Sources of Corporate Environmental Performance

Dorothy Thornton
Robert A. Kagan
Neil Gunningham

In recent decades, business leaders, along with some academics and politicians, have called for greater flexibility in American environmental regulation. Existing regulatory laws, they have argued, have brought about significant improvements in corporate environmental performance, but often at an unnecessarily high cost. More importantly, further gains in environmental performance seem to them to require not regulatory prescription but industrial creativity—which in turn depends on a more creative partnership between government and industry.

The key to the necessary innovation, the argument continues, may be found in government policies that are specifically designed to encourage forward-looking corporate environmental management—for example, by offering corporate leaders greater flexibility in how they comply with government regulation. Such policies are manifested in governmental programs such as the U.S. Environmental Protection Agency's "Project XL." A considerable literature has developed on "the greening of industry," documenting major corporations'

The authors are grateful to scores of pulp mill managers, regulatory officials, industry consultants, and environmental activists—all of whom must remain anonymous—for their cooperation and insight. We extend special thanks to Magali Delmas, Cary Coglianese, Michael Hanemann, Kathryn Harrison, Bill Howard, Jessica Landman, Aseem Prakash, Joe Rees, Christine Rosen, Keith Smith, Jeffrey Smoller, and Beth Vaughan, all of whom provided discussion and critique. David Sonnenfeld, Katherine Harrison, Peter May, and anonymous reviewers all gave us valuable advice on earlier drafts. Biyi Abesina provided valuable research assistance. David Vogel and the *California Management Review* provided funding for a workshop on Corporate Environmental Management, which provided a forum for discussing the study and its findings. The Center for the Study of Law and Society, University of California, Berkeley, provided space, administrative assistance, and social support for the research project that led to this article. This article draws upon material previously published in *Law and Society Review* "Explaining Corporate Environmental Performance: How Does Regulation Matter?" and in *Shades of Green, Business, Regulation and Environment,* Stanford University Press, 2003.

steadily increasing commitment to formal environmental management systems, such as those issued by the International Organization for Standardization.

On the other hand, the extent to which regulatory officials and policy-makers can and will rely on enhanced corporate environmental management to make significant advances in environmental performance depends on the answers to some fundamental empirical questions:

- What motivates business firms to seek "environmental excellence"—to go "beyond compliance" with environmental law?
- How important is traditional regulatory direction and legal threat in that regard?
- How far beyond compliance can we really expect profit-constrained business firms to go?
- Most importantly, what about differences among businesses? Why do some companies achieve better environmental performance than others? What distinguishes the environmental leaders from the laggards?

Notwithstanding some valuable studies,[1] we still know too little about why individual corporations behave as they do in the environmental arena, what drives some to become leaders and others laggards, and hence what social policy tools are likely to prove most effective in achieving improved corporate environmental performance. This article reports the results of a research project—a study of 14 pulp and paper manufacturing mills in Australia, New Zealand, British Columbia, and the United States—which was designed to advance the search for answers to the questions noted above.

Over the last three decades, tightening regulatory requirements and intensifying political pressures brought about large improvements and considerable convergence in environmental performance by all the pulp manufacturers, most of which have gone "beyond compliance" in several ways. However, some facilities reduced pollution more than others. Those differences do not correlate with the national regulatory regimes. Rather, the differences stemmed from variations in "social license" pressures (particularly from local communities and environmental activists) and corporate environmental management style. Yet economic pressures imposed limits on "beyond performance" investments even by environmental leaders. To produce large gains in environmental performance, regulation still seems to be the key, but less as a system of hierarchically imposed, uniformly enforced rules than as a coordinative mechanism, narrowing the spread between corporate leaders and laggards.

Dorothy Thornton is a Researcher at the School of Public Health, University of California, Berkeley. <dot@alum.mit.edu>

Robert A. Kagan is a Professor of Political Science and Law at the University of California, Berkeley. <rak@uclink4.berkeley.edu>

Neil Gunningham is a Professor of the Regulatory Institutions Network, School of Resources, Environment and Society, Australian National University. <Neil.Gunningham@anu.edu.au>

Research Method

We studied 14 pulp manufacturing mills in four countries with substantial timber and pulp and paper industries: Canada (British Columbia), Australia, New Zealand, the United States (the states of Washington and Georgia). We chose pulp mills because they represent a chemical-intensive, heavily polluting sector of the economy whose impact on the local environment has resulted in close scrutiny not only by regulatory agencies, but also by environmental and community groups. This research design allowed us to examine how advocacy organizations and local communities, as well as regulatory agencies from different jurisdictions, have influenced corporate environmental performance. In addition, because pulp mills have been obliged to develop complex systems of internal regulation and record keeping, we were able to study differences among firms in management styles and to obtain relatively detailed data concerning their control technologies and emissions. We focused on mills using a similar chemical-intensive technology so that we could make meaningful comparisons among the environmental performance of different mills. Furthermore, we felt that our findings might reasonably be generalized to other capital-intensive, mature, heavy industries.

