Are Risk Regulators Rational? Evidence from Hazardous Waste Cleanup Decisions

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A large literature in economics and social science focuses on how people reason about risks. Reactions of individuals to risk frequently depart from behavior predicted by full information variants of expected utility theory. Risk regulators are human and are subject to political pressures that are reflective of people's attitudes toward risk. As a result, the public policies they espouse may reflect errors in judgment about risk.

Many biases stem from misperceptions of risk. Individuals overestimate small probabilities, overestimate the risks associated with highly publicized dangers, and have preferences over the manner (not just the magnitude) in which risks arise. Environmental risks associated with hazardous waste sites may be particularly prone to such errors since they involve small risks that are highly publicized. Indeed, the general public ranks hazardous waste sites as the leading environmental risk.[1]

A growing literature also analyzes how the decisions of risk regulators depart from choices predicted in a standard benefit-cost framework. As Roger G. Noll and James E. Krier (1990) point out, since regulators are both human and political their decisions may reflect risk "biases." Regulators may exhibit these biases as individuals and because their constituents will express regulatory demands based on risk perceptions.[2] Risk regulators may take into account the identity of the parties exposed to risk, the level of scrutiny by interest groups, the nature of congressional representation of affected constituents, and the degree of political activity by potentially exposed individuals.[3] Errors in risk perceptions and risk decisions cause individuals to diverge from expected utility maximization. Similar errors by policy makers and the influence of risk politics cause regulators to diverge from social welfare maximization.

This paper examines decisions made by federal and state regulators at hazardous waste sites addressed by the Superfund program to determine how their decisions diverge from those predicted by expected utility theory and benefit-cost analysis. We analyze whether risk perceptions and politics influence two decisions central to the "how clean is clean" debate at Superfund sites—the selection of chemical cleanup targets and the expenditure of remediation funds at these contaminated sites. We also explore the interactive influence of risk-perception factors and political demands.

Previous research on the regulation of chemical risks in standard setting indicates that decisions reflect evidence of risk biases and responsiveness to political factors. In assessing the determinants of the EPA's decision to cancel pesticide registration, Maureen L. Cropper et al. (1992) found that the EPA was more likely to cancel a pesticide in instances featuring higher risks to the maximally exposed individual user, lower benefits associated with continued use of the pesticide, higher values of intervention by environmental groups (mea-

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[1] See U.S. Environmental Protection Agency (EPA) (1987) for a report on this survey evidence.

[2] This theme is also articulated in Richard J. Zeckhauser and Viscusi (1990). Noll (1989) provides a more general assessment of the interaction between political concerns and regulatory policy, which is a central theme of this paper.

[3] Political factors have long played a prominent role in local hazardous waste policies. See, among others, Linda Cohen (1981), Howard Kunreuther and Douglas Easterling (1990, 1992), and Kunreuther and Rajeev Gowda (1990).

sured by regulatory comments), and lower values of interventions by business groups. In the decision of which chemicals to regulate across different agencies, Viscusi (1995) found that the federal government was much more likely, for a given level of risk, to regulate risks arising from synthetic chemicals than those arising from naturally occurring sources. This result is consistent with the "reference risk effect" (Viscusi et al., 1987) and the "status quo" bias established by William Samuelson and Zeckhauser (1988). In a review of 132 regulatory decisions involving cancer risks, Curtis C. Travis et al. (1987) found that in choosing which chemical risks to regulate, federal agencies were strongly influenced by the levels of maximum individual cancer risks [e.g., every risk above 4×10^{-3} was regulated and no action was taken (with one exception) on risks below 1×10^{-6}]. There was not a "strong correlation between the size of the population exposed and the likelihood of regulation," but there was an influence of total population risks (e.g., expected annual cancer deaths) on the likelihood of regulation. George Van Houtven and Maureen L. Cropper (1996) stress the importance of examining regulator decisions about risk rather than simply focusing on statutory guidelines, for they find that the EPA considered both costs and risks in issuing standards even in programs where legislation indicated costs were not to be considered.

There is mixed evidence on how Superfund regulators respond to the nature of risks and the nature of the community bearing these risks. Shreekant Gupta et al. (1995) found that in setting cleanup targets at Superfund sites the agency did not appear to take cleanup costs into account (consistent with the congressional admonition to protect health without consideration of costs), did set more protective standards in minority areas, and left higher risks in places with higher baseline risks (interpreted as resulting from a diminishing marginal utility from cancer cases averted). John A. Hird (1993, 1994) found that once sites were in the EPA's pipeline for remediation, the progress of the site through the phases of site investigation, record of decision (i.e., cleanup decision), and remediation did not depend on the socioeconomic characteristics of the counties containing the sites. He also found that the relevant congressional Superfund oversight committees had little or no impact on the extent or pace of cleanups of sites in the districts/states of committee members. Rae Zimmerman (1993) found that communities with higher percentages of minorities were less likely to have cleanup decisions in place than other communities, while communities with sites that generated more controversy (as measured by news media coverage and a survey of EPA site managers) were more likely to have cleanup plans established. Marianne Lavelle and Marcia Coyle (1992) found that progress toward cleanup was slower in minority communities, which were also more likely to have less permanent remedies selected. In a larger study controlling for many factors, Gupta et al. (1996) found that in selecting the permanence of a site remediation, the agency was not significantly influenced by the median household income or racial composition of the surrounding population.

This article makes four distinct contributions to the growing literature on agency decisions about risk. First, we base our analysis on a detailed assessment of the costs and benefits of hazardous waste cleanups. Using geographic information systems (GIS) technology and block group-level Census data, we develop estimates of the expected number of cancer cases avoided on a site-level basis. The risk data used in these calculations are the most comprehensive in the literature and are calculated on a consistent basis across sites. The estimated cost per cancer case avoided serves as a direct efficiency measure.

Second, we analyze how cleanup decisions and the efficiency of cleanup decisions are affected by a variety of risk variables. These measures capture the influence of potential biases in the response to risk that have been found in various survey and laboratory settings. Thus, we examine whether identified patterns of irrationality in individual decision-making influence the agency's hazardous waste cleanup decisions.

Third, we also explore the role of political factors in influencing cleanup decisions using measures of voter turnout and congressional voting records. While some previous studies have investigated whether political factors influence EPA decisions, they have noted that regulators could be concerned about the preferences of affected parties because of efficiency concerns. If one holds constant demographic factors associated with willingness to pay to avoid risks or preserve the environment, however, one would not expect the likelihood of collective action by constituents to matter if regulators were only concerned about efficiency.

Fourth, we examine the role of political factors and risk measures and their interactive effect in influencing the efficiency of cleanup decisions. Does the effect of political variables, for example, enhance the efficiency of cleanups by making them more responsive to those exposed to risks, or are political factors most powerful when the economic rationale for cleanup is weakest? Ours is the first analysis to distinguish the differential effect of such influences based on the relative efficiency of the cleanup decision.

