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NEWS & ANALYSIS

Empirical Research on the Deterrent Effect of Environmental Monitoring and Enforcement

by Mark A. Cohen

This Article reviews the empirical research on the effectiveness of monitoring and enforcement of environmental policy in deterring individuals and firms from violating environmental laws or achieving an improved level of environmental performance. It considers both “monitoring” activities (such as government inspections) and “enforcement” activities (such as sanctions, remedial actions, and other mechanisms designed to punish and/or bring a firm into compliance). It also evaluates “informal” monitoring and enforcement pressures, such as the role that public information has on firm compliance. However, it does *not* consider the role of liability laws (torts, nuisance actions, etc.) in compelling polluters to reduce emissions.¹ Likewise, except for a few studies in Canada, it does not address enforcement analyses conducted outside the United States.²

Until recently, there have been surprisingly few empirical studies of environmental enforcement. Comprehensive data on compliance and enforcement are only beginning to become available to researchers. Thus, the few studies that have been published focused either on oil spills (where the U.S. Coast Guard maintains a comprehensive data set), or on specific industries such as the pulp and paper industry, where the U.S. Environmental Protection Agency (EPA) funded and/or assisted researchers in their data collection efforts. Data availability is rapidly changing as EPA has integrated all of its enforcement and monitoring data by facility and is beginning to make facility-level data freely available to the public on their website. Thus, this is an opportune time to take a fresh look at the theory and evidence of environmental deterrence.

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1. This Article is based largely on Mark A. Cohen, *Monitoring and Enforcement of Environmental Policy*, in 3 INTERNATIONAL YEARBOOK OF ENVIRONMENTAL AND RESOURCE ECONOMICS (Thomas H. Tietenberg & Henk Folmer eds., 1999), and a related Paper Presented at the Forum on Deterrence of Environmental Violations and Environmental Crime, Before the National Institute of Justice and U.S. Environmental Protection Agency (July 12-13, 1999). For a review of environmental liability issues, see INNOVATION IN ENVIRONMENTAL POLICY: ECONOMIC AND LEGAL ASPECTS OF RECENT DEVELOPMENTS IN ENVIRONMENTAL ENFORCEMENT AND LIABILITY (Thomas H. Tietenberg ed., 1992).
2. Only a few empirical studies have been published outside the United States. Given dramatically different base levels of compliance, enforcement, and legal institutions, the studies were determined to be beyond the scope of this Article.

This Article is organized as follows. It first provides a brief overview of the economic theory and empirical research on environmental deterrence. It then examines the performance measures that have been used to date. Thereafter, it reviews what is known about the relative effectiveness of various monitoring and enforcement mechanisms. It goes on to explore the role of information in environmental deterrence. For example, what effect does providing information to the public have on environmental outcomes? Finally, it briefly assesses the most critical informational gaps and offers suggestions for future research.

Theory and Evidence on Environmental Deterrence

Although the purpose of this Article is to examine the empirical evidence on environmental deterrence, it is useful to review the underlying theories that explain deterrence.

Optimal Penalty Theory and Deterrence

Economists who study firm compliance and deterrence invariably start with the “optimal penalty” model of Gary Becker.³ The basic insight of that seminal article is that potential offenders respond to both the probability of detection and the severity of punishment if detected and convicted. Thus, deterrence may be enhanced either by raising the penalty, by increasing monitoring activities to raise the likelihood that the offender will be caught, or by changing legal rules to increase the probability of conviction. Becker's model ultimately leads to an “efficient” level of crime, whereby the marginal cost of enforcement is equated to the marginal social benefit of crime reduction. Thus, given individual preferences and enforcement technologies, both the crime rate and the level of monitoring and enforcement activities are determined by this model.

The simple Becker model has been extended in many directions, taking into account the complexities of different situations.⁴ For the purposes of this Article, the following factors are worth mentioning: (1) unlike street crime that is almost always “intentional,” most environmental violations are byproducts of otherwise socially beneficial activities and are stochastic in nature, thus raising a potential concern about overdeterrence; (2) since environmental offenses often involve multiple actors within a firm, deterrence is not

3. Gary S. Becker, *Crime and Punishment: An Economic Approach*, 76 J. POL. ECON. 169 (1968).

4. Mark A. Cohen, *Environmental Crime and Punishment: Legal/Economic Theory and Empirical Evidence on Enforcement of Federal Environmental Statutes*, 82 J. CRIM. L. & CRIMINOLOGY 1054 (1992), and COHEN, *supra* note 1, discuss the Becker model in the context of environmental offenses.

only an issue between the government and the polluter, but also between the firm and the employee, and between owners and managers of the firm; (3) extra-legal “punishments” such as moral stigma and loss in reputation may also deter offenders; and (4) since the *perceived* risk of punishment determines the level of deterrence, it is important to consider the level of awareness of rules and technologies by potential offenders.

Empirical Evidence on Deterrence

Empirical studies of monitoring and enforcement generally ask two questions: (1) How does the regulatory agency enforce its regulations? For example, does it rely upon routine or targeted inspections? Which facilities are more likely to be targeted? How does it determine the severity of punishment? (2) Does more monitoring and enforcement lead to an increase in compliance or improvement in the environment? This Article is primarily interested in the second question.⁵ However, since firm compliance and regulatory enforcement are both endogenous, it is often important to empirically address both questions in the same research project.

