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Innovation, Cost and Environmental Regulation: Perspectives on Business, Policy and Legal Factors Affecting the Cost of Compliance

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PERSPECTIVES ON BUSINESS, POLICY AND LEGAL FACTORS AFFECTING THE COST OF ENVIRONMENTAL COMPLIANCE

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The proceedings of this workshop are summarized in the Appendix to this report, and contained in full at the website of the Economics and Environment Division of EPA's Office of Policy, at www.epa.gov/economics.

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Executive Summary

This report presents and synthesizes current research regarding the hypothesis that the cost of implementing environmental regulations may be expected to be significantly reduced by low-cost process and other innovations carried out by regulated firms. This hypothesis has been popularized by Professor Michael Porter, who argues that "properly designed environmental standards can trigger innovation that may partly or more than fully offset the costs of complying with them." The report offers various perspectives on the hypothesis, drawing from economics, organizational, and legal theory, together with the implications of such perspectives for the analysis of policy.

In addition, an appendix to the report presents the summary of a workshop held on April 30th, 1999 that brought together some of the leading researchers on the subject. Perhaps the most salient theme running through the workshop presentations was agreement on the need to adapt our environmental regulatory framework to be friendlier to innovation and pollution prevention. Recommendations varied from legal reforms that retain strict standards while allowing greater flexibility in compliance alternatives, to a greater understanding and consideration of technology options and characteristics in the regulated industry.

The Porter hypothesis is supported in part by theories of competitiveness that posit that any regulation that requires a company to re-examine its production process generates a probability of innovation in that process that may benefit overall competitiveness and reduce or even eliminate costs of compliance. In addition, a second strand to this theory adds that environmental regulation in particular may lead to improved competitiveness, as pollution represents wasted resources which could be more effectively used. Regulation which requires reduced pollution therefore inherently favors more productive processes.

However, the evidence supporting the Porter hypothesis has tended to be anecdotal. It includes case studies of various industries which reveal win-win situations, as well as reports on company programs that have documented consistent cost savings from waste reduction activities. All these examples suffer from possible selection bias, making it difficult to generalize their findings. In addition to these industry case studies, a study of U.S. states found that those with strict environmental laws have better economic performance than those with lower standards. However, that study sheds little light on causal factors, and economists have tended to dismiss is as an unsupported and possibly spurious positive correlation.

In contrast, the economics literature that measures firms' actual costs of compliance with environmental regulations shows generally that regulation has imposed positive costs, although the costs are to some degree offset by savings from innovation. This research examines plant-level data to identify any productivity penalty from pollution control expenditures, using data from the Pollution Abatement Costs and Expenditures Survey and Census of Manufactures in dynamic general equilibrium analyses. Recent work using a fixed effects model reveals that, on average, environmental regulation did occasion economic costs, but the costs were reduced 18 cents per dollar by efficiency gains in a number of industries, leaving a net cost of $.82. The costs observed in individual industries varied widely. Although some research identifies high long-run costs associated with environmental regulation, the study using a fixed effects model shows that these results may be caused by failing to account for inter-plant differences.

In an effort to move beyond the stalemate suggested by the research described above, this report examines the nature and potential of real-world legal and business barriers that may prevent industry from achieving least-cost, innovative or pollution prevention goals. This review reveals that the design of environmental regulation exerts a significant effect on the cost of compliance. Overall, many of the problems of inflexibility in our current system could be avoided by better designed regulations, including a greater effort to set overall performance standards such as mass standards. A central problem identified is that the design of discharge rate standards based on "available" or "feasible" control technologies under the Clean Water Act and Clean Air Act strongly discourage innovation. This review suggests that the legal setting may be the primary determinant as to whether businesses can innovate to reduce compliance costs.

Fundamentally, achieving the benefits suggested by the Porter hypothesis requires that environmental regulation cause a firm to re-examine its process technologies to find greater efficiencies and cleaner processes. Small changes in standards will not encourage firms to make such a review. Only standards that make significant reductions while allowing flexibility in the response adopted by industry are likely to effect innovation and change in production processes. Our current regulatory system therefore provides a highly imperfect arena in which to test the Porter hypothesis, as the design of regulations appears to have at least as great an impact on the costs of compliance as do the traditional economic forces which might lead to innovation.

Another potential source of barriers to achieving the benefits suggested by the Porter hypothesis is identified in the literature on firm behavior and management, which reveals that many aspects of firm structure and incentives do not foster innovation. Research has identified problems caused by: production staff not being

responsible for environmental compliance; the treatment of environmental costs in incentive structures and in accounting systems; lack of time; imperfect communications structures; the influence of habits and routines; and industry rigidity.

