ISSN 1045-6333

OPTIMAL CLEANUP AND LIABILITY AFTER ENVIRONMENTALLY HARMFUL DISCHARGES

A. Mitchell Polinsky

and

Steven Shavell

Discussion Paper No. 114

9/92

Harvard Law School
Cambridge, MA 02138

The Program in Law and Economics is supported by a grant from the John M. Olin Foundation.

September 1992

OPTIMAL CLEANUP AND LIABILITY AFTER ENVIRONMENTALLY HARMFUL DISCHARGES

A. Mitchell Polinsky

and

Steven Shavell*

Abstract: This article studies how liability for environmentally harmful discharges affects the incentives of firms to engage in cleanup and invest in precautions, as well as the incentives of consumers to purchase the goods whose production leads to discharges. Our main conclusion is that making firms responsible for cleanup and strictly liable for any remaining harm will lead to the socially optimal outcome. We also show that under the negligence approach -- whereby a firm is liable for damages only if it fails to take appropriate precautions or to engage in proper cleanup -- the outcome will not be optimal: too much of the good will be purchased.

---

* Stanford University and Harvard University (1992-93); and Harvard University, respectively. Both authors also are affiliated with the National Bureau of Economic Research. Polinsky's research was supported by the John M. Olin Program in Law and Economics at Stanford Law School and by the Program in Law and Economics at Harvard Law School. Shavell's research was supported by the National Science Foundation (grant no. SES-911-1947). This article was stimulated by the authors' prior work as consultants to the Exxon Corporation in connection with the Valdez oil spill.

1. Introduction

The damage caused by an environmentally harmful discharge often can be mitigated by efforts to undertake cleanup. (By "cleanup" we mean any activity that reduces the harm after the discharge has occurred.) For example, after an oil spill, oil can be removed from beaches, bird and animal rescue centers can be established, and fish can be restocked. Or after toxic wastes have leaked from a storage facility, contaminated soil and groundwater can be treated and barriers can be constructed to reduce further diffusion of the waste.

The damage from environmental discharges also depends on the precautions taken to prevent them. For instance, the use of double-hulled rather than single-hulled supertankers often would eliminate the spillage of oil in the event of a grounding. Additionally, the number of environmental discharges depends on the level of consumption of the good whose production gives rise to the discharges. If, for example, less plastic is used to manufacture products, there will be less chemical waste and fewer waste-disposal accidents.

This article studies how liability for environmental discharges affects the incentives of firms to engage in cleanup and invest in precautions, as well as the incentives of consumers to purchase the goods whose production leads to discharges. Our main conclusion is that making firms responsible for cleanup and strictly liable for any remaining harm will lead to the socially optimal outcome: firms will appropriately clean up and take proper precautions, and consumers will purchase the correct amount of the good. We also show that under the negligence approach -- whereby a firm is liable for damages only if it fails to take appropriate precautions or to engage in

proper cleanup -- the outcome will not be optimal: too much of the good will be purchased.

Section 2 presents our basic analysis, Section 3 extends it in several important respects, and Section 4 briefly discusses current practice in light of the analysis.[1]

2. Basic Analysis

2.1. The Model. We consider a model in which production of a good is associated with the risk of an environmental discharge and in which, if a discharge occurs, cleanup effort by the responsible firm can reduce the level of harm. Also, a firm can reduce the risk of a discharge by exercising precautions. Let

c = cost of producing a unit of the good, exclusive of the expense of precautions;

x = cost of precautions per unit of the good;

$p(x)$ = probability of a discharge per unit of the good; $p'(x) < 0$; $p''(x) > 0$;

y = cleanup expenditures if a discharge occurs;

$h(y)$ = harm due to a discharge, given y; $h'(y) < 0$; $h''(y) > 0$.

---

[1] The contribution of this article is to apply ideas from the economic theory of liability to the problem of environmentally harmful discharges when post-discharge mitigation of harm by cleanup activities is a significant issue. The standard model of liability treats the level of harm if an accident occurs as fixed; we add the possibility that the injurer can spend money to reduce the harm (by cleanup effort).