Figure 1 contains a list of empirical studies on the effectiveness of government enforcement activities on environmental deterrence. Due to data availability, most of these studies have been conducted on either the oil transport or pulp and paper industries. In some cases they measure compliance, but often they measure pollution levels directly—whether or not a firm is out of compliance with any existing laws. In general, these studies show that both increased government monitoring and increased enforcement activities result in reduced pollution and/or increased compliance.

Studies that measure both monitoring/enforcement and pollution/compliance at the *plant* level have documented a *specific* deterrent effect. *Specific deterrence* refers to the effect that an inspection or enforcement activity targeting a particular firm has on that firm’s subsequent environmental performance. Other studies have measured monitoring and enforcement at an aggregate level, e.g., state, region, or port. In many cases, the demonstrated effect could be labeled *general deterrence*. General deterrence refers to the effect of an enforcement activity on the behavior of a large number of persons or firms.

It is not always possible to determine whether the estimated effect is due to specific or general deterrence. For example, even though a government enforcement policy might target specific firms, the researcher may only have aggregate measures of compliance or pollution or firm-specific measures that cannot be tied directly to government enforcement efforts. In that case, since the researcher observes aggregate emissions, one does not know if the enforcement policy affects all potential polluters or only those who are targeted. On the other hand, if the policy is not firm specific—such as a Coast Guard patrol of a port area looking for spills—any effect that is observed must be general deterrence.

A series of empirical studies beginning in the mid-1980s have documented a *general* deterrent effect on both the frequency and volume of oil spills from increased Coast Guard monitoring activities. However, the magnitude of any deter-

rent effect differs by monitoring activity, and there is some evidence that “targeted” monitoring—where “high-risk” vessels are targeted for increased inspections—enhances the deterrent effect of Coast Guard activities. To date, there is no evidence that government-imposed penalties have any deterrent effect on oil spills. A second series of studies beginning in the early 1990s have documented a *specific* deterrent effect of government monitoring activities at pulp and paper mills. Aside from oil spills and pulp and paper mills, few industries have been studied.

The next two sections of this Article examine these studies in more detail. Initially, the performance measures used in these studies are analyzed. The Article then reviews the various enforcement methods and legal mechanisms that have been studied and examines the magnitude of any estimated deterrent effect.

Performance Measures in Deterrence Research

Performance measures in environmental deterrence research generally fall into one of two categories: (1) actual levels of pollution and (2) compliance status. In some cases, both measures are used. Although legal lines might be clearly drawn, the theoretical literature does not generally distinguish between civil and criminal violations or between legal and illegal pollution—they are all negative externalities. Thus, it is not surprising that some studies focus on legal determinations such as compliance, while others focus on pollution itself—whether or not there is an “illegal” discharge and whether the pollution was caused accidentally or intentionally.

One difficulty with measuring performance is that most measures are self-reported. This is analogous to the problem encountered in measuring street crime, where the Federal Bureau of Investigation’s Uniform Crime Reports (UCR) actually reflects the number of crimes reported to police. Thus, a change in the UCR data might reflect a change in the actual crime rate or a change in reporting behavior (or a combination of the two).⁶ To the extent that enforcement agencies increase their monitoring resources, one would expect there to be a decrease in pollution due to deterrence. However, there is also likely to be an offsetting increase in reported pollution due to higher detection rates. It is often difficult to separate out these two effects. Nevertheless, carefully designed empirical studies are often able to address this problem through indirect methods.

To date, studies of oil spills have measured the frequency and/or size of spills as opposed to compliance with vessel safety or pollution control regulations. The earliest studies measured the volume of oil spilled for each individual spill.⁷ More recent data reported by the Coast Guard allowed re-

6. In the case of street crime, the Bureau of Justice Statistics conducts an ongoing national survey of U.S. households to determine their rate of victimization. The National Criminal Victimization Survey (NCVS) is thus independent of either police reporting or police budgets. No such independent survey is conducted on environmental offenses—and it is not obvious how such a “victimization” survey could even be implemented.

7. See Dennis Epple & Michael Visscher, *Environmental Pollution: Modeling Occurrence, Detection and Deterrence*, 27 J.L. & ECON. 29 (1984); Mark A. Cohen, *Optimal Enforcement Strategy to Prevent Oil Spills: An Application of a Principal-Agent Model With “Moral Hazard,”* 30 J.L. & ECON. 23 (1987); Eric E. Anderson & Wayne K. Talley, *The Oil Spill Size of Tanker and Barge Accidents: Determinants and Policy Implications*, 71 LAND ECON. 216 (1995).

5. COHEN, *supra* note 1, contains a comprehensive literature review of studies addressing the first empirical question.

searchers to measure spill frequency.⁸ Other performance measurements have included frequency of injured personnel and deaths,⁹ and the number of illegal incidents of dumping of used oil in each state.¹⁰

Note that none of the oil spill studies cited distinguish between spills that were caused by noncompliance, e.g., inadequately maintained equipment or intentional spillage, versus those caused by accidents or natural causes. This is somewhat surprising since the data are available.¹¹ For policy purposes, it might be interesting to disentangle the deterrent effect by “cause” of spill.

