. Another is that a company can voluntarily change its behavior more quickly than EPA can implement a law. Yet another is that voluntary programs can often achieve better environmental protection than regulatory programs and do so more cost-effectively. Fisher noted that EPA has often seemed to view programs that do not cost and hurt a lot as accomplishing little in the way of environmental protection. However, she said, the success of voluntary pollution reduction has started to show the agency that pain does not necessarily translate into environmental gain.

There are potential barriers to the success of voluntary programs, Fisher reported. From EPA's perspective, one is that these programs may not measure up to regulatory programs in terms of stating goals, gauging whether goals have been met, and sustaining achievements. Another barrier is the lack of openness, at times, of corporations and government to a change in their roles as regards environmental protection. EPA must begin to deal with consumer behavior, and corporations must become leaders in the environmental arena. Yet another barrier, Fisher noted, is that unlike traditional regulatory programs in which fines are an incentive for compliance, voluntary programs must rely on favorable publicity or other incentives to induce corporate participation.

In her remarks on why corporations are initiating voluntary pollution reduction programs, Joan Z. Bernstein, vice president for environmental policy and ethical standards at Waste Management Incorporated, noted that U.S. companies have come to realize that the public does not consider them to be good environmental stewards. As a result, these companies have felt the need to devise their own programs for achieving environmental goals—programs, they believe, that are successful in part

because of the absence of regulatory constraints.

Michael Pierle, corporate vice president for environment, safety, and health at the Monsanto Company, spoke about the roles of various economic sectors in making voluntary programs sustainable in the United States and abroad. He noted the importance of promoting environmental values among people in the workplace, but said employees often distrust compliance requirements, which can be highly proscriptive and nonsensical from a business perspective. To get cooperation in creating voluntary programs that make good business sense, said Pierle, it is important to reenforce and reward employees' sense that environmental protection is an intrinsic value and not an imperative handed down by regulatory agencies and upper management.

Pierle also noted the role of consumers in promoting environmental values. If consumers demand environmentally friendly products and production processes, he said, they will help sustain environmental protection efforts, even at some cost to themselves.

Government can also play a role in fostering an environmental ethic. If it is willing to move away from a command-and-control system and instead work closely with people to bring about change, said Pierle, the public will be more receptive to and supportive of pollution prevention efforts.

William Walsh, a consultant to Greenpeace's atmospheric and energy program, offered some contrasting views on voluntary efforts to protect the environment. He rejected EPA's efforts, under the Bush administration, to rely less on traditional regulation and more on encouraging voluntary efforts by business. He said these efforts are bad public policy and an abdication of governmental responsibility.

Walsh noted several problems with voluntary efforts. One, he said, is the short-term economic advantage over competitors that some businesses can gain by not investing in such efforts. Another is that many corporate pollution prevention initiatives are aimed at garnering good public relations rather than achieving true progress. Some initiatives address public perceptions that a company is not environmentally responsible, but do not necessarily result in real gains in environmental protection, particularly where overseas operations are involved. Although so-called right-to-know laws have compelled companies to disclose data on their pollutant emissions in the United States, Walsh said, they are not designed to compel disclosure of data on these emissions from their overseas facilities. Other problems with voluntary pollution reduction programs, said Walsh, are that they are not likely to be targeted at the production or use of substances that have particularly adverse effects on the environment, and that they lack objective measurements of success.

There is also a problem of institutional inertia and resistance in U.S. industry itself, said Walsh. He noted that if the United States is really losing its edge in steel production, automobile production, and other areas, it is unlikely that American business as a whole will change the way it thinks about the environmental impacts of its activities. In support of this statement, Walsh cited the lack of response by businesses to a 1985 report by the Office of Technology Assessment, which estimated that 50 percent of the hazardous waste currently produced could be reduced virtually immediately with minor housekeeping changes and minor investments in production changes. If the benefits of these changes and investments—less economic waste and greater productivity and competitiveness—have not induced waste reduction thus far, Walsh wondered, is it reasonable to expect that a further emphasis on voluntarism would do so?