In addition, real-world considerations of risk, strategy and other factors may create disincentives for investing in potentially attractive pollution prevention for completely legitimate business reasons. These range from small firm characteristics that preclude any consideration or development of alternative technologies, to high hurdle rates for new investment, to the lock-in effect of high-cost capital equipment that is already in place.

Although all these factors help to explain whether businesses are likely to be able to innovate in response to environmental regulation, their richness and complexity also indicates the need for greater understanding and analysis. Improvements in regulatory design, and in ways to improve management decisions like environmental management systems, offer ways to help firms achieve the win-win situations, and achieve environmental goals at low cost.

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Introduction

Some authors have stated that environmental regulation, properly structured, can result in win-win situations in which production costs decline as environmental benefits rise. Professor Michael Porter, and before him Professor Nicholas Ashford, have advocated such a view as part of a broader hypothesis that posits that any pressure placed on a firm that creates greater incentives to innovate may be ultimately good, as it leads to the kinds of innovation and improvement that benefits competitiveness and profitability.

This hypothesis in some ways conflicts with traditional economic theory, which indicates that regulations imposing additional environmental requirements on industry would tend to reduce profitability and competitiveness. Indeed, much of the economic literature points to such a negative correlation between environmental regulation and costs. Another view suggests that the costs may be partly but not entirely offset by efficiency gains which are prompted by the effort to reduce pollution in response to regulation. These economic studies would infer that environmental regulation requires a careful cost-benefit assessment that weighs the social benefits of improved environmental quality with the necessary private costs to implement any regulation.

ELI is attempting to identify the circumstances and reasons that may lead to situations where process improvements and innovations due to regulation result in cost reductions or savings to private firms. In doing so we will test the real-world situation in which firms operate to identify social, legal and economic reasons that may lead to such win-win situations.

I. The Hypothesis that Environmental Regulation May Result in Lower Costs or Net Profits

Professor Michael Porter puts forth the following hypothesis:

> "This paradigm of dynamic competitiveness raises an intriguing possibility: in this paper, we will argue that properly designed environmental standards can trigger innovation that may partly or more than fully offset the costs of complying with them" (Porter 1995b at 98).

This builds upon earlier work by Nicholas Ashford and others that "health, safety and environmental goals can be co-optimized with economic growth though technological innovation" (Ashford, Ayers and Stone 1985).

These statements imply a continuum whereby the solution to some pollution problems may result in increased net costs, others may have costs reduced but not eliminated from innovation, while a third set exhibits true "win-win" characteristics with economic profits realized though innovation prompted by the regulation.

Two distinct elements support this hypothesis. The first emphasizes the role of innovation in a modern theory of dynamic competitiveness, as Porter states that "the new paradigm of international competitiveness is a dynamic one, based on innovation" (Porter 1995b at 97). This emphasis on innovation raises the benefits expected from thorough-going reassessment of production processes such as that occasioned by new and stringent environmental regulation. In this element, any pressure placed on an industry that forces firms to pay greater attention to innovation may be broadly beneficial as innovation is necessary to gain or retain market share and profitability in the modern marketplace.

According to this element the hypothesis might be recast thus: "Any regulation that requires a company to re-examine its production process generates a probability of innovation in that process that will reduce or even eliminate costs of compliance." Accordingly, the degree and design of the regulation imposed is critical. The hypothesis does not even apply unless regulation is both sufficiently stringent and flexible so that firms re-evaluate their production processes. This reveals serious problems in the environmental field, as many of our environmental regulations are designed in a way that discourages precisely such a re-examination of process technology. Instead they are designed to impose "control technologies" that are economially reasonable or achievable. In addition, they raise standards sporadically and hence create no continuous drivers for improvement, further discouraging investigation into better technologies. These regulatory barriers to achieving win-win scenarios are widespread in our laws, and as described further below, deserve far more attention than they are receiving.

The second strand adds to this concept the particular reasons why environmental regulation may lead to improved competitiveness, as pollution represents wasted resources which could be more effectively used. Porter states, "the reason [pollution control may enhance competitiveness] is that pollution often is a form of economic waste.... [P]ollution ... is a sign that resources have been used incompletely, inefficiently or ineffectively" (Porter 1995a at 122) and "efforts to reduce pollution and maximize profits share the same basic principles, including the efficient use of inputs, substitution of less expensive materials and the minimization of unneeded activities" (Porter 1995b at 106). Regulation which requires reduced pollution therefore inherently favors more productive processes. Reasons within and without the firm that may promote or prevent the achievement of win-win solutions are further described below in part III.