Studies of industrial pollution from pulp and paper mills and steel mills have focused on both total levels of pollution (whether legal or not) and the compliance status of each facility. Thus, Magat and Viscusi measured three variables: (1) reported pounds per day of biochemical oxygen demand (BOD), (2) the compliance status of the facility (as a 0-1 dummy variable), and (3) whether or not the facility reports its emissions as required by law (0-1 dummy).¹² Other authors have generally replicated these measures.¹³ However, Laplante and Rilstone included a separate measure of total suspended solids (TSS) and measures “noncompliance” as a continuous variable relative to allowable emissions instead of previous authors that measure noncompliance as a 0-1 dummy variable.¹⁴ Nadeau measures noncompliance as the number of days of a violation.¹⁵

As this brief review suggests, although existing studies have relied upon two broad categories of performance measures, the detailed measures vary considerably. Part of the difference in performance measures is attributable to availability of data and the type of industry or pollutant being studied. However, even ignoring those differences, researchers have not standardized a definition of environmental performance.

Monitoring and Enforcement Methods and Legal Mechanisms in Deterrence Research

This section reviews the various enforcement methods and legal mechanisms that have been studied in the empirical environmental deterrence literature. In general, the goal of this research is to identify which monitoring or enforcement

mechanisms (if any) are effective in improving environmental performance. Most of these studies have focused on monitoring and enforcement mechanisms by regulatory agencies. Few if any have examined the effectiveness of alternative legal mechanisms, e.g., criminal versus civil. The choice of which methods and mechanism to study has largely been dictated by the institutional details and the availability of data.

Effectiveness of Government Monitoring and Enforcement Methods

The earliest empirical analysis of the effectiveness of environmental monitoring and enforcement appears to be Epple and Visscher’s 1984 study, which examined the Coast Guard’s monitoring of oil spill transfer operations.¹⁶ The researchers concluded that increased monitoring activity resulted in lower oil spill volume and estimated the “elasticity of expected spill size” with respect to monitoring to be -0.31 . In other words, a 10-percent increase in Coast Guard monitoring hours was estimated to yield a 3.1-percent reduction in oil spill volume. Since Epple and Visscher did not have access to individual vessel transfer data, they estimated the probability of a spill aggregated at the port level by quarter. The result was an estimate of the elasticity of spill frequency with respect to monitoring of $+0.21$ (r: Table 7). That is, they estimated a 10-percent increase in monitoring leads to a 2.1-percent *increase in detected spills*. This conclusion illustrates the earlier observation that increased monitoring has two offsetting effects: higher detection coupled with higher deterrence. Apparently in this case, the detection effect outweighed any deterrent effect.

In a subsequent article by Cohen, the Epple and Visscher analysis was extended by comparing the effectiveness of three different types of Coast Guard activities: (1) actual monitoring of oil transfer operations, (2) random port patrols designed to detect spills, and (3) inspections of vessels to determine whether or not they were in compliance with oil spill prevention regulations.¹⁷

The first method—monitoring of oil transfer operations—was found to be an effective deterrent by reducing oil spill volume, with an elasticity of -0.17 . Since it was not known exactly which transfer operations were monitored and which vessels spilled oil, it is unclear whether this was a *specific* or *general* deterrent effect. Although a *specific* deterrent effect (the crew might take more care when Coast Guard personnel are present) was expected, there might also be a *general* deterrent effect to all vessels that transfer oil. If vessel captains believe there is a higher probability of being monitored in the future, they might take more care in training personnel or keeping equipment properly maintained—regardless of whether or not they are ultimately monitored.

The second method—random port patrols—was also found to be effective, with an elasticity of -0.20 . This would likely be a *general* deterrent effect, since it raises the probability of detection for all vessels entering a particular port. Finally, the third method—compliance inspections—was found to be ineffective at reducing spill volume.

8. See Montserret Viladrich-Grau & Theodore Groves, *The Oil Spill Process: The Effect of Coast Guard Monitoring on Oil Spills*, 10 ENVTL. & RESOURCE ECON. 315 (1997); K. Gawande & T. Wheeler, *Measures of Effectiveness for Government Organizations*, 45 MGMT. SCI. 42 (1999).

9. Gawande & Wheeler, *supra* note 8.

10. Hilary Sigman, *Midnight Dumping: Public Policies and Illegal Disposal of Used Oil*, 29 RAND J. ECON. 157 (1998).

11. Indeed, Cohen, *supra* note 7, uses the “cause” of the spill as an explanatory variable in modeling the Coast Guard’s penalty policy.

12. Wesley A. Magat & W. Kip Viscusi, *Effectiveness of the EPA’s Regulatory Enforcement: The Case of Industrial Effluent Standards*, 33 J.L. & ECON. 331 (1990).

13. See, e.g., P.C. Liu, *Regulator Inspection and Violation Deterrence Under Clean Water Act Regulation of Pulp and Paper Mill Water Pollution* (1995) (unpublished Ph.D. dissertation, Stanford University) (on file with author) and Benoit Laplante & Paul Rilstone, *Environmental Inspections and Emissions of the Pulp and Paper Industry in Quebec*, 31 J. ENVTL. ECON. & MGMT. 19 (1996).

14. Laplante & Rilstone, *supra* note 13.

15. Lewis W. Nadeau, *EPA Effectiveness at Reducing the Duration of Plant-Level Noncompliance*, 34 J. ENVTL. ECON. & MGMT. 54 (1997).