When businesses are serious about something, said Walsh, they do not rely on voluntarism to achieve it. Companies do not ask their vendors to voluntarily increase the quality of their supplies; they demand increased quali-

Kirk Prouty Photography

In his remarks to the RFF Council, William Walsh, a consultant to Greenpeace's atmospheric and energy program, said that voluntary pollution prevention as a matter of public policy will not truly protect the environment.

ty or find a better vendor. This suggests that, if the country is seriously concerned about environmental protection, there must be well-defined protection objectives and enforced compliance.

Walsh maintained that the voluntary approach to environmental problems is fundamentally anti-democratic because, in his view, questions about materials use and technology advancement ought to be up for public discussion. If the focus is on a voluntary ethic rather than on the establishment of clearly enunciated and enforceable goals, with time tables for meeting these goals, public participation will be largely removed. Voluntary pollution prevention as a matter of public policy, said Walsh, will not truly protect the environment. If a consensus on global environmental issues such as ozone depletion and climate change cannot be reached in this country, he asked, how is the United States going to deal with the voluntary environmental protection efforts of other nations that have different agendas and that are at different stages of development? The limitations of voluntarism, said Walsh, are too great to make it our public policy. Instead, he suggested, the pollution prevention ethic must be institutionalized within the federal regulatory system.

Kirk Prouty Photography

Gilbert F. White fellows selected

Resources for the Future has awarded Gilbert F. White postdoctoral fellowships for the 1992–1993 academic year to Charles W. Abdalla and Stephen W. Salant. Abdalla, an associate professor in the Department of Agricultural Economics at Pennsylvania State University, will be conducting research on policies to reduce agricultural runoff in the Chesapeake Bay region. Salant, a professor of economics at the University of Michigan, will continue his research on the management of nonrenewable resources.

RFF awards $90,000 in grants

Resources for the Future has awarded $90,000 in research grants to individuals at four universities and one college. The awards were made through the RFF Small Grants Program, which provides financial support to researchers at universities and other nonprofit institutions in the United States and abroad to study issues related to the environment, natural resources, and energy.

This year RFF awarded grants to the following individuals for research on the subjects indicated:

• Richard L. Hall, University of Michigan: Private Groups, Public Lobbies, and Constituency Interests: Mobilizing Bias in Environmental and Energy Policy Making.

• Thomas M. Selden, Syracuse University: Air Pollution and Development: Carbon Dioxide and Chlorofluorocarbons.

• James S. Shortle, Pennsylvania State University: Public Policies to Facilitate Sustained Growth with Protection of Natural Resources and the Environment in Costa Rica.

• James L. Smith and Dan Levin, University of Houston: Experimental and Empirical Research on Auctions with Entry.

Discussion papers

RFF discussion papers convey the preliminary findings of research projects for the purpose of critical comment and evaluation. Unedited and unreviewed, they are available at modest cost to interested members of the research and policy communities. Price includes postage and handling. Prepayment is required. To order discussion papers, please send a written request, accompanied by a check, to Discussion Papers, External Affairs, Resources for the Future, 1616 P Street, N.W., Washington, D.C. 20036-1400.

The following papers have recently been released.

Center for Risk Management

• "Public Preferences for Life Saving," by Maureen L. Cropper, Sema K. Aydede, and Paul R. Portney. (CRM92-01) Free

• "Acts of God and Acts of Man: Recent Trends in Natural Disasters and Major Industrial Accidents," by Theodore S. Glickman, Dominic Golding, and Emily D. Silverman. (CRM92-02) Free

Energy and Natural Resources Division

• "Political Structure and Global Resource Use: A Typology," by Peter M. Morrisette. (ENR92-04) $5.00

• "An Assessment of Energy Security Externalities," by Michael A. Toman. (ENR92-05) $5.00

