Redistributing Risk

Chris Whipple

HEALTH OR SAFETY regulation can reduce risk. Or it can simply *transfer* risk from one technology to the next, or from one risk bearer to another. We ban some substances or technologies or practices on grounds of risk, only to see less desirable and, in many cases, more hazardous alternatives chosen. When we eliminate one risk, another springs up in its place. William Havender has noted, for example, that the leading alternatives to the pesticide EDB may not be any safer than EDB and have not been studied to the same degree.

No one knows how prevalent such cases are. Certainly many, if not most, actions taken to reduce health and safety risks do their job without provoking conspicuous risk shifts. But if unanticipated risk substitutions are common in cases where the stakes and public visibility are high, they are likely to be more common in cases that receive little analytical or public attention.

Here I describe the many ways in which risk shifts occur. Some of them are indirect and easy to overlook. Greater awareness of the nature of these shifts may encourage analysts to anticipate them, and may eventually lead to risk management approaches which avoid the myopia that now seems so widespread.

Chris Whipple is technical manager of the Energy Study Center, Electric Power Research Institute, Palo Alto, California, and a past president of the Society of Risk Analysis. The views here are his own.

Direct Substitutes

Regulators often seem to assume that, as Peter Huber puts it, "new products and processes generally add to the risk burden of our environment." In fact, he correctly points out, "most new products do not 'add to,' they 'substitute for.' " The process can be seen at work in such major human endeavors as the provision of energy, transportation, and food. In the energy area, for example, new power plants are built to more stringent standards and are usually lo-

cated at more remote sites than old plants. When a new coal or nuclear plant begins operation, it displaces the power (and risk) produced by older, more polluting plants. Richard Wilson of Harvard analyzed this phenomenon and concluded in 1979 that new electricity sources offer net health *benefits*. Yet the conclusion—or even the *possibility* of such a conclusion—is rarely reflected in current regulatory decisions governing coal or nuclear power. New plants are stalled for years over risk issues that are small compared with the existing risks in the supply system that the new plants could displace. And so, after a decade of vigorous regulation and ambitious research into the health impacts of energy alternatives, the irony is that the most hazardous fuel by virtually all accounts, firewood, is among the fuels now experiencing the most rapid growth.

... after a decade of vigorous regulation and ambitious research into the health impacts of energy alternatives, the irony is that the most hazardous fuel by virtually all accounts, firewood, is among the fuels now experiencing the most rapid growth.

Another energy choice with risk implications is posed by weatherstripping, which reduces the hazards associated with energy use, but increases the hazards of indoor air pollution—specifically, radon gas. Henry Hurwitz, Jr., reports that if the conventional assumptions used in energy risk analysis are applied to indoor radon, a 20 percent reduction in air infiltration would appear to produce an added lifetime lung-cancer risk on the order of 200 cases per million people exposed. As energy risks go, this is substantial. Similarly, though there is dispute over how risky it is to use an unvented kerosene heater in a tightly insulated house, it seems logical to suspect that the risk exceeds that of smoke from a distant power plant. While indoor pollution is now getting some regulatory attention, such risks were not considered in the energy policy deliberations that led the government to promote conservation and alternative energy sources. Congress, in assigning responsibility for nuclear power regulation to the Nuclear Regulatory Commission and for coal to the Environmental Protection Agency, has created a regulatory structure that discourages these agencies from basing government policy on energy risks considered in total.

Cyclamate and saccharin offer another textbook example of the hazards of looking at risks one at a time. The absolute degree of human risk posed by these substances is not known, but high-dose animal tests seem to show more danger from saccharin than from cyclamate. Based on these animal tests, Canada has banned saccharin but kept cyclamate legal. So how did the United States manage to do the reverse? Perhaps by considering the two substances separately, several years apart, rather than considering artificial sweeteners in general. The case for comparing the risks from sweeteners, especially given the clear public and congressional demand for a low-calorie sweetener, seems overwhelming. But the Food and Drug Administration (FDA) operates under the legal assumption that carcinogenic risks in the food supply from food additives should be eliminated, not compared.