Our sample of 14 mills is reasonably representative of the pulp and paper industry. We studied all mills that met our inclusion criteria in Washington, New Zealand, and Australia. In Georgia, two out of five mills were excluded for logistical reasons; and in British Columbia, out of 14 mills we chose one mill with a reputation for environmental performance, two with a reputation for average or below average performance, and one because its parent corporation operated mills in other jurisdictions.

We used a combination of detailed qualitative and quantitative data gathered in 1998-1999 to compare environmental performance by each of those 14 mills. In terms of qualitative data, we conducted on-site, semi-structured interviews with environmental managers at each facility and, in most cases, with mill managers as well as corporate environmental managers. We asked for detailed histories of particular environmental actions the facilities had taken. To obtain a more rounded perspective, for each facility we also interviewed relevant regulators and local environmental activists, along with some industry analysts, environmental consultants, and trade association officials.

We used a variety of quantitative and qualitative environmental performance indicators, focusing primarily on measures of water pollutants.[2] Although we were not able to obtain exactly the same environmental performance measures for all mills in our sample over the same time periods (largely because governmental reporting and record keeping demands vary somewhat across jurisdictions), we were able to obtain data for most mills in our sample on the following measures:

- *Biological Oxygen Demand (BOD),* measured in kg/day, is a standard measure of organic pollutant content of water, and is a universally important measure of effluent quality. We were able to obtain 1998 and/or 1999 BOD

data for 12 mills in the U.S., Canada, and New Zealand (but not in Australia).[3]

- *Total Suspended Solids (TSS),* measured in kg/day, is the standard measure of particulate content of water, and is another universally important measure of effluent quality. We were able to obtain 1998 and/or 1999 TSS data for 12 mills in the U.S., Canada, and New Zealand (but not in Australia).
- *AOX,* measured in kg/ton of pulp produced, measures the level of absorbable organic halides (including chlorinated organics such as dioxin) in mills' effluent waters. AOX is used as a proxy measure for dioxins and furans, a family of persistent chlorinated organic compounds that accumulate in the food chain and have been associated with the poisoning of aquatic life, ecosystem damage, and possible human health effects. We were able to obtain comparable 1998 and/or 1999 AOX data for 9 mills in the U.S., Canada, and New Zealand (but not Australia).
- *Chemical Spills.* For 7 mills in the U.S., we were able to obtain data on the incidence of accidental spills of chemicals used in the pulping and bleaching process. Such spills can result in toxic water pollution and overwhelm the mills' wastewater treatment systems, and they also are an indicator of the relative quality of the mills' environmental management program.

Theoretical Approach: The License Model of Corporate Environmental Behavior

To frame our analysis, we developed what we call the "license model" of corporate environmental behavior. Corporate managers, at least in closely watched industries like pulp and paper manufacturing, operate within what we (and they) thought of as a multi-stranded "license to operate." Each strand of the license to operate represents the demands of a set of stakeholders who police and enforce compliance. One strand of the license to operate is legal: the facility's regulatory permits and statutory obligations embody the demands of regulators, legislators, and judges. A second strand is the "social license." The terms of the social license represent the demands of local and national environmental activists, local community groups, and, on occasion, the general public. These demands are enforced by the same groups through the threat of adverse publicity or through complaints to local government and regulators. The terms of the social license might be more demanding than those of the legal license—for example, social actors who have to live with an odor might well demand stricter control of odorous emissions than do remote legal actors. The third strand of the license to operate is economic: the demands of top management, lenders, and investors for cost-cutting and profitability. The economic license *can* operate as a limit on *environmental* investment. However, markets can sometimes punish firms that attract adverse publicity as a result of regulatory enforcement actions or social enforcement actions such as consumer boycotts. Putting these strands together, the license model suggests that a particular facility's environmental

performance is shaped by the relative "tightness" of its regulatory, social, and economic licenses to operate, as enforced by external stakeholders.

However, the terms of each strand of the license to operate are often ambiguous and far from certain. They are subject to interpretation and renegotiation by corporate executives. For example, the impact of potential community group action is, to some extent, affected by how company management chooses to respond. Deciding whether a particular environmental investment is a "win-win" or a "win-lose" investment is a matter of judgment, affected by management attitudes. In our model, corporate environmental management style operates as a filter, an intervening variable between external license pressures and corporate environmental performance.