The evidence supporting the Porter hypothesis has tended to be anecdotal, relating to case studies of various industries that reveal win-win situations. These include vinyl chloride, (Doniger 1978), distilled spirits (ELI Forum 1993) and others (Strasser 1997; Palmer, Oates and Portney 1995; Portney 1994; Ashford 1985). One study of the chemical industry identified 181 source reduction activities, only one with a positive cost, and 2/3 of which paid themselves back in less than six months (Dorfman 1992 at 22). A six-industry study conducted by the Management Institute for Environment and Business (1996) generally found that environmental regulation did impose costs, but that many instances could be found where companies gained competitive advantage in process efficiency and product quality though innovations spurred by environmental pressures. Company programs to reduce wastes have also documented consistent cost savings from waste reduction activities. 3M reports that its Pollution Prevention Pays generated 3,000 projects preventing 575,000 tons of pollution and saving over $530 million from 1975 to 1992 (Smart 1992). However, all these examples suffer from possible selection bias, making it difficult to generalize their findings.

In addition to these industry case studies, a study by Meyers (1993) found that states with strict environmental laws have better economic performance than those with states with lower standards. However, its sheds little light on causal factors and economists have tended to dismiss is as an unsupported and possibly spurious positive correlation (Jaffee 1995 at 157).

Porter notes that: "These examples and many others like them do not prove that companies always can innovate to reduce environmental impact at low cost," but that "the opportunity to reduce costs by diminishing pollution should thus be the rule, not the exception." This is despite industry opposition to environmental regulation and the often-restrictive nature of that regulation (Porter 1995a at 127). An Office of Technology Assessment agrees that "even though an aggressive pollution prevention effort can reduce compliance costs, particularly when compared to the current end-of-pipe approach, industry still faces compliance costs that increase production costs" (OTA 1994 at 85).

A more thorough discussion of these issues is made below, starting with the economic critiques of the assertions in the Porter hypothesis, followed by an examination of policy and economic factors that may tend to reject or favor the hypothesis. Thorough treatment is given to the role of regulatory barriers to innovation, as it appears that the degree and design of regulation plays a significant role, together with more purely economic considerations, in a firm’s ability to innovate to reduce the costs of compliance.

II. Traditional economic views

A. Critiques of the Porter Hypothesis

"The conventional wisdom is that environmental regulations impose significant costs, slow productivity growth, and thereby hinder the ability of U.S. firms to compete in international markets" (Jaffee 1995 at 133; Schmalensee 1994). EPA has estimated the direct costs of environmental compliance to be $115 billion or 2.1 percent of GDP in 1990 (USEPA 1990), and some authors estimate that additional indirect costs of regulation are two to three times greater (Weitzman 1994).

Although there are several reasons why the effects of environmental regulation on competitiveness may be small and hard to define, the prevailing view asserts several reasons why environmental costs should negatively affect productivity (Jaffee 1995 at 150, 158):

a) A first argument refers to straight displacement - dollars which go to environmental quality do not go towards production. Gray and Shadbegian (1993) found a 1.5/1 ratio between environmental costs and output.

b) Second, the new practices required by environmental regulation may be less efficient than the former ones, which in theory would have been set at an optimum. One example is that of emissions controls for nitrogen oxides (NOx) which require boilers to be set at less than thermodynamically efficient combustion temperatures (Schmalensee 1993). This is directly opposed to Porter's hypothesis, which stresses efficiency gains.

c) A third argument is that the costs occasioned by environmental regulation actually have a negative multiplier effect, as environmental investment crowds out other investment which could lead to productivity gains. Hazila and Kopp (1990) found that regulation magnifies environmental cost because of restrictions in investment and labor supply. Also, Jorgensesn and Wilcoxen (1990) found the indirect cumulative effects of regulations reduce the average growth rate of GNP by 0.2%.

d) A fourth area concerns productivity losses due to unnecessary rigidity or poor design of environmental laws. These do not contradict Porter, who also emphasizes the need for innovation-friendly regulation. Although this subject is treated in more detail below, the type of regulation promulgated clearly has a major impact on whether regulation can result in economic gains, and can to some extent explains the discrepancy between the Porter hypothesis and plant-level studies showing a positive correlation between environmental regulation and economic costs.

Empirical analyses of these adverse effects have found positive economic costs from environmental regulation. A number of studies cited by the Office of Technology Assessment revealed between an 8 and 16 percent decline in productivity growth rate due to environmental regulation in the 1970s over all manufacturing sectors, and up to 44% for certain industries (OTA 1994 at 323).

Several authors have examined plant-level data to identify any "productivity penalty" from pollution control expenditures. These have used data from the Pollution Abatement Costs and Expenditures (PACE) Survey and Census of Manufactures in dynamic general equilibrium analyses to estimate the long-run consequences of environmental regulation. Hazila and Kopp (1990) found that regulation magnifies environmental cost because of restrictions in investment and labor supply. Also, Jorgensesn and Wilcoxen (1990) found the indirect cumulative effects of regulations reduce the average growth rate of GNP by 0.2%. Research by Gray and Shadbegian (1994) found a weak negative correlation, that output fell between 1 and 1.5 for every unit of pollution control expenditure depending in the model used. They found marginal cost of $1.74 for paper mills, $1.35 for oil refineries and $3.28 for steel mills, but also report lower results ($0.55, $0.97 and $2.76) for a fixed-effects model (see also Palmer and Simpson 1993).