Our findings indicate that most of the significant influences on Superfund site decisions do not follow the expected pattern for efficient risk management. Policy makers sometimes respond to the expected costs of remediation and the expected number of people exposed to cancer risks in the desired economic direction. While both of these factors would be consistent with a standard benefit-cost analysis, their consideration is inconsistent with the remediation policies enunciated by the Congress (which directs the EPA to make Superfund decisions without explicitly requiring it to examine costs) and the agency (whose cleanup decisions are stated in terms of individual risk reduction without regard to the populations exposed to these levels of risk). Cleanup target selection does reflect biases from the individual risk-perception literature, such as the availability effect (e.g., more highly publicized chemicals that create high risks receive more stringent targets) and the anchoring phenomenon (e.g., regulators tolerate a higher cleanup target risk the greater the baseline risk). Politics also plays a role in remediation decisions, since communities with higher voter turnouts are more likely at times to have lower final risks remaining at sites and to have more spent to avert an expected case of cancer. We find these political influences are most influential for the least cost-effective site cleanups and the lowest site risks. Overall, we find that Superfund expenditures do not fare well when evaluated in terms of cancer prevention. At the median site expenditure in our sample, the cost per case of cancer prevented is in excess of $6 billion.

Section I describes the Superfund decision-making process and the data base we developed to analyze these hypotheses. Section II provides estimates of the influences on the selection of cleanup target risk level and the costs incurred per case of cancer prevented, and Section III explores determinants of the distribution of the costs per case of cancer averted. Section IV summarizes conclusions about the role of perceptions and politics in the management of environmental risks.

I. Superfund Decision-making

A. *Program Prescriptions*

The Superfund program provides federal money for the cleanup of contaminated hazardous waste sites. Risks to human health at contaminated sites can be dealt with in a number of ways, including institutional controls that limit access to a site, containment of wastes or their removal to repositories, or the treatment of contaminated groundwater and soils. In 1986 Congress revised the program and gave the agency explicit directions on site remediations. The EPA was to favor treatment that "permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances" (42 U.S.C. 9621(b)(1)). The legislation also declared that remedial actions at sites must meet federal environmental standards considered to be "applicable or relevant and appropriate" requirements (ARARs) and mandated that, with few exceptions, state ARARs had to be met at Superfund sites if they were more stringent than federal ones. In 1990 the EPA announced guidelines indicating that two criteria, overall protection of human health and the environment and the attainment (or specific waiver) of federal and state ARARs, would serve as the thresholds that must be met by every site remedy. After these thresholds were met, site managers could consider factors such as permanence of remedy, reduction of toxicity, cost-effectiveness, and state and community acceptance of a remedy. In 1991 the agency provided further guidance on cleanup actions, which stated that "where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the noncarcinogenic hazard quotient is less than one, action generally is not warranted unless there are adverse environmental impacts" (U.S. Environmental Protection Agency, 1991). The directive stated that remedial actions at sites with cancer risks between 10^{-4} and 10^{-6} were up to the discretion of the site decision maker and that once a remediation was undertaken the cleanup goal should be in the 10^{-4} to 10^{-6} range. In practice, the cleanup goal is often more stringent.

By 1992 there were reports of over 36,000 contaminated sites of potential concern to the EPA. Using a ranking method called the Hazard Ranking System that combines information on contamination levels with potential exposure to populations, the EPA has placed nearly 1,400 sites on the National Priorities List (NPL), which qualifies a site for the expenditure of federal remediation funds. At each site the EPA undertakes remedial investigation and feasibility studies, which include an assessment of cancer and noncancer risks and a discussion of the costs of remediation options. Given the risk and cost information generated at the site and the legislative and regulatory framework enunciated, the regional EPA administrator officially issues at each site a Record of Decision (ROD) that describes which remedy has been chosen and what the target cleanup goals are, expressed in terms of chemical concentration or risk levels remaining after remediation. A remedial project manager supervises decisions at each site. The "regulators" whose decisions we are modeling here thus involve different levels of EPA officials, some of whom will be familiar with the minute details at sites and others of whom focus on broader policy objectives.

EPA conducts the risk assessments according to a given set of guidelines, the 1989 U.S. EPA *Risk Assessment Guidance for Superfund* (RAGS). EPA characterizes the cancer and noncancer risk pathways at a site by the time scenario of exposure (e.g., does the pathway involve current or future uses of the site?), exposed populations (residents? workers?), exposed age-group (adult or child?), population location (onsite? offsite?), medium location (onsite or offsite?), exposure medium (soil or groundwater?), and exposure route (dermal? ingestion?) (Katherine D. Walker et al., 1995). Estimating these risks involves assumptions about the duration of exposure, frequency with which an individual is exposed, ingestion rates for water and soil, contaminant concentration, and chemical toxicity. The EPA's guidelines encourage conservatism in the estimate of scenarios (e.g., future residential land use is often assumed even if the surrounding area is industrial) and conservatism in parameter assumptions (e.g., upper-bound estimates are used for exposure duration, and the 95-percent confidence limit on the estimate of the mean concentration of the chemical or the maximum detected concentration is used, whichever is lower, to represent a chemical's concentration at a site). These biases, in effect, institutionalize ambiguity aversion biases.[4]

B. *The Superfund Sample and the Empirical Models*

Our analysis of the response of regulators to risks uses an original data base that we developed using the extensive risk and cost data generated by the Superfund policy decision process. For the set of 267 nonfederal sites where cleanup decisions were made in 1991–1992, we collected cost information on these sites and risk data on a subsample of 150 sites (Hamilton and Viscusi, 1995). This yielded a human health risk database with information on over 20,000 chemical-level risk pathways at the 150 sites, which enabled us to develop estimates of the number of cancer cases averted by remediations and the cost of cancer averted at these sites (Hamilton and Viscusi, 1998).[5] For a subset of the sample, the Records of Decision provided detailed information on the risk levels and chemical concentrations chosen as cleanup targets. We coupled this site-specific information

[4] This phenomenon is, for example, consistent with the kind of irrationality reflected in the well-known Ellsberg Paradox.

[5] A chemical-level risk pathway indicates the risk to a particular population arising from a given exposure media arising from a specific chemical contaminant at a site, e.g., the risk to current on-site residents from consumption of groundwater contaminated with benzene.

with a series of other variables not often available in the EPA analyses, such as population density.

In this paper we focus on two decisions at these sites: the cancer risks selected as cleanup targets (e.g., the individual lifetime excess cancer risks that will remain after cleanup) and the implied cost per cancer case averted at each site. The primary unit of analysis in the target risk study is the chemical pathway. For a given chemical at a site where the baseline and target concentration of risk were provided in site documents, we analyze how the target risk chosen (i.e., the risk from the chemical that will remain after site cleanup) varies for the 2,888 pathways at 86 sites where these targets were announced in 1991–1992. At the broader site level, we investigate how expenditures per case of cancer prevented varied across 130 sites.