For complementary discussions of the control of environmental discharges, see, for example, Burrows, Rowley, and Owen (1974), Cohen (1986; 1987), Epple and Visscher (1984), and Segerson (1989; 1990). None of these articles, however, focuses on and formally models how liability rules affect an injurer's incentive to clean up after a discharge.

Assuming for simplicity that all consumers of the good are identical, let

z = production of the good per individual;

$u(z)$ = utility from consumption;

w = wealth;

and suppose that the total utility of an individual is $u(z) + w$. We will assume as well that firms that produce the good are in a competitive market, so that the price of the good equals the cost of production plus any relevant cleanup and liability costs. Let

r = price of the good.

2.2. The Social Optimum. Social welfare is assumed to equal the utility of individuals less the total costs of production, including costs associated with discharges:

$$u(z) + w - z\{c + x + p(x)[y + h(y)]\}. \tag{1}$$

Let the optimal x, y, and z be denoted by asterisks.

It is clear from the form of (1) that y^* minimizes $y + h(y)$, so that y^* is determined by the first-order condition

$$-h'(y) = 1. \tag{2}$$

In other words, cleanup expenditures should be undertaken until the marginal reduction in harm from spending a dollar equals a dollar.

It also is clear from (1) that x^* minimizes $x + p(x)[y^* + h(y^*)]$, so that x^* is determined by

$$-p'(x)[y^* + h(y^*)] = 1. \tag{3}$$

That is, precautions should be invested in until the marginal reduction in expected harm and cleanup expenditures (at their optimal levels) equals a dollar.

Given x^* and y^*, z^* is determined by the condition

$$u'(z) = c + x^* + p(x^*)[y^* + h(y^*)]. \tag{4}$$

In other words, production of the good should occur until the marginal utility from the good equals the full cost of production, including the expected harm, the expected cleanup costs, and the costs of taking optimal precautions.

2.3. Strict Liability. Assume now that if a firm causes a discharge, it will be responsible for cleanup and strictly liable for any harm remaining after cleanup.

Thus, if a discharge occurs, a firm's expenses will its cleanup costs, y, plus its liability for harm, $h(y)$, so it will choose y to minimize $y + h(y)$, meaning that it will select y^*. Because the firm knows that it will choose y^* and bear costs of $y^* + h(y^*)$ if a discharge occurs, it will select its level of precautions to minimize its unit costs $c + x + p(x)[y^* + h(y^*)]$, so it will choose x^*. Consequently,

$$r = c + x^* + p(x^*)[y^* + h(y^*)]. \tag{5}$$

Since individuals will choose z to maximize

$$u(z) + w - rz, \tag{6}$$

their selection of z will satisfy

$$u'(z) = r, \tag{7}$$

which is to say that (4) will be satisfied.

In summary, we have

Proposition 1. If firms that cause environmental discharges are made responsible for cleanup and strictly liable for any remaining harm, they will take socially optimal precautions to prevent discharges and undertake the socially optimal amount of cleanup if a discharge occurs. Moreover, consumers will purchase the socially optimal amount of the good whose production gives

rise to discharges.

2.4. Negligence. Under the negligence rule, we assume that if a discharge occurs, a firm will be liable for harm either if it failed to take appropriate precautions, $\hat{x}$, or if it failed to engage in appropriate cleanup, $\hat{y}$; otherwise it will not be liable for harm. We further suppose that the courts select $\hat{x} = x^*$ and $\hat{y} = y^*$.

Then it can be shown that a firm will choose x^* and y^*.[2] Since firms therefore will not be found liable, the price of the product will be

$$r = c + x^* + p(x^*)y^*, \tag{8}$$

which is less than (5) by $p(x^*)h(y^*)$. Consumers then will choose z such that

$$u'(z) = c + x^* + p(x^*)y^*, \tag{9}$$

which implies that they will purchase more of the good than z^*.[3]

Thus, we have

Proposition 2. If firms that cause environmental discharges are made liable for harm if they were negligent either in terms of precautions or cleanup effort, they will take socially optimal precautions to prevent discharges and undertake the socially optimal amount of cleanup if a discharge