Cures Worse Than Diseases

Sometimes the source of new risk is not the substitute for a hazardous product but the very measures taken to make that product less hazardous. Here the classic example is TRIS, the fire-retardant chemical. Back in the early 1970s, the Consumer Product Safety Commission hurriedly adopted a rule requiring manufacturers to treat children's pajamas with the chemical. Only some five years later, well after the rule had been implemented, did concern shift to the potential cancer risk from absorbing TRIS through the skin. Similarly, the 1976 swine flu vaccination program, which caused numerous cases of Guillain-Barré syndrome, now appears to have been harmful on balance.

These decisions look bad in hindsight. Yet at the time they were made, the risks of waiting for more analysis undoubtedly seemed worse than those of going ahead. But there are other cases in which the foreseeable risks of a safety measure are apparently being ignored. For example, farmers are developing pest-resistant crop strains in order to avoid the regulatory

problems and publicly perceived risks with pesticides. But, according to biochemist Bruce Ames, these strains are high in natural toxins which often produce positive results in mutagenicity tests and in other tests deemed relevant to human risk identification; moreover, natural toxins are typically several percent of the dry weight of a plant and *must* be consumed, whereas pesticides are present only in trace amounts and can generally be washed off.

Another situation, studied by Lester Lave in 1983, involves the proposal of the National Highway Transportation Safety Administration (NHTSA) to recall middle-sized GM cars (A-cars) for inspection and, if needed, replacement of defective axle buttons. By Lave's analysis, the risk to the owner of such a car from a failure of this particular part over the car's useful life would have been less than a tenth of the risk from driving a few miles; in other words, the risk of driving to and from the GM dealer for the recall inspection would have significantly exceeded the risk that would have occurred without the recall. Obviously, the risk was trivial. And happily good sense prevailed in this case. After delaying its decision for almost two years (in which the accident experience of these autos was found to conform to GM's prediction), NHTSA agreed with GM to recall only cars whose axles came from GM's Buffalo plant (a high-defect group).

Diseases Worse Than Cures

Some safety measures, on the other hand, do generally reduce risk—but are unjustifiably attacked because they present a lesser risk of their own. We have all known people who explain their failure to use seat belts by arguing that it is sometimes safer not to be buckled in. Often the argument is accompanied by a vivid description of accidents where the driver was thrown clear or was able to escape from a burning or submerged car. Undoubtedly there *are* cases in which safety measures adversely contribute to the probability of accident or the seriousness of its consequences. But the appropriate focus here is the *net* effect of a safety measure. Seat belts clearly do provide a net safety benefit, even though they occasionally do harm. Most people would regard a ban on seat belts, based on occasional adverse events and in disregard of their safety benefits, as stupidity of high order.

Why, then, do we accept comparable actions in other contexts? When the FDA proposed to ban sodium nitrite, the debate initially

Most people would regard a ban on seat belts, based on occasional adverse events and in disregard of their safety benefits, as stupidity of high order.... Why, then, do we accept comparable actions in other contexts?

stressed the weak evidence for sodium nitrite's carcinogenicity as well as the aesthetics of gray meat, rather than the strong evidence that the chemical prevents botulism. Net risk was ignored. Currently, scientists are studying several compounds produced when water is chlorinated, and the public is being told of carcinogens in the drinking water. Often overlooked is the fact that chlorine is added in the first place to disinfect the water and protect the public health. Manufacturers are becoming unwilling, for reasons of liability and licensing cost, to produce vaccines and other drugs that entail a small probability of adverse side effects—for example, pertussis (whooping cough) vaccine. Yet it is clear beyond dispute that many of these products offer net public health benefits.

"Life might have been more risky, but it was cheerier with the old, bright food colors."

At the risk of drawing too strong an inference from a few cases, let me suggest that the degree to which net risks are considered depends on the perceived risk of going without the safety measure. Driving without seat belts is a risk we all know about, but botulism and whooping cough are no longer perceived to be serious threats. The irony is that the perception is accurate—but only because we do use the nitrites and vaccines that are now being attacked as unacceptably dangerous.

Occupational Risk Transfers

So far my examples have been limited to the alternative risks faced by the consumer. Each risk that is eliminated seems to give rise to a new risk that may partially or entirely offset the anticipated safety gain. But there is another type of risk transfer that involves a shift of risk between individuals. Here we learn that increasing one person's safety often reduces another's.

