Challenging the Enforcement of Environmental Regulation

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Abstract

If a firm can contest the enforcement of an environmental regulation, then neither increasing the probability nor severity of the fine will guarantee a reduction in the illegal dumping of waste. The only policy that unambiguously decreases illegal dumping is lowering the price at legal dump sites because increasing the probability or severity triggers investment into a legal war chest to challenge the fine, while a decrease in the costs of legal dumping does not. If the regulator can only imperfectly monitor a firm's behavior so the firm can be accused of another firm's behavior, then strategic commitment to challenge enforcement will lead to overinvestment in the legal war chest, an increased fraction of illegal dumping, and an overall increase in total costs relative to the nonstrategic case.

Four out of every five decisions I make are contested in court.

--William K. Reilly
Administrator, US EPA

I. Introduction

The enforcement of environmental regulations has been examined in a variety of different contexts. In the case of perfectly enforceable constraints, the conventional rule is that the profit maximizing firm will employ pollution control until the margin benefit equals the marginal cost of resultant fines. Even under imperfect enforcement, this simple rule is not significantly altered unless the fine on pollution is partially avoided [see for example Harford (1978), Viscusi and Zeckhauser (1979), and Lee (1984)].

We relax two assumptions common to this literature. First, we relax the assumption that a firm does not challenge the enforcement of an environmental regulation. The firm no longer passively allows the regulator to impose a fine or penalty. As Kambhu (1990) points out, a firm is actually quite active.[1] While the regulator attempts to impose a fine, a firm can invest significant resources in a legal war chest to contest the action. Firm response to the U.S. Environmental Protection Agency's (EPA) attempt to implement Superfund is a good example.[2] Rich (1985) argues that firms will spend more than $8 billion in litigation costs contesting the EPA's efforts to fine disposal of hazardous wastes, 79 percent to be paid by private parties. Yandle (1988) contends that eliminating these costs would free enough resources to clean more than 400 additional Superfund sites. Significant resources are being devoted to challenge the enforcement of the environmental regulator.[3]

Second, we relax the presumption that the regulatory agency only confronts one firm. An additional complication stems from recognizing that multiple firms are regulated and that monitoring by the agency is imperfect. Often the regulatory agency cannot perfectly distinguish the illegal waste disposal activities of one firm from another. In this case, a firm that has been accused by a regulatory agency as having violated a standard has additional incentive to question the fine by identifying other firms who may also be responsible for the violation.

This paper examines the efficacy of regulating illegal dumping of hazardous waste if the firm can challenge the enforcement of the regulation. Using a simple cost minimization model, we demonstrate that neither the traditional tactics of increasing the probability nor the severity of a fine will guarantee a reduction in illegal dumping. The policy that unambiguously reduces illegal dumping is to lower the cost of legal dumping because both monitoring and the fine trigger investments to challenge the regulator, thereby providing more incentive to increase the fraction of illegal dumping. Lowering the costs of legal dumping, however, does not provide the same incentive. Additionally, when the regulator cannot perfectly monitor the source of pollution we also show that a firm's strategic commitment to a legal war chest for fighting off accusations made by the regulator or other firms increases overall illegal waste disposal by both firms. Now the firm reacts to both the regulator and the other firm, increasing the incentive to invest more to challenge enforcement. This induces the firm to further increase the fraction of illegal dumping. These results suggest that optimal enforcement strategies should account for the interplay between enforcement and the firm's defense investments.

2. A Model of Illegal Dumping

Beginning with the Solid Waste Disposal Act of 1965, regulators have been concerned about the disposal of hazardous material. Fears of illegal "midnight" dumping have prompted policymakers to enact a common monitoring and enforcement scheme.[4] Following Linder and McBride (1984), assume a fine, F, for illegal dumping is set by a national agency with the responsibility of enforcement left to the local agency. The local agency's goal is to use their budget efficiently to correctly identify any violations of the law [Crocker (1984)]. Reflecting current thinking, Russell (1990) argues that to ensure high rates of compliance, firms must face "very high expected penalties" (p. 274).