---

[2] Suppose that the firm acts negligently by choosing $x < x^*$ and/or $y < y^*$. Then its unit costs are $c + x + p(x)[y + h(y)]$, but this exceeds $c + x^* + p(x^*)[y^* + h(y^*)]$ since x^* and y^* minimize unit costs; also, the latter expression exceeds $c + x^* + p(x^*)y^*$. Hence, the firm is better off choosing x^* and y^* than acting negligently. Furthermore, it is not in the interest of the firm to exceed the standards x^* and y^*. That this is true with respect to y is obvious since the firm is trying to minimize $c + x + p(x)y$, which is increasing in y. That x^* is preferred by the firm to any x exceeding x^* can be shown by the following reasoning. The derivative of $c + x + p(x)y$ with respect to x is $1 + p'(x)y$. Since x^* minimizes $x + p(x)[y^* + h(y^*)]$, we know that $1 + p'(x^*)[y^* + h(y^*)] = 0$. This implies that $1 + p'(x)y^* > 0$ at x^*; that $1 + p'(x)y^*$ also is positive for $x > x^*$ follows from the assumptions that $p'(x) < 0$ and $p''(x) > 0$. Hence, x^* is the optimal choice for the firm.

[3] This follows from the concavity of u(.) and the fact that the right-hand side of (9) is less than the right-hand side of (4).

occurs. However, consumers will purchase a socially excessive amount of the good whose production gives rise to discharges and therefore a socially excessive number of discharges will occur.

Remarks. (a) The result that precautions and cleanup effort are optimal depends on the assumption that the court's standards are optimal. If they are not, then firms will not choose x^* and y^*, but instead will adhere to the standards $\hat{x}$ and $\hat{y}$ (unless they exceed x^* and y^* by a large amount).

(b) The conclusion that consumers will purchase too much of the good derives from the fact that the price does not reflect the harm due to discharges.[4]

3. Extensions

3.1. Limited Assets of Firms. Since the harm caused by an environmental discharge can be substantial even if the scale of operations of the responsible firm is small, in many cases firms will not have assets that are sufficient to pay for the harm. For instance, a small pesticide company could release a carcinogen that affects thousands of people and that causes harm greatly exceeding the assets of the company.

Under strict liability, if a firm's assets are less than the harm, it will take less than optimal precautions and engage in less than optimal cleanup, since it will bear liability that is lower than the full harm. (In addition, the price will be too low, leading to excessive consumption.) Under the negligence rule, however, firms might continue to take optimal precautions and to engage in optimal cleanup despite their inability to pay for the full

---

[4] The result that the amount consumed will be excessive under the negligence rule reflects the general point made in Polinsky (1980) and in Shavell (1980).

harm. This is because there is a strong incentive under the negligence rule to meet the court-determined standards for precaution and cleanup: the firm thereby avoids liability altogether. Thus, when firms' assets are limited relative to the harm, the negligence rule could be superior to the strict liability rule (at the very least, it is less inferior).[5]

3.2. Escaping Liability. Firms sometimes can escape liability after causing a discharge, perhaps because the discharge is difficult to discover (for example, waste oil dumped into the ocean) or because the injurer is difficult to identify (for example, when many firms use a common toxic waste disposal site over many years). To the extent that firms can escape liability, their expected liability falls; consequently, the effects on their behavior and on our conclusions are similar to those just discussed when firms' assets are limited.

However, in principle courts can offset the effects of escaping liability by increasing the magnitude of liability. If the level of liability is set equal to the harm multiplied by the inverse of the probability of being found liable (for instance, multiplied by three if the chance of liability is one-third), then expected liability will equal harm, and all of our results will apply. (Note, however, that raising the level of liability makes it more likely that the limited assets factor will be relevant.)

3.3. Measurement of Harm. Our conclusions presume that harm can be measured accurately, but this is sometimes difficult. In the context of natural resource damage assessments, for example, the estimation of harm to scenic areas and to animals that do not have market value has been found to be

---

[5] To the extent that the limited assets factor applies, it also is an argument in favor of direct regulation of the precaution decision and cleanup effort of firms.

problematic and controversial.[6] This is because it is not clear how to go about determining the value placed on such resources, including whether their mere existence (aside from their use) should enter into the calculations.