Environmental Management Style

We created a typology of "corporate environmental management styles," based on the attitude managers' expressed towards environmental problems, their actions and implementation efforts to meet specific stakeholder demands, and their explanations for those actions. From this data, we constructed five types:

- Environmental Laggards,
- Reluctant Compliers,
- Committed Compliers,
- Environmental Strategists, and
- True Believers.

Each successive managerial "type" displayed incrementally greater commitment to compliance (or "overcompliance") with regulatory requirements. The True Believers and Environmental Strategists scanned more intensely and more broadly for environmental information and "win-win" opportunities, and they were more likely to see an environmental investment as "win-win" even if it did not clearly meet numeric return on investment criteria. That is, they tended to see the pursuit of environmental excellence as a real business strategy, not just a regulation-based constraint. Each successive "type" has a higher level of responsiveness to legal and social stakeholder demands; the True Believers, for example, made their operations more transparent than did the Environmental Strategists. Finally, each successive type manifested a greater commitment to developing reliable implementing routines for their environmental policies, integrating environmental control more tightly with production and quality control.[4]

In applying this typology to our sample, we found that there were certain "break points" that distinguished the various management styles. True Believers appeared to be morally driven in their pursuit of environmental excellence. So, for example, managers at mill WA4 expressed more willingness to treat investment in environmental performance as a goal in itself and, indeed, seemed to perceive many more environmental expenditures as "affordable" and "desirable"

than did most other firms, including Environmental Strategists. Environmental Strategists made strategic use of corporate environmental policy and most (but not all) believed that the current socio-political climate required them to be excellent environmental performers. Thus, their commitment to environmental excellence appeared to be socio-politically contingent, rather than the apparently non-contingent moral commitment of True Believers. The typical viewpoint was expressed by an official at mill BC2:

> "Public opinion is huge. If the public is opposed to you, you risk shutdown. . . . We became responsible environmental stewards because it's not in our financial interest to risk our operations being closed down. . . . The fundamental thing . . . is blending a business strategy with an environmental strategy. We are a financial entity. . . . We need to make assets work financially. . . . We start with a vision of the plant in three to five years—including an environmental and community perspective. Then we do the business planning."

Committed Compliers, while also strategic in their approach to environmental performance, tended to define all strategy and demands in reference to regulatory requirements and tended to set goals wholly in terms of regulatory requirements, whereas Environmental Strategists were much more broad in their considerations. All of these groups took compliance with the law for granted for either moral or strategic reasons. Reluctant compliers, however, tended to comply because they did not want to get caught and face regulatory action and the adverse publicity that might flow from it. Other possible consequences were not generally taken into account.

> "That budget is submitted up the line. We seldom get even half of what we ask for given to us . . . The most persuasive case is an order from the agency: Do this or we will shut the operation down. Below that, next in the hierarchy is where the agency has said this was required of you and you missed the deadline. Next down from that would be, this is required of you, but only in the future. Next down from that is 'We'd like to do it but no one is beating us over the head to do it.' But very seldom do you get money for this stuff."

In our sample of 14 mills, we identified no Environmental Laggards, two Reluctant Compliers, four Committed Compliers, four Environmental Strategists, and two True Believers.

Findings

Convergence in Environmental Performance across Mills

Over the last few decades there has been a dramatic reduction in the polluting emissions of pulp mills in all jurisdictions we studied—on the order of 80 or 90 percent for several leading measures of water pollution in wastewater.[5] There has also been a considerable narrowing of differences between environmental "leaders and laggards" in levels of pollution control. All of the mills in our sample generally were in compliance with their regulatory permits. None

TABLE 1. Emissions as a Percentage of BOD and TSS Limits in Mills' Regulatory Permits, 1998-1999

BOD		TSS	
Facility	**Performance as % of Limit**	**Facility**	**Performance as % of Limit**
BC2	25	BC2	31
BC3	13	BC3	21
BC4	16	BC4	39
GA1	34	GA1	14
GA3	85	GA3	66
WA1	55	WA1	42
WA2	72	WA2	57
WA3	14	WA3	14
WA4	32	WA4	40

Note: Data is sorted by jurisdiction. The first two letters of facility name indicate its jurisdiction: BC = British Columbia, GA = Georgia, WA = Washington.

of the mills we studied were regulatory laggards in the sense of being ignorant of, or systematic evaders of, their "regulatory licenses."

