Applying Cost-Benefit Analysis to Past Decisions: Was Protecting the Environment Ever a Good Idea?

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Executive Summary

One of the most contentious issues in contemporary debates over environmental policy is whether regulators should use cost-benefit analysis in evaluating their decisions. Cost-benefit analysis requires that the costs and benefits of a proposed course of action (including benefits such as saving human lives and protecting human health) be quantified and then translated into dollar terms. Cost-benefit analysis of proposed regulations is said to be necessary in order to avoid adopting inefficient rules that would impose ruinous economic costs. Such analysis is also said, in theory, to be a neutral, objective method of evaluating policies, offering transparent judgments on the merits of a proposal.

Fans of cost-benefit analysis who argue that this technique is a neutral tool for evaluating public policies must be able to show that it is not simply a one-way street to deregulation. Thus, in evaluating their arguments, it is instructive to ask a simple question: if this analytical device had been applied in the 1970s and earlier, would it have endorsed the early successes of health and environmental regulation? Or would it have led to negative judgments wherever and whenever it was applied? The latter is the more accurate answer, with just a few exceptions, as we demonstrate in this report.

The first wave of modern environmental protection, beginning in the 1960s and 1970s, cleaned up the air and water, protected fragile ecosystems, and achieved great gains in public health – without reliance on cost-benefit analysis, and clearly without destroying the economy. Why can't we continue to make environmental policy this way? Advocates of cost-benefit analysis must believe that times have changed: perhaps past environmental policies have already hit all the easy targets, where the need for regulation was obvious; in the standard metaphor, all the low-hanging fruit might already have been picked.

If this were the case, then the environmental regulations of the past should easily pass a cost-benefit test. If today's methods of cost-benefit analysis had been applied in the past, would it have given its blessing to the early regulations which now look so successful in retrospect? The answer is no. We have compiled three case studies in coming to this conclusion: the removal of lead from gasoline in the 1970s and 1980s, the decision *not* to dam the Grand Canyon for hydroelectric power in the 1960s, and the strict regulation of workplace exposure to vinyl chloride in 1974. The technique would have gotten the answer wrong in all three cases. Each case study illustrates, in a different manner, the damage that cost-benefit analysis could have done in the past, had it played the central role that is proposed for it today. The problems with cost-benefit analysis of regulations lie deep within the methodology;[1] it would have done no better a generation ago than it does now.

Our case studies look back in time, to three key decisions of the 1960s and 1970s – decisions widely regarded as policy successes today. In each case we review the history of the regulatory process, and then ask what would have happened if cost-benefit analysis, based on the information then available, had been the determining factor in the decision.

Lead in Gasoline

The removal of lead from gasoline in the 1980s provides the universal, constantly cited example of the positive contribution cost-benefit analysis can make to environmental protection. The actual story is more complicated than the latter-day legend; it would be more accurate to say that cost-benefit analysis played a supporting role in the final act of a drama that spanned most of the twentieth century. Lead was first added to gasoline in the early 1920s, in order to improve automotive performance, and was used for fifty years despite clear early warnings of severe health hazards. By the early 1970s, the combination of new research, growing environmental awareness, the mandates of the Clean Air Act, and changes in automobile technology led EPA to adopt regulations requiring the rapid removal of about 80 percent of the lead in gasoline.

That 1970s decision was justified by serious, but not precisely quantified, concerns about human health impacts. It set a technology-based standard on precautionary grounds, combined with a discussion of its economic feasibility. As lead levels dropped in the late 1970s, a national health survey that was coincidentally occurring at the same time was able to document the resulting rapid improvement in health outcomes. Then, when the Reagan administration threatened to stall or reverse lead regulations in the early 1980s, it was possible to do a cost-benefit analysis confirming the desirability of continuing on a course to remove lead – because the survey provided such strong evidence that the first round of regulation had led to a sharp decline in children's blood lead levels and because scientific research by that time had better documented the harmful health effects of lead on humans. In other words, the traditional 1970s regulation that removed 80 percent of the lead enabled the 1980s cost-benefit study to show that we should continue removing lead, and in fact remove almost all of the remaining 20 percent. But if we had waited, in the 1970s, for a cost-benefit study to show net benefits from the larger first round of lead removal, we might still be waiting today.

Damming the Grand Canyon

The role of cost-benefit analysis in protecting the Grand Canyon is less well known, though it was crucial in Congressional debates in the 1960s. In this case, a cost-benefit analysis played a key role in protecting the environment – but only because it got the numbers so completely wrong. A water diversion and development scheme for Arizona, vigorously advocated by the state's politicians and by some federal agencies, would have built two huge dams on the Colorado River to generate hydroelectric power, just above and below the Grand Canyon. Natural water flows through the canyon would have been disrupted, and flooding from new reservoirs would have backed up many miles into Grand Canyon National Park, as well as covering nearby upstream and downstream areas.

A modified form of cost-benefit analysis was performed by the Bureau of Reclamation, the federal agency that wanted to build the dams. The Bureau's analysis showed that generating the same amount of electricity from thermal power plants would cost up to twice as much as the dams. The dams were defeated in part by popular opposition organized by the Sierra Club and other groups, and in part by an influential cost-benefit analysis prepared by RAND Corporation analysts. The RAND analysis, disagreeing with the Bureau of Reclamation's conclusions, showed that the dams were not the least-cost way to generate electricity, because nuclear power was then predicted to be marginally cheaper.

Back in the 1960s, the relentless escalation of nuclear power plant costs was still in the future. The prevailing fantasies about nuclear costs were just one step removed from the industry's early propaganda about nuclear power being "too cheap to meter." At 1960s fantasy prices, new reactors were a slightly better deal than the dams; with the information on nuclear costs available just 6-8 years later, the RAND analysis would have flipped over to favoring the dams. As it happened, RAND's error helped to sway Congress and save the Grand Canyon for posterity.

Vinyl Chloride in the Workplace

Our third case study represents a more typical regulatory decision of decades past, in the sense that no cost-benefit analysis was performed before the rule was adopted, although regulatory agencies did take costs into account. The drastic reduction in allowable workplace exposure to vinyl chloride, required by the Occupational Safety and Health Administration (OSHA) in 1974, was, like EPA's 1970s lead policy, adopted at a time when serious health risks were becoming visible, but without the precise quantification of dose-response relationships and monetization of health benefits that are required for a formal cost-benefit comparison. Responding to a wave of deaths from a rare cancer that is strongly associated with vinyl chloride, OSHA rapidly cut the allowable workplace exposure limit to a small fraction of the previous limit. Over the years since 1974, information has emerged about a broad range of hazards due to very low levels of vinyl chloride, confirming the need for OSHA's strict standard to protect workers' health.

If a cost-benefit study had been done, its calculations would likely have weighed the costs to industry of reducing vinyl chloride exposure versus the value of the avoided deaths. Using the dollar values that cost-benefit analysts have assigned to avoided deaths, we can calculate the number of deaths required to "justify" the vinyl chloride regulation, *i.e.*, to make the monetized benefits at least as great as OSHA's estimate of compliance costs. Even using today's higher values per avoided death, the number of required deaths is much higher than the numbers of actual deaths that caused alarm in the early 1970s. Using the lower values for life that were accepted in the 1970s, about one out of every seven workers in the industry would have had to die from vinyl chloride exposure each year in the absence of regulation, in order for the benefits of regulation to have outweighed the costs. If these deaths were discounted over the latency period of the cancers, as is often done in contemporary cost-benefit analyses, it would have been even harder to show positive net benefits for the regulation. At a 1970s-era discount rate of 10 percent and a 1970s-era value of life, the regulation would have had to prevent the deaths of the entire industry workforce every year for the benefits to outweigh OSHA's advance estimate of the costs. With cost-benefit analysis as the regulatory framework, the vinyl chloride rule would not have been issued.

Introduction

We have argued elsewhere that environmental protection does not cause economic harm,[2] and that the widely cited "evidence" of huge regulatory costs is erroneous on several grounds.[3] Indeed, the entire cost-benefit project is problematic and incoherent. In a cost-benefit analysis, analysts add up the costs – for example, for pollution control equipment – and compare them to estimates of the monetary value of the resulting benefits – for example, the dollar value of the deaths and diseases avoided by reducing pollution. This effort routinely fails, primarily because the benefits of health and environmental protection are vitally important, but cannot be meaningfully expressed in monetary terms. In a word, the benefits are priceless.[4] The attempt to assign monetary prices, while required for the cost-benefit calculation, ends up distorting, misrepresenting, and narrowing the priceless values of life, health, and nature, and belittling the widespread concern for the well-being of future generations.

In practice, therefore, cost-benefit analysis is an opaque and technically intricate process accessible only to experts, and one that all too frequently recommends rejection of sensible policies, on the grounds that their costs exceed economists' estimates of their benefits. In the hands of John Graham, the Bush Administration's "regulatory czar" at the Office of Management and Budget (OMB), cost-benefit analysis has been used as a powerful weapon against regulatory initiatives proposed by the Environmental Protection Agency (EPA) and other agencies.