To establish an efficiency reference point for the analysis, consider a regulator making a site remediation decision on the basis of a benefit-cost analysis of the reduction in cancer risks arising from contamination at the site. The regulator will consider the reduction in individual cancer risk, expressed as the baseline risk B minus the target risk T.[6] Note that B and T are the actual cancer risks as calculated from risk assessment methodology as specified by the EPA. The number of averted cancer cases from remediation is the change in individual risk $(B - T)$ multiplied by the population E exposed to the baseline risk. The value to the social welfare maximizing regulator of this reduction in expected cancers is the number of expected cancer cases averted multiplied by the value V per cancer case averted. The cost C of the given remediation is a function of initial site contamination, the final target risk T chosen as the cleanup target, and additional chemical and site characteristics S which affect the remediation costs, such as the treatment of contaminated soil or groundwater. The social welfare maximizing regulator will thus choose T to maximize social welfare, so that marginal benefits lost from raising the target risk equal the marginal cost savings from a less stringent target for the optimally chosen policy.

There are several reasons why the target risks chosen by the EPA may diverge from those predicted in the social welfare maximizing example. Regulators may, of course, not be maximizing this efficiency measure but may have other more narrowly defined objectives such as reducing risk to a reasonable level. Even if the objective is to generate policies that produce the greatest gains in societal welfare, decisions could be flawed in a number of ways. Regulators might reason on the basis of perceived risks because they are attempting to represent the risk perceptions of their constituents. Regulators also might reason on the basis of perceived risks because they exhibit the risk-perception patterns evident among individuals in their daily risk choices.

Regulator decisions may also diverge from those predicted by social welfare maximization if regulators (or their constituents) value different populations differently. A well-known bias in contingent valuation studies known as the scope effect is that individual estimates of willingness to pay for some environmental amenity may be invariant to the scope of the good being purchased. For example, survey respondents report the same willingness to pay to save 2,000 migratory waterfowl as for 200,000 migratory waterfowl.[7] The practical consequence of this bias for hazardous waste cleanup decisions is that the valuation of the cleanup actions may not be sufficiently sensitive to the number of people exposed. Indeed, the stated EPA risk-assessment policies incorporate this scope effect since the agency expresses cleanup targets in terms of reduction of individual risk levels rather than an analysis of reduction in expected cancer cases overall. If some individuals are more highly valued by regulators, perhaps because they are more politically active and hence more likely to scrutinize regulator actions, then the nature of who bears the risk may also affect site-level Superfund decisions.

The empirical analysis here will focus on two measures of regulatory stringency—the natural

[6] For simplicity we focus on the benefits of cancer reduction since most policy action triggers are tied to cancer effects rather than other benefits from site remediation.

[7] See William H. Desvousges et al. (1992), Peter A. Diamond and Jerry A. Hausman (1994), Michael W. Hanemann (1994), and Paul R. Portney (1994), who discuss such influences.

logarithm of the target risk level T and the natural logarithm of the cost per case of cancer prevented. The target risks are often very small (e.g., 10^{-9}) but are not zero so that taking the logarithm of T is feasible. We estimate two different variants of a target risk model using the 2,888 chemical pathways as the unit of observation:

$$(1)\quad \ln T_{ij} = \alpha + \sum_{k=1}^{m} \beta_k X_{ijk} + \sum_{k=1}^{n} \gamma_k Z_{jk} + \epsilon_{1ij},$$

and

$$(2)\quad \ln T_{ij} = \alpha_j D_j + \sum_{k=1}^{m} \beta_k X_{ijk} + \epsilon_{2ij},$$

where T_{ij} is the risk target for chemical i at site j, X_{ijk} is a chemical pathway characteristic k for chemical i at site j, β_k is the regression coefficient for characteristic k among the set of variables in X_{ijk}, Z_{jk} is site characteristic variable k that varies only by site j not by chemical, γ_k is its coefficient, D_j is a dummy variable that takes on a value of 1 for site j and 0 otherwise, and ϵ_{1ij} and ϵ_{2ij} are random error terms. The site attributes in Z_{jk}, such as the voting rate of the community, are of independent interest so we first estimate equation 1 in which we include a vector of site characteristic variables and a single constant term α rather than the site-specific constant terms. Inclusion of the site-specific constant terms in equation 2 makes it possible to analyze the influence of chemical characteristics controlling for all other fixed site-specific influences.

Since EPA guidance directives (1991) treat risks greater than or equal to 10^{-4} differently (i.e., risks this high trigger site remediations), we separate our analysis of standard setting into two samples. We run specifications (1) and (2) for high-risk pathways, defined as those representing risks of 10^{-4} or greater, and for low-risk pathways, those with risks less than 10^{-4}. Since a given pathway at a site may contribute multiple observations to the analysis, residuals may be correlated within a pathway. We account for this by estimating robust standard errors, which take into account the presence of correlated errors within data clusters.[8]

The analysis of the log of the cost per case of cancer Q_j at site j has a similar specification except that the unit of observation is at the site level, leading to a sample of 130 sites. The site-level fixed-effects term drops out, and the variables depend only on the site j, not particular chemicals i. The resulting equation to be estimated is

$$(3)\qquad \ln Q_j = \alpha_3 + \sum_{k=1}^{n} \psi_k Z_{jk} + \epsilon_{3j},$$

where Z_{jk} is the value of variable k at site j, ψ_k is its coefficient, and ϵ_{3j} is a random error term. We exclude some site characteristics from the cost-per-cancer-case analysis because of the much smaller sample size at the site level. For the cost per case of cancer analysis, the chemical-specific variables in X_{ijk} drop out of the analysis because the cost data are at the site level.[9]

Both T and Q are jointly determined by the choice of the cleanup option and its associated cost and target risk level. These measures differ to some extent in that policy decisions involve a choice among policy options and not just the level of stringency of a particular policy option.[10] Thus, for example, there could be several policy choices that achieve the same target risk level with differing costs per case of cancer. Our analysis of target risk levels and cost per case of cancer can be viewed as a reduced-form analysis in which we treat the target risk levels and cost per cancer case as functions of exogenous chemical and site characteristic measures.

[8] See Peter J. Huber (1967) and William H. Rogers (1993) for discussion of this procedure. Clusters were based upon unique pathways defined by site, exposure medium, time frame, exposure location, and age of the potentially exposed population.

[9] Although the number of variables was great, multicollinearity was not a major problem in the target risk analysis with large sample size, and only minor amendments were needed for the cost-per-cancer-case analysis.

[10] Gupta et al. (1996) find that the agency's decision about the permanence of a site remediation is affected by factors such as cleanup costs.