Mills were doing more than simply complying with their regulatory permits. As indicated by Table 1, all of the mills for which we could obtain quantifiable regulatory permit limits had gone beyond compliance, reducing the discharge of key water pollutants to levels well below those specified by their permits. Their activities fell into one of four types of "beyond compliance" environmental protection measures:

- *Win-win measures* that improve environmental performance and that will increase corporate profits[6]—Among these measures might be the installation and operation of waste-recycling systems, which can lower raw chemicals costs and waste treatment and storage costs.[7] Similarly, a corporation may invest in new production equipment that is both more efficient and less polluting.[8] For example, 8 of our 14 pulp mills had invested in an expensive, advanced technology knows as oxygen delignification, which reduces the need for chlorine or chlorine dioxide as a bleaching agent; those mills had done so primarily because financial analyses had indicated that oxygen delignification was cost-effective for their particular operations, reducing expenditures on chemicals.[9]
- *Margin of safety measures* that "overcomply" with regulatory requirements (much as a motorist might drive 5 mph below the speed limit on a well-policed highway)—Many pulp mills had constructed effluent treatment systems that provide a greater degree of pollution reduction than required by regulations or their permits (or which have a larger-than-required

capacity) in order to ensure that irregularities or breakdowns in normal operations do not result in a serious violation.

- *Anticipatory compliance measures* that "overcomply" with current legal requirements because a firm anticipates future tightening of the legal license and wishes to avoid the excessive costs of retrofitting relatively new equipment.
- *Good citizenship measures* that go beyond existing regulatory requirements and that are not justified in terms of traditional, quantitative financial analyses of likely return on investment, but rather, are justified on the grounds that such actions will enhance the firm's reputation for good environmental citizenship, and will, in the long run, be "good business"—The numerous pulp mills we studied had invested in fairly expensive measures to reduce the foul odors from their chemical process, primarily to meet social license (rather than legal license) pressures.

Explaining Improvement and Convergence

The environmental performance of pulp mills appears to have improved and converged because the terms of firms' regulatory licenses in all jurisdictions have converged. In all jurisdictions, permits have made increasingly stringent demands and, in addition, there has also been a tightening of social license pressures for better environmental performance. However, while regulation and social pressures converge in pushing for better environmental performance, in an increasingly competitive world pulp market, economic license pressures everywhere constrain how far firms can go in a "green" direction: none of the mills in our sample had leapt far ahead of the others by adopting very innovative new environmental technologies or products (for example, by running a totally chlorine free (TCF) bleaching operation or creating a completely 'closed loop' mill, with no discharges to surrounding waterways). The net result of accommodating to the demands of the three different types of license is that a firm can neither afford to drop too low, nor aim too high: hence the considerable convergence in performance.

The *largest* reductions in pulp mill discharge (to water) of harmful pollutants have stemmed from investments in expensive technologies, particularly secondary waste-water treatment facilities, oxygen delignification systems, and the substitution of chlorine dioxide for elemental chlorine as a bleaching agent (which often required construction of a chlorine dioxide plant). The primary engine of that movement has been periodic "tightening" of governmental regulatory licenses and the performance standards they set.[10] Major investments in prevention and control technology have been made in response to pending or anticipated regulatory rules—that is, the expectations of more demanding regulations in the future have generated "anticipatory" or "margin of error" compliance.[11]

TABLE 2. Environmental Performance by Pulp Mill, 1998-99

BOD		TSS		AOX		PRODUCTION	
Mill	**kg/day**	**Mill**	**kg/day**	**Mill**	**kg/ton**	**Mill**	**Tons/day**
BC3	993	BC2	2,349	GA2	0.10	BC4	725
BC4	1,000	BC3	2,484	BC3	0.31	WA4	763
WA4	1,271	WA4	3,147	WA3	0.34	BC2	1,102
NZ1	1,600	WA3	3,487	BC1	0.46	NZ1	1,137
WA3	1,996	BC4	3,525	NZ2	0.54	BC3	1,201
BC2	2,302	GA1	3,637	BC2	0.58	WA1	1,291
GA1	2,367	BC1	4,282	BC4	0.60	WA2	1,351
BC1	2,549	WA1	5,846	WA4	0.91	NZ2	1,732
WA1	3,848	GA3	7,178	WA2	3.49	BC1	1,854
GA3	4,663	WA2*	7,212	WA1	—	GA1	2,025
WA2*	4,726	NZ1	7,900	NZ1	—	WA3	3,431
NZ2	4,,917	NZ2	8,070	GA1	—	GA2	—
GA2	—	GA2	—	GA3	—	GA3	—
AUS	—	AUS	—	AUS	—	AUS	—

Note: Data is sorted by performance level.