16. Epple & Visscher, *supra* note 7.

17. Cohen, *supra* note 7.

These results illustrate the importance of carefully disaggregating the type of enforcement activity to fully understand the deterrent effect of enforcement. Although the Epple and Visscher 1984 analysis found an overall deterrent effect, the disaggregation of the same data in Cohen 1987 found that more “bang for the buck” could be obtained by shifting resources around within the enforcement budget.

Changes in data collection policies now allow researchers to estimate the frequency of spills relative to the number of oil spill transfer operations. Viladrich-Grau and Groves found that Coast Guard monitoring has an even larger effect on spill frequency than on spill size.¹⁸ Average penalties in the prior period have no effect on oil spills. This may be attributable to the fact that Coast Guard penalties are only a small fraction of the cost of mandatory cleanup. Perhaps the most interesting part of their study, however, examines the Coast Guard’s newly implemented monitoring policy of classifying ships into “low risk” (infrequently monitored) and “high risk” (always monitored). This is reminiscent of theoretical models of monitoring that recommend this form of targeted enforcement, as described by Winston Harrington and others.¹⁹ Viladrich-Grau and Groves concluded that the two-tiered enforcement policy is effective in reducing the cost of enforcement without having a negative effect on the environment.

Magat and Viscusi measured compliance inspections at each pulp and paper mill as a 0-1 dummy variable depending on whether that facility was inspected anytime during the quarter.²⁰ They tried several different lagged variables, and found that a one-quarter lag worked best. Each inspection resulted in a 20-percent reduction in BOD levels, 50-percent reduction in noncompliance, and fewer facilities failing to report their emission levels as required by law.

Liu’s 1995 study replicated the Magat and Viscusi 1990 analysis with more recent data following new Coast Guard enforcement strategies.²¹ Unlike Magat and Viscusi, Liu found that increased monitoring does *not* reduce the number of known violations. Liu explained this result by noting that during the more recent time period of his study, EPA undertook two types of inspections—discretionary and routine. Routine inspections designed to detect reporting violations were likely to increase the number of known violations. Discretionary inspections targeted firms with previous violations and were expected to deter noncompliance. The combination of these two inspection mechanisms thus had an indeterminate effect on the number of observed violations. This result is also consistent with the Epple-Visscher finding that the number of detected oil spills increases with monitoring activities.

Laplante and Rilstone, in a 1996 study, incorporated the fact that government inspections are not exogenous and firms likely respond to the *expectation* of monitoring.²²

They estimate a probit regression equation where the dependent variable is the probability of being inspected and independent variables include plant capacity, prior inspection history, etc. The predicted value of this regression equation becomes the “expected inspection” rate for each firm. The Laplante and Rilstone 1996 study finds this “expected inspection rate” to be a significant explanatory variable in compliance, raising the issue of how much deterrence is due to the perceived threat versus actual level of monitoring and enforcement—a topic worthy of study.

Lewis Nadeau’s 1997 analysis also studied the U.S. pulp and paper industry, but defined slightly different monitoring and enforcement variables than previous authors.²³ He interpreted a monitoring variable to include each instance in which a plant is either inspected or tested. Enforcement was defined as each incident of an administrative, civil, or judicial remedy including penalties. Overall, he found that a 10-percent increase in monitoring activity leads to a 0.6-percent to 4.2-percent reduction in violation time. A 10-percent increase in enforcement resulted in a 4.0-4.7-percent reduction in violation time.

Finally, a 1998 paper by Eric Helland²⁴ examined whether government policies are consistent with the “targeted” enforcement recommendations made by Harrington and others.²⁵ Helland found that firms determined to be out of compliance are more likely to self-report a violation in subsequent periods. This self-reporting behavior is consistent with a model of firms trying to regain credibility with the government so they are taken off a “target” list. Unlike the results in Viladrich-Grau and Groves,²⁶ who found targeted enforcement deterred subsequent oil spills, Helland concluded that pulp and paper mills with past violations (one year earlier) did not significantly improve compliance.²⁷

Alternative Legal Institutions

The previous section focused on government regulatory monitoring and enforcement, which constitutes the bulk of empirical studies on environmental deterrence. However, several alternative institutions also have an effect on environmental compliance behavior, including private citizen suits, criminal law enforcement, and internal firm monitoring and compliance policies. Although studies exist of these alternative institutions, few of them have been able to address deterrence directly. This section reviews those studies.

Criminal Law Enforcement

Virtually every environmental law in the United States includes criminal provisions.²⁸ In general, it is thought that im-

18. Viladrich-Grau & Groves, *supra* note 8.

19. See, e.g., Winston Harrington, *Enforcement Leverage When Penalties Are Restricted*, 37 J. PUB. ECON. 29 (1988).

20. Magat & Viscusi, *supra* note 12.

21. Liu, *supra* note 13.

22. Laplante & Rilstone, *supra* note 13. This approach was first introduced in Mary E. Deily & Wayne B. Gray, *Enforcement of Pollution Regulation in a Declining Industry*, 21 J. ENVTL. ECON. & MGMT. 260 (1991), who were primarily interested in modeling government activities, not in the effectiveness of those activities.