However, recent work by Morgenstern and Pizer found that the results of these studies may depend more on the model being used:

> "While we are able to replicate their general results ..., we show that those results depend critically on strong assumptions about homogeneity among plants. Specifically, they assume that differences in plant location, age and management have no effect on either productivity or environmental expenditure - an assumption that seems unlikely to be satisfied in practice. Allowing for such differences (by estimating a fixed-effects rather than a pooled model) substantially reduces the estimated economic costs associated with an incremental dollar of reported expenditures. Our results, in fact, allow us to statistically reject the hypothesis that the economic cost of an additional dollar of reported environmental expenditure is much more than one dollar" (Morgenstern and Pizer 1998 at 9).

Their analysis of four heavily regulated manufacturing industries using a fixed effects model showed that on average, environmental regulation did occasion economic costs, but the costs were reduced 18 cents per dollar by efficiency gains, leaving a net cost of $.82. Individual industries varied considerably. For the plastics industry, a one dollar increase in PACE expenditures was partially offset by an 80 cent cost savings in non-environmental production costs (leaving 20 cents net costs); in pulp and paper, a 36 cent savings; in petroleum, a 2 cent savings; but in steel, a 41 cent cost increase.

At the 95 percent confidence level, the true economic cost ranges from negative 2 cents (a profit) to positive $1.68. Although findings for the four individual industries were not at the statistical significant level, they indicate the potential for environmental expenditures to induce significant cost savings, and rule out the possibility that cost increases are high. The analysis showed that using pooled estimates which de-emphasize differences between plant would have resulted in a much higher estimate of indirect effects of environmental regulation, to $2.73, and is more in line with other estimates. They suggest these higher numbers are overestimates. Their study shows that current environmental regulations result in positive costs, but that these are somewhat offset by related savings.

A second finding of the Morgenstern and other studies is the variability among sectors. This reflects both that some environmental problems are more difficult to solve than others, which Porter admits, but also the effects of regulation in the industry. The steel industry is a particularly interesting case, as several of the studies cited report unusually high environmental compliance costs for the steel industry (Morgenstern 1998, Joshi 1998, Gray and Shadbegian 1993). However, an Environmental Law Institute study of barriers to innovation in six industries also shows that the steel industry faces particularly inflexible environmental regulations, which has significant problems in implementing cost-reducing technology (ELI 1998; Swift 1997). Part of the reason why compliance cost is higher in steel therefore has to do with the rigidity of the environmental regulation affecting the industry.

Porter attempts to rebut the findings of these plant-level studies, primarily by pointing out that few find significant effects, and all operate in the context of the highly imperfect current regulatory system, which is biased against innovation. He states:

> "A number of studies have failed to find that stringent environmental regulation hurts industrial competitiveness. Meyer (1992, 1993) tested and refuted the hypothesis that U.S. states with stringent environmental policies experienced weak economic growth. Leonard (1988) was unable to demonstrate statistically significant offshore movements by U.S. firms in pollution-intensive industries. Wheeler and Mody (1992) failed to find that environmental regulation affected the foreign investment decisions of U.S. firms. Repetto (1995) found that industries heavily affected by environmental regulations experienced slighter reductions in their share of world exports than did the entire American industry from 1970 to 1990. Using Bureau of Census data of more than 200,000 large manufacturing establishments, the study also found that plants with poor environmental records are generally not more profitable than cleaner ones in the same industry, even controlling for their age, size and technology."

He concludes after his review that:

> "Of course, these studies offer no proof for our hypothesis, either. But it is striking that so many studies find that even the poorly designed environmental laws presently in effect have little adverse effect on competitiveness. After all, traditional approaches to regulation have surely worked to stifle potential innovation offsets and imposed unnecessarily high costs of compliance on industry ... Thus, studies using actual compliance costs to regulation are heavily biased towards finding that such regulation has a substantial cost. In no way do such studies measure the potential of well-crafted environmental regulations to stimulate competitiveness."

B. Elements Supportive of the Porter Hypothesis

While economists have been generally unwilling to accept Porter's position that a private firm's costs may decline or reach zero due to environmental regulation, they do agree that net social costs of regulation can be positive. These findings stress general equilibrium effects of regulation, and require a careful weighing of social benefits versus private costs.