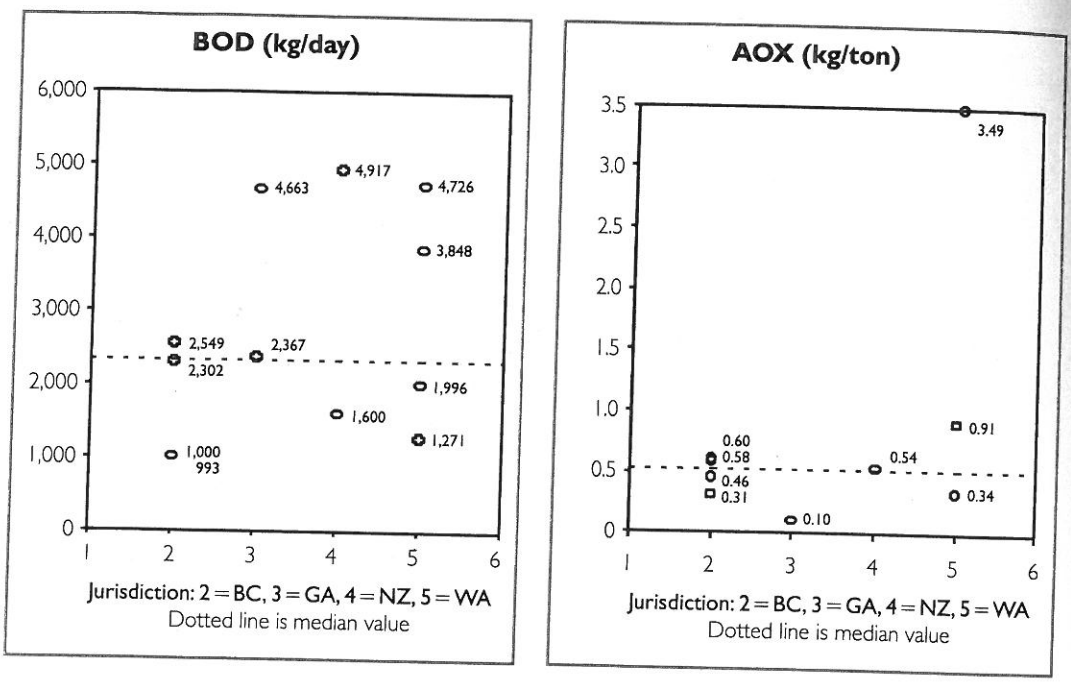
*This facility uses two different pulp production technologies on site, one of which is far more polluting than the technology used at all the other facilities in our sample. The numbers shown here (for BOD and TSS) are figures constructed to estimate what pollutant discharges would have been if all production had been by the cleaner process. These are not the actual figures discharged by the facility.

Variation in Environmental Performance

Despite dramatic improvements in environmental performance, and moves to perform beyond compliance, pulp mills still generate significant adverse environmental effects. Even as environmental performance at mills has improved, our understanding of more subtle environmental impacts has improved in tandem. Modern-day levels of BOD discharges are not nearly as oxygen depleting as they were thirty years ago, but they still decrease dissolved oxygen levels and therefore still decrease species diversity.[12] Similarly, although modern production processes and secondary treatment of pulp mill effluent generally prevent acute toxicity in aquatic life, field and laboratory research still shows adverse environmental impacts due to pulp mill wastes, including problems with enzymes involved in normal growth and development,[13] and changes in fish population structure (such as age at maturity, ratio of male to female).[14] In addition, changes in community structure, particularly declines in species diversity, have also been observed.[15]

Nor has convergence in environmental performance in the pulp and paper industry been complete. At the end of the 20th Century, on some key measures (such as BOD, TSS, and AOX) the relative "laggards" emitted between three and four times more pollution than leaders (see Table 2).

FIGURE 1. Average Emissions of BOD and AOX Grouped by Jurisdiction



Explaining Variation

Why have some pulp mills done a better job in reducing pollution than others? It is not due to differences in production levels: environmental performance was not correlated to production level.[16] Nor is it due to differences in the stringency of the mills' various regulatory licenses: pulp mills' level of environmental performance did not correlate closely with the regulatory jurisdiction in which they operated or the type of regulatory regime they faced. We found no consistent difference among regulatory jurisdictions in the environmental performance of "their" pulp mills, as shown by Figure 1.

BOD emissions do not cluster tightly by regulatory jurisdiction. Except for AOX emissions for mills in British Columbia, where regulations call for zero AOX emissions by the end of 2002, AOX emissions do not cluster tightly by regulatory jurisdiction. Even with this intense jurisdiction-specific pressure, two of the four BC pulp mills in our sample were slightly above the overall median in AOX emissions. Similarly, despite the supposedly greater deterrent threat of the legalistic American approach to regulation (with strict enforcement and high penalties for violations), the mills in the United States in 1998-1999 were as likely to be in the bottom half as in the top half of the environmental performance league. Moreover, the American mills in Washington (considered by some a politically "greener" state) did not do significantly better on average than those in Georgia. Indeed, variations among mills within each state were as large as differences across jurisdictions.