• "The Limits of Economic Instruments for International Greenhouse Gas Control," by Michael A. Toman and Stephen M. Gardiner. (ENR92-06) $5.00

• "Contracting Incentives in Electricity Generation Fuel Markets," by Karen L. Palmer, Peter Fox-Penner, R. David Simpson, and Michael A. Toman, with assistance from Gayle Killam. (ENR92-07) $5.00

• "Controlling Irrigation Return Flows," by Kenneth D. Frederick. (ENR92-08) $5.00

• "Perspectives on Global Climate Change: A Review of the Adaptation and Mitigation Approaches," by Peter M. Morrisette. (ENR 92-09) $5.00

• "Federalism and Offshore Oil Leasing," by Margaret A. Walls. (ENR92-10) $5.00

• "Transactional Arrangements and the Commercialization of Tropical Biodiversity," by R. David Simpson. (ENR 92-11) $5.00

• "Sea-Level Rise and Coastal Management Policies in the United States," by Benjamin Noble. (ENR92-12) $5.00

National Center for Food and Agricultural Policy

• "Economic Effects of Removing U.S. Dairy and Sugar Import Quotas," by Steven A. Neff and Timothy E. Josling. (FAP92-01) $3.00

• "Policy Errors: Wrong Assumptions, Unexpected Events, and Policy Responses," by George E. Rossmiller, Dale E. Hathaway, and Alvaro Umana. (FAP92-02) $3.00

Quality of the Environment Division

• "Can Hedonic Models Value Air Quality? A Meta Analysis," by V. Kerry Smith and Ju Chin Huang. (QE92-06) $2.25

• "Measuring Use and Nonuse Values for Landscape Amenities: A Contingent Behavior Analysis of Gypsy Moth Control," by Paul Jakus and V. Kerry Smith. (QE92-07) $2.25

• "Economic Incentives for Environmental Protection: Integrating Theory and Practice," by Robert W. Hahn and Robert N. Stavins. (QE92-08) $2.25

• "Vehicle Emissions, Urban Smog, and Clean Air Policy," by Alan J. Krupnick. (QE92-09) $2.25

• "Ethical Motivations and Nonuse Value," by Raymond J. Kopp. (QE92-10) $2.25

• "Welfare Maximization in Economic Theory: Another Viewpoint," by Shmuel Amir. (QE92-11) $2.25

• "Nonmarket Valuation of Environmental Resources: An Interpretative Appraisal," by V. Kerry Smith. (QE92-12) $2.25

• "Strategic Planning for Urban Environmental Quality Management in Asia: An Economic Framework for Analysis," by Walter O. Spofford, Jr. (QE92-13) $2.25

• "Accounting for Environmental Costs in Electric Utility Resource Supply Planning," by A. Myrick Freeman III, Dallas Burtraw, Winston Harrington, and Alan J. Krupnick. (QE92-14) $2.25

• "The Social Costs of Electricity: How Much of the Camel to Let into the Tent?" by Dallas Burtraw and Alan J. Krupnick. (QE92-15) $2.25

• "Welfare Effects, Omitted Variables, and the Extent of the Market," by V. Kerry Smith. (QE92-16) $2.25

• "The Environmental Cost of Sustainable Welfare," by Shmuel Amir. (QE92-17) $2.25

• "Cost-Effectiveness of Enhanced Motor Vehicle Inspection and Maintenance Programs," by Virginia McConnell and Winston Harrington. (QE92-18) $2.25

• "Social Costing of Electricity and the Benefits of Demand-Side Management," by Karen L. Palmer. (QE92-19) $2.25