In this report, however, we do not mount a critique from outside the technique of cost-benefit analysis. Instead, we examine an argument that proponents of cost-benefit analysis have offered as a linchpin of the case for cost-benefit: that this technique is neither anti- nor pro-regulatory, but is a neutral tool for evaluating public policy. In making this argument, these observers have often invoked the use of cost-benefit analysis to support previous regulatory decisions (their favorite example involves the phase down of lead in gasoline, which we shall shortly discuss) as a sign that this technique can be used to support as well as to undermine protective regulation. As we demonstrate, however, the fact is that cost-benefit analysis would have stood as an obstacle to early regulatory successes. Before turning to our case studies illustrating this point, we first take a brief look at previous efforts to undertake retrospective cost-benefit analyses of important regulatory achievements.

Looking Backward

We are not the first to explore cost-benefit analyses of past regulatory decisions. Some retrospective cost-benefit studies have supported environmental protection; some commentators have suggested that such studies show that cost-benefit analysis contains no systematic bias against environmental regulation.[5] We believe that the wrong lesson has been drawn from these studies, exaggerating the prospects for cost-benefit analysis to support environmental protection in the future.

One widely cited retrospective study is a multi-year, peer-reviewed EPA study of the first 20 years of the Clean Air Act (1970–1990), published in 1997. This study found benefits from air pollution regulation equal to about 40 times the costs.[6] More recently, annual analyses by OMB's Office of Information and Regulatory Affairs (OIRA) have estimated, retrospectively, the monetized costs and benefits of major regulations of the recent past. The OIRA report for 2004 estimates that major EPA regulations adopted from 1993 to 2003 imposed $22-24 billion in costs, and yielded $38-132 billion in benefits.[7] OIRA cautions against getting too excited about these upbeat numbers:

> The majority of the large estimated benefit of EPA rules is attributable to reduction in public exposure to a single air pollutant: fine particulate matter. Thus, the favorable benefit-cost results for EPA regulation should not be generalized to all types of EPA rules or to all types of clean-air rules.[8]

In general, as OIRA suggests, cost-benefit analysis tends to endorse efforts to reduce a handful of high-volume air pollutants. The huge estimated benefits of these measures account for EPA's favorable analysis of the Clean Air Act as well as OIRA's numbers for EPA regulations as a whole. Look beyond the criteria air pollutants, and the evidence becomes quite sparse for cost-benefit analysis supporting environmental protection. Furthermore, Graham's office is busily working to reduce the apparent benefits of controlling even these widespread and harmful air pollutants.[9]

Moreover, EPA's positive cost-benefit analysis even here would not have been possible at the time the Clean Air Act protections were put in place. A huge proportion of the benefits found by EPA were due to regulating emissions of fine particles in the air – but the full magnitude of the harm done by such particles was not known for many years after the Act was first implemented. If a favorable cost-benefit analysis of the Clean Air Act's regulation of fine particles had been required before adoption of the Act, the result would have been the same as in the lead and vinyl chloride case studies we examine in this paper: the Act's requirements would have been rejected for lack of sufficiently definitive data.

In another frequently cited study, economist Richard Morgenstern assembled twelve case studies of regulations where EPA's economic analyses played an important role.[10] His case studies, written by analysts who played a major role in the regulatory process, were chosen to highlight the positive contribution of EPA's economic analyses (through the first term of the Clinton administration).

Morgenstern's case studies divide naturally into three groups. In four cases, no monetization of benefits was attempted, so no formal quantitative comparison of costs and benefits was possible. In four cases, some benefits were monetized, but the regulatory decision was based on technology standards or other criteria, and did not maximize net benefits. In the remaining four cases, cost-benefit analysis appeared to endorse the final decision, weakly in one case and strongly in the other three. However, in two cases the cost-benefit analysis was not completed until after a decision had been made on other grounds, so it was not a factor in the regulatory process. The two cases where cost-benefit analysis was a crucial input into decision-making both involved lead pollution. The famous cost-benefit analysis of removing lead from gasoline is the subject of one of our case studies in this report. The regulation of lead in drinking water was almost a sequel to lead in gasoline, addressed by the same analysts using much of the same data, just a few years later.

Like Morgenstern, we find that cost-benefit analysis played little role in the regulatory processes we evaluate. Good thing, too, since we also find that requiring a positive cost-benefit analysis before adoption of regulations, as currently advocated, would have prevented some of the great policy successes of the past decades. Our first example involves getting the lead out of gasoline.

Lead in Gasoline

Whenever fans of cost-benefit analysis want to show how it can be used to protect the environment, they cite the example of EPA's phase down of lead in gasoline in the 1980s. With this rule, EPA ordered a more than tenfold reduction of levels of lead in gasoline. EPA's decision was supported by an extensive cost-benefit analysis which demonstrated that the benefits of the phase down greatly outweighed the economic costs. Such notable regulatory scholars as John Graham,[11] Robert Hahn,[12] Richard Stewart,[13] Cass Sunstein,[14] and Jonathan Wiener[15] have pointed to the influence of cost-benefit analysis on the 1980s-era lead phase down as evidence of the evenhandedness of this analytical framework.

However, that cost-benefit analysis only appeared in the last act of a long drama. To summarize the plot in brief: leaded gasoline, introduced in the 1920s despite clear early warnings of severe health hazards, dominated the market for fifty years.[16] Regulations removing most of the lead from gasoline were finally adopted in the 1970s, and upheld by the courts in a landmark legal decision. The 1970s regulation was adopted on a precautionary basis without reliance on cost-benefit analysis, under the Clean Air Act's provision giving the Environmental Protection Agency the authority to "control or prohibit" fuel additives if they "will endanger the public health or welfare."[17] The EPA's new rule was quickly effective in lowering blood lead levels. One convenient side effect was the creation of the data that then allowed a later cost-benefit analysis, in the 1980s, to confirm the wisdom of staying the course and even going further to remove the last bit of lead from our fuel. Thus the cost-benefit analysis of the 1980s phase down of lead in gasoline would not have been possible in the absence of the more important 1970s-era regulation – which was not itself based on cost-benefit analysis. Had we waited in the 1970s, as some argue we should do in policy disputes today, for cost-benefit analysis to show us the way, we might still be waiting now.

Lead Comes Knocking

Lead was introduced into gasoline in the 1920s, at a time of fierce competition in the growing market for automobiles. Then as now, two of the features that could set one car apart from another were power and speed. Increasing compression in the car engine increases power and speed, but it can also increase "knocking," or the loss of power accompanied by the familiar popping sound of very old cars.[18]

General Motors set out to find an anti-knock compound that would allow its cars to increase their power and speed without increasing knocking. Thomas Midgley Jr., an engineer in a GM research lab, tested numerous substances for this purpose – including tetra ethyl lead (TEL). Pursuing the enticing possibility of a substance one could patent (and thus corner the market in), Midgley shunted to the side another potential anti-knock compound, ethanol, in favor of TEL.[19] As Jamie Lincoln Kitman puts it in his indispensable account of the development of TEL, "any idiot with a still" could make ethanol, which made it far less attractive as an anti-knock compound to the profit-conscious GM.[20]

GM, at the time controlled by Pierre du Pont, eventually teamed with Standard Oil of New Jersey to form a new company – the Ethyl Corporation – to market TEL.[21] Even before this, plants in Ohio and New Jersey were busy making the chemical. The problems started immediately. Within the first month of producing TEL, a worker died at the Ohio plant.[22] Eventually fifteen workers died, and hundreds more fell ill.[23] Workers called one production facility in New Jersey the "House of Butterflies" because high lead exposure caused hallucinations which led workers to swat imaginary insects off of their bodies.[24]

The Surgeon General convened a panel of experts to study the potential health effects of TEL, but gave them only seven months in which to come to a conclusion. Ethyl voluntarily suspended production of TEL while the Surgeon General's committee did its work.[25] The committee did find more lead in the blood of people occupationally exposed to lead – such as chauffeurs and garage men – but was unable to find health effects from these higher exposures within the committee's tight timeline.[26] The committee ultimately found "no good grounds for prohibiting the use of ethyl gasoline … as a motor fuel, provided that its distribution and use are controlled by proper regulations."[27] (Those "proper regulations" did not appear until almost 50 years later.) The panel also issued the following cautionary note:

> It remains possible that, if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from this investigation. Longer experience may show that even such slight storage of lead as was observed [among humans] in these [1925] studies may lead eventually to recognizable lead poisoning or to chronic degenerative diseases of a less obvious character... The vast increase in the number of automobiles throughout the country makes the study of all such questions a matter of real importance from the standpoint of public health.[28]

It would be many years, however, before anyone took up the issue again. Within months of the committee's report, TEL was back on the market.

The 'Kehoe Rule'

For fifty years, the makers of leaded gasoline would deny this basic fact about lead: it is a poison. When faced with the warnings of public health authorities about the potentially dire effects of spewing lead into the atmosphere from millions of automobiles, the industry had a simple response: prove it.

In a 1922 letter to his brother Irénée (the head of DuPont Chemical), GM chief Pierre du Pont described TEL as "a colorless liquid of sweetish odor, very poisonous if absorbed through the skin, resulting in lead poisoning almost immediately."[29] Yet for the next fifty years, the makers of leaded gasoline would deny this basic fact about lead: it is a poison. When faced with the warnings of public health authorities about the potentially dire effects of spewing lead into the atmosphere from millions of automobiles, the industry had a simple response: prove it.