TABLE 3. Correlation Coefficients of Corporate Income and Income to Sales Ratio with Mill-level Environmental Performance, Technology, and Management Style

	1998-99 BOD	1998-99 TSS	1998-99 AOX	1998-99 Obj Tech	1998-99 Subj Tech	1998-99 Mgmt Style
Corp. income-sales ratio 1990-94	Not sig.	Not sig.	−0.96	0.84	0.63	−0.62*
Corp. income 1990-94	−0.61	−0.65	Not sig.	0.77	0.55**	Not sig.

*Note, the sign is negative because True Believers were ranked 1 or 2, and Reluctant compliers were ranked 7.
**Only statistically significant at a p = 0.10 level, all others statistically significant at a p = 0.05 level (2-tailed).

Nor was variation in environmental performance closely related to economic variables: differences in mills' environmental performance were not consistently correlated with profitability or size (in terms of sales) of the parent corporation. While it might seem logical to conclude that firms that are more profitable should have better environmental records than firms in the same industry that are struggling financially, we found only weak support for this proposition among the mills in our sample. We divided the mills in our sample into three categories based on the average annual sales of their corporate parents during the 1998-1999 period.[17] We found *no* significant statistical difference for average 1998-1999 BOD, TSS, and AOX emissions for each corporate size category. The same was true when we correlated corporate net income and change in corporate stock price (up or down) with their mills' environmental performance. Mills whose corporate parents were presumably experiencing milder economic constraints in 1998-1999 did *not* have lower BOD, TSS, AOX levels than mills whose corporate parents were doing less well in that period.[18]

On the other hand, when we compared contemporary (1998-1999) environmental performance data with earlier corporate financial data (1990-1994) we found that mills owned by more profitable (ratio of income to sales) parent corporations in the early 1990s generally had lower emissions in the late 1990s and also had better pollution control technology in the late 1990s (see Table 3).

"Social license" demands did matter in improving environmental performance—mills with more active local environmental groups and those that had been subjected to anti-chlorine campaigns by Greenpeace tended to have lower pollution emissions and to take more "beyond compliance" measures like odor control.

By far the strongest relationship we found, however, was that between environmental management style and environmental performance: average emissions for True Believers were substantially lower than those for Environmental Strategists, whose emissions were substantially lower than the average for Committed Compliers, whose emissions were substantially lower than the average for Reluctant Compliers (see Table 4).

TABLE 4. Management Style and Environmental Performance (Average Discharges of BOD, TSS, AOX, 1998-1999)

Environmental Performance	Management Style							
	True Believer		Environmental Strategist		Committed Complier		Reluctant Complier	
	Value	n	Value	n	Value	n	Value	n
BOD (kg/day)	1,288	3	2,304	4	3,607	4	4,726	1
TSS (kg/day)	4,510	3	3,439	4	6,155	4	7,212	1
AOX (kg/ton)	0.44	3	0.46	3	0.57	2	—	0

True Believers and Environmental Strategists not only tended to invest in better pollution control technology, they also achieve larger incremental gains in environmental performance by virtue of a more dedicated approach to day-to-day environmental management (what we have called "implementation"). Thus True Believers, we found, have fewer costly and environmentally harmful accidental spills of pulping chemicals. In addition, in a long-term comparison of one True Believer and one Reluctant Complier, the True Believer showed a pattern of *continuous improvement* in environmental performance over time, independent of equipment changes, whereas the Reluctant Complier do not.

While environmental management style is clearly important, there are limits to the extent to which it shapes environmental performance. No mill in our sample, including True Believers, could ignore the capital constraints imposed by their economic licenses—True Believers and Environmental Strategists were not way ahead of others in terms of innovative technologies or approaches. No True Believer or Environmental Strategist had a stellar record of finding and adopting major win-win opportunities that its competitors did not.

Conclusion

Pulp manufacturing is a commodity industry, in which firms cannot easily capture and retain market advantages by developing a reputation for "greenness."[19] Hence most large improvements in environmental performance are linked to expensive investments in new technologies that in turn have been mandated, in effect, by periodic tightening of all firms' regulatory licenses. While situations may be different and it is risky to generalize, other capital intensive, highly competitive, mature, highly scrutinized, heavy industries may resemble the pulp industry in the dynamics of environmental improvement.