It is conventional wisdom that reducing public risk is never free. It is less often recognized that reducing *public* risk often means creating *occupational* risk. An example from the French nuclear power program provides a perfect illustration. In 1981, Jacques Lombard and Francis Fagnani analyzed the trade-offs between public and occupational protection involved in selecting systems to control liquid and gaseous effluents during normal operations of nuclear power plants. Nine systems were analyzed, six of which are used in French reactors. In eight of the nine, the installers or monitors of the control system suffered a radiation dose that exceeded the reduction in the public radiation dose—in two cases, by a ratio of 400 to 1.

There is nothing inherently wrong with taking such safety measures. After all, occupational risk and public risk occur under markedly different conditions of information, consent, and compensation. Whether the value system implicit in this decision is appropriate is an interesting political question. But what is relevant here is that these occupational risks exist, and are likely to exist whenever someone says "go make things safer." If we tell the owners of city buildings to reinforce their masonry so that bricks do not fall on passersby, workers may be killed in falls from scaffolding.

A generalized analysis of occupational risk transfers was made in 1979 by researchers on a joint risk-assessment project of the International Atomic Energy Agency and the International Institute for Applied Systems Analysis. The authors, Stuart Black and Friedrich Niehaus, examined the safety of workers who were producing safety equipment and concluded that "total risk cannot be reduced beyond any given limit." They continued:

> At a certain point the occupational and public risk of producing safety equipment becomes higher than the reduction achieved in an existing risk. Based on data from the Federal Republic of Germany it has been estimated that 1 equivalent death or 6000 equivalent lost man-days are caused during the construction and installation of safety equipment costing about $33 million. Thus, expenditures on safety at marginal costs of risk reduction higher than $33 million per equivalent life saved would actually lead to an increase in risk. One might conclude that it had been made "too" safe. Furthermore, this expenditure implies that 1400 man-years of effort [the labor that $33 million buys] per equivalent life have been used for no net gain in safety.

Clearly, one can make an argument against paying huge sums per unit of risk reduction simply on grounds of risk itself. It seems ridiculous to spend $33 million (or whatever the appropriate number for the U.S. situation would be) to shift a fatality or disabling injury from one individual to another. But that is what we do when we look at risks too narrowly and apply risk criteria that are too conservative.

It seems ridiculous to spend $33 million ... to shift a fatality or disabling injury from one individual to another. But that is what we do when we look at risks too narrowly and apply risk criteria that are too conservative.

Cures That Aggravate Diseases

Another form of risk substitution consists of changes in human behavior in response to regulation. For example, as bicycles became increasingly popular in the 1970s, bicycle acci-

dents—as well as measures for reducing the accidents—increased. The problem prompted four authors at the University of California at Santa Barbara to launch a study in which they correlated year-to-year accident trends with five engineering steps used to improve bike safety—more and wider bikeways, bicycle traffic circles, bike-free zones where many accidents had occurred, and so on. The results suggested that the engineering steps had predominantly *increased,* not decreased, accidents. The apparently surprised analysts searched for possible reasons.

> It is hard to immediately know what to make of this finding. Perhaps the roundabout directly made bike riding more hazardous or, alternatively, bike riders took advantage of the improved traffic flow to increase their speed. The latter is the interpretation apparently favored by University engineers.

One can find many other examples of this phenomenon of offsetting behavior. Noting that the fatality rate from tractor accidents was roughly constant from 1920 to the late 1960s in spite of many engineering improvements, Chauncey Starr speculated in 1971:

> This situation might indicate that the risk arises from the mode of use of the tractor, rather than inadequate machine design. In view of the highly variable terrain, and types of operation in which tractors are used, it is likely that the individual fatality risk level is established by the individual operator as acceptable to him.

In a quite different area W. Kip Viscusi has discovered another version of the phenomenon—an apparent correlation between child-resistant packages and an increase in accidental poisonings. It is likely, he says, that "consumers have been lulled into a less safety-conscious mode of behavior by the existence of safety caps." And Gilbert White's classic study of natural hazards found that a massive program to reduce flood losses by building dams had encouraged people to settle on flood plains. The dams offered protection most of the time, but infrequent floods caused more extensive damage than had occurred before the program was undertaken. In other words, a high-probability, low-consequence risk of many smaller floods was replaced by a low-probability, high-consequence risk of a few big ones.