II. Target Risk and Cost per Cancer Case

EPA officials who make the cleanup decisions at Superfund sites have a number of stated criteria to guide them. If the overall lifetime excess cancer risk to an individual from site contamination is 10^{-4} or higher, EPA guidelines suggest that the site should be remediated so that the remaining risk is somewhere within the 10^{-4} and 10^{-6} interval or below. If baseline risks are already within this range, the site manager has discretion to remediate. If there exist state or federal standards from other environmental programs that apply to a chemical (e.g., ARARs), then the remediation should meet these standards. The cleanup goals enunciated by site managers are generally not expressed at the site level. Instead, they are target chemical concentrations or chemical pathway risks that will remain after the EPA's remediation has been carried out. Our analysis thus focuses on the chemical risk pathway as the unit of analysis. We focus on cancer risks since there is not a good standard metric that allows one to compare noncancer risks (e.g., some chemicals give rise to noncancer effects such as skin rashes, while others generate liver damage).

Figure 1 indicates that if we treat the EPA Superfund risk assessments at face value and examine chemical pathway risks, these risk levels are high compared to many other regulatory programs. For 480 of the 2,888 chemical pathways, the risk is at least 10^{-4}. These risks are high in part because of conservative assumptions made about parameter values in the risk assessments (Viscusi et al., 1997). The distribution of the remediation pathway risks remaining at sites shifts downward after remediation, as only 104 pathways pose a risk of at least 10^{-4}. As Figure 1 illustrates, there is a corresponding increase in the number of pathways posing a risk of 10^{-6} or less after remediation.

The log of the chemical target risks (i.e., the individual lifetime excess cancer risk remaining from a chemical pathway after site remediation is completed) is the unit of analysis in our initial examination of reactions to risk. The 86 sites in the sample with both baseline and target risk data averaged 34 chemical risk pathways with associated baseline and target risks.

A. *Target Risk Equation Estimates*

Table 1 reports the regression estimates of equation (1) and the counterpart fixed-effects estimates of equation (2) for both high- and low-risk chemical pathway samples. We distinguish the high- and low-risk pathways because of the different policy criteria based on pathway risk levels. In each case, the natural logarithm of the target risk after remediation is the dependent variable. Higher (lower) values of the dependent variable reflect less (more) stringent cleanup in terms of the level of risk that is permitted to remain at the site. Standard errors reported are robust to the possible presence of correlated errors across chemicals within a given pathway of a site.

Our results provide strong support for the influence of risk perceptions and politics on the selection of remediation targets at Superfund sites. Consider first the two principal measures of the potency of the chemicals. In both the overall and the fixed-effects estimates, more toxic chemicals and chemicals associated with a higher initial risk level have higher target risks after remediation. Thus, there is less stringent regulation in terms of the outcome of the more potent chemicals. This result could reflect efficiency concerns, as there may be increased costs for remediating more toxic chemicals as, for example, these may take longer to remediate. There also may be increased marginal costs of cleanup. Other possibilities include regulators exhibiting diminishing marginal utility for cancer cases averted or anchoring, so that the initial level of risk influences perceptions about what remaining risks are safe. For example, if regulators' notion of what is a "safe" level of risk is anchored by the estimation from the baseline risk assessments, they will select higher remaining risk targets at sites with higher initial levels of risk.

One risk measure that is influential in leading to more stringent risk targets is not a measure of chemical potency but rather the chemical's public notoriety.[11] Controlling for various risk-

[11] The number of times the chemical is mentioned in the Lexis general news file from 1988–1992 as hazardous or toxic and carcinogenic is the chemical media citations variable, which serves as a measure of availability bias. The more frequent the mention of a given chemical in the

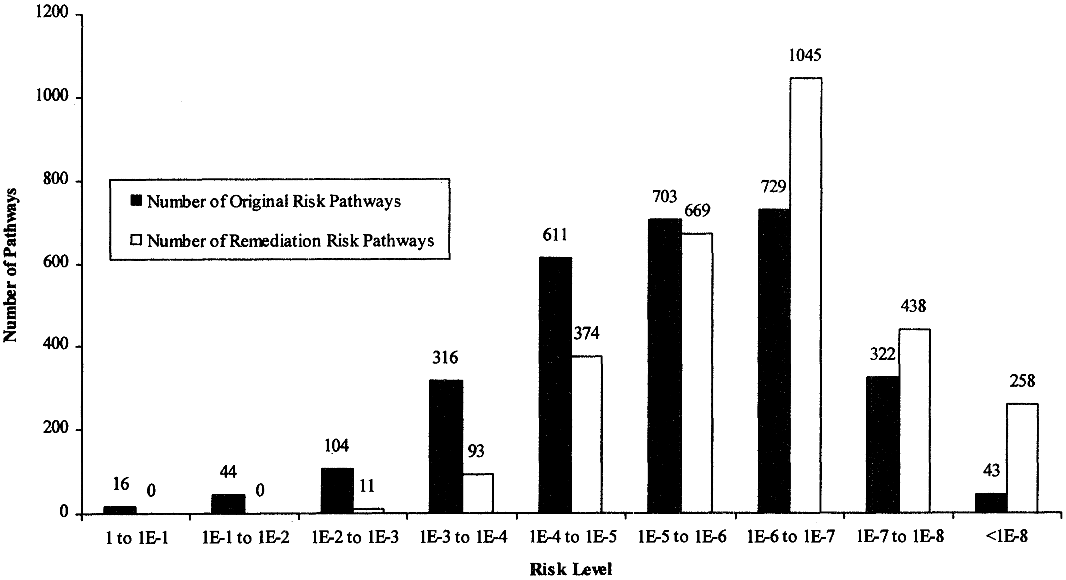

FIGURE 1. COMPARISON OF ORIGINAL AND REMEDIATION CHEMICAL RISK PATHWAY LEVELS

level measures, the larger the number of mentions of a chemical in the popular press the more stringent is the target risk selected in the case of high-risk pathways. This result is consistent with the availability heuristic, since both regulators and those surrounding sites may view particular carcinogens as more dangerous if they have received more media coverage. The higher perceived baseline risks for more publicized chemicals will cause the regulators to set a lower target risk T. If a given T appears more dangerous for more highly publicized chemicals, this will also promote the selection of a more stringent cleanup level.

Perhaps the most surprising chemical pathway variable in terms of its lack of statistical significance is whether the time frame of the pathway is current. The interaction of this variable with whether the site is a residential pathway (i.e., the current resident pathway variable) is also not statistically significant, except in the high-risk fixed-effects equation. These results suggest that the presence of current exposed populations to health risks generally does not enter EPA's decision with respect to the stringency of cleanup. By treating existing populations exposed to risk with the same weight as is placed on hypothetical populations based on changes in future land uses, EPA is failing to adjust the hypothetical risk scenarios for the fact that there is some probability that there will not be such future exposed populations. Moreover, if they are exposed, the discounted benefits of preventing their exposure will be less than will arise from protecting current populations now at the site. The higher target risk level for residential pathways is also inconsistent with health-based concerns. This may reflect a skepticism on the part of policy makers, who may believe that these residential scenarios are less likely to arise and consequently will have a lower expected value.[12]

The estimates in Table 1 include risk-perception

popular press (e.g., coverage of PCBs), the more likely it is that regulators or residents will perceive the chemical as dangerous even controlling for the level of the risk and its toxicity. More frequently cited chemicals consequently should receive lower risk targets. We also include the number of times a site was mentioned in news coverage. Sites with more coverage should have more prominence with the general public and may appear to be riskier, leading to a lower level of T and a higher value of Q.