Assume the local agency takes the firm's expenditures to avoid detection as given and chooses a level of enforcement, m, to apprehend all illegal dumpers.[5] The local authority tries to apprehend and convict the firm whenever illegal dumping is detected, while the firm expends resources, k, attempting to avoid detection or to contest any potential fine. Let w denote the unit cost to challenge the environmental authority. The probability, $p(m,\alpha,k)$ that the local agency will detect any illegal dumping and successfully impose a fine is positively related to their monitoring efforts and the firm's fraction of illegal dumping, α $(0 \leq \alpha \leq 1)$, in which the firm engages, and is inversely related to the firm's ability to challenge enforcement $p_m > 0$, $p_\alpha > 0$, and $p_k < 0$. Subscripts denote relevant partial derivatives.

The firm's cost of illegal disposal is composed of two parts. First, the firm has a cost, z, of illegal disposal even if not detected. Second, the firm's expected fine, $p(\cdot)F$, is an additional cost of operation. Write the expected costs of illegal disposal

$$\alpha[(1 - p(m,\alpha,k))z + p(m,\alpha,k)(z + F) + wk]. \tag{1}$$

Assume the remaining fraction of waste $(1 - \alpha)$ is legally disposed at a government-approved waste site at a per unit cost L.

The representative risk neutral firm's problem is to minimize costs by selecting how much waste to dump illegally, α, and how much effort to expend challenging enforcement, k, to reduce the probability of a fine

$$Min\ [[1 - \alpha]L + \alpha[(1 - p(\cdot)]z + p(\cdot)(z + F) + wk]. \tag{2}$$

Assume Nash behavior such that $\partial m/\partial k = \partial k/\partial m = 0$. First-order conditions for an interior solution are

$$\alpha: \quad z + p(\cdot)F + \alpha p_\alpha F = L \tag{3}$$

$$k: \quad \alpha p_k F + w = 0. \tag{4}$$

Second-order conditions are assumed to hold whenever (3) and (4) hold:

$$D \equiv F^2[(2p_\alpha + \alpha p_{\alpha\alpha})\alpha p_{kk} - (p_k + \alpha p_\alpha k)^2] > 0,$$
$$F(2p_\alpha + \alpha p_{\alpha\alpha}) > 0, \text{ and } \alpha p_{kk}F > 0.$$

Equation (3) marks the conventional result that the firm will equate the marginal expected cost of illegal dumping to the known cost of legal disposal. Equation (4) states that the firm will attempt to question the authority of the regulator until its marginal productivity equals its cost. We now consider how changes in the regulator's three policy tools (m,F,L) will affect the firm's optimal level of illegal dumping, α^*.

3. Illegal Dumping with and without Challenging Enforcement (Perfect Monitoring)

We examine the comparative statics for illegal dumping to illustrate the impact of the firm contesting the rules of the regulator attempting to impose a fine on illegal dumping. We assume perfect monitoring: the regulator can always assign the fine to the firm who dumps illegally. Since the regulator has only one firm to contend with, this is reasonable. First, consider the traditional baseline case where the firm's contesting expenditures are fixed, $k = k^o$, [e.g., Lawyer (1986)]. The following proposition summarizes the comparative static results for the baseline case.

Proposition 1: If the firm's ability to challenge enforcement is exogenous, then a reduction in illegal dumping of hazardous waste is guaranteed if the regulator increases the fine, increases the probability of detection, or reduces the cost of legal dumping:

$$\partial\alpha^*/\partial F = -(p + \alpha p_\alpha) / F(2p_\alpha + \alpha p_{\alpha\alpha}) < 0 \quad (5)$$

$$\partial\alpha^*/\partial m = -(p_m + \alpha p_{\alpha m})/F(2p_\alpha + \alpha p_{\alpha\alpha}) < 0; \quad \text{if } p_{\alpha m} \geq 0 \quad (6)$$

[5]

$$\partial\alpha^*/\partial L = 1/F(2p_\alpha + \alpha p_{\alpha\alpha}) > 0. \quad (7)$$

Three appealing, but predictable, results emerge from Proposition 1. If the regulator increases either the probability or the severity of the fine, or if the costs of legal dumping are reduced, then the firm will decrease its illegal dumping [also see Becker and Stigler (1974)].