The cases described here can be generalized simply enough: safety measures can reduce the incentive to act safely. Sam Peltzman shook up the automobile safety community in 1975 when he published an analysis finding that the health benefits of auto safety devices were illusory—that, instead, reductions in driver fatalities had been virtually offset by increased pedestrian deaths and nonfatal accidents. While these results are disputed, the principle has undoubtedly affected the thinking of risk regulators. The emphasis has shifted from engineered safety features to tighter social control of driver behavior. Recent safety gains have come from tougher enforcement of drunk driving laws, maintenance of the 55 mph speed limit, and, in several states, mandatory use of seat belts. Perhaps the upsurge in popularity of high-performance cars indicates that many drivers now feel safe enough. If Peltzman is even roughly correct, the nation's bicyclists and pedestrians would be well advised to take cover.

... a massive program to reduce flood losses by building dams had encouraged people to settle on flood plains. The dams offered protection most of the time, but infrequent floods caused more extensive damage than had occurred before the program was undertaken.

The Health Benefits of a Material World

It is now understood that resources used for risk control are unavailable for other social purposes. It is less often appreciated that the public health is sensitive to income and economic growth. In our risk analyses we account for the direct health benefits that risk-reducing investments provide, but we do not generally consider the health benefits that would occur if these resources were simply used to increase per capita income. Yet the links between economic well-being and health have long been known, even if the mechanisms that drive this relation (medical care, diet, shelter, and other material standards) are not fully understood by expert observers.

A brief digression on the amazing rate of increase in life expectancy is in order. As of 1983, U.S. life expectancy at age thirty-five has increased by 0.6 years since 1980, by 2.8 years since 1970, 3.4 years since 1960, 4.6 years since 1950, and 10 years since 1900.* The first thing one notes is that, contrary to conventional wisdom, life expectancy gains are not slowing down, but are actually increasing. Recent increases have been about 0.2 years a year, whereas the 1950–83 rate of increase was 0.14 years a year and the 1900–1950 rate was 0.11 years a year. This acceleration is also observed for life expectancy at age forty-five and sixty-five and, since 1970, at age twenty-five. For a perspective on these numbers, note that the longevity gain between 1980 and 1983 was slightly greater than that which would occur by the permanent elimination of all motor vehicle accidents.

... the links between economic well-being and health have long been known, even if the mechanisms that drive this relation ... are not fully understood.

What part of this longevity gain results from income growth? Since we do not understand the origin of the gains, we cannot estimate the health benefits of income growth with great confidence. Nevertheless, a few analyses have been made. Samuel Preston estimates that, between 1938 and 1963, about 16 percent of the gain for the world as a whole came from increases in per capita national income. He cautions that this estimate is highly uncertain, especially for the poorest countries; confusing the issue is the fact that, worldwide, life expectancy is increasing at a rapid rate, but only a small part of the increase can be explained by economic factors. Nevertheless, applying Preston's rough estimate of 16 percent to the 1970–83 gain of 2.8 years, the answer to my question is slightly less than half a year. The figure would be higher for those under age thirty-five, lower for those over thirty-five. In terms of mortality, a life expectancy gain of slightly less than half a year converts to roughly 50,000 fewer deaths a year in the United States.** M. Harvey Brenner estimated that the 3 percent decline in the real per capita income trend in the 1973–74 recession produced 59,996 excess mortalities.

While I emphasize the imprecision of these estimates, they do suggest that the influence of economic changes on health is substantial. Just because we cannot measure economy-related health effects precisely does not mean they are unimportant. And certainly the evidence here, given a plausible relationship and significant effect in a large population sample, is better than that for many risks now regulated. Fuller details of the argument have been developed by Brenner and Aaron Wildavsky.

Given that even the simple, direct risk substitutions described above so often fall into cracks in the regulatory structure, it should come as no surprise that the health impacts from the economic consequences of regulatory decisions are routinely ignored. As we have seen, safety requirements often shift risks to workers who make safety equipment. It is also clear that safety investments use resources that would otherwise be used to increase income, and that even small income changes are associated with health changes that may be larger than the risks of concern. While it may be politically attractive in some quarters to portray our industrial economy as sustained only by the toleration of large public or occupational hazards, the evidence is that in the aggregate economic growth *extends* life.