[12] See Hamilton and Viscusi (1994) for documentation of the dominance of hypothetical future on-site resident scenarios in the EPA risk assessments.

TABLE 1—REGRESSION ESTIMATES OF THE LN OF THE TARGET RISK LEVEL[a]

	(i) High risk	(ii) Low risk	(iii)[b] High risk	(iv)[b] Low risk
Chemical pathway				
Volatile organic compound	1.005 (0.656)	−1.011*** (0.222)	1.704** (0.839)	−0.512** (0.204)
Inorganic compound (metals)	3.434*** (0.566)	0.228 (0.196)	3.530*** (0.646)	0.484*** (0.153)
Log of the chemical toxicity $(mg/kg\text{-}day)^{-1}$	0.503*** (0.082)	0.191*** (0.036)	0.577*** (0.089)	0.194*** (0.036)
Log of the initial chemical pathway risk	0.158** (0.077)	0.751*** (0.034)	0.181** (0.087)	0.783*** (0.032)
Chemical media citations (in thousands), 1988–1992	−0.865** (0.399)	0.014 (0.151)	−1.007** (0.465)	−0.087 (0.137)
Soil pathway	0.581 (0.739)	−0.481 (0.367)	−0.007 (0.809)	−0.627* (0.345)
Time frame of pathway is current	1.585 (1.156)	−0.080 (0.397)	1.357 (0.887)	0.034 (0.312)
Residential pathway	0.579* (0.324)	0.663** (0.287)	0.597*** (0.227)	0.516** (0.218)
Current resident pathway	−2.034 (1.360)	0.296 (0.459)	−2.229* (1.199)	0.562 (0.422)
Child pathway	−0.337 (0.344)	0.048 (0.252)	−0.310 (0.244)	−0.061 (0.104)
Remediation target concentrations based on state regulatory standards	−0.019 (0.412)	−0.245 (0.217)	−0.930* (0.518)	−0.089 (0.254)
Remediation target concentrations based on stated human health risk	0.566 (0.486)	−0.444* (0.262)	1.011* (0.579)	−0.607*** (0.228)
Site characteristics				
Chemical industry site	1.242* (0.658)	−0.649 (0.556)		
Manufacturing site	0.576 (0.468)	0.109 (0.322)		
Landfill	−1.327** (0.571)	−0.336 (0.356)		
Industrial waste site	0.933 (1.000)	−0.170 (0.635)		
Site location—Suburban	−0.237 (0.504)	0.576 (0.434)		
Site location—Rural	−0.908 (0.852)	1.499** (0.657)		
Total number of operable units	−0.698*** (0.249)	−0.168 (0.181)		
Area of the site in square kilometers	−0.082 (0.123)	0.026 (0.056)		
Hazard ranking score	−0.036 (0.030)	−0.016 (0.020)		
Site media citations, 1988–1992	0.163 (0.134)	−0.044 (0.061)		
National Priorities List listing for site between 1981–1984	0.324 (0.607)	0.277 (0.312)		
National Priorities List listing for site between 1985–1988	0.304 (0.569)	0.110 (0.330)		
Federal enforcement cleanup	1.415 (2.803)	0.723 (1.378)		
State enforcement cleanup	1.289 (2.883)	0.505 (1.535)		

TABLE 1—*Continued.*

	(i) High risk	(ii) Low risk	(iii)[b] High risk	(iv)[b] Low risk
Site lead being negotiated	0.597	0.605		
	(2.610)	(1.410)		
Fund-led cleanup	1.651	−0.496		
	(2.544)	(1.586)		
Number of waste-generating facilities within a 1-mile radius	0.024	−0.023		
	(0.030)	(0.020)		
Population (in thousands) per square mile, 1-mile ring	−0.211*	0.179*		
	(0.117)	(0.097)		
Minority population percentage for the 1-mile ring	−0.046***	−0.016*		
	(0.012)	(0.008)		
Mean household income of residents within 1-mile ring	0.046***	0.033***		
($ thousands)	(0.016)	(0.012)		
County voting percentage, 1988	−0.013	−0.056**		
	(0.032)	(0.024)		
Environmental group members per 1,000 state residents	−0.475***	0.121		
	(0.172)	(0.149)		
House League of Conservation Voters' score, 1988–1992	0.016*	−0.003		
	(0.009)	(0.007)		
Senate League of Conservation Voters' score, 1988–1992	−0.065***	−0.020		
	(0.016)	(0.013)		
R^2	0.582	0.662	0.700	0.756

Notes: Significance levels using two-tailed tests: * = significant at 10 percent; ** = significant at 5 percent; *** = significant at 1 percent.

[a] All standard errors are robust standard errors based on the clustered model. Clusters were based upon unique pathways defined by site, exposure medium (soil?), time frame (current?), exposure location (resident?), and age (child?). $N = 479$ in 132 clusters for high-risk group. $N = 2,409$ in 220 clusters for low-risk group. The robust clustered model also included indicators of site location by EPA region. Omitted dummy variables are: semivolatiles, other site types, urban, 1989–1992 National Priorities List listing date, unspecified site lead, and federal standards.

[b] The model also included fixed-effect variables by site for 85 of the 86 sites represented by the 2,888 chemical pathways. Omitted dummy variables were for semivolatiles and federal standards. Sample sizes as above.

variables calculated at the site level, which also influence target selection. Landfills receive more stringent risk targets in the high-risk sample, perhaps because the representativeness heuristic means that Superfund landfills are seen as similar to notorious leaking landfills. Note that the variables related to risk-perception bias of availability/representativeness, such as the chemical media citations variable and the landfill dummy, are statistically significant only for the high-risk sample. This result is consistent with biases coming into play when risks are large enough to command regulators' or local residents' attention. Sites which are mentioned more in the media did not receive lower chemical target risks.[13]

[13] Though site-level media coverage could be viewed as endogenous, we lack good instruments to estimate coverage. Dropping this variable leaves the other results unchanged in terms of their statistical significance, sign, and general magnitude. The endogeneity of variables such as media coverage and hazard ranking score (HRS) means that the coefficients estimated for variables likely to influence coverage or the HRS will only capture the partial effects of these variables. Consider the case of measuring the influence of chemical toxicity, which can affect a site's HRS. The toxicity elasticity presented will only be a partial elasticity based on holding constant the

The site characteristic variable results indicate that broad population-based concerns may affect standard settings, even though EPA guidelines focus on individual rather than population risks. For high individual risk levels the agency sets more stringent cleanup standards the greater the population density. The agency adopts the opposite course for low-level risks, where as population density rises the agency sets less stringent standards. This may be in part because as density increases scrutiny of regulator actions dealing with low-level risks may be less likely if people are less likely to monitor agency decision-making as the number of people in an area grows. Rural sites also received less stringent requirements in the low-risk sample. If regulators believed that these sites were less likely to experience residential development in the future, then this variable could be capturing some of the effects associated with distinctions between current and future residential pathways.