As described in greater detail below, traditional economics also supports the importance of several of the factors that may lead to reducing the cost of environmental regulations. First, most economists would agree that the way we regulate is important and would concur with Porter's principles for innovation-friendly regulations. In fact, inflexible regulation can impose competitive disadvantages in industries where foreign competitors face more flexible forms of regulation (MIEB 1995). A recent study comparing ex-ante and ex-post regulatory costs also suggests that actual costs tended to be lower than predictions more often for regulations using a flexible or market-based design (Harrington et al. 1999). The structure of regulations may actually be the major determinant of their cost, an issue discussed below.

A second traditional finding would be that environmental regulation may lead to innovations in compliance technology, which would be expected to reduce costs over time. A third would be that there can be competitive advantages or benefits to certain industries or firms due to environmental regulation. Most frequently cited is the environmental technology industry, many parts of which would not exist were it not for environmental regulation. Another beneficiary would be large firms, which may have a comparative advantage due to their size and research capability when an industry sector is subject to stringent new environmental regulation. Finally, traditional economists may accept that there may be first mover advantages to firms in a country which exerts leadership in an environmental area if other countries are expected to follow suit later.

These assertions, although consistent with the Porter hypothesis, are not reflective of his broader statements concerning the possibility or even likelihood of cost savings to private firms through process improvements and innovations due to regulation. It is this latter issue this report examines.

III. Identifying the Factors Relevant to the Porter Hypothesis

This research is intended to explore the legal, social and economic factors that may affect Porter's hypothesis that "properly designed environmental standards can trigger innovation that may partly or more than fully offset the costs of complying with them." This hypothesis does not state that innovations will always be profitable, but in this research we interpret it to state that expected innovation would significantly reduce the costs otherwise occasioned by the environmental regulation (Porter 1995b).

We first examine the influence that the kind of environmental regulatory framework exerts on costs. Second, we examine factors which may reduce costs in response to environmental regulation that arise from within a firm, and thirdly external factors such as industry structure, the timing of regulation, and social or sectoral economic benefits.

A. The Design of Environmental Regulation

A key to the Porter hypothesis requires that environmental regulation cause a firm to re-examine its process technologies to find greater efficiencies and cleaner processes. This requires two things of the regulation - that it be strict, as small changes in standards will not cause such a review, and that it not impose rigid requirements, permitting innovation and change in production processes.

The strictness of regulation has been called "the most important factor" influencing radical technological innovation (Ashford 1994 at 297). Otherwise, regulation only leads to incremental or end-of-pipe changes; the incentives to create more fundamental innovations are not present. Ashford points out that regulation can be stringent because it requires a significant reduction, because it imposes significant costs, or because compliance requires a significant technological change. Thus, although early environmental laws rarely stimulated innovation, OSHA regulations were more likely to do so due to their stringent nature (OTA 1995).

The design of an environmental regulation also exerts a significant effect on the cost of compliance. Although this issue is regularly mentioned by economists studying costs, it rarely forms an integral part of their assessments, in part because it is difficult to quantify. In the United States, however, the nature of regulation may determine to a great extent the cost of compliance, and is therefore an independent variable which should be taken into account in cost studies.

Porter emphasizes the importance of this issue, and states:

> "[T]he current system of environmental regulation in the United States often deters innovative solutions or renders them impossible. The problem with regulations is not its strictness. It is the way in which standards are written and the sheer inefficiency with which regulations are administered. Strict standards can and should promote resource productivity. The United States regulatory process has squandered his potential, however, by concentrating on cleanup instead of prevention ...." (Porter 1995a at 129).

He identifies eleven design factors for innovation-friendly regulation (Porter 1995a at 124):

1. Focus on outcomes, not technologies;
2. Enact strict rather than lax regulation;
3. Regulate as close to the end user as practical, while encouraging upstream solutions;
4. Employ phase-in periods;
5. Use market incentives;
6. Harmonize or converge regulations in associated fields;
7. Develop regulation in sync with other countries or slightly ahead of them;
8. Make the regulatory process more stable and predictable;
9. Require industry participation in setting standards from the beginning;
10. Develop strong technical capabilities among regulators;
11. Minimize the time and resources consumed in the regulatory process itself.

Other economists and writers have agreed strongly with his views (Jaffee 1995 at 152; Hahn and Stavins 1991). However, in general few have taken this issue into account in subsequent studies of plant-level costs incurred by environmental regulation. Instead, they attribute those costs to economic factors. If, however, the economic response of firms is severely constrained by regulatory design, as we argue, the studies mentioned above might be better interpreted as studies reflecting the design of regulatory systems, not of the true economic costs of the regulation.