The trouble was, it was hard to prove that the day-to-day, low-level exposures to lead caused by leaded gasoline hurt people. The kinds of health effects we now know come from lead – reduced learning capacity, neurological disorders, and high blood pressure – are quite common, and have several potential causes, so that it is difficult to say which portion of these effects is due to lead. Thus, although the U.S. government had suspected the risks of adding lead to gasoline from the very beginning, it would not seriously try to regulate leaded gasoline until lead had been pouring from almost every automobile in the country for half a century.

The "prove it's dangerous" approach was dubbed by Jamie Kitman the "Kehoe Rule" after Robert

Kehoe, the medical director for the Ethyl Corporation, who pursued and perfected the approach during decades of asserting the safety of leaded gasoline. The Kehoe Rule was particularly effective in silencing dissent because most of the lead-related research conducted in the middle part of the twentieth century was funded by the interested industries themselves. Kehoe maintained that the blood lead levels of the people most exposed to lead – those who were exposed on the job – gave little cause for alarm because these levels were not a great deal higher than the blood lead levels of the presumably unexposed "control" population.[30]

The idea that high levels of lead in the blood were natural, normal, and benign got its comeuppance from an unlikely source: a geochemist studying the age of the Earth. Clair Patterson's research on this subject involved precise chemical analysis of ocean sediments and archaeological material, which incidentally established that the contemporary body burden of lead was far above pre-industrial levels.[31] His findings directly refuted Kehoe and the lead industry's claim that the blood lead levels prevailing in the U.S. were natural.

Like many other scientists who dared challenge the lead industry's story line, Patterson found himself at the receiving end of the industry's wrath and was materially (and adversely) affected by it.[32] Nevertheless, scientific findings by Patterson and others had begun to chip away at the factual basis for the industry's longstanding denials of the potential dangers of leaded gasoline.

Congress Acts

With the passage of the federal Clean Air Act Amendments of 1970, the era of leaded gas finally began to draw to a close. The Act directed the brand-new Environmental Protection Agency to regulate fuel additives (of which lead was the most important) if either of two conditions was met. First, Congress told EPA to regulate a fuel additive if the agency found that it "will endanger the public health or welfare."[33] Second, EPA was to do so if the additive would impair the performance of the pollution control devices that were also being required by the amendments to the Act.

A review of the legislative history leading to these developments shows considerable concern in Congress about the potential dangers of airborne lead. It also reveals, however, how keenly aware Congress was of the scientific uncertainty that continued to surround this issue.[34] Perhaps it goes without saying that Congress performed no cost-benefit analysis of the consequences of its decision to require regulation of fuel additives; none would have been possible, given the lack of quantitative data on the health and welfare effects of leaded gasoline.

Within weeks of the adoption of the amendments,[35] EPA's first Administrator, William Ruckelshaus, had declared that leaded gasoline endangered the public health and welfare and impaired the performance of catalytic converters, and had given public notice that he intended to issue a regulation reducing allowable levels of lead in gasoline.[36]

In 1972, EPA proposed a significant reduction in the allowable levels of lead in gasoline,[37] requiring removal of most of the lead within just a few years. EPA also proposed to require the availability of at least one grade of unleaded gasoline. The agency thought lead would damage the catalytic converters which were required on new cars in order to reduce other forms of harmful air pollution. In addition, the agency also thought that lead itself was a threat to public health. Although EPA could not put exact numbers on the health effects caused by lead, it thought the existing scientific evidence was strong enough to justify strict limits on lead in gas. The agency stated that the then-existing levels of airborne lead were "associated with a sufficient risk of adverse physiologic effects to constitute endangerment of public health."[38] It concluded that its proposals to regulate lead would "provide for the protection of health in major urban areas within the shortest time reasonably possible."[39]

In 1973, EPA responded to the extensive public comments it had received on leaded gasoline by retreating somewhat from the 1972 proposal. The agency extended the deadline for the reduction of lead in gasoline and changed the calculations used to demonstrate refineries' compliance with the agency's requirements.[40] At the same time, EPA also softened its earlier claims about the link between airborne lead levels and public health. The agency admitted that scientific findings suggesting a correlation between air lead levels and blood lead levels could not "be taken as conclusive evidence that airborne lead by itself is a current public health problem."[41] Even so, EPA worried that airborne lead might be contributing to "excessive total lead exposures among the general urban population."[42]

As noted above, in order to regulate lead in gasoline for purposes of protecting public health, EPA was required by Congress to find only that lead "will endanger public health." It was not required to perform a cost-benefit analysis of reducing lead in gasoline, and it did not do so. Indeed, in its 1973 proposal, EPA admitted that "the benefits associated with the accelerated lead reduction have not been quantified."[43]

In December 1973, EPA issued final regulations on the subject.[44] Large refineries were required to remove roughly 80 percent of the prevailing (early 1970s) level of lead from gasoline by 1979, and small refineries had to meet the same target by 1982.[45] The agency explained:

> [I]t is difficult, if not impossible, to establish a precise level of airborne lead as an acceptable basis for a control strategy.... [However,] [s]trong evidence existed which supported the view that through these routes [air and dust] airborne lead contributes to excessive lead exposure in urban adults and children. In light of this evidence of health risks, the Administrator concluded that it would be prudent to reduce preventable lead exposure.[46]

EPA explained that it had extended the deadline for lead reduction from four to five years in order to "moderate the economic and technological impacts of the regulations during the period over which the reduction would be accomplished." EPA continued: "though the benefits associated with the ... lead reductions have not been quantified, the Administrator has concluded that this approach is not unreasonably costly and will prudently prevent unnecessary exposure to airborne lead."[47] Indeed, as Robert Percival and his co-authors have pointed out, "[c]osts ... were projected to be less than 0.1 cent per gallon refined, adding only between $82 million and $133 million to the total of $1.5 billion the industry was to invest in refining capacity through the year 1980."[48]

In a hard-fought court battle, industry tried to resuscitate the Kehoe rule, arguing that EPA should not be allowed to regulate unless it could prove leaded gasoline had actually harmed identifiable people in the past. Nonetheless, EPA's new restrictions on leaded gasoline were upheld.[49] The court's ultimate decision in the case is considered a landmark in U.S. environmental law because it established that EPA could act in a precautionary fashion, rather than waiting for scientific certainty about the harmfulness of a substance before acting. EPA set its standards for lead based on the goal of protecting children from lead exposures that would harm their health and cognitive development.

NHANES and Needleman

Around the same time that EPA's initial lead phase down was taking effect, additional evidence of the wisdom of EPA's actions was accumulating.

The little-remarked National Health Survey Act of 1956 required periodic national surveys of the population's health.[50] This statute, also enacted without reliance on cost-benefit analysis, led to a national study in 1976-80 of children's blood lead levels.[51] The National Health and Nutrition Examination Study – called NHANES II because it was the second of its kind – showed marked decreases in children's blood lead levels in the period examined. Because this period coincided with the implementation of EPA's reduction of lead in gasoline, it was possible to study the relationship between the reduced blood lead levels found in NHANES II and the reductions in leaded gasoline required by EPA. The relationship turned out to be remarkably consistent: children's blood lead levels declined in direct proportion with the reduction of lead in gasoline. This relationship became a cornerstone of EPA's 1980s-era economic analysis of requiring further reductions in the lead content of gasoline.

In the same period, Herbert Needleman published his path-breaking study demonstrating a link between children's blood lead levels and IQ.[52] The study answered the question that had dogged lead researchers for decades: even if blood lead levels were higher than they naturally would be, was this causing any harm? Needleman's answer was an emphatic yes. Needleman's study also made it possible to state, in quantitative terms, the effect of reducing blood lead levels on human health and well being.

Unfortunately, Needleman suffered the same fate as other lead researchers before him who had dared take on the lead industry. Researchers funded by the lead industry challenged his work, going so far as to press a formal charge of scientific misconduct with the National Institutes of Health.[53] As Needleman put it in later years, after he had been completely exonerated, "If you ever want to be intensively peer-reviewed, just produce a study with billions of dollars of implications and you will be reviewed to death."[54]

Meanwhile, the lead industry was also active on another front: with President Ronald Reagan's election in 1980 after campaign promises to make government smaller, arguments in favor of relaxing the requirements for lead in gasoline suddenly gained a more sympathetic hearing. At this point, cost-benefit analysis did play a useful supporting role in helping Congress and sympathetic administrators to uphold the previous commitment to removal of lead from gasoline, despite the wavering of top Reagan appointees.