Although EPA appears to respond to economic concerns relating to the population at risk, it also reacts to political concerns. The higher the voter turnout in the area, the lower the target risk chosen when risks are low. Note that when risks are high, political activity has no effect on standards. It is when risks are low that political activity matters. This finding is consistent with previous results that indicate that differences in the potential for residents to engage in collective action affect how polluters treat the distribution of environmental risks (Hamilton, 1993, 1995). Similarly, the higher the membership in environmental groups per 1,000 residents in the state, the lower the target risk set for high-level risks. The higher the support [as measured by League of Conservation Voters' scores for 1988–1992] by a state's senators for environmental legislation, the lower the risk targets set by the EPA. This result may reflect responsiveness to congressional principals by regulatory agents, or if environmental constituents are represented by environmentalists this effect may simply reflect additional responsiveness of regulators to local preferences for environmental protection.[14]

The community variable results go against some popular beliefs. At sites with higher average income levels in the 1-mile ring around a site, a higher risk target will be set. This result may be because regulators believe wealthier residents are less likely to be exposed as assumed in the risk assessments (e.g., groundwater exposures assume well-water consumption, while wealthier residents may be connected to public systems). However, the finding is also consistent with environmental equity concerns focusing more policy attention on risks to the economically disadvantaged. This latter hypothesis is consistent with the influence of a higher minority percentage in an area, which leads to the selection of a more stringent risk target.

Several possible factors may be at work. Since these remediation decisions were made after the policy debate over environmental equity began, regulators may have been more conscious of the treatment of risks to the poor and minorities. In addition, the risk-perception literature (see James H. Flynn et al., 1994) demonstrates that minorities are more likely to perceive given levels of environmental risks as high risks to human health, which could generate more demand for risk regulation in these communities. Regulators might also believe that calculated risks in minority communities were more likely to arise (e.g., if minorities were more likely to consume contaminated groundwater). Since there are no adjustments for this influence in EPA's site-level risk analyses, regulators may treat reported risks more stringently in these communities.

For the high-risk pathways, the elasticities of the target risk variable with respect to several of the key statistically significant variables were as follows: environmental group membership (−4.82), senators' environmental voting records (−4.12), the pathway's initial risk level (0.16), chemical toxicity (0.50), residents' income (1.84), and the minority percentage in the 1-mile ring (−1.06). For the low-risk pathways, the mix of statistically significant variables was somewhat

HRS. The total elasticity would reflect a direct effect and an indirect effect through the influence of the HRS. We thank a referee for this point.

[14] To the extent that environmental group membership and legislator votes reflect the values that residents place on the environment, then these variables could also represent values an efficiency-minded regulator would consider in making cleanup decisions. The significance of the voter turnout variable represents a political bias, however, since it reflects the likelihood a regulator will face local scrutiny or pressure.

different, including the following elasticities: voter turnout (−2.97), the initial risk level (0.75), chemical toxicity (0.19), and residents' income (1.43). Overall, political factors appear to be the most influential in terms of the degree of responsiveness of the cleanup stringency to changes in the variable level.

B. *Cost per Case of Cancer Estimates*

Another way to examine the reactions of regulators to risks at Superfund sites is to explore the determinants of the site-level expenditure of cleanup funds and the implied costs per cancer case averted by remediations. To calculate the costs per case of cancer, we calculate the site-specific risk data with block group-level Census population data using the geographic information systems methodology.[15] The site remediation costs for the sample of sites with matching risk data had a mean of $15.0 million (1993$). The range of site costs from $57,000 to $133.9 million reflects differences in both stringency of remedy selection and degree of contamination. Superfund site documents focus only on individual risk levels. The mean number of cancer cases averted over a 30-year period is 5.6, with a range from 0 to 652 and a median of .019 cancer cases averted per site. The mean cost per cancer case averted implied by the EPA expenditures at the sample of 130 sites is $11.7 billion, with a range from less than $20,000 to $961 billion. The median cost per case of cancer was $418 million, and only 36 of 130 were below $100 million per cancer case averted.[16] These estimates take EPA's conservative risk assessments at face value and assume no latency period for cancer. Making such adjustments (for a sample of 99 sites) leads to a median cost per case of cancer above $1 billion.[17] If remediation expenditures are analyzed based on averting cancer cases alone, the Superfund program has relatively high regulatory costs.

Table 2 presents estimates of the equation for the log of the cost per cancer case averted. Many of the influences reflected in Table 2's analysis of the cost per case of cancer avoided are similar to those in the target risk selection estimates. Sites with a high maximum pathway risk are associated with a lower cost per case of cancer, which parallels the result from Table 1 that cleanup levels are less stringent if the risk at the site is high. As the presence of current exposed populations did not affect the target risk level, even though it should have led to more stringent regulations on an efficiency basis, in the cost per case of cancer regression estimates there is not a statistically significant influence of time frame on expenditures. Rather than setting more stringent standards with a higher cost per case of cancer for current exposed populations, EPA incurs as high a cost per case of cancer when there are only potential future populations at risk. Thus, the target risk level and cost per case for cancer results are reflective of a common pattern of influence. The higher population density leads to a lower cost per case of cancer averted because the presence of a substantial exposed population makes cleanup more efficacious from a benefit-cost standpoint. What should be emphasized, however, is that EPA is not pursuing a policy of equalizing the marginal cost per case of cancer avoided across sites, which would be the efficiency dictum if cancer were the only outcome of policy interest. Rather, by basing its policies on an individual risk approach that does not reflect the size of the exposed population or whether the population now exists at the site, EPA is often failing to recognize important aspects of the overall benefit consequences of its efforts.

Politics does influence the cost per cancer case avoided. The most influential political variable in Table 2 is the county voting percentage in 1988. Counties with high voter turnout have sites in which the cost per case of cancer avoided is greater, indicating a greater willingness of EPA to expend funds on cleanup at sites with substantial political influence. The elasticity of the cost per case of cancer with respect to voter turnout is quite high—4.14. Political pressures exert a powerful influence on the degree

[15] See Hamilton and Viscusi (1999) for further details on how we estimated the cancer cases presented.