23. Nadeau, *supra* note 15.

24. Eric Helland, *The Enforcement of Pollution Control Laws: Inspections, Violations, and Self-Reporting*, 80 REV. ECON. & STAT. 141 (1998).

25. Harrington, *supra* note 19.

26. Viladrich-Grau & Groves, *supra* note 8.

27. Helland, *supra* note 24.

28. For a thorough treatment of “environmental crimes” including legal definitions and citations, see JOHN F. COONEY ET AL., ENVIRONMENTAL CRIMES DESKBOOK (Environmental Law Institute 1996); MARY CLIFFORD, ENVIRONMENTAL CRIME: ENFORCEMENT, POLICY AND SOCIAL RESPONSIBILITY (1998); and Cohen, *supra* note 4.

posing a criminal sanction is more costly to the government than imposing a similar sanction through the administrative process.²⁹ Most economists have thus argued that criminal sanctions should be reserved for cases where the “optimal” monetary penalty is too high to be collected.³⁰ In that case, one might mandate a period of incarceration for the individual violator. An alternative view of criminal sanctions is that they help educate or shape preferences of the public who are potential violators.³¹ Given these competing theories, future empirical research on the deterrent effect of civil versus criminal enforcement is warranted.

Private Law Enforcement

Although enforcement is ultimately the government’s responsibility, the government does not necessarily initiate all enforcement activity. In some instances, private parties are given the right to initiate enforcement actions through the administrative agencies or the courts. There are several reasons why governments might adopt this dual enforcement approach. Private citizens who are directly affected by pollution might be better situated to detect environmental violations in their neighborhoods and can be a good judge of whether or not they are concerned enough about this pollution to take some action. They might also save government enforcement resources. However, if the government allows private enforcement, it needs to take into account the level of enforcement expected from private parties in determining the penalty level to impose. Otherwise, a dual enforcement approach might lead to overdeterrence—a situation whereby the firm spends more than is socially optimal to prevent pollution.

Naysnerski and Tietenberg, in a 1992 study, argued that the demand for private enforcement is related to the perceived need for more enforcement by environmentalists.³² Thus, when EPA enforcement fell in the early 1980s, private citizen suits grew in response. However, another reason why private enforcement increased was the reduced cost of obtaining information useful in citizen suit actions due to new EPA recordkeeping regulations. Thus, rules designed to make private enforcement easier are likely to result in increased scrutiny—and deterrence.

Naysnerski and Tietenberg also argue that private enforcement is useful in filling a gap in enforcement against public polluters. Public polluters, e.g., municipal water or sewage facilities, are seldom the target of enforcement actions by public agencies. Private enforcers are apparently less reluctant to file lawsuits against public polluters.

Internal Firm Compliance Programs/Incentives

Much of the literature on environmental enforcement assumes the firm is a monolith, with decisions made by management being implemented as directed. Thus, the govern-

ment enforcement agency can simply monitor and enforce against *firm* activities and not worry about the *individuals* involved. However, corporate managers have their own enforcement problem in trying to convince employees to act on the company’s behalf. For example, suppose corporate policy strongly favors compliance with hazardous waste regulations. A local manager whose bonus depends on his unit’s profitability might decide to dispose of hazardous wastes illegally to boost his bonus. Thus, employee shirking is always a possible source of emissions that are not only against the law but also against firm policy. Anecdotally, there is evidence that some environmental crimes were indeed caused by rogue employees acting against the interest of their employers.³³

Recent literature has focused on this principal-agency relationship within the firm and its effect on environmental compliance.³⁴ This Article is primarily concerned with two issues: (1) whether the employee or the firm should be punished for an environmental violation, and (2) how optimal penalty theory can be used to encourage the corporation to monitor its own employees.

Segerson and Tietenberg, in a 1992 study, and Polinsky and Shavell, in a 1993 study, addressed the first question by considering the case of an employee who commits a law violation on behalf of a corporation.³⁵ In that case, corporate and individual penalties are perfect substitutes if the employee can bear the full cost of the penalty. However, if the employee cannot bear the full burden of the penalty, the government might impose it on the company. Since the penalty cannot be shifted to the employee, either the firm must spend more on ex ante monitoring of the employee’s behavior, or the government must incarcerate the offender.

In a 1994 study, Arlen and later, in a 1997 study, Arlen and Kraakman addressed the second question—how to structure penalties so that the company has an incentive to monitor its own employees.³⁶ Arlen noted that if the penalty is too high, firms might prefer not to know about their employee’s conduct for fear of paying a high penalty. A lower penalty would reduce this perverse incentive so that firms will continue to monitor their employees. Arlen and Kraakman proposed an alternative approach, in which a firm is offered a reduced penalty if it effectively monitors, investigates, and reports any violations to the government. This is largely how the U.S. Sentencing Commission Guidelines for Organizations are structured (although their penalty provisions do not yet apply to environmental offenses).³⁷

Finally, Alexander and Cohen, in a 1998 study, argued if it is in the best interest of shareholders to comply with environmental laws, one would expect compliance to be more prevalent in firms where top management incentives are

33. See, e.g., Cohen, *supra* note 4, at 1086-87.

34. See COHEN, *supra* note 1, for a review of the literature.

35. Kathleen Segerson & Thomas Tietenberg, *The Structure of Penalties in Environmental Enforcement: An Economic Analysis*, 23 J. ENVTL. ECON. & MGMT. 179 (1992); A. Mitchell Polinsky & Steven Shavell, *Should Employees Be Subject to Fines and Imprisonment Given the Existence of Corporate Liability?*, 13 INT’L REV. L. & ECON. 239 (1993).