Now let the firm expend resources on a legal war chest to reduce the probability of being fined. We can now demonstrate that an increase in the expected penalty is insufficient to guarantee a reduction in illegal dumping. Relaxing the presumption that $k = k^0$, Proposition 2 summarizes the comparative static results.

Proposition 2: If the firm's ability to challenge enforcement is endogenous, then a reduction in illegal dumping can only be guaranteed by a reduction in the cost of legal dumping. Increasing the fine or probability of detection could result in increased illegal dumping.

$$\partial\alpha^*/\partial F = -F[(2p_\alpha + \alpha p_{\alpha\alpha})\alpha p_{kk} - \alpha p_k(p_k + \alpha p_{\alpha k})]/D \tag{8}$$

$$\partial\alpha^*/\partial m = -F^2[(p_m + \alpha p_{\alpha m})p_{kk}\alpha - \alpha p_{km}(p_k + \alpha p_{\alpha k})]/D \tag{9}$$

$$\partial\alpha^*/\partial L = (p_{kk}F\alpha)/D > 0. \tag{10}$$

If the ability to contest a regulation is endogenous, increasing the probability and the severity of a fine have ambiguous impacts on the firm's level of illegal dumping. Increasing the severity of the fine is ambiguous if the first bracketed term on the right hand side of (8) is positive due to second-order conditions, while the second term is negative if $p_{\alpha k} < 0$, the most realistic assumption. There is a countervailing impact between the direct effect of F on the firm and the indirect effect of F on the investment to challenge the regulator. The direct effect gives incentive to reduce illegal dumping, but the indirect effect gives incentive to increase the investment to challenge, thereby increasing the function of illegal dumping. Which effect dominates is unknown.

Increasing the probability through increased m is also ambiguous since, although the first bracketed term in (9) is positive if $p_{\alpha m} \geq 0$, the sign of the second term is unknown. The sign depends on how the firm's expenditures on k affect the marginal productivity of the regulator's efforts to increase the probability, p_{km}. If the k decreases the marginal productivity of the regulator ($p_{km} < 0$), then the second term is negative, thereby having a countervailing indirect impact on the first term. Again there are countervailing direct and indirect effects. The firm may then actually increase its proportion of illegal dumping if there is an increase in the probability or severity of the fine. We cannot support the argument that an increase in expected penalties will automatically result in reduced illegal dumping.[7]

Proposition 2 suggests that the policy that still has an unambiguously negative impact on illegal dumping is decreasing the costs of legal dumping. This result occurs because changing the cost of legal disposal does not affect the firm's contribution to the legal war chest. Consequently, there is no indirect incentive to increase illegal dumping because more resources are being used to challenge authority. This result softens Kamhbu's (1990) argument that a command system may be preferred if the ability to challenge enforcement exists, since we find that the incentive-based policy is still a powerful tool. The incentive is compatible in that it supports both the goal of the regulator-reduced illegal dumping and the goal of the firm-reduced costs.[8]

4. Illegal Dumping with Imperfect Monitoring

An important consideration in this analysis is the agency's absolute ability to monitor the firm's illegal dumping. An immediate question is what happens if more than one firm exists, and the agency cannot perfectly distinguish between the illegal dumping of one firm and that of another? In the case of agrichemical contamination of groundwater, the regulator may have difficulty determining the nonpoint source of the pollutant [see Segerson (1990); Shogren and Crocker (1991)]. The firm's probability of being fined is now a function of its illegal dumping and the illegal dumping of all other firms, $p_i = p_i(\alpha_1, \alpha_2, \ldots \alpha_i, \ldots \alpha_n; k_i, m)$.