[16] These results reflect EPA's risk-assessment practices and have not been adjusted to reflect the "conservatism" practices that lead to an upward bias in the risk estimates. This is similar to the median cost per cancer case averted of $388 million we found in a larger sample of 145 sites.

[17] See Viscusi and Hamilton (1996) and Hamilton and Viscusi (1999).

TABLE 2—DETERMINANTS OF LOG (COST PER CANCER CASE AVOIDED)[a]

Site characteristics	Parameter estimate	Standard error
Log of the maximum pathway risk at the site	−0.379***	0.083
Existence of cancer risk pathways at site under current scenario	−0.845	0.539
Site location—Suburban	−1.308**	0.651
Site location—Rural	−1.710**	0.734
Both soil and groundwater costs expended at the site	−0.863	1.162
Total number of operable units	−0.247	0.274
Area of the site in square kilometers	−0.025*	0.015
Hazard ranking score	0.012	0.030
National Priorities List listing for site between 1981–1984	1.655***	0.576
National Priorities List listing for site between 1985–1988	1.129*	0.574
Number of waste-generating facilities within a 1-mile radius	0.016	0.035
Population (in thousands) per square mile, 1-mile ring	−0.606***	0.151
Minority population percentage for the 1-mile ring	−0.009	0.014
Mean income of residents within 1-mile ring ($ thousands)	−0.008	0.024
County voting percentage, 1988	0.080**	0.040
Environmental group members per 1,000 state residents	−0.208	0.150
House League of Conservation Voters' score, 1988–1992	0.0008	0.009
Senate League of Conservation Voters' score, 1988–1992	0.008	0.022

Notes: Significance levels using two-tailed tests: * = significant at 10 percent; ** = significant at 5 percent; *** = significant at 1 percent. $R^2 = 0.453$.

[a] The model also included indicators of site location by EPA region. Omitted dummy variables are: urban site location, 1989–1992 National Priorities List listing date, and presence of soil or groundwater costs only. White heteroskedasticity-adjusted standard errors are reported. $N = 130$.

of inefficiency in the cleanup expenditures. These results reflect the same pattern of influence as in the target risk regressions, though the magnitude of the elasticity is larger.

The presence of minority populations and people of different income groups did not, however, affect the cost per case of cancer averted under EPA policy decisions. The greater valuations of risk by the more affluent also do not affect policy decisions. The cost per case of cancer avoided is lower at large sites, which may be reflective of their greater risks and potential economies of scale in cleanup.

III. The Distribution of Cost-Effectiveness

From the standpoint of economic efficiency, it is desirable to focus cleanup efforts on the most cost-effective sites. Many risk analysts have noted that there is substantial heterogeneity in the efficacy of risk-reduction policies and that efforts with a cost-per-life-saved value above some cutoff level, such as $5 million per life, should not be pursued if mortality risks are the sole matter of concern. Such targeting may save considerable resources at very little opportunity cost in terms of health benefits forgone.

How large these opportunity costs will be depends on the distribution of the efficacy of cleanup actions. Supreme Court Justice Stephen Breyer (1993) has hypothesized that there is often a 90–10 principle whereby society derives 90 percent of the benefit from the most effective 10 percent of the risk-reduction expenditures. To explore the relationship for our Superfund sample we ranked the sites from the most cost-effective to the least cost-effective. Thus, the comparison is across sites, given the cleanup policies selected, rather than within a site for differing gradations of cleanup.

Table 3 reports the distribution of these cost-effectiveness values for different 5-percentile groupings of site expenditures. Virtually all of the expected cancer cases to be reduced—over 99 percent—are prevented by the first 5 percent of expenditures. Although many of these initial allocations are clearly worthwhile, by the 5th percentile the marginal cost reaches $145 million. At the median site expenditure, the cost per case of cancer prevented is in excess of $6

TABLE 3—SUMMARY OF SUPERFUND COST-EFFECTIVENESS[a]

Percentage of remediation expenditures, ranked by cancer cost-effectiveness	Cumulative percentage of total expected cancer cases averted (sites = 99)	Marginal cost per cancer case averted ($ millions)
5	99.47	$ 145
25	99.86	$ 1,107
50	99.96	$ 6,442
75	99.97	$ 28,257
95	99.98	$241,058

[a] Using the following assumptions: average exposure concentrations and intake parameters, 3-percent discount rate for cost, 3-percent discount rate for cancers, and assuming a 10-year latency period for the development of cancer.

billion, and at the least cost-effective 5 percent of the expenditures, the cost per case of cancer rises to above $200 billion.

The interesting economic issue is what factors drive these decisions of quite different efficacy. Is EPA simply implementing an identical, rigid set of policy concerns for all sites or is there a different character of the influences that are operational for sites of differing efficacy? To explore these issues, we will analyze the determinants of the value of the log of the cost per case of cancer averted at different fractiles of the distribution using a quantile regression model. More specifically, the estimated coefficients of the cost per cancer $\mathbf{Q}$ at the τth quantile satisfy

$$\text{(4)} \quad \text{Quant}_\tau(\mathbf{Q}_i|\mathbf{X}_i) = \mathbf{X}_i'\boldsymbol{\beta}_\tau, \quad i = 1, \ldots, n,$$

where $\mathbf{X}_i$ is a $k \times 1$ vector of covariates and the vector of coefficients for the τth quantile is designated by $\mathbf{B}_\tau$.[18]

Table 4 reports the estimates of an OLS equation and quantile regression models for the analog of the results in Table 2. Some insignificant variables were not included in this model so as to attain convergence. The asymptotic standard errors reported are bootstrap standard errors.

The results in Table 4 reinforce and extend the implications of the earlier results. The maximum pathway risk reduces the cost per cancer case in a similar manner for all quantiles, as the presence of the substantial risks is always influential. Current cancer pathway risks do not affect the cost per cancer case except at the 90th percentile, where they reduce the costs per case. Site media citations are not consistently influential. The National Priorities List listing from 1981–1984 generally makes the cost per case higher, perhaps because the sites from that era that remain as cleanup targets in 1991–1992 are the least cost-effective. Population density enhances cost-effectiveness, where this influence is greatest for the most cost-effective sites.

The most intriguing results pertain to the effect of the dominant political variable in the analysis—the county voting percentage. The earlier analyses suggested that political factors may promote inefficiency. These results document the locus of this effect. The voting variable strongly affects the cost per cancer case and target risk selection in OLS analyses, but the quantile regression results indicate that this effect is highly selective. For sites with cost-effectiveness at the median or better, the voting percentage does not affect the cost-per-cancer-case level selected. Influences such as the risk level and population density are more influential for these more cost-effective sites. However, at the two upper percentiles of the cost-effectiveness distribution, higher voting rates boost the cost per case of cancer averted. These political factors are consequently only influential at the most inefficient sites where the dollar costs per case of cancer are in the billions. Moreover, at these sites, the political factors increase the extent of the inefficiency. Politics only matters through its adverse effect on the most inefficient cleanups.