Economists have identified particular problems with environmental regulations, to which we will add more general observations. One situation cited by economists is that the new source bias in some environmental laws can discourage investment in new, more efficient plants. This is certainly the case with some laws, such as the Clean Air Act, which for its first decades only regulated new sources and not existing sources, creating a barrier to new investment, especially in the utility industry (Nelson, Tietenberg and Donihue 1993). Additional issues involve the strictness of regulation, and whether they provide firms with adequate time to develop cost-effective responses.

However, practitioners and other writers have identified a more widespread set of problems in current environmental regulation, especially concerning the widespread "best available technology" type standards. Such standards are inflexible and may severely limit innovation, creating higher costs than necessary.

This subject has been extensively treated in the literature on regulatory barriers. A federal advisory committee on the subject has published several reports on the nature and strength of the barriers to innovation created by current forms of regulation (USEPA 1991, 1993). A report and survey by the Environmental Law Institute confirm these barriers, and point to the need for overall performance standards (ELI 1998; EPA 1998). Several other institutions have also recently completed studies on the reform of our environmental laws (Davies 1998). These analyses have identified overlapping problems in the current design and implementation of environmental laws that discourage least-cost compliance and innovation.

Although this study will not detail regulatory barriers, a brief overview serves to illustrate the embedded and pervasive nature of this problems in our major environmental laws. A central problem identified has been that the design of most standards under the Clean Water Act and Clean Air Act require EPA to establish technology-based discharge rate limits based on "available" or "feasible" technologies. For air such standards include "reasonably available control technology" (RACT) for existing sources, "best available control technology" (BACT) for new sources and maximum achievable control technology (MACT) for hazardous pollutants. Water standards include "best available technology economically achievable" (BAT). [42 U.S.C. 7502(c)(1)(RACT); 42 USC 7475(a)(4) (BACT); 42 U.S.C. 1311(b)(2)(A) (BAT)]. While these standards avoid the pitfalls of setting technology mandates, they severely limit innovation for many reasons:

a) *restrictive design*: rate-based standards inherently limit technology options compared to mass-based performance standards, as they discourage or may even preclude technologies which reduce amounts but not rates. They may also emphasize, or even dictate, end-of-pipe compliance solutions instead of the process changes which can lead to the results suggested by the Porter hypothesis.

b) *require "available" and "control" technologies*: many key environmental standards require EPA to set standards based on "available" technologies already in use, a backward-looking standard which may preclude innovative or "outside-the-box" solutions; the laws typically also require EPA to base standards on "control" technologies, reinforcing the end-of-pipe paradigm.

c) *no incentive for further progress*: fixed rate standards create no incentives for compliance that goes beyond the stated limits.

d) *limitations of the point source context*: almost all environmental laws fix the specific rate limits for basic and hazardous pollutants on each specific point source based on the above standards. Even if new process technologies are cleaner overall, they cannot be permitted if one point source exceeds a single parameter, creating inflexibility.

e) *permitting system reinforces conservative choices*: once EPA has gone through the often-adversarial process of identifying the acceptable "available" "control" technologies, industries and permit writers face high risks deviating from these standards. While such regulation may temporarily increase a certain technology use, it then blunts experimentation and innovation, both because it does not encourage further progress, and because the adversarial and conservative nature of permitting under this method tends to reject the innovative or new (Strasser 1997; EPA 1993, 1991).

f) *high costs of delay*: our current system takes one to two years to permit new or modified major pollution sources due to the need to apply technology-based rate standards to every point source. This can be the greatest cost imposed by pollution control. In contrast, mass-based performance standards can be designed to be much more efficient - transactions under the Acid Rain Program for instance generally take less than 24 hours.

g) *federalized permitting system*: our federalized permitting systems can create high barriers to commercializing innovative technologies under "ACT" type standards because all the barriers to acceptance must be repeatedly overcome in each state until the technology becomes generally accepted. In contrast, overall or mass-based performance standards require government monitoring but not technology review, greatly lowering the barriers created by federalized systems.

A different set of regulatory issues generally govern solid and hazardous wastes. These are government by different statutes, notably the Resource Conservation and Recovery Act (RCRA), and Superfund legislation. Although their design is not based on "ACT" type standards, regulatory and industry officials consider our environmental systems regarding wastes as the most problematic of the major environmental statutes in a recent survey (EPA 1998b at 17). RCRA requires "cradle to grave" tracking and treatment of hazardous wastes, which may preclude "cradle to cradle" recycling; its definition of waste, for example, may cause process chemicals that would otherwise be reclaimed and reused to be labeled as wastes and force their disposal (ELI 1998a).