Recent contributions and grants

Resources for the Future has recently received corporate contributions from the following corporations and corporate foundations: ARCO Chemical Company; ARCO Foundation; Agway Foundation; American Petroleum Institute; ASARCO Incorporated; Ashland Oil, Inc.; BHP Minerals International; Browning-Ferris Industries, Inc.; CF Industries, Inc.; Chevron Corporation; CIBA-GEIGY Corporation, Agricultural Division; Consolidated Edison Company of New York, Inc.; Dominion Resources; DowElanco; The Duke Power Company Foundation; EG&G, Inc.; Electric Power Research Institute; Enron Corporation; Exxon Corporation; Ford Motor Company Fund; Georgia-Pacific Corporation; Hershey Foods Corporation; IBM; ICI Americas Inc.; The Mead Corporation; The Merck Company Foundation; Mitchell Energy & Development Corp.; Monsanto Company; Ocean Spray Cranberries, Inc.; Olin Corporation Charitable Trust; Pacific Gas and Electric Company; Pioneer Hi-Bred International, Inc.; Potlatch Foundation II; Rhone-Poulenc Ag Company; Southern California Gas Company; Stone & Webster Engineering Corporation; Syntex Corporation; Texaco Foundation; Union Camp Corporation Charitable Trust; Union Carbide Corporation; Westvaco Corporation; Weyerhaeuser Company Foundation; and Wisconsin Electric Power Company.

Matching gifts were provided by Citibank and GE Foundation. In addition, The G. Unger Vetlesen Foundation awarded a $50,000 grant to the Climate Resources Program of the Energy and Natural Resources Division, and The Pew Charitable Trusts awarded a $350,000 matching grant to the Center for Risk Management in support of the center's Rational Risk Reduction Program.

New report

Assigning Liability for Superfund Cleanups: An Analysis of Policy Options, by Katherine N. Probst and Paul R. Portney

Implementing the Superfund law, which comes up for reauthorization in 1993, has been a challenge for the U.S. Environmental Protection Agency (EPA). Potentially responsible parties (PRPs) are frequently unwilling to enter into voluntary agreements to clean up contaminated sites because, under joint and several liability, any one firm willing to shoulder its part of a cleanup could end up footing the bill for the entire operation. In addition, many firms resent the imposition, with the passage of Superfund in 1980, of retroactive liability for waste disposal actions that were legal when they were carried out.

Probst and Portney analyze the pros and cons of the current liability scheme and four alternatives to it. These alternatives include using the Superfund Trust Fund to finance the "orphan share" of cleanups (in cases where a responsible party is not financially viable or cannot be identified, thus freeing a participating firm from liability for damages it has not directly caused); releasing PRPs from liability at all closed landfills where municipal and industrial wastes were co-disposed; releasing PRPs from liability at sites that closed before 1981; and creating a program for Superfund to finance entirely the cleanup of all sites now on EPA's National Priorities List.

The authors conclude that the site cleanup process could be expedited by changing Superfund's liability standards, but that it could also be speeded up under the current system. They find that transactions costs could be reduced through modification of Superfund liability, but that relaxing Superfund's liability standards would have some adverse effects. They also conclude that any of the alternatives that they consider as possible modifications to the present liability standards will create at least some new inequities, even as they ameliorate others, and that much better data are needed to assess the financial implications of the present liability standards as well as any proposed alternatives to them.

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Former, current RFF board members receive awards

Henry R. Linden, a member of the board of directors of Resources for the Future, has received the Homer H. Lowry Award for Excellence in Fossil Energy Research. Linden is the third recipient of the award, which is given annually by the U. S. Department of Energy to an individual judged to have made notable scientific contributions to oil, coal, or natural gas technologies. The founding president of the Gas Research Institute, Linden is recognized worldwide as an expert in natural gas and synthetic gaseous fuels technologies. Currently, he is the Max McGraw Professor of Energy and Power Engineering and Management at the Illinois Institute of Technology and director of the institute's Energy and Power Center.

Robert M. White, a member of the RFF Corporation and of the advisory council for RFF's Center for Risk Management, has been awarded the Tyler Prize for Environmental Achievement, one of the most prestigious prizes of its kind, by the University of Southern California. White is currently president of the National Academy of Engineering. He was a member of the RFF board of directors from 1980 to 1989.

About contributions to RFF

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