The potential fine faced by any firm is transferable. If firm 1 is accused of violating a standard, firm 1 may in turn accuse firm 2 in hopes of avoiding part or all of the fine. Evidence of this type of behavior is noted by a recent article in the Wall Street Journal (April 2, 1991) describing a Utica, New York court case. "Filing the federal-court suit were two big corporations that, themselves accused of violating antipollution statutes had agreed to commence a $9 million cleanup of [a] landfill. And they were trying to squeeze $5 million of that cost from hundreds of Utica-area towns, school districts and small-business owners" [p. 1].

There is an interdependence between firms creating an environmental conflict. As in most conflicts, the firms may appeal to some form of strategic commitment to lower the risk of financial liability [see Dixit (1987)]. In our case, the firm can contribute strategically to the legal war chest, k, which can be used to contest enforcement of the regulation and to fend off the accusations of other firms.

To examine the impact of strategic commitment to a legal war chest, we introduce a second firm. Let the probability of firm 1 being fined now be written as

$$p^1 = p^1(\alpha_1, \alpha_2, k_1), \tag{11}$$

where we assume

$$p_2^1 \equiv \partial p^1/\partial \alpha_2 > 0, \; p_{22}^1 \equiv \partial^2 p^1/\partial \alpha_2^2 < 0, \; and \; p_{1k}^1 \equiv \partial^2 p^1/\partial \alpha_1 \partial k_1 < 0,$$

$$p_1^1 \equiv \partial p^1/\partial \alpha_1 > 0, \; p_{11}^1 \equiv \partial^2 p^1/\partial \alpha_1^2 < 0,$$

implying p_1^1 is strictly positive and decreasing in k. Assume symmetric firms such that similar conditions hold for firm 2. Note that we withhold the government's monitoring expenditures, m, from (11) for notational convenience.

Following Brandon and Spencer (1983), consider a two-stage game where the firms first contribute to the war chest and then make their decision on what fraction of waste to dump illegally. To solve use backward induction, where the firms select the level of dumping to minimize costs

$$\underset{\alpha_i}{Min}\; C^i = [1 - \alpha_i] L + \alpha_i [(1 - p^i(\alpha_1, \alpha_2, k_i) z + p^i(\cdot)(z + F)] + wk_i.$$

For simplicity assume that, except for the potential fine, there are zero costs of illegal dumping, z z = 0. Given (11) and z = 0, the first- and second-order conditions for an interior solution for firm i are

$$\begin{aligned} C_i^i &\equiv -L + p^i F + \alpha_i p_i^i F = 0 \\ C_{ii}^i &\equiv 2p_i^i F + \alpha_i p_{ii}^i F > 0 . \end{aligned} \tag{12}$$

Equation (12) represents the implicit illegal dumping reaction function for firm i. Except for the more detailed probability function and z = 0, equation (12) is identical to (3). Note that the solution to (12) now depends on k_1 and k_2 such that

$$\alpha_1 = \alpha_1(k_1, k_2) \text{ and } \alpha_2 = \alpha_2(k_1, k_2) .$$

The slope of the implicit reaction function is determined by totally differentiating (12)

$$\frac{d\alpha_i}{d\alpha_j} = -(p_j^i + \alpha_i p_{ij}^i) F / C_{ii}^i < 0 \qquad (i \neq j), \tag{13}$$

since by assumption of $p_j^i > 0$ and $p_{ij}^i > 0$ implying α_j increases both the total and marginal expectations of being fined for illegal dumping. Using these restrictions, to guarantee the existence and uniqueness of the equilibrium given the firm's reaction functions, we assume the firm's own effects of illegal dumping on marginal costs exceed the cross effects of illegal dumping,

$$\theta \equiv C_{11}^1 C_{22}^2 - C_{12}^1 C_{21}^1 > 0 . \tag{14}$$

Under the new structure, consider the strategic commitment to the war chest. Firm i selects k_i to minimize

$$\min_{k_i} q^i \equiv [1 - \alpha_i(k_1, k_2)] L + \alpha_i(k_1, k_2) p^i(\alpha_1(k_1, k_2), \alpha_2(k_1, k_2), k_i) F + wk_i, \tag{15}$$

yielding the following first-order condition:

$$q_i^i \equiv \frac{\partial \alpha_i}{\partial k_i}\left[-L + p^i F + \alpha_i p_i^i\right] + \alpha_i F\left[p_j^i \frac{\partial \alpha_j}{\partial k_i} + p_k^i\right] + w = 0.$$