Misdirected Incentives

My focus so far has been risk shifts arising from administrative regulation, but that is only one of several approaches to risk control. Nonadministrative approaches to risk management—for example, insurance, common law, and self-management—often operate through incentives. And when these nonadministrative sys-

*These data are from the Metropolitan Life Insurance Company *Statistical Bulletin,* July–September 1984. Life expectancy at age thirty-five instead of at birth was chosen to avoid longevity gains due to decreases in infant mortality not related to the risk issues described here.

**Richard Schwing found that longevity changes in years correspond to roughly 0.02 times the annual death rate per 100,000 population ("Risks in Perspective—Longevity as an Alternative to 'Lives Saved,'" General Motors Research Publication GMR-2133, February 26, 1976).

tems ignore risk transfers, they are likely to misdirect incentives.

When property is insured, the owner's incentive to protect it from harm is reduced. Collectively, this insurance incentive increases loss; the term for this is moral hazard. Socially, we accept this situation because we believe that the added losses are small, and the benefits of risk-spreading through insurance large. But, because incentives are important, insurance companies generally do not insure property for its full value. Deductible amounts provide at least some of the correct incentive.

Tort law provides an incentive to carefully manage risks we create for others. But the first rule is "do no direct harm." Taking a hypothetical case, consider a vaccine that saves a hundred lives while causing two deaths. If no alternative treatment were available, this vaccine would seem to be worth having, since it saves on balance ninety-eight lives a year. In today's legal environment, however, it appears likely that compensation—quite possibly including *punitive* damages—would be paid to the estates of the two people killed. To the extent that these deaths were foreseeable, the liability might be sufficiently large to discourage production of the vaccine. As desirable as it may be to socialize the risk of adverse reactions to a vaccine, the incentives seem misplaced if liability for risk precludes a risk reduction. There is, moreover, an asymmetry here, in that the risk that is present without the vaccine is not socialized.

As desirable as it may be to socialize the risk of adverse reactions to a vaccine, the incentives seem misplaced if liability for risk precludes a risk reduction. There is, moreover, an asymmetry here, in that the risk that is present without the vaccine is not socialized.

Some argue that such liability creates an important incentive to reduce risks, even those of risk-reducing products. This may be true for established products, but the liability also provides a powerful disincentive to those who would develop new risk-reducing products. Here a regulatory approach seems preferable to liability. As safer products are developed, approvals for older, more hazardous ones could be withdrawn.

Self-management of risk depends on accurate information about what is risky. But a series of articles published in 1981 illustrates that even medical experts can fail to recognize a risk transfer, and even with a well-studied risk (*American Journal of Epidemiology*, vol. 114, no. 1). Separate studies of populations of Japanese-Americans in Hawaii, Yugoslavs, Puerto Ricans, and Americans found a correlation between *lower* blood cholesterol levels and *higher* cancer incidence. The studies suggest that a low cholesterol level poses as much risk of cancer as a high level poses of heart disease, a finding that one would be hard pressed to find reflected in either the professional or popular literature regarding the risks from cholesterol. Undoubtedly, many people with low blood cholesterol now avoid cholesterol-rich foods. As is common with epidemiological studies, the studies raise more questions than they answer, and there is by no means a consensus on the implications among epidemiologists. But the findings did prompt the late distinguished epidemiologist Abraham Lilienfeld to write: "These data . . . provide a lesson for epidemiologists. . . . [and] clearly indicate that we should not become so specialized in our research endeavors with respect to one disease entity that other entities are ignored."

Regulatory Externalities

Just as it is no longer acceptable for industry to ignore externalities, it is equally inappropriate for risk managers, including regulators, judges, doctors, and others, to ignore the consequences of their actions. Under narrowly considered risk decisions, risk transfers are a type of externality. One means of detecting and perhaps reducing the incidence of unanticipated risk transfers is for risk and policy analysts to be aware of the systemic factors, described here, that frequently give rise to these effects. Full disclosure of transfers by risk assessors and regulators should be the goal; and, wherever legally feasible, a net risk point of view should be taken in interpreting congressional intent in risk legislation.