Gorsuch Winks

A month after taking office, President Reagan formed the "Task Force on Regulatory Relief," headed by Vice-President George H.W. Bush. The ostensible purpose of the Task Force was to coordinate actions among the various executive agencies and also to oversee compliance with Reagan's brand-new Executive Order 12291, requiring agencies to conduct cost-benefit analyses for significant new regulatory initiatives.[55] The real aim of the Task Force was to reduce regulation any way possible.[56]

One of the first actions to come within the sights of the Task Force was EPA's lead phase down.[57] The phase down was nearly, but not quite, complete: although EPA had required large refineries to meet its new limits by 1979, small refineries were given until 1982 to do so. In 1982, following a Task Force recommendation, EPA not only proposed to delay the requirement for small refineries,[58] but also invited public comment on whether to relax the requirements for large refineries as well.[59]

Reagan's EPA Administrator at the time, Ann Gorsuch, appears to have been on the same page as the Task Force. During a meeting with Ethyl representatives, she was asked whether she would enforce the existing rules to phase down lead. Her reported response: she winked.[60]

Nevertheless, the public outcry over news that the phase down might be weakened made EPA back off from its proposals. Eventually, the 1970s-era rules were tightened rather than relaxed,[61] and a federal court upheld the new rules almost in their entirety, even going so far as to opine that a complete ban on lead in gasoline would be justified.[62]

By March 1983, Gorsuch had resigned amidst a scandal arising out of the Superfund hazardous waste program. One EPA official was sent to jail for lying to Congress about the matter.[63] Over a thousand EPA employees had lost their jobs early on in the Reagan administration,[64] and the remaining employees' morale had hit an all-time low. It was time to restore credibility to the embattled agency.

Ruckelshaus and Cost-Benefit to the Rescue

Just weeks after Gorsuch resigned, EPA's first Administrator, William Ruckelshaus, returned to the agency in its time of need. One of his stated aims was to restore rigorous analysis and to displace the political forces that had recently dominated the agency's actions.[65] Alvin Alm, his deputy, later recalled that at the time the agency was "really in need of some help," and that the agency's new leaders needed to "creat[e] confidence that we were getting work done."[66]

It is only at this late date in the story that cost-benefit analysis made its famous, and helpful, appearance. Within six months of the regime change at the agency, Alm asked EPA's economics office (the Office of Policy, Planning and Evaluation) to put together a preliminary cost-benefit analysis of further regulation of lead in gasoline, including an outright ban. As Albert Nichols, who became intimately involved with the eventual analysis, recalled, Alm became interested in reviving the lead issue both because of a remark by a lobbyist for the ethanol industry (ethanol was a potential substitute for lead)[67] and because "lead appeared to offer an opportunity to demonstrate that the risk management principles being promoted by Administrator William Ruckelshaus and Alm were not just a sophisticated way of saying 'no' to proposed regulations; they also could help identify cases in which additional regulation was justified."[68]

Although Albert Nichols' account of EPA's decision to do a cost-benefit analysis of further lead reductions states that EPA "was *not* under significant pressure from … environmental groups to take additional action,"[69] Nichols also acknowledges, in a footnote, that "[o]ther prominent environmentalists – such as Ellen Silbergeld of the Environmental Defend Fund – had been active for many years in efforts to reduce lead."[70] Others recall a more prominent role for environmental groups, in particular the Environmental Defense Fund, in persuading EPA to take another look at lead. Robert Percival, now a professor of law at the University of Maryland but then a young attorney at the Environmental Defense Fund, suggested during a meeting with Alvin Alm in the fall of 1983 that EPA undertake a cost-benefit analysis of phasing out lead from gasoline.[71] Several years later, Alm wrote that one of EPA's most important achievements – the 1980s-era phase down of lead in gasoline – had "come about through a chance encounter" with someone he did not know, who had suggested doing a cost-benefit analysis of further lead regulation.[72]

Whatever the origins of Alm's request, EPA's analysts complied, producing a cost-benefit analysis clearly demonstrating that additional regulation of leaded gasoline was amply justified in economic terms. Armed with this analysis, EPA not only upheld the original rule, but adopted a new rule in 1985 that went much farther, requiring the removal by 1988 of about 90 percent of the lead that was still allowed in gasoline under the 1970s rule.[73] By this time, EPA felt confident enough to be able to include in its final economic analysis enormous benefits from reducing blood pressure in men through phasing out lead in gasoline: these benefits alone, EPA predicted, would be about ten times higher than the total costs of the rule by the late 1980s.[74]

Crunching the Numbers

The second wave of reduction of lead in gasoline, required by EPA in the 1980s, is the example widely touted as evidence that cost-benefit analysis is a neutral decision-making tool, tilting in favor of neither regulation nor laissez faire.

However, the cost-benefit analysis performed by EPA in the 1980s could not have been performed if the regulation of the 1970s, the ensuing "first wave" removal of roughly 80 percent of the lead in gasoline, and the government-sponsored national survey of blood lead levels had not already occurred. EPA's cost-benefit analysis depended crucially on evidence gained from the studies showing a strong relationship between reduction of lead in gasoline and reduction in blood lead levels in children. This evidence was available only because regulation had already achieved such a substantial reduction of lead in gasoline. It is indeed useful that the lead cost-benefit analysis helped to prevent backsliding in the early years of the Reagan administration, and even justified the rapid removal of most of the remaining lead from gasoline. But this is very different from doing the job alone, or even playing the leading role.

Moreover, the story of cost-benefit analysis in supporting lead regulation stands almost alone: it is so universally cited that a skeptical observer might ask, is there an additional example of cost-benefit methods being used to support environmental protection? According to participants in the studies, the cost-benefit analysis of leaded gasoline and the subsequent study of lead in drinking water (done just a few years later by the same analysts, using much of the same data) were "anomalous" successes, drawing on unusually strong data sets and enjoying a clear mandate from above to support protective regulations.[75] Normally, of course, it is not possible to remove most of a pollutant from the environment, in order to develop the data supporting the removal of the remainder. And the political and administrative support for regulation that existed when Ruckelshaus returned to the EPA in the mid-1980s has been sadly lacking in the opening years of the twenty-first century.

In different hands, with a different political agenda, the cost-benefit analysis of lead regulation could have looked quite different. Recently, one prominent regulatory analyst has shown how this might have happened. Randall Lutter, formerly at OMB and now chief economist at FDA, was, between government jobs, ensconced at the American Enterprise Institute, where he frequently wrote on the supposed dangers of over-protection against hazardous substances. Regarding lead, Lutter proposed to rethink the approach to the benefits of lead reduction. Rather than indirectly valuing the immense health improvements and the gains in children's IQ that have been traced to lead reductions, as EPA has done, Lutter argued that society should not value lead removal any more highly than individuals do.[76] Moreover, he suggested that individual valuations could be determined from studying what parents spend on chelation therapy to lower their children's lead levels. Since chelation is proven to work only for very high levels of lead poisoning, there is unsurprisingly little evidence that people choose to spend money on it for more common, chronic low-level lead problems. Applying the chelation yardstick, Lutter found that EPA had overstated the benefits of lead reduction, perhaps by as much as eight-fold. In Lutter's view, therefore, less protective expenditure would be warranted – and the historic role of cost-benefit analysis in supporting lead reduction could have been less important.

Thus it is not only the strong data and robust empirical studies that allowed cost-benefit analysis to support environmental protection in this case. Also crucial was the political support for a methodology that valued benefits relatively expansively. A different methodology, like Lutter's, could point in the opposite direction. The use of cost-benefit analysis by an Administration hostile to environmental protection will almost certainly not produce the equivalent of another lead phase down.

Damming the Grand Canyon

> Leave it as it is. You cannot improve on it. The ages have been at work on it, and man can only mar it… What you can do is to keep it for your children, your children's children, and for all who come after you, as one of the great sights which every American if he can travel at all should see.
>
> - *Theodore Roosevelt on the Grand Canyon*[77]

> What's so special about the Grand Canyon anyway?
>
> - *Ken Wilson, Western Area Power Administrator*[78]

The water wars of the arid American West have transformed the natural landscape. With the help of countless billions of public dollars, the region's meager supplies of water have been rerouted to allow agriculture, industry, and residential development to flourish on barren desert lands, as described by Marc Reisner in his classic account, *Cadillac Desert*.[79] At times, the "water wars" have almost ceased to be metaphorical: in 1934, Arizona mobilized its National Guard in an attempt to stop construction of a dam that would divert Colorado River water into California.[80]

In the 1960s, collateral damage in the water wars nearly claimed parts of the Grand Canyon, as huge dams were proposed on the Colorado River, just above and below the national park. The dams were defeated in part by the massive opposition organized by the Sierra Club and other environmentalists – and in part by an influential cost-benefit analysis performed by RAND Corporation economists, showing that the economic benefits of the dams were slightly less than the costs.

This could be considered a triumph for the environmentally benign use of cost-benefit analysis, except for one drawback: the RAND analysis is, in retrospect, absurd. The same methodology combined with better information, which became available just a few years later, would have led to the opposite conclusion and firmly endorsed the dams.

Razing Arizona

The Colorado River is one of the few major sources of water in Arizona, skirting the northern and western edges of the state. Most of the agriculture, industry, and people in Arizona are hundreds of miles away, many of them in and around Phoenix and Tucson – and separated from the river by mountains as well as desert. The proposed damming of the Grand Canyon arose as part of the Central Arizona Project, a colossal scheme to move water from the river to the people.

After decades of battles in the courts and in Congress (as well as the armed confrontation at the riverbank in 1934), Arizona finally won a legal entitlement to a significant share of the Colorado River's water in the early 1960s. This cleared the way for the Central Arizona Project, proposed years earlier, to proceed. However, the effort needed multi-billion-dollar financing to build its enormous aqueducts, and huge amounts of energy to pump the water up over the mountains.