From the first-order condition (12) we know the first term in brackets equals zero, implying

$$q_i^i \equiv \alpha_i \, p_k^i \, F + w + \alpha_i p_j^i \, \frac{\partial \alpha_j}{\partial k_i} \, F = 0. \tag{16}$$

From (4) we know cost is minimized when $\alpha_i \, p_k^i \, F + w = 0$. Therefore, to determine how investment is affected by strategic commitment we must sign the term $(\partial \alpha_j / \partial k_i)$. Differentiate (12) with respect to α_1, α_2, and k_1, to obtain the following system of simultaneous equations:

$$\begin{aligned} C_{11}^1 \, d\alpha_1 + C_{12}^1 \, d\alpha_2 &= - C_{1k}^1 \, dk_1 \\ C_{21}^2 \, d\alpha_1 + C_{22}^2 \, d\alpha_2 &= 0, \end{aligned} \tag{17}$$

where

$$C_{ii}^i \equiv (2p_i^i + \alpha_i p_{ii}^i) F > 0,$$

$$C_{ij}^i \equiv (p_j^i + \alpha_i p_{ij}^i) F > 0,$$

$$C_{ik}^i \equiv (p_{ki}^i + \alpha_i p_k^i) F < 0.$$

Now apply Cramer's Rule to obtain

$$\frac{d\alpha_1}{dk_1} = - C_{1k}^1 C_{22}^2 / \theta > 0 \tag{18}$$

$$\frac{d\alpha_2}{dk_1} = C_{1k}^1 C_{21}^2 / \theta < 0, \tag{19}$$

since $\theta > 0$ from condition (14). This now implies from equation (16) th

$$\alpha_i p_k^i F + w = -\alpha_i p_j^i \frac{\partial \alpha_j}{\partial k_i} F > 0, \tag{20}$$

since $(d\alpha_2/dk_1) < 0$ and $(d\alpha_2/dk_1) = (d\alpha_1/dk_2)$ by symmetry. Equation (20) implies that you are actually overinvesting in the war chest.

From this structure we can now compare the behavior of the firm in the strategic case [e.g. (15)] to the nonstrategic case (Nash) described by (2). The following proposition summarizes the results.

Proposition 3: Relative to the Nash equilibrium, strategic commitment to challenge a regulation leads to (a) overinvestment in the legal war chest; (b) an increased fraction of illegal dumping by both firms; and (c) an increase in total costs.

The implication of Proposition 3 is that when there is a chance the regulator will falsely accuse a firm of another firm's illegal dumping, the firm has even more incentive to protect themselves. The firm who strategically commits to the war chest will overinvest relative to the Nash case since it now recognizes the interdependence between firms. Firm 1 notes that firm 2 also has a similar incentive to challenge the regulator for both justified and unjustified claims. The question of liability must be established, but with imperfect detection both firms must protect themselves from both their own and the other firm's illegal dumping.

Overinvestment in a legal war chest lowers the probability of paying a fine, which prompts the firm to feel safer in disposing of a larger fraction of wastes illegally. We say nothing about the absolute level of illegal dumping, but only consider the fraction of waste dumped illegally. To determine total waste we would need to introduce another choice variable, output, into the analysis. If the firm reduced total output by more than it increases the fraction of illegal dumping, then the total pollution level would actually decrease. We leave the formalities for future research.