For such industries, regulatory standard setting clearly matters a lot. Even True Believers cannot leap far out ahead unless they have a reasonable degree of certainty that the level of performance attained by their innovations will become mandatory for their competitors. Yet corporate attitudes and commit-

ment matter too. Environmental management makes a difference, even if it does not achieve the same kind of dramatic, abrupt improvement that results from equipment changes. Day-to-day incremental change can aggregate to significant effects over time, on the order of 50% declines in emissions over a 15-year period.

One implication of this analysis is that regulators would be well advised to identify industry leaders, find ways of rewarding them for their beyond compliance and management commitment efforts, and work closely with them in determining what innovations are feasible and can be made the basis of regulation for the entire industry.

Notes

1. Asseem Prakash, *Greening the Firm: The Politics of Corporate Environmentalism* (Cambridge, UK: Cambridge University Press, 2000); Forest L. Reinhardt, *Down to Earth: Applying Business Principles to Environmental Management.* (Boston, MA: Harvard Business School Press, 2000); Cary Coglianese and Jennifer Nash, eds., *Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals?* (Washington, D.C.: Resources for the Future, 2001).
2. Discharges from pulp mills have historically and substantially reduced the dissolved oxygen content of their receiving waters. Thus, reducing water pollution from pulp mills has been regarded as one of the most important aspects of a mills environmental performance.
3. The mill-level data on BOD, TSS, and AOX is not easily available to the public in accessible form, amenable to cross-mill comparison. Thus, we were able to obtain some data for all 14 mills, but not the same set of data for all mills. Time periods over which the reported emissions data was averaged (daily, monthly, or annual) often varied from jurisdiction to jurisdiction, i.e., some jurisdictions reported monthly average emissions in lbs./day while others reported annual average emissions in lbs./day. The time period for which various kinds of data was available for different mills varied (2 years, 1 year), i.e., at some mills our data represent averages over a 21-month period during 1998-1999, at others over a 1-year period (1998 or 1999).
4. A more complete account can be found in Neil Gunningham, Robert A. Kagan, and Dorothy Thornton, *Shades of Green: Business, Regulation and Environment* (Stanford, CA: Stanford University Press, 2003).
5. See Douglas A. Armstrong, Keith M. Bentley, Sergio F. Galeano, Robert J. Olszewski, Gail A. Smith, and Jonathan R. Smith, Jr., "The Pulp and Paper Industry," in Deanna J. Richards, and Greg Pearson, eds., *The Ecology of Industry: Sectors and Linkages* (Washington D.C.: National Academy Press, 1998), p. 123; American Forest and Paper Association [AF&PA], *Environmental, Health and Safety Principles Verification Program, Progress Report*, 2002, pp. 5, 6, and 12; Gunningham et al., op. cit., p. 42; D. Thornton, "The Effect of Management on the Machinery of Environmental Performance," Ph.D. diss., Health Services and Policy Analysis, University of California, Berkeley, 2001. In addition, between 1990 and 1999, British Columbia regulators report that the 22 pulp mills in that province reduced BOD emissions (as measured in kg/ton) by 91%, TSS emissions by 50%, and AOX emissions by 83%. They also report that the survival rate of fish exposed to pulp mill effluent improved from 50% survival in 70% effluent to 99% survival in 100% effluent.
6. Michael Porter and Claas van der Linde, "Green and Competitive: Ending the Stalemate," *Harvard Business Review*, 73/5 (September/October 1995): 120-134; Michael Porter and Claas van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives*, 9/4 (1995): 119-132.
7. Reinhardt, op. cit.
8. A survey of production managers in German business corporations concerning the effects of environmental protection measures indicated that "in 65 percent of all production divisions [that responded to the questionnaire], cost reductions have been achieved through modifications to manufacturing processes, production cost reductions in 49 percent, and energy and material cost reductions in about one third of companies." U. Steger, "How German Companies are Dealing with Environmental Issues," in K. Fischer and J. Schot, eds., *Environ-*

mental Strategies for Industry: International Perspectives on Research Needs and Policy Implications Island Press (Washington, D.C.: Island Press, 1993), p. 162.