The Bureau of Reclamation, the federal agency that dammed so many western rivers, had been "solving" problems like this since the 1940s. Its preferred method was called "river-basin accounting," treating the development of a river and related waterworks as a single project. Profitable dams could be built on fast-flowing rivers, generating hydroelectric power that would finance money-losing irrigation and water diversion schemes, as well as powering the massive pumping stations required to move the water. If the projects in a river basin were unbundled, the logic of the market might dictate building the dams but skipping the irrigation and other unprofitable pieces of the picture. However, the federal government repeatedly bought the whole package deal, as the New Deal enthusiasm for big public construction projects meshed with the local interests of Western politicians – many of them ideologically opposed to expensive public-sector initiatives that benefited anyone else.[81]

By the time the Central Arizona Project got underway, most of the best sites on the Colorado had been taken for earlier developments. The only remaining options for big, profitable "cash register dams" that would finance the project were the Marble Gorge (or Marble Canyon) Dam and the Bridge Canyon Dam, later renamed Hualapai Dam to "honor" a Native American community. Marble Gorge, just upstream from the Grand Canyon National Park, would have flooded the Inner Gorge, essentially the first 40 miles of the river's course through the canyon. Hualapai, downstream from the National Park, would have created a 94-mile-long reservoir, entirely flooding the Grand Canyon National Monument and extending 13 miles into the National Park itself.

Both dams were included in the revised Central Arizona Project proposal, launched in 1963. In support of the proposal, the Bureau of Reclamation performed an economic analysis comparing the dams to thermal (fossil fuel) power plants; the result was that the dams were much cheaper, with benefit/cost ratios of 2.0 and 1.7. These numbers emerged from a variant of cost-benefit analysis that is common in evaluation of power plants. The analysis assumes that if the dams were not built, something else would have to be built to generate the same amount of electricity. Thus the "benefit" of building the dams is that it would avoid the construction of the next-best alternative – which was a thermal power plant, according to the Bureau of Reclamation. A benefit/cost ratio of 2.0 for a dam means that the "benefit," *i.e.*, the avoided cost of an equivalent power plant, is twice the cost of the dam.

In the Bureau's analysis, almost nothing was said about recreational benefits, and no mention was made of the value of the existence of the Grand Canyon per se (what environmental economists now call "existence value" or other varieties of "non-use value"). The analysis simply compared the two methods of generating electricity. Although referred to at the time as a cost-benefit analysis, this might be better described as a cost-effectiveness analysis, seeking the minimum-cost way to meet the goal of generating a fixed amount of electricity.[82] The Bureau's result, strongly favoring the dams, is not a surprising one. Hydroelectric facilities built at places where large rivers are flowing rapidly downhill – like the Marble Canyon and Bridge Canyon sites – are routinely among the lowest-cost sources of electricity. If nothing of importance is lost due to the creation of the reservoir or other changes in river flow, hydroelectric development on fast-flowing major rivers is frequently a profitable way to generate electric power.

Yet many people naturally felt that something of great importance would be lost. The Sierra Club quickly organized widespread, vocal opposition to the dams, easily winning the war for public opinion. Defenders of the dams suggested that the elevated water level of the Hualapai reservoir would allow more visitors to see the canyon from tour boats; the Sierra Club asked if we should also flood the Sistine Chapel so that tourists could get closer to the ceiling. Soon thereafter, the IRS revoked the Sierra Club's tax-exempt status.[83]

Too Cheap to Meter

After four years of debate, the dams were defeated in 1967. While love of nature in general and the Grand Canyon in particular played an essential role, the Sierra Club and other opponents of the dams did not win on environmental arguments alone. Also crucial to the outcome was a rival cost-benefit analysis by two RAND Corporation economists, Alan Carlin and William Hoehn. Their work was publicized by the Sierra Club and Congressional opponents of the dams, and presented and debated at length in the Congressional hearings on the issue. Using a methodology much like the Bureau of Reclamation analysis, Carlin and Hoehn compared the dams to the cheapest alternative source of electricity; they again included almost nothing for the value of recreation, environmental amenity, or the existence of the Grand Canyon. But Carlin and Hoehn used a different alternative source of power as their benchmark. They compared the dams to nuclear power plants, which they believed to be astonishingly cheap.

Opponents of the dams did not win on environmental arguments alone. Also crucial was a rival cost-benefit analysis by two RAND Corporation economists... [who] compared the dams to nuclear power plants, which they believed to be astonishingly cheap.

Although their predictions of nuclear costs turned out to be hopelessly below the mark, Carlin and Hoehn did no worse than most people writing about nuclear power in the mid-1960s. At the time, nuclear power was a relatively new idea, still on the verge of commercial application. The hazards of nuclear power were not yet well known; the escalating costs of nuclear plants were not yet in sight. Instead, industry and government boosters of the new technology promoted the notion that nuclear energy would soon be "too cheap to meter." A decade of intensive research and development in the 1950s, mostly government-sponsored, had led to the first orders for nuclear plants in the early 1960s – and to wild optimism about the future of the technology. Almost half of the plants ordered during 1964-66, the years just before and during the Carlin-Hoehn analysis, were sold on fixed-price terms, with substantial subsidies from vendors seeking to increase their share of an exploding new market. The *average* plant being ordered in those years was more than three times the size of any that had yet been built, accompanied by exaggerated hopes about the declining costs that would come with growth.[84]

In 1967 the federal Atomic Energy Commission predicted that there would be 1,000 nuclear plants in operation by the year 2000, a prediction that turned out to be almost ten times too high. While 196 nuclear plants were ordered by electric utilities between 1967 and 1974, many of the later orders were cancelled.[85] After 1974, the energy crisis led to an abrupt halt to the growth in demand for electricity, and hence diminished interest in building new plants. Meanwhile, the seemingly endless series of hazards, accidents, and near-misses at nuclear plants led to one expensive requirement for redesign after another. Each safety problem appeared to be controllable, at an additional cost – with the result that costs were steadily driven upward.

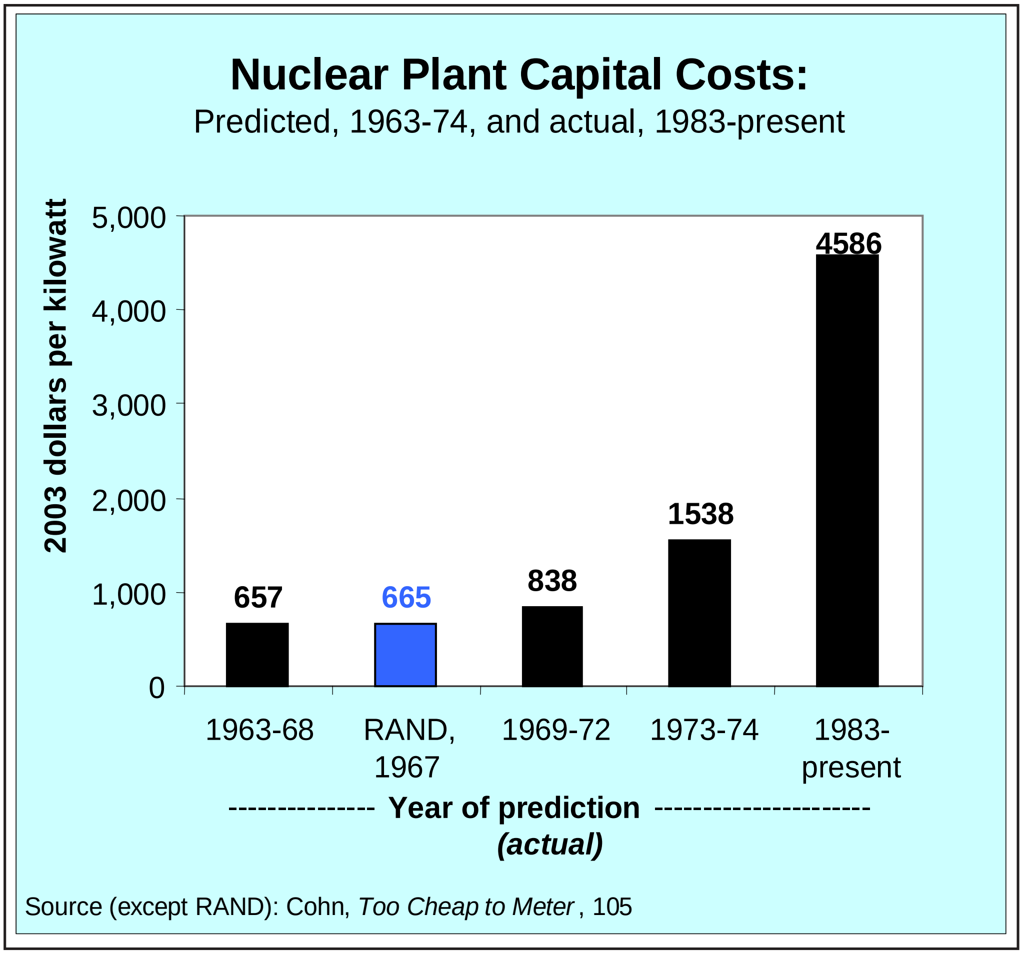
A recent analysis of nuclear power offers a retrospective evaluation of early cost forecasts:

> The magnitude of nuclear cost forecasting errors [before 1970] was extraordinary. Nuclear plants persistently cost about twice the inflation adjusted price predicted when they were purchased. The last forty-three plants coming on line in the U.S. (1983-present) cost… more than six times the constant dollar sum projected in the mid-sixties, and generate electricity at… more than five times the average rate predicted from 1963-1972.[86]

What the RAND analysis of the Grand Canyon essentially did was to compare the proposed dams to new reactors at 1960s fantasy prices. The result was that the reactors were slightly – not enormously – cheaper, so that the dams narrowly failed the cost-benefit test. In the first version of the Carlin-Hoehn analysis, the Marble Canyon dam had a benefit-cost ratio of 0.95 (that is, a reactor at fantasy prices was just 5 percent cheaper than the dam), while Hualapai had a ratio of 0.86 (a reactor beat this dam by 14 percent). Subsequent revisions lowered the ratios; in what appears to be the final version, published after the dams had been defeated, the ratios were 0.76 for Marble Canyon and 0.61 for Hualapai.[87]

Even the Sierra Club was briefly disoriented by the mirage of the cheap nuclear alternative. As David Brower, the head of the Sierra Club at the time, said in an interview recalling the battle over the Grand Canyon, "...Alan Carlin, who was of the Rand Corporation, an economist, began to feed numbers into the system that were devastating. The principal argument that Larry Moss [a nuclear engineer working for the Sierra Club] was coming up with was we could go to nuclear instead. I was trapped in that briefly, but got out of that trap."[88] At the height of the debate, in the Sierra Club Bulletin of May 1966 – described as the "Grand Canyon issue" – editor Hugh Nash wrote, in arguing against the dams, "Cheaper electricity is available from other sources… A nuclear power plant in New Jersey will produce power for 4 mills (compared with the dam's 5.3 mills) by 1969… Proponents of the dams try to make out that nuclear power is still pie in the sky. Not so. The TVA has contracted for a nuclear power plant which… will generate power for only 2.37 mills per kilowatt-hour."[89]

The RAND cost-benefit analysis involves many technical details; however, the decisive economic data are the capital costs of constructing the dams, on the one hand, and equivalent-sized nuclear plants, on the other. In each case the huge one-time costs are converted to annual charges, assuming that the construction costs will be paid back over the lifetime of the facility – just as a mortgage converts the one-time cost of buying a house to a series of payments over many years. In the RAND analysis, the "mortgage payments" on the construction cost amount to two-thirds or more of the annual cost of owning and



operating either the dams or the nuclear plants.

In the final revision of their analysis of the dams, Carlin and Hoehn estimated the capital cost of building the dams, in 2003 dollars, at a total of $4.27 billion, or $2,186 per kilowatt of electrical generating capacity.[90] The capital cost of equivalent nuclear power plants, they thought, would be less than a third as much: about $1.3 billion total, or a mere $665 per kilowatt of capacity.[91] The Carlin-Hoehn prediction of nuclear costs is very much in line with other forecasts from the mid-1960s, as seen in the graph at right. Forecasts from that era averaged $657 per kilowatt, virtually identical to the Carlin-Hoehn guess.[92] That is to say, the RAND study appeared to rely on the "sound science" of its day, but failed to notice – along with most of its contemporaries – that that "science" was unusually reliant on wishful thinking rather than hard data.

The analysis of the Grand Canyon occurred just before the rapid escalation in the costs of nuclear power. By 1969-72, forecasts of nuclear costs had risen more than 25 percent, to $838 per kilowatt; even this moderate increase would have eliminated most or all of the projected economic advantages of nuclear power over the dams. Two years later, in 1973-74, forecasts of nuclear costs had jumped to $1,538 per kilowatt, more than double the mid-1960s level. Redoing the RAND analysis with this figure would clearly reverse the benefit/cost ratio. That is, using the cost estimates available 6-8 years after the RAND study, the same methodology would end up agreeing with the Bureau of Reclamation (and common sense) that big dams are the cheapest way to generate electricity, if that is all that matters.

Furthermore, as the graph above shows, nuclear costs continued to rise well beyond the level of the 1973-74 forecasts. The last plants completed – those that came on line in 1983 or later – had average capital costs of $4,586 per kilowatt, almost seven times the RAND estimate. (All costs cited here have been converted to 2003 dollars, so these increases are not due to inflation.)

An Expensive Aqueduct Runs Through It

The dams were defeated, but not the Central Arizona Project which they were supposed to finance. Indeed, the Central Arizona Project was approved by Congress, without dams or other visible revenue sources, in 1968. The aqueduct is 336 miles long and 80 feet wide. Construction started in 1973 and finished in 1993 at a cost of over $4 billion, of which $1.6 billion will be paid back to the federal government by users over the first 50 years of operation.[93] Unless water levels are above average, the Colorado may not have enough water for all the commitments made to Arizona, other states, and Mexico; the water that is supposed to flow through the expensive aqueduct may not always be there.[94]

As if taking the RAND analysis to heart, the huge Palo Verde nuclear plant was built in Arizona, planned within a few years of the defeat of the dams. Construction began in 1976 and finished in 1988. The cost, according to the plant's operators, was $2608 per kilowatt in 2003 dollars, or almost four times the RAND projection.[95] At this price, needless to say, nuclear power was more expensive by far than the dams would have been, and also more expensive than the thermal power plants which the Bureau of Reclamation offered as the next-best alternative to the dams.

In the end, the Grand Canyon was preserved for future generations to see, as Theodore Roosevelt urged. In the more prosaic present, however, there were large numbers of people who wanted water and electricity provided in an inhospitable environment. Damming the Grand Canyon was unmistakably the cheapest, but not the best, way to provide these services to central Arizona. (Important questions about the wisdom, and the sustainability, of urban development in the midst of a desert lie just beyond the scope of this discussion.)

The RAND analysis that was instrumental in saving the Grand Canyon was right for the wrong reasons, erring spectacularly in favor of one environmental objective only by drastically underestimating another environmental problem. A cost-benefit analysis of the Grand Canyon performed today would include new categories of non-use value: what is the mere existence of the Grand Canyon worth to people who may or may not use (*i.e.*, visit) it? What is the value of the opportunity to pass it on to the next generation? Yet the calculation of huge existence values for unique natural wonders such as the Grand Canyon introduces a new set of problems into cost-benefit analysis. Estimates of these values differ widely, with similar survey questions about the dollar value of major national parks eliciting numbers that are almost 100 times as large in one academic study as in another.[96] Existence values are important, but they do not bear much resemblance to prices; they are real, but they are not really numbers.[97]

If you support the preservation of the Grand Canyon, how would you react to a study showing that the benefits of the Canyon, including its existence value to the American people, were 20 percent lower than the benefits of damming it for hydroelectric development? Would you accept this as scientific proof that the Grand Canyon should be dammed, despite your personal preferences? Or would you insist that the value of its existence must have been underestimated, because you know that it is worth more than that? The former answer is difficult to imagine, but the latter implies that there is no empirical information conveyed by estimates of existence value. Rather, existence values offer only an awkward translation of independently established conclusions into the artificially constrained language of economics.

The cost-benefit analysts of the 1960s, of course, knew nothing about the theoretical dilemmas and measurement problems surrounding existences values. It is fortunate, in retrospect, that they knew equally little about the economics of nuclear power.

Vinyl Chloride in the Workplace

> "There is little dispute that [vinyl chloride] is carcinogenic to man and we so conclude. However, the precise level of exposure which poses a hazard and the question of whether a 'safe' exposure level exists cannot be definitively answered on the record. Nor is it clear to what extent exposures can be feasibly reduced. We cannot wait until indisputable answers to these questions are available, because lives of employees are at stake."
>
> \- *Occupational Safety and Health Administration, 1974*[98]

> "That some must die so that all can eat is one thing; that some must die so that all can have see-through food packaging is another."
>
> \- *David D. Doniger*[99]

Polyvinyl chloride, also known as vinyl or PVC, is a ubiquitous plastic, used in plumbing, siding, toys, car interiors, medical equipment, and countless other products. Vinyl chloride, the chemical building block from which PVC is made, is a known human carcinogen.[100] Since vinyl chloride can be emitted, either in plants where it is made or where it is used to make PVC, workers in those plants are at risk of hazardous exposures on the job.[101]

In 1974 the Occupational Safety and Health Administration (OSHA) adopted a strict new standard that sharply reduced allowable workplace exposure to vinyl chloride. Consistent with its governing statute, the agency did not justify the rule on the basis of a cost-benefit analysis. Rather, the strict exposure limit was based on the level OSHA determined industry could meet – or, in the words of the statute, the "feasible" limit.[102] The agency acted in response to a series of deaths attributable to vinyl chloride exposure, combined with disturbing new information on carcinogenicity of vinyl chloride in laboratory animals. OSHA acted on precautionary grounds, taking action when evidence of harm began to appear without waiting for precise, definitive quantification of the expected effects.