Proof: The proof of Proposition 3 follows directly from Brander and Spencer (1983). To prove part (a), apply the mean value theorem

$$\Delta g = g(k^s) - g(k^N) = \nabla g(\bar{k})\,(k^s - k^N),$$

where $\nabla g(\bar{k})$ is the gradient of g evaluated at $\bar{k}$ and $\bar{k} = k^N + \beta(k^S - k^N)$ for some $\beta \in (0, 1)$.

Let $k^N = (k_1^N, k_2^N)$ be the Nash war chest, $k^s = (k_1^s, k_2^s)$ be the strategic war chest, $\Delta k_i = k_i^s - k_i^N$, and $\Delta q_i^i = q_i^i(k^s) - q_i^i(k^N)$. Note that then $\Delta q_1^1 = q_{11}^1\,\Delta k_1 + q_{12}^1\,\Delta k_2$ and $\Delta q_2^2 = q_{21}^2\,\Delta k_1 + q_{22}^2\,\Delta k_2$. This implies

$$\Delta k_1 = (q_{22}^2\,\Delta q_2^1 - q_{12}^2\,\Delta q_2^2)/\varphi \tag{21}$$

$$\Delta k_2 = (q_{21}^2 \Delta q_1^1 - q_{11}\Delta^1 q_2^2)/\varphi, \tag{22}$$

where $\varphi = q_{22}^2\,q_{11}^1 - q_{21}^2\,q_{12}^1 > 0$ by the assumption that own effects dominate cross effects. From (21) and (22),

$$\Delta k_1 + \Delta k_2 = \left[\Delta q_1^1 (q_{22}^2 - q_{21}^1) + \Delta q_2^2 (q_{11}^1 - q_{12}^1)\right]/\varphi, \tag{23}$$

where $q_{22}^2 - q_{21}^2 > 0$ and $q_{11}^1 - q_{12}^1 > 0$ by own terms again dominating cross terms. To sign (23) we need to sign Δq_i^i. Note that $\Delta q_i^i = q_i^i(k^s) - q_i^i(k^N)$. Since $q_i^i(k^s) = 0$ from (16) and $q_i^i(k^N) = \alpha_i p_j^i$ $(\partial \alpha_j/\partial k_i)\,F < 0$ from (4), (16), and (19) then $\Delta q_i^i > 0$. Therefore, from equation (23), $\Delta k_1 + \Delta k_2 > 0$, implying that firms overinvest in effort, given strategic behavior relative to Nash behavior.

To prove part (b), note that since $\alpha_1 = \alpha_1(k_1, k_2)$ and $\alpha_2 = \alpha_2(k_1, k_2)$, then

$$\Delta \alpha_1 = \frac{\partial \alpha_1}{\partial k_1}\,\Delta k_1 + \frac{\partial \alpha_1}{\partial k_2}\,\Delta k_2.$$

By symmetry $\Delta k_1 = \Delta k_2 = \Delta k$, and

$$\frac{\partial \alpha_1}{\partial k_2} = \frac{\partial \alpha_2}{\partial k_1};$$

therefore,

$$\Delta\alpha_1 = \left(\frac{\partial\alpha_1}{\partial k_1} + \frac{\partial\alpha_1}{\partial k_2}\right)\Delta k$$

$$\Delta\alpha_2 = \left(\frac{\partial\alpha_2}{\partial k_1} + \frac{\partial\alpha_2}{\partial k_2}\right)\Delta k.$$

From (18) and (19),

$$\Delta\alpha_1 = \left(C^1_{1k}(C^2_{21} - C^2_{22})\Delta k\right)/\theta = (\Delta\alpha_2) > 0. \tag{24}$$

Equation (24) is positive since own effects dominate cross effects. This implies that the fraction of illegal dumping by both firms increases with strategic commitment.