36. Jennifer Arlen, *The Potentially Perverse Effects of Corporate Criminal Liability*, 23 J. LEGAL STUD. 833 (1994); Jennifer Arlen & Reinier Kraakman, *Controlling Corporate Misconduct: An Analysis of Corporate Liability Regimes*, 72 N.Y.U. L. REV. 687 (1997).

37. U.S. SENTENCING GUIDELINES MANUAL Ch. 8 (1999).

29. However, this may not always be true. In the United States, for example, charging a corporation with a crime makes it easier for the government to obtain documents that might provide evidence against corporate officials who were involved in the criminal activity.

30. Cohen, *supra* note 4, at 1061-62.

31. See, e.g., Kenneth G. Dau-Schmidt, *An Economic Analysis of the Criminal Law as a Preference-Shaping Policy*, 1990 DUKE L.J. 1.

32. Wendy Naysnerski & Tom Tietenberg, *Private Enforcement of Federal Environmental Law*, 68 LAND ECON. 28 (1992).

more closely aligned with shareholders.³⁸ The authors provided empirical evidence that publicly traded firms whose top management incentives are more closely aligned with shareholders are less likely to commit corporate crimes. This suggests that crimes that are discovered and prosecuted by federal authorities have not generally been crimes that were in the best interest of shareholders. Instead, for large, publicly traded firms, they are likely to be caused by negligence or employee shirking—not by deliberate company policy. This has important implications for the types of enforcement policies that the government pursues. Unfortunately, little data is available that would allow for comparable questions to be addressed for smaller, closely held firms.

Role of Information in Deterrence Research

The role of nonregulatory enforcement tools such as the impact of information disclosure on firm behavior is an important emerging topic in the economics of enforcement. One impetus for this growing interest appears to be the experience with the toxic release inventory (TRI) disclosure requirements. Firms emitting more than a certain amount of chemicals into the air, water, or land are required to report the type and amount of emissions to EPA—even for emissions that are legal. James Hamilton estimates that the first such disclosure had a significant effect on the market value of publicly traded firms—a negative abnormal stock price return of -0.3 percent for the average firm.³⁹ Following the first disclosure of TRI, firms dramatically reduced their emissions. Konar and Cohen, in a 1997 study, compared firm-specific reductions to the abnormal returns estimated by Hamilton and found that the firms with the largest negative abnormal returns upon the initial announcement of TRI emissions were the firms that reduced their emissions the most.⁴⁰ Thus, it appears that the TRI information disclosure program had a significant deterrent effect on firm emissions. The interesting question remains as to why information disclosure had this effect—both on stock prices and on subsequent emissions. Possible explanations include expectations of future targeted enforcement scrutiny of high emitters or public pressure to voluntarily reduce emissions. It is also possible that investors take this information as a signal of an inefficient production process and/or bad management.

It is important to keep in mind that information disclosure under the TRI program is about legal emissions. Mandatory disclosure programs such as TRI might be thought of as substitutes for regulatory programs that attempt to use community or other external pressures to encourage firms to reduce emissions voluntarily. In contrast, information disclosure about law violations might be another form of penalty in addition to any direct government-imposed monetary fine. To the extent information disclosure about *legal* emissions had an effect on firm valuation and subsequent *legal* emissions, one should expect similar if not greater effects for information disclosure about *illegal* emissions.

Information that a firm has been sanctioned for violating environmental laws may be of interest to shareholders or lenders for a variety of reasons. To the extent that the monetary sanction reduces the expected value of the firm, this will affect the share price and/or bond rating of the firm. It may also give lenders pause about risking more capital on that particular firm. Other costs might include future debarment from government contracts, targeted enforcement by EPA, and lost sales to “green” consumers. Several recent studies have focused on bad environmental news in the United States and Canada, such as oil or chemical spills or the announcement of civil or criminal enforcement actions.⁴¹ Although they generally demonstrate a negative stock price effect, these studies have not compared the loss in stock value to the cost of penalties, cleanup, etc. To the extent that a firm sanctioned \$1 million by the government incurs a market value decline of \$1 million, for example, these studies would be of little interest to those interested in environmental deterrence. The question is whether the stock price decline reflects any additional “reputation” penalty. Two recent studies find that stock price declines associated with negative environmental events do *not* exceed expected penalties, thus calling into question the notion that the stock market is an effective enforcement mechanism.⁴²

Aside from the stock market, there are other ways in which non-legal pressure might result in environmental deterrence. Several recent studies have explored the role of community pressure and other forms of informal sanctions in bringing about improved environmental performance.⁴³ These papers generally find support for informal community pressure and social norms as playing an important role in emissions and/or compliance. The ability of communities to play this role is likely to be an increasing function of income and education level. One problem with analyzing the role of community pressure across different regional areas is the potential for endogeneity of both plant and community location. For example, a firm that wants to build a new plant will likely choose a location that is more receptive to high pollution plants. Similarly, people who choose to live in a neighborhood nearby an existing polluter are likely to have a higher tolerance for pollution.