In the years since then, data have accumulated to confirm the toxicity of low doses of vinyl chloride, and on the range of organs affected by vinyl chloride exposures. These data have repeatedly confirmed the wisdom of OSHA's action. It is clear in retrospect that OSHA was right to regulate vinyl chloride exposure strictly. But what would have happened if OSHA had used cost-benefit analysis to make its decision, using the data that were available at that time? If performed in the manner favored today, such an analysis would have guided OSHA in the wrong direction, justifying little if any regulatory action.

Incriminating Evidence

Laboratory experiments documented the toxicity of vinyl chloride as early as 1925, and a range of adverse effects were documented in people in the 1930s and 1940s.[103] In the 1950s, Dow Chemical found that inhalation exposure to vinyl chloride damaged the liver and kidneys of laboratory animals; the company took steps to decrease employees' exposures, but did not inform them of the hazard. Two men died after acute inhalation exposure to vinyl chloride in 1960.[104] In the mid-1960s, industry researchers found that many vinyl chloride workers suffered from a disease they named acroosteolysis — a painful and disabling disease affecting bones and connective tissue, especially in the hands.[105] Industry worked actively to hide the link between vinyl chloride and acroosteolysis from the public.[106]

The industry had established its own standard for vinyl chloride exposure in 1954, limiting the "time-weighted average" over the course of a work day to 500 parts per million (ppm), but allowing short-term exposures above that limit.[107] In 1967, as evidence of the hazards of vinyl chloride continued to grow, industry lowered its standard to a 200 ppm time-weighted average, and 500 ppm absolute exposure limit.[108] OSHA, which was founded in 1970, initially adopted the industry standard for vinyl chloride in 1971; the agency's first review of the issue in depth came in 1974.[109]

Evidence about the effects of vinyl chloride on human health continued to accumulate, in particular concerning one uncommon form of cancer, angiosarcoma of the liver. It is a rare disease; in the 1970s there were only 20 to 30 cases per year of angiosarcoma in the U.S.[110] The disease is strongly associated with vinyl chloride exposure, occurring among PVC workers at 400 to 3,000 times the rate in the general population.[111] In January 1974, B.F. Goodrich announced the death of three PVC workers from angiosarcoma of the liver.[112] This disclosure tipped the balance, making it clear to regulators that workers were dying from vinyl chloride exposure.

At the same time, other serious evidence about the health effects of vinyl chloride was bursting into public view. Data linking vinyl chloride to cancers in laboratory animals were first presented at a conference in 1970.[113] An Italian scientist, Perluigi Viola, published data in 1971 showing that rats exposed to high doses of vinyl chloride developed a variety of tumors. Meanwhile, another Italian researcher, Cesare Maltoni, had been hired by the European chemical industry to conduct additional tests on vinyl chloride. In 1972 he found that kidney and liver cancers appeared in laboratory animals exposed to 250 ppm vinyl chloride — that is, at half the short-term exposure limit accepted at the time. The American and European industries entered a secrecy agreement to prevent public circulation of this new information.[114] But more damaging information continued to appear. By the time of a public hearing held by OSHA in 1974, Maltoni presented evidence of carcinogenicity in animals exposed to levels as low as 50 ppm of vinyl chloride.[115]

In response, OSHA issued an emergency standard in April 1974, requiring companies to keep vinyl chloride levels at or below 50 ppm. OSHA then held hearings to determine what the permanent standard for occupational vinyl chloride exposure should be. The agency initially proposed a standard of "no detectable level" of vinyl chloride in air; industry vigorously opposed this proposal, arguing it would force factories to shut down. Over the course of the hearings, thousands of pages of testimony were submitted from industry, unions, and occupational health experts. Industry representatives argued that low levels of vinyl chloride exposure had not been demonstrated to harm human health, and that strict regulation of the carcinogen would put factories out of business. Labor and health advocates argued for stronger regulation. OSHA issued a permanent standard for occupational vinyl chloride exposure in October 1974, setting a maximum allowable exposure level of 1 ppm averaged over an eight-hour period. The standard was a slight retreat from the "no detectable level" proposal, in response to industry objections.[116] However, 1 ppm was the next-strongest vinyl chloride standard considered by the agency, and a huge improvement over previous standards.

What OSHA Knew

At the time of OSHA's decision, substantial incriminating evidence was available on the carcinogenicity of vinyl chloride, but many questions remained unanswered. OSHA's success in regulating vinyl chloride depended on the agency's willingness to take precautionary action in the face of uncertainty. Had the agency attempted to estimate a monetary value for the likely benefits of reducing vinyl chloride exposure, it would have had difficulty making the case for the regulation. Much of the information required for the "benefits" side of the balance sheet was simply unknown at the time of OSHA's decision.

For example, OSHA had no firm estimate of how many people had been or would be killed by angiosarcoma of the liver resulting from vinyl chloride exposure. There was not enough information available, either from the Italian studies or from the U.S. fatalities, to draw a dose-response curve. OSHA was aware of carcinogenic hazards to other organs, including the lung, kidney, brain and skin, as well as some non-cancer effects,[117] but the agency possessed little epidemiological data on the relationship of these other disorders to vinyl chloride exposure in humans. The extent of OSHA's knowledge about the applicability of animal data to human health was also limited. It would not have been possible, in other words, to quantify the expected health impacts resulting from a given exposure level. Quantifying effects, however, is exactly what cost-benefit analysis requires. In the absence of hard estimates of the magnitudes involved, many benefits would typically be omitted from a cost-benefit analysis – in effect, valued at zero.

Although precise quantitative estimates of impacts were not available, important aspects of both laboratory (animal) and epidemiological (human) evidence were available to OSHA in 1974. Animal evidence available to OSHA at the time of the ruling included data from Cesare Maltoni and others showing high levels of cancer in laboratory animals exposed to concentrations as low as 50 ppm of vinyl chloride. In one set of experiments, 200 mice were exposed to 50 ppm of vinyl chloride in air for eleven months; half of them died.[118] In short, the allowable exposure level established by OSHA's emergency action in early 1974 was still high enough to kill laboratory animals within months.

On top of the laboratory evidence, OSHA also knew that vinyl chloride workers were dying. There were at least 13 confirmed cases of angiosarcoma of the liver, which had led to deaths at B.F. Goodrich, Union Carbide, Firestone Plastics, and Goodyear Tire & Rubber.[119] In OSHA's view, the link between cancer and vinyl chloride was clear from these animal and human data.[120]

What OSHA did not have was any hard information on the effects of vinyl chloride exposure below 50 ppm. The industry presented arguments that an exposure threshold for tumor induction had been identified; OSHA discussed and rejected this view.[121] Instead, OSHA's final ruling cited the conclusion of the Surgeon General's Ad Hoc Committee, which found that "safe exposure levels for carcinogenic substances cannot be scientifically determined," and noted that testimony provided by the National Institute for Occupational Safety and Health (NIOSH) also supported the view that no safe threshold could be defined.[122] Retreating under industry pressure from the "no detectable level" standard favored by NIOSH and others on scientific grounds, OSHA adopted the next-best option.

Vinyl Chloride Since 1974

In the years since OSHA's decision, scientists have continued to collect information on the health effects of vinyl chloride exposure, and have continued to document the growing number of people affected. For example, a 1976 article documented an increased likelihood of birth defects in populations living near vinyl chloride polymerization facilities.[123] A 1977 article presented evidence suggesting that non-occupational exposure routes, such as living near a polymerization or fabrication plant, might also play a role in causing angiosarcoma of the liver.[124] A 1980 review article found that research since the OSHA ruling had shown vinyl chloride to be carcinogenic to other organs, including the brain and lung.[125] A 1986 article supported a link between vinyl chloride exposure and testicular damage in laboratory animals.[126] An epidemiological study published in 1990 linked vinyl chloride exposure to human liver tumors other than angiosarcoma.[127]

In summary, since OSHA's 1974 ruling, the evidence on health hazards associated with vinyl chloride exposure has steadily mounted. In retrospect, we know that vinyl chloride exposure posed severe hazards to workers – and the communities around the manufacturing plants – even at low doses. OSHA acted decisively on the incriminating information that was already available at the time of the ruling; subsequent history has shown that the costs of inaction would have been even higher than OSHA knew at the time. With this history in mind, in the next section we look at what might have transpired if OSHA had relied on formal cost-benefit analysis to arrive at its decision.

Cost-Benefit Analysis

If OSHA had used cost-benefit analysis to evaluate its options in 1974, what would the result have been? For cost-benefit analysis, we need dollar values. On the "cost" side, OSHA had access to a variety of estimates. Industry representatives had put forward several estimates of what it would cost to reduce workplace vinyl chloride exposure. In addition, OSHA commissioned an independent study, by the consulting firm Foster D. Snell, to gauge the likely costs of several regulatory options.[128]

OSHA's consultant analyzed the costs of several regulatory options, but did not produce estimates for the cost of the 1 ppm standard that was ultimately adopted. For a somewhat looser standard, they estimated annual compliance costs of $109 million.[129] A widely cited account of the regulation, published in 1995 by the Office of Technology Assessment, says that the best information available to OSHA implied that the cost of the 1 ppm standard would be $1 billion. (OTA 1995) It appears likely that this is a total cost for conversion, not an annual cost.[130] If so, it implies an annual compliance cost of roughly $200 million.[131] Had OSHA carried out a cost-benefit analysis, we assume it would have relied on a figure of about $200 million for annual costs.