To prove part (c) note that $\Delta q^i = q^i_i \Delta k_i + q^i_j \Delta k_j = (q^i_i + q^i_j)\Delta k$ by symmetry, and from (16)

$$q^i_i = \alpha_i p^i_k F + \alpha_i p^i_j \frac{\partial\alpha_j}{\partial k_i} F$$

and

$$q^i_j = \alpha_i p^i_j \frac{\partial\alpha_j}{\partial k_j} F + \frac{\partial\alpha_i}{\partial\alpha_j}\left[-L + p^i F + \alpha_i p^i_i F\right] \tag{25}$$

where the second term on the right hand side of (25) equals zero from (12). Therefore,

$$\Delta q^i = \left[\alpha_i p^i_k F + \alpha_i p^i_j F\left[\frac{\partial\alpha_i}{\partial k_i} + \frac{\partial\alpha_i}{\partial k_j}\right]\right]\Delta k = (\Delta q^j) > 0 \tag{26}$$

from (20) and (24), and since $\Delta k = \Delta k_1 + \Delta k_2 > 0$ then equation (26) implies total costs increase with strategic commitment relative to Nash.

Q.E.D

The comparative static results of changes in the regulatory tools remain qualitatively unchanged. At higher levels of monitoring, m, there is a direct impact that decreases the fraction of illegal dumping, but an indirect impact that increases the legal war chest, thereby increasing the fraction of illegal dumping. We do not know whether the direct or indirect effect dominates. A similar result holds for a higher value of the fine, F. Again, the direct and indirect effects have countervailing incentives. The only unambiguous result is that as the cost of legal dumping decreases, L, then the equilibrium results in less illegal dumping. This follows because there is no indirect effect on the war chest. Reducing L does not provide any incentive to challenge the authority of the environmental regulator.

5. Conclusion

A firm's ability to challenge the enforcement power of a regulator plays a major role in the efficacy of environmental regulation. Given perfect monitoring, simply increasing the expected value of a fine or penalty is insufficient to guarantee a decrease in illegal dumping of hazardous waste if the firm's ability to contest the regulation is endogenous. A policy of decreasing the price at legal dump sites resulted in the only unambiguous decrease in illegal dumping. In addition, we consider when the regulator cannot perfectly monitor illegal action, such that he cannot distinguish between the actions of one firm from another. In this case, if the firms strategically commit to their legal war chests, then relative to the Nash case they overinvest in effort to challenge authority, increase the fraction of illegal activity, and increase their overall cost. Given our results, a relevant query is, how does the ability to challenge enforcement have an impact on the effectiveness of other forms of regulatory action such as taxes or tradable permits. We unavoidably leave this for future exploration. Regardless of the action, however, our results support the recent effort of the U.S. Environmental Protection Agency, which is attempting to use negotiations to preempt suits on regulations, thereby potentially reducing the social costs of environmental conflicts.

Endnotes

1. Kambhu (1990) demonstrates that when firms contest environmental regulations it may be more socially beneficial to use a command and control approach rather than an incentive-based regulation.

2. See Dower (1990) for more details on Superfund. Also see Tietenberg (1989).

3. William Reilly, administrator of U.S. EPA notes that "[w]e spend as much time designing our rules to withstand court attack as we do getting the rules right and out in the first place." See Reilly (1991).

4. See Copeland (1991) for a discussion of illegal dumping in the context of international trade of waste materials. He finds incentives to dump illegally in international waters given unilateral policy restrictions of the trade of waste.

5. Magat and Viscusi (1991) provide a detailed description of the U.S. Environmental Protection Agency's monitoring and enforcement procedure in the pulp and paper industry. They note that firms do engage in protracted haggling with the agency that has led to prolonged litigation.

6. The assumption that $p_{\alpha_m} \geq 0$ implies that the marginal impact of being fined due to increased illegal dumping does not decrease with increased monitoring.

7. Malik (1990) also demonstrates that if an offender invests resources to reduce the probability of a fine, then it is suboptimal to set the fine as high as possible. He finds that the ability to screen an individual is critical in selecting the optimal level of the fine. Screening can range from simple questions to using a lie detector in court.

8. Note that in most cases of hazardous waste the regulator still controls entry into the market. Therefore, an incentive-based system of subsidizing legal disposal coupled with controlled entry could decrease illegal disposal of hazardous waste.

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