38. Cindy R. Alexander & Mark A. Cohen, *Why Do Corporations Become Criminals? Ownership, Hidden Actions, and Crime as an Agency Cost*, 5 J. CORP. FIN. 1 (1998).

39. James T. Hamilton, *Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data*, 28 J. ENVTL. ECON. & MGMT. 98 (1995).

40. Shameek Konar & Mark A. Cohen, *Information as Regulation: The Effect of Community Right-To-Know Laws on Toxic Emission*, 32 J. ENVTL. ECON. & MGMT. 109 (1997).

41. M. Muoghalu et al., *Hazardous Waste Lawsuits, Stockholder Returns, and Deterrence*, 7 S. ECON. J. 357 (1990); Paul Lanoie & Benoit Laplante, *The Market Response to Environmental Incidents in Canada: A Theoretical and Empirical Analysis*, 60 S. ECON. J. 657 (1994); R.D. Klassen & C.P. McLaughlin, *The Impact of Environmental Management on Firm Performance*, 42 MGMT. SCI. 1199 (1996).

42. See Jonathan Karpoff et al., *Environmental Violations, Legal Penalties, and Reputation Costs* (Oct. 23, 1998) (unpublished working paper, Social Science Research Network); Kari Jones & P.H. Rubin, *Effects of Harmful Environmental Events on Reputations of Firms* (1999) (unpublished working paper, Emory University) (both on file with author).

43. See, e.g., Sheoli Pargal et al., *Formal and Informal Regulation of Industrial Pollution: Comparative Evidence From Indonesia and the United States* (1997) (unpublished working paper #1797, World Bank Policy Research); Seema Arora & Timothy N. Cason, *Why Do Firms Volunteer to Exceed Environmental Regulations? Understanding Participation in EPA's 33/50 Program*, 72 LAND ECON. 413 (1996); Nancy Brooks & Rajiv Sethi, *The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics*, 32 J. ENVTL. ECON. & MGMT. 233 (1997); Shameek Konar & Mark A. Cohen, *Why Do Firms Pollute (and Reduce) Toxic Emission?*, (1998) (unpublished working paper, Owen Graduate School of Management, Vanderbilt University) (unpublished papers on file with author).

Suggestions for Future Research and Conclusion

Over the past 15 years, empirical research has demonstrated that increased monitoring and enforcement can deter violations and improve environmental performance. We also know that enforcement does not occur in a vacuum and that understanding the motivations and incentives of both polluters and enforcement agencies should be an important component of any study of enforcement. However, there is a lot yet to be learned.

We probably know the least about the most important and fundamental topic in enforcement—why firms comply with the law. Two promising areas of research on this topic are: (1) incorporating social norms, community pressure, and firm reputation into the analysis, and (2) opening up the “black box” of the firm and incorporating incentives within the organization. These are both complex topics that require an understanding of a diverse set of literatures—including topics such as corporate governance, principal-agency theory, and economic models of social norms. Although recent attempts to empirically estimate the factors that cause firms to voluntarily reduce emissions have been promising, much work needs to be done.

Another significant gap in our knowledge relates to the interaction of the various institutions that affect compliance behavior. Among the questions worth pursuing are:

What is the trade off between monitoring and penalties? (Although previous studies found little deterrent effect of penalties, most of those studies were conducted in regulatory areas in which penalties were only a small fraction of the cost to the polluter. The effect of increasing monetary sanctions has yet to be studied.)

Are citizen suits a substitute for or a complement to government enforcement?

What role do firm reputation and market forces play in the enforcement equation?

Does organizational structure affect a firm's propensity to comply? If so, how should this be taken into account in designing appropriate enforcement policies?⁴⁴

Is “information” really an enforcement tool that government agencies can use at a very low cost? If so, what are the social costs and benefits of providing information to the public in an effort to affect firm behavior?

How can a diverse set of institutional actors with their own agendas, e.g., EPA, Sentencing Commission, courts, private enforcement activities, market forces, coordinate so that the outcome at least approximates optimality?

These are just a few of the questions worth exploring.

The remaining portion of this section highlights two important topics that require further study: (1) cost-benefit analysis of monitoring and enforcement programs and (2) the risk of overdeterrence.

Cost-Benefit Analysis of Monitoring and Enforcement

Although empirical studies have demonstrated the effectiveness of government activities such as inspections and monitoring, one must take care in drawing strong policy conclusions from these studies. Each empirical study is necessarily limited by the scope of the data, level of compliance, government enforcement, technology, etc. in the industry being studied. Thus, it is not clear how transferable any results are from one program or time period to another. Further, few studies have attempted to characterize the social costs and benefits of government monitoring or enforcement activities. Thus, a finding that increased monitoring leads to increased compliance, for example, does not tell us if the marginal cost of increased monitoring is outweighed by the benefits of increased compliance. It also does not tell us if there are other less costly methods of monitoring and enforcement or more productive methods that could be employed for the same level of government expenditures.

A few studies have attempted to answer these questions. In a 1986 study, this author combined data on government enforcement expenditures, the probability of detection, the cost of cleaning up an oil spill, and the environmental damage caused by a spill, and estimated the optimal cleanup costs and penalty as a function of the size of the spill.⁴⁵ Although the study concluded that the Coast Guard's enforcement policy passed a cost-benefit test—both in the aggregate and at the margin—it also found that improvements could be made by shifting resources. Magat and Viscusi, in their 1990 analysis, were less sanguine about whether EPA enforcement policy passed a cost-benefit test in their analysis of pulp and paper mills.⁴⁶ Although they show the value of benefits exceed the cost of inspections, it is not clear that they exceed the cost of regulatory compliance.