Perhaps the best example of the problems with technology prescriptions and rate-based standards is offered by the history of regulation of sulphur dioxide by electric generating facilities, which allows a retrospective review of the effects of different regulatory strategies. Cost estimates have been made of various regulatory

strategies to attain a similar reduction level. Mandating scrubbers, which allows no room for innovation except in scrubber technology, is the most expensive, at $7 billion a year. Continuing the use of the rate-based emissions standards in effect for new sources from 1977 to 1990 also results in technology prescriptions and would cost $4.5 billion. The mass-based or performance standard adopted in 1990 - an emissions cap and allowance trading system - was estimated to cost $2.5 billion, and even less if the barriers to trading are overcome (Burtraw, 1996; ELI 1998). Each of these systems allows progressively greater room for technology choice and innovation, and as can be seen, have a dramatic impact on overall cost. Interestingly, fulfilling even optimistic interpretations of the Porter hypothesis, the current flexible system allows about a fourth of firms to comply at a profit due to unexpected innovation (Ellerman et. al. 1998). Another study compares the U.S. and Swedish pulp and paper industries, and found that Swedish producers adopted in-process innovations earlier than their U.S. counterparts, in part because of inflexibility imposed by U.S. regulations (MIEB 1995). Studies of pollution prevention also points to the need to reform regulatory barriers (Strasser 1997; Boyd 1998a at 43).

Overall, many of the problems of inflexibility in our current system could be avoided by better designed regulations, such as mass-based standards, emissions cap and trading programs, and a greater effort to set overall performance standards (Porter 1995a, Ashford 1985, Jaffee 1995). The strictness of the regulation is also important in promoting more radical innovations.

The point to be made is that our current regulatory system provides a highly imperfect and variable arena in which to test the Porter hypotheses. The design of regulations appears to have at least as great an impact on the costs of compliance as the traditional economic forces which might lead to innovation. Any empirical study of cost therefore faces the difficult task of distinguishing between the lack of innovation caused by the rigidity of the regulatory system and that caused by the inability of the firm to implement cost-effective solutions.

B. Economic and Other Factors Within the Firm

This section explores the reasons that arise from within firms that may affect a firm's ability to innovate in response to environmental regulation, and that may lead to the situation that the Porter hypothesis predicts. In general, the internal structure and functioning of large firms plays a major role affecting a firm's decisions whether to investigate or invest in potential pollution prevention solutions, and potentially also in suboptimal behavior.

A fundamental tenet of the Porter hypothesis is that regulation may lead to process innovations and other improvements that are more efficient and hence profitable. Porter stresses "that pollution often is a form of economic waste... [P]ollution

... is a sign that resources have been used incompletely, inefficiently or ineffectively" (Porter 1995a at 122). Regulation therefore forces investigation into improved resource productivity and may lead to more efficient processes. In this way, pollution prevention actions parallel overall quality concerns, which include the need to use inputs more efficiently, eliminate the needs for hazardous substances, hard-to-handle materials, and eliminate unneeded activities. The kinds of process improvements to comply with environmental regulations that would be expected to lead to cost savings include:

- higher yields;
- better utilization of existing materials;
- substitution of less costly materials;
- higher consistency and quality;
- pollution often reveals flaws in the product design or pollution process;
- savings through reduced costs of handling, storage and disposal of discharges;
- pollutant stream becomes a useable resource or product.

Environmental regulation may also lead to the discovery and development of wholly new processes and products. These more fundamental process changes may require companies to make a thorough examination of alterative technologies and processes and invest in significant research, in contrast to the more incremental changes typically under the control of plant personnel, described above. The parallel between pollution prevention and efficiency means the research is focused on more efficient and productive processes, which may be more profitable and hence rewarding in itself.

This may be the least acceptable element of the Porter hypothesis to most economists. According to Jaffee: "Economists have been generally unsympathetic to these arguments because they depend upon firms being systematically ignorant of profitable production improvements or new technologies that regulation brings forth" (Jaffee 1995 at 155). While they are willing to admit that regulation may stimulate innovation in compliance technology, and to some extent innovation in processes, such as patents, they believe it unlikely that this can greatly offset the costs otherwise occasioned.

Research on within-firm behavior and decision-making reveals many factors that may affect decisions concerning environmental compliance. On the one hand, financial, strategic and technological considerations may create disincentives for investing in potentially attractive pollution prevention for legitimate business reasons. However, internal systems for knowing, communicating and managing are more imperfect within firms than is appreciated (Sinclair-Desgagné 1997; Gabel 1998). Such factors are rarely taken into account in evaluations of costs of compliance, and provide a rationale why reorganizing forces like environmental regulation can result in attractive cost savings. This section sets forth factors that may make the Porter hypothesis more likely, and where additional investigation may be warranted.