[18] See Roger Koenker and Gilbert Bassett, Jr. (1978) for further discussion as well as Moshe Buchinsky (1994). We use a bootstrap estimator to obtain the value of the asymptotic standard errors.

TABLE 4—QUANTILE REGRESSION RESULTS FOR LOG (COST PER CANCER CASE AVOIDED)[a]

	Percentile for quantile regression Coefficient (standard error)					
Variable	OLS	0.10	0.25	0.50	0.75	0.90
Log of the maximum pathway risk at the site	−0.381***	−0.374***	−0.383***	−0.390***	−0.356***	−0.445***
	(0.075)	(0.140)	(0.102)	(0.074)	(0.101)	(0.128)
Existence of cancer risk pathway at site under current scenario	−0.891*	−0.192	−1.294	−0.889	−1.107	−1.747*
	(0.531)	(0.844)	(0.960)	(0.872)	(0.763)	(1.011)
Site media citations, 1988–1992	−0.139	−0.245	0.054	−0.064	−0.242*	−0.160
	(0.117)	(0.255)	(0.196)	(0.125)	(0.135)	(0.232)
National Priorities List listing for site between 1981–1984	1.553***	1.889**	1.398*	1.155	2.338***	2.273***
	(0.527)	(0.862)	(0.740)	(0.851)	(0.612)	(0.706)
National Priorities List listing for site between 1985–1988	0.854*	0.765	0.350	1.033	0.984*	1.877**
	(0.507)	(0.717)	(1.004)	(0.741)	(0.569)	(0.872)
Population (in thousands) per square mile, 1-mile ring	0.600***	−1.055**	−0.825**	−0.247	−0.406*	−0.285
	(0.152)	(0.472)	(0.365)	(0.281)	(0.206)	(0.338)
County voting percentage, 1988	0.079**	−0.013	0.014	0.083	0.114**	0.139**
	(0.037)	(0.086)	(0.057)	(0.056)	(0.050)	(0.056)
Pseudo R^2(R^2 for OLS)	0.442	0.359	0.268	0.265	0.357	0.418

Notes: Significance levels using two-tailed tests: * = significant at 10 percent; ** = significant at 5 percent; *** = significant at 1 percent.

[a] All models also included a series of variables for site location (suburban, rural), minority population, income, environmental group members, Senate League of Conservation Voters' score, both soil and groundwater costs expended, and six EPA region variables. To reduce convergence problems some insignificant variables from the earlier analysis were omitted.

IV. Conclusions

Cleanups of hazardous waste sites in the Superfund program inevitably involve decisions about risk, since they affect the potential exposure of residents to contaminants, and decisions that are political, since they allocate limited funds across sites. Prior research on risk regulation indicates that regulator decisions may reflect biases in risk perception (Viscusi, 1995) and that who bears the risks may affect how they are treated (Cropper et al., 1992). Previous work on the Superfund program has found mixed evidence on the degree that characteristics of the surrounding community or their political representatives influence cleanup selections (Hird, 1993, 1994; Zimmerman, 1993; Gupta et al., 1995, 1996).

This article made four distinct contributions to the literature on risk regulation and Superfund decision-making. We combined detailed risk information with Census data to yield a direct measure of cleanup efficiency, the cost per cancer case averted. We used multiple measures describing the character of risks to establish that biases in risk perception are reflected in cleanup decisions. We demonstrated that the likelihood that residents will engage in collective action does cause regulators to adopt more stringent cleanup standards and spend more to avert cancer cases. We also revealed that differences in political power matter to push regulators toward greater inefficiency in remediation decisions.

If decision makers at Superfund sites targeted for cleanups were concerned solely with social welfare maximization, then these regulators would choose target risks for cleanups based on factors related to marginal social benefits (e.g., expected cancer cases) and marginal social costs (e.g., factors which influence remediation costs, such as site characteristics and baseline risks). Unfortunately, many of the critical economic concerns do not affect decisions in the desired manner.

Our analysis reveals that regulators' choice of risk targets is influenced by many additional factors relating both to risk perceptions and the political nature of the community bearing the risks. For high-risk pathways, chemicals with more citations in the popular press, landfill sites, and pathways with lower baseline risks all received more stringent risk targets. These results are consistent with various phenomena found in the risk-perception literature, such as the availability heuristic. Perhaps equally disturbing is the failure of key benefit variables to affect decisions in the expected manner. The presence of a risk to people based on current land-use patterns rather than hypothetical future uses did not increase the stringency of the regulation. Pathways exposing current residents generally did not receive more stringent standards. EPA is thus failing to target its efforts to reflect the overall health implications of risks to currently exposed populations.

What does appear to be influential are a variety of political influences pertaining to the nature of the community. Sites in counties with higher voter turnouts, states with more environmentalists, and states with senators with stronger environmental voting records were all more likely to have stricter environmental cleanup targets. Scrutiny from the bottom up and top down may influence regulator selections. Environmental membership and legislator votes may proxy for the values individuals place on the environment, so those variables could relate to local valuations that an efficiency-minded regulator would consider. The degree of constituent political activities, measured by voter turnout, should not influence regulators unless they are affected by political concerns. A major drawback of political pressure is that it does not serve here as a mechanism for promoting efficiency-based concerns. Indeed, higher voter turnout has a greater effect in increasing stringency when the risks are small. These political pressures push EPA further away from an efficient policy design.

The cost per case of cancer prevented analysis yielded results that were in many respects similar. However, in this case simply the mean value of the cost per case of cancer, which was measured in billions of dollars, was quite telling. EPA cleanup policies are an outlier among government regulatory programs on any efficiency basis, assuming cancer prevention is the primary objective. The benefits of Superfund cleanup are highly concentrated at a very small percentage of sites, with most cleanup actions failing any reasonable efficiency test. The quantile regression results highlighted the pivotal role of political factors for inefficient cleanups, whereas the most desirable cleanups were not influenced by voting rates.

In sum, these results indicate that in hazardous waste cleanup decisions risk-perception biases and risk politics matter. One cannot distinguish with the current information whether risk perceptions matter primarily because they reflect biases of regulators as individuals or regulators as representatives of constituents with biased perceptions, a topic with significant implications about the efficiency of regulator decisions. We can, however, indicate the impact on social welfare of the likelihood that residents will engage in collective actions. Recent debates have reprised the question on the degree that democracy promotes efficiency (see Gary S. Becker, 1983; Donald Wittman, 1989, 1995; John R. Lott, Jr., 1997). We find that in the Superfund program collective action is most effective when risks are small and when expenditures to avert cancer cases are many orders of magnitude greater than figures that emerge from private-market decisions. In the cleanup of hazardous waste sites, our work indicates that greater scrutiny from residents pushes regulators away from decisions likely to maximize social welfare.

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