If harm is inaccurately measured and underestimated, then firms will tend to take inadequate precautions and to engage in inadequate cleanup; also, product prices will be too low and too much will be consumed. Conversely, if harm is overestimated, precautions and cleanup will be socially excessive, and consumption will be too low.

4. Concluding Comments

Let us briefly consider current policies regarding environmentally harmful discharges. Consistent with our analysis, the rule of strict liability is widely relied upon to control environmental discharges.[7] However, cleanup activities often are supervised by a government agency, rather than decided upon solely by the party that caused the discharge. Moreover, such agencies frequently emphasize restoration as the goal for cleanup efforts.[8] To the extent that this goal is achieved, the amount spent

---

[6] See generally Note (1992).

[7] Grigalunas and Opaluch (1988, p. 511), for example, observe that:

> "Various pieces of environmental legislation provide strict liability for damages from spills of oil or hazardous substances. These include the Outer Continental Shelf Lands Act Amendments of 1978, the Comprehensive Environmental Response, Compensation and Liability Act of 1980, CERCLA's recent amendments, the Superfund Amendments and Reauthorization Act of 1986 and the Water Quality Act of 1987 as amended." [footnotes omitted]

[8] For instance, the U.S. Department of the Interior is required by law to pursue restoration as its goal when implementing natural resource damage assessment procedures. See State of Ohio v. U.S. Department of the Interior, 880 F.2d 432, 459 (D.C. Cir. 1989) ("Our reading of the complex of relevant provisions ... convinces us that Congress established a distinct preference

on cleanup is likely to be socially excessive and, as a consequence, firms will be induced to take excessive precautions and to charge (at least under strict liability) excessively high prices for their products.

According to our analysis, the supervisory role of the government in cleanup activities is not necessary, provided that firms are made strictly liable for the harm remaining after cleanup (or, if a negligence rule is used, provided that firms are made liable if they fail to invest in the socially optimal amount of cleanup). However, if firms do not have assets that are sufficient to pay for the harm remaining after cleanup, they will, as we remarked above, engage in too little cleanup, in which case government supervision of cleanup activities (and regulation of precaution decisions) might be justified.

---

for restoration cost as the measure of recovery in natural resource damage cases").

References

Burrows, Paul, Charles Rowley, and David Owen, "The Economics of Accidental Oil Pollution by Tankers in Coastal Waters," Journal of Public Economics, Vol. 3 (August 1974), pp. 251-268.

Cohen, Mark A., "The Costs and Benefits of Oil Spill Prevention and Enforcement," Journal of Environmental Economics and Management, Vol. 13, No. 2 (June 1986), pp. 167-188.

Cohen, Mark A., "Optimal Enforcement Strategy to Prevent Oil Spills: An Application of a Principal-Agent Model with Moral Hazard," Journal of Law and Economics, Vol. 30 (April 1987), pp. 23-51.

Epple, D., and M. Visscher, "Oil Spill Frequency and Size: Modeling Occurrence, Detection and Deterrence," Journal of Law and Economics, Vol. 27 (April 1984), pp. 29-60.

Grigalunas, Thomas A., and James J. Opaluch, "Assessing Liability for Damages Under CERCLA: A New Approach for Providing Incentives for Pollution Avoidance," Natural Resources Journal, Vol. 28, No. 3 (Summer 1988), pp. 509-533.

Note, "'Ask a Silly Question ...': Contingent Valuation of Natural Resource Damages," Harvard Law Review, Vol. 105, No. 8 (June 1992), pp. 1981-2000.

Polinsky, A. Mitchell, "Strict Liability vs. Negligence in a Market Setting," American Economic Review, Papers and Proceedings, Vol. 70, No. 2 (May 1980), pp. 363-367.

Segerson, Kathleen, "Risk and Incentives in the Financing of Hazardous Waste Cleanup," Journal of Environmental Economics and Management, Vol. 16 (January 1989), pp. 1-8.

Segerson, Kathleen, "Liability for Groundwater Contamination from Pesticides," Journal of Environmental Economics and Management, Vol. 19 (1990), pp. 227-243.

Shavell, Steven, "Strict Liability versus Negligence," Journal of Legal Studies, Vol. 9, No. 1 (January 1980), pp. 1-25.