Before examining these research issues, we note that several studies demonstrate that financial, strategic and technological considerations may create disincentives for investing in potentially attractive pollution prevention for legitimate business reasons. These range from small firm characteristics that preclude any consideration of alternatives, to high hurdle rates for new investment, to the lock-in effect of high-cost capital equipment that is already in place. These may in fact support the Porter hypothesis, as they show that opportunities to take cost-effective pollution prevention actions may exist that firms would be forced to implement if regulations were adopted. However, they also show how normal business constraints may discourage investment in pollution prevention.

A six-industry study of barriers to innovation by the Environmental Law Institute found that "normal economic and business conditions" created the principle barrier to implementing innovative and cost-saving technologies in three of the six industries studied. In the dry cleaning industry, the small size and lack of research or financial capacity in virtually all firms in the industry precluded research or development of several promising alternatives to the use of perchloroethylene, the principal solvent used in dry cleaning. In the pulp and paper industry, the high capital cost of equipment in place meant that $10-20 million per mill is needed to retrofit or redesign the equipment to achieve greater pollution reductions. This, together with the low number of new mills being built, limits the adoption of known pollution prevention technologies. Only in the third case, wastewater treatment, was it apparent that undue conservatism and resistance to change by conservative owners, typically governments, inhibited innovation (ELI 1998).

A similar conclusion was reached at the firm level, in a study of three cases of unsuccessful implementation of pollution prevention opportunities by individual firms (Boyd 1998a):

> "As the cases show, basic concepts from business and financial theory suggest that the firm's investment decisions were financially rational. This is contrary to the view that firms suffers from a myopic inability to appreciate cost-saving P2 investments. Instead, significant unresolved technical difficulties, uncertain market conditions, and, in some cases, regulatory barriers or insufficient emissions enforcement, rendered the investments financially unattractive. In many cases, the mystery of why firms do not pursue P2 opportunities can be resolved by simply having a deeper understanding of the costs, benefits and risks associated with those investments."

In this study, two of the three firms failed to implement pollution prevention (P2) actions due to legitimate internal business reasons. In one, the firms failed to implement a P2 solution because it had a high internal hurdle rate for investment of 86%. This high benchmark was created because another possible investment delivered

this rate of return, and absorbed the capital available to the firm. In another case, a firm's restructuring and desire to not invest in under-performing sectors of the business precluded an investment in an otherwise profitable pollution prevention opportunity until that sector of the firm was spun off as an independent unit.

1. Environmental regulation may increase research

An argument favoring the Porter hypothesis is that environmental regulation leads firms to additional research regarding compliance options and possible process changes which would not have been undertaken absent the impetus of regulation. This research may result in process improvements and new technologies that are profitable.

There are many examples of profitable results from such research, that reveal that environmental regulations created win-win situation by forcing firms to re-examine assumed barriers to innovative technologies. The Acid Rain Program forced firms to test assumptions about barriers including rail transport bottlenecks and capability of existing boilers to handle earthy western low-sulphur coal without major modification. Both barriers were surmounted by investment in one case and innovation in fuel blending technology in the other. Regulations of the distilled spirits and beer industries have led to the discovery of new waste treatment technologies that eliminate wastes while creating profitable by-products. Regulation of the dry cleaning industry have led to testing of "wet cleaning" technologies that tests show are fully equivalent and cheaper (ELI 1998 at 60; UCLA 1996). These again suggest the importance of the role of regulation in prompting additional research.

Traditional economic theory would not agree that such research should often produce significant economic gains. The "real question is not whether searching produces new ideas but whether particular searches that are generated by regulation systematically lead to more or better ideas than searches in which firms would otherwise engage" (Jaffee 1995 at 156). Since firms are presumably engaged in a profit-maximizing amount of research before the environmental regulation placed greater needs on them, the additional research prompted by regulation should not in theory be consistently profitable.

There are reasons why firms may in fact systematically under-invest in research. The first is that evidence from current businesses indicate that the highly competitive global marketplace has caused many basic manufacturing industries to dramatically reduce research budgets, especially for basic research. A survey of research of environmental technology firms revealed that even these generally devote only 2-3% of revenues to research, and 90-100% of this is applied research with short-term time frames (ELI 1997b). Research by the National Academy of Sciences reveals similar trends in industry at large (NAS 1995). The second is that the full benefits of research

may not be captured by the firm making the research, but may benefit the entire sector or economy. This is treated below in section C.

2. Organizational structure and incentives in firms

The literature on firm behavior and environmental issues reveals that many aspects of firm structure and incentives do not foster innovation. Findings include problems due to production staff not being responsible for environmental compliance (OTA 1994); how environmental costs are treated in incentive structures (Gibbons 1998) and in accounting systems (Ditz 1995); lack of time; communications structures (Bolton and Dewatripont 1994); the influence of habits and routines (Gabel and Sinclair-Desgagné 1998); and industry rigidity.

Manufacturing firms have typically responded to the need to comply with environmental regulations by creating a