How Much Deterrence Is Enough?

Closely related to the need for more cost-benefit analyses is the concern that increased deterrence may have negative consequences (beyond the cost to the government of monitoring and enforcement). In particular, there is a risk that too much deterrence will have the effect of stifling other socially desirable activities. Unlike street crime that has no social utility, most environmental offenses are byproducts of socially desirable production or distribution processes. Thus, the risk of “overdeterrence” is very real in this context. Some environmental offenses are treated as strict liability and merely accidental discharges might be subject to criminal liability.⁴⁷ Increasing the severity of punishment for these types of violations might also deter some “good actors” from engaging in the activity at all. Another concern with the continued trend toward criminalizing environmental offenses is the possibility that it will trivialize the criminal law and hence reduce the moral stigma associated with more egregious forms of environmental contamination.

44. Among other things, Deily & Gray, *supra* note 22, find that multi-plant firms often display a pattern of compliance or noncompliance across plants owned by the same firm.

45. Mark A. Cohen, *The Costs and Benefits of Oil Spill Prevention and Enforcement*, 13 J. ENVTL. ECON. & MGMT. 167 (1986).

46. Magat & Viscusi, *supra* note 12.

47. Cohen, *supra* note 4, at 1102-04.

Figure 1
Empirical Research on Environmental Deterrence

Authors (Year)	Industry or Pollutant	Outcome Measures (unit of analysis in parenthesis)	Input Measures	Key "deterrence" findings
I. OIL SPILLS				
Epple, Visscher (1984)	Oil transfer operations (tankers and barges)	(1) Volume of oil spilled (incident) (2) Frequency of spills per transfer (aggregated by port)	Number of hours of Coast Guard enforcement by port by quarter	General deterrent effect
Cohen (1987)	Oil transfer operations (tankers and barges)	Volume of oil spilled (incident)	Same as Epple-Visscher but disaggregated by: (1) vessel inspections, (2) transfer operation monitoring, and (3) port patrols	General deterrent effect; varied by type of Coast Guard activity
Anderson and Talley (1995)	Oil transport operations (tankers and barges)	Dollar value of lost oil and vessel damage due to tanker or barge accidents (incident)	Same as Cohen (1987)	Same as Cohen (1987)
Viladrich-Grau and Groves (1997)	Oil transfer operations (tankers and barges)	(1) Frequency of oil spills per transfer (vessel) (2) Volume of oil spilled (vessel)	(1) Probability of being monitored (2) Average fine (3) Targeted monitoring	(1) Monitoring is a deterrent (2) Fines had no deterrent effect (3) Targeted monitoring is more effective
Gawande and Wheeler (1999)	Deep draft vessels over 100 tons displacement	(1) Frequency of deaths and missing persons (vessel) (2) Frequency of injured (vessel) (3) Frequency of pollution incidents (vessel)	Number of hours of Coast Guard monitoring, disaggregated by: (1) inspection of hull, (2) inspection of machinery, and (3) administrative matters	Specific deterrent effect; varied by type of Coast Guard activity
II. PULP & PAPER				
Magat and Viscusi (1990)	U.S. Pulp & Paper Mills	(1) Pounds per day of BOD (2) 0-1 dummy variable for compliance status (3) Nonreporting of discharge levels (all at facility level)	0-1 dummy for inspection in prior quarter (measured on a per plant basis)	Specific deterrent effect is found for all three measures
Liu (1995)	U.S. Pulp & Paper Mills	Same as Magat and Viscusi (1990)	Same as Magat and Viscusi (1990), but distinguish between "routine" and "discretionary" enforcement	(1) No specific deterrence from routine enforcement (2) Specific deterrence found for discretionary enforcement
Laplante and Rilstone (1996)	Canadian Pulp & Paper Mills	(1) BOD emissions (facility) (2) TSS emissions (facility) Measured both in the absolute and relative to their allowable discharge levels	"Expected inspection" rate	(1) Specific deterrent effect (2) More frequent self-reporting
Nadeau (1997)	U.S. Pulp & Paper Mills	Number of days of violation (facility)	(1) Average number of enforcement actions (2) Average number of monitoring actions (inspections and tests)	(1) Specific deterrent effect (2) 10% increase in frequency of enforcement actions is more effective than 10% increase in monitoring actions
III. OTHER INDUSTRIES				
Sigman (1998)	Illegal dumping of used oil in each state	Number of reported illegal dumping incidents per month (state)	(1) Number of enforcement actions per hazardous waste facility by state (2) Max. fine for hazardous waste violation by state	(1) Deterrent effect for enforcement actions (2) No deterrent effect from maximum fine levels
Deily and Gray (1991)	U.S. Steel Mills	(1) 0-1 dummy variable if out of compliance in any quarter of a year (facility)	(1) Total number of enforcement actions by plant by year (2) Total number of inspections by plant by year	(1) Specific deterrent effect (especially for lagged enforcement or inspections) (2) Multiplant firms more likely to be in compliance