9. Other mills, particularly those who relied on different type of wood as an input or who had different customer demands, had declined to install oxygen delignification in the 1990s, for their analyses indicated that the technology would not be cost-effective for their operations.
10. Not every regulatory-inspired technology change resulted in improved environmental performance. In some cases, changes in technology driven by legal license demands had no measurable or lasting effect on environmental performance.
11. However, at one (of two examined) mill with an exemplary environmental management style, environmental performance improved significantly above and beyond the installation of new, expensive equipment.
12. The lower the dissolved oxygen content of a waterbody, the lower the species diversity found in that waterbody. G. Seegert, D. Brown, and E. Clem, "Improvements in the Pigeon River Following Modernization of the Champion International Canton Mill," *Biological Sciences Symposium Proceedings* (Atlanta, GA: TAPPI Press, 1997); P.K. Sibley, D.G. Dixon, and D.R. Barton, "Impact of Bleached Kraft Pulp Mill Effluent on the Nearshore Benthic Community of Jackfish Bay, Lake Superior," *Water Quality Research Journal of Canada*, 36/4 (2001): 815-833.
13. C.M. Chen, M.C. Liu, M.L. Shih, S.C. Yu, C.C. Yeh, S.T. Lee, T.Y. Yang, and S.J. Hung, "Microsomal Monooxygenase Activity in Tilapia (Oreochromis Mossambicus) Exposed to a Bleached Kraft Mill Effluent Using Different Exposure Systems," *Chemospher*, 45/4-5 (2001): 581-588; M.G. Dube and D.L. MacLatchy, "Endocrine Responses of Fundulus Heteroclitus to Effluent from a Bleached-Kraft Pulp Mill Before and After Installation of Reverse Osmosis Treatment of a Waste Stream," *Environmental Toxicology and Chemistry*, 19/11 (2000): 2788-2796; A. Karels, E. Markkula, and A. Oikari, "Reproductive, Biochemical, Physiological, and Population Responses in Perch (Perca Fluviatilis L.) and Roach (Rutilus Rutilus L.) Downstream of Two Elemental Chlorine-Free Pulp and Paper Mills," *Environmental Toxicology and Chemistry*, 20/7 (2001): 1517-1527; A. Karels and A. Oikari, "Effects of Pulp and Paper Mill Effluents on the Reproductive and Physiological Status of Perch (Perca Fluviatilis L.) and Roach (Rutilus Rutilus L.) during the Spawning Period," *Annales Zoologici Fennici*, 37/2 (2000): 65-77; A. Karels, M. Soimasuo, and A. Oikari, "Effects of Pulp and Paper Mill Effluents on Reproduction, Bile Conjugates and Liver MFO (Mixed Function Oxygenase) Activity in Fish at Southern Lake Saimaa, Finland," *Water Science and Technology* 40/11-12 (1999): 109-114; K.R. Munkittrick, M.E. McMaster, L.H. McCarthy, M.R. Servos, and G.J. Van Der Kraak, "An Overview of Recent Studies on the Potential of Pulp-Mill Effluents to Alter Reproductive Parameters in Fish," *Journal of Toxicology and Environmental Health-Part B-Critical Reviews*, 1/4 (1998): 347-371; J.L. Parrott, M.R. van den Heuvel, L.M. Hewitt, M.A. Baker, K.R. Munkittrick, "Isolation of MFO Inducers from Tissues of White Suckers Caged in Bleached Kraft Mill Effluent," 41/7 (2000): 1083-1089.
14. D.G.J. Larsson and L. Forlin, "Male-Biased Sex Ratios of Fish Embryos near a Pulp Mill: Temporary Recovery after a Short-Term Shutdown," *Environmental Health Perspectives*, 110/8 (2002): 739-742; Munkittrick et al., op. cit.
15. T.G. Kovacs, P.H. Martel, and R.H. Voss, "Assessing the Biological Status of Fish in a River Receiving Pulp and Paper Mill Effluents," *Environmental Pollution*, 118/1 (2002): 123-140; Sibley et al., op. cit.
16. The correlation between BOD and production and TSS and production in our sample was 0.2 and 0.1 respectively. The reason for this low correlation is probably that the quality of the control technology and how well it operates appears to be far more important than production level in determining environmental performance. In a time-series study of two facilities over 30 years, improvements in technology led to abrupt and dramatic (70% declines) improvements in environmental performance. Production level has a highly significant put low magnitude effect on environmental performance. Thornton, op. cit. Thus, if all other things are equal, production level does affect pollutant load and an increase in production level will lead to an increase in pollutant load. However, if the control technology that improved environmental performance by 70% fails for some reason, pollutant loads increase by 200% and the effect of production level, as compared to the effect of how well the control technology is operating, is very small.
17. For the most part, we could obtain only corporate-level financial data rather than facility-level data, but we felt corporate-level data might adequately capture any relationships of interest because although individual mills are expected to be financially independent to a

considerable degree, they generally have some level of access to corporate financial resources for major capital investments, particularly for environmental investments where mill-level failings might result in negative reputational consequences for the corporation.

18. The correlation between corporate size (as measured by annual sales 1998-1999) and mill-level emissions was −0.09 (for BOD), 0.13 (TSS), and 0.02 (AOX). The correlations between corporate net income (1998-1999) and mill-level emissions were 0.21 (for BOD), −0.05 (TSS), and 0.46 (AOX), none of which were statistically significant.
19. Reinhardt, op. cit.