At the time of the ruling, OSHA lacked much of the data on benefits that cost-benefit analysts would rely on today. The agency noted that about threequarters of the employees with the highest vinyl chloride exposure had not been located; that the average latency period for development of liver cancers appeared to be 20 years; and that the dose-response relationship for angiosarcoma of the liver was not known. For all these reasons, there was no way to determine the total number of people who would ultimately be affected. Evidence on other cancers or non-cancer diseases caused by vinyl chloride was even less complete. In many cost-benefit analyses, benefits with such inadequate data are routinely ignored, on the grounds that they are impossible to quantify.

However, even in the absence of hard data on benefits, it is possible to do the calculation in reverse: what estimates would have been needed for the regulation to pass a cost-benefit test? The principal benefit is the reduction in deaths caused by vinyl chloride exposure; how many lives would OSHA have had to think it was saving in order to justify an annual cost of $200 million? That is, if human lives were expressed as dollar values and placed on one side of the scale, how many lives would it take to balance out $200 million in expenses for the industries using vinyl chloride?

The calculation can be done either with recent estimates of the dollar value of a life, or with the much lower estimates that were common back in 1974. The highest value of a life that has been widely employed for regulatory analysis is EPA's estimate of $4.8 million in 1990 dollars, used in a number of decisions in the late 1990s.[132] This value was based largely on statistical analysis of the wage differentials between slightly more and less dangerous jobs. Frequently the value of life has been adjusted to account for inflation; for example, in the arsenic cost-benefit analysis, completed in 2000, EPA adjusted the $4.8 million figure up to the equivalent in 1999 dollars, or $6.1 million. If this estimate is similarly adjusted back to 1974, the value of a human life in that year's dollars was $1.81 million. Thus, to "break even" against a $200 million cost in 1974, OSHA's standard would have had to save about 110 human lives per year.

The revelations that spurred OSHA into action involved 13 cases of vinyl chloride workers who died of angiosarcoma. In retrospect, this is not an unreasonable estimate for the annual death rate from angiosarcoma of the liver caused by vinyl chloride exposure.[133] It would have been impossible for OSHA to argue that more than 100 workers were dying of angiosarcoma each year; and data were not available on any other causes of death linked to vinyl chloride. Therefore, cost-benefit analysis would have supported the industry contention that the benefits of strict regulation of workplace exposure did not justify the expense.

The above calculation is only one version of what a cost-benefit analysis might have looked like. Another variant would have argued even more strongly against the regulation. The crucial estimate of $1.81 million per life is a modern figure transported back in time. At the time of the OSHA decision, in 1974, the wage-risk calculations used to value life in the 1990s were not yet widely accepted; much lower values of life were in use for cost-benefit calculations. In the infamous calculation in the Ford Pinto controversy, which occurred at about the same time, Ford's economists cited government agency estimates of the value of a life of only $200,000, based largely on lost earnings.[134] If OSHA had actually tried to do a cost-benefit analysis in 1974, it might easily have ended up using the "Pinto value" of $200,000 per life. With this value per life a regulation would need to save 1,000 human lives per year in order to break even against a $200 million cost.

A total of about 1,500 workers were employed in vinyl chloride production in 1974, and about another 5,600 worked in PVC resin production, for a total of just over 7,000 in the affected industries.[135] Thus to support OSHA's regulation with a cost-benefit analysis using the "Pinto value," it would have been necessary to show that one of every seven workers in the industry would have died from vinyl chloride exposure each year in the absence of regulation.

If the agency had discounted future benefits, the number of deaths required to support the regulation would have been even larger. The average latency period for angiosarcoma cases is about 20 years. If the value of a human life is discounted at a 3 percent discount rate over the average 20-year delay before the diagnosis of fatal cancer, then each life becomes worth only 55 percent as much:[136] the $1.81 million "modern value" drops to a present value of $1 million, while the $200,000 "Pinto value" shrinks to $110,000. At these rates, about 200 deaths per year in the former case, or around 2,000 in the latter, would have to be averted in order for the policy to be worth its $200 million annual cost. A higher discount rate, which analysts commonly used at the time, would have reduced the present value of the fatalities even more, raising the number of averted deaths required to "justify" the regulation even farther beyond the bounds of plausibility. At a 7 percent discount rate, the break-even number of avoided deaths is about 400 per year with the modern value of life, or 4,000 with the Pinto value. At a 10 percent discount rate, the break-even point jumps to roughly 700 with the modern value, or 7,000 – the entire workforce of the industry – with the Pinto value. That is, using a 10 percent discount rate and the value of life estimated in the 1970s, it would be necessary to show that every worker in the industry, every year, would have died in the absence of the standard, in order to justify the regulation in cost-benefit terms.

The report by OSHA's consultants included estimated costs for more lenient standards, with ceilings of 10, 25, or 50 ppm of vinyl chloride in the air. These would have required smaller, but still substantial, numbers of avoidable deaths to "justify" their adoption in cost-benefit terms. With the number of known deaths in the low two figures, cost-benefit calculations would indicate that even these standards were too expensive for the benefits that would be achieved.

An Unexpected Bargain

As it turned out, the advance estimate of the costs of reducing vinyl chloride exposure was just that: an estimate. Producers quickly adopted innovative technologies that made it much easier to limit vinyl chloride in air. A 1978 study estimated that the industry had spent only $20 million per year – a tenth of the predicted value – on compliance in the four years since the rule was passed.[137] A former economist at the Department of Labor concluded that the actual cost of complying with the standard was only 7 percent of the predicted cost.[138] According to a later retrospective overview by the Office of Technology Assessment, the total cost of compliance with the regulation was about a quarter of what had been estimated, and none of the producers were driven out of the industry by regulatory costs.[139] Whether the actual costs were 7 percent, a tenth, or a quarter of the original estimate, it is clear that compliance costs were a fraction of the best guess OSHA was able to come up with in advance. Meanwhile, our knowledge of the benefits continues to grow as the evidence accumulates on a wide variety of disorders associated with vinyl chloride exposure. OSHA did not know any of this at the time of the ruling; but its precautionary decision has been vindicated by the science, as well as the economic information, that has accumulated since 1974.

Cost-benefit analysis would have argued strongly against OSHA's prescient regulation; once again, it would have been wrong in retrospect.

Conclusion: Wrong Every Time

If EPA had been required to conduct a cost-benefit analysis before taking lead out of gasoline, the agency might never have acted. Ironically, that would have meant that the famous 1980s cost-benefit analysis of removing lead from gasoline would never have happened either, because there would have been no data on falling levels of lead in children's blood. Likewise, cost-benefit calculations with realistic nuclear costs would have led the RAND analysts to the obvious conclusion that they happily and mistakenly missed: big dams are a very cheap way to generate electricity, if that is all that matters. And cost-benefit analysis would have shown that vinyl chloride regulation was too expensive for the benefits it produced. It would seemingly have been optimal, in cost-benefit terms, to have allowed more workers to die of cancer every year in order to have cheaper vinyl siding on the market.

Our country has enacted many farsighted, protective laws and regulations governing public health and the environment. Economic analysis has sometimes played an important supporting role in improving these regulations. But economics has not been the gatekeeper, allowed to make the final decision on which regulations will take effect and which will not. A rigid insistence on making regulations pass cost-benefit tests would, in retrospect, have gotten the wrong answer time after time. There is no reason to expect the same narrow methods to perform any better today.

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End Notes

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92. Data in Figure 1, other than the RAND forecast, are from Too Cheap to Meter, *supra* note 83, at 105, table 4.3, converted to 2003 dollars using the GDP deflator as in the previous calculations.
93. *See* the CAP website, http://www.cap-az.com/.
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95. The construction cost was reportedly $5.9 billion; capacity is 3810 MW, implying an average cost of $1549 per kilowatt. *See* http://www.srpnet.com/power/stations/paloverde.asp. Construction began in June 1976 and ended in

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131. The Snell report amortized capital costs over 10 years at 12 percent. Applying this rule, the annual carrying cost for a $1 billion investment would be $177 million; for a $856 million investment, the annual carrying cost would be $151 million. Assuming that there are operating costs as well as capital costs for compliance, we obtain a very rough estimate of $200 million per year.
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About the Center for Progressive Regulation

Founded in 2002, the Center for Progressive Regulation is a nonprofit research and educational organization of university-affiliated academics with expertise in the legal, economic, and scientific issues related to regulation of health, safety, and the environment. CPR supports regulatory action to protect health, safety, and the environment, and rejects the conservative view that government's only function is to increase the economic efficiency of private markets. Through research and commentary, CPR seeks to inform policy debates, critique anti-regulatory research, enhance public understanding of the issues, and open the regulatory process to public scrutiny. Direct media inquiries to Matthew Freeman at mfreeman@progressiveregulation.org. For general information, email info@progressiveregulation.org. Visit CPR's website at www.progressiveregulation.org.

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