A net risk perspective offers obvious public health benefits. In some cases this perspective may also avoid political conflicts about regulatory decisions. As examples given here have indicated, some decisions not to regulate a small risk can be defended on risk grounds alone. When this is possible, the regulator avoids the complex value-based arguments familiar in cost-benefit debates.

Regulators should also take care to understand that traditional practices that tempt them to put their thumb on one side of the risk scales, such as the tendency to overemphasize distinctions between old and new risk or natural and man-made risk, will generally lead to greater loss of life than will policies that are insensitive to the origin of the risk. Our values toward risk need not be neutral in these and other qualitative dimensions, but we should understand that aversion to risks with undesirable qualities can lead to risk-increasing transfers. This happens when people who are afraid to fly travel by automobile.

... the tendency to overemphasize distinctions between old and new risk or natural and man-made risk ... will generally lead to greater loss of life than will policies that are insensitive to the origin of risk.

Likewise, one frequently encounters the attitude that "conservatism" in the analysis of uncertain risks is the best way to protect the public. But this is not true when risk transfers are likely. Adopting "worst-case" assumptions about a substance or technology can amount in practice to adopting "best-case" assumptions about a substitute that may in fact be worse. At the very least, such an approach diverts resources from more beneficial ends.

Finally, a degree of modesty would be welcome in targeting small risks involving complex processes where unknown risk transfers can easily swamp the intended result. Two major sources of risk transfer—occupational risk transfer and the risk effects of slowing down economic growth—are apparently of special importance in the case of small, diffuse risks that are expensive to eliminate. Indeed, it may be that case-by-case elimination of small risks not only is less cost-effective in health terms than are measures to improve economic growth, but at times actually can conflict with those measures.

Looking for risk transfers would appear, at first glance, to further complicate the already complicated business of risk regulation, increasing the analytical burdens on agency staff and policy makers. But the stakes involved are high enough to make it worthwhile. When we recognize that it is often difficult to bring about a net risk reduction, let alone an improvement in social well-being, we will be better able to deal with the risks we face. ■

Selected Readings

Bruce Ames, "Dietary Carcinogens and Anticarcinogens," *Science,* September 23, 1983.

Stuart Black and Friedrich Niehaus, "How Safe is 'Too' Safe," *IAEA Bulletin,* vol. 22, no. 1 (1980).

M. Harvey Brenner, *Estimating the Effects of Economic Change on National Health and Well-Being,* U.S. Congress, Joint Economic Committee, June 15, 1984.

William Havender, "EDB and the Marigold Option," *Regulation,* January/February 1984.

Peter Huber, "Exorcists vs. Gatekeepers in Risk Regulation," *Regulation,* November/December 1983.

Henry Hurwitz, Jr., "The Indoor Radiological Problem in Perspective," *Risk Analysis,* March 1983.

Mark Johnson, Nancy Jurik, A. R. Kreb, and Terrence Rose, "The Wheels of Misfortune . . . ," *Evaluation Quarterly,* November 1978.

Lester Lave, Testimony at a NHTSA Statutory Hearing Regarding Initial Determination of Defect, May 4, 1983.

Jacques Lombard and Francis Fagnani, "Equity Aspects of Risk Management . . .," *Nuclear Safety,* September-October 1981.

Sam Peltzman, *Regulation of Automobile Safety,* American Enterprise Institute, 1975.

Samuel Preston, *Mortality Patterns in National Populations,* Academic Press, 1976.

Chauncey Starr, *Perspectives on Benefit-Risk Decision Making,* Colloquium Report, National Academy of Engineering, 1972.

W. Kip Viscusi, "Regulating Consumer Product Safety," American Enterprise Institute, 1984.

Gilbert F. White, *Human Adjustment to Flood,* University of Chicago Geography Department Research Paper #29, 1945.

Aaron Wildavsky, "Wealthier Is Healthier," *Regulation,* January/February 1980.

Richard Wilson, "The Environmental and Public Health Consequences of Replacement Electricity Supply," *Energy,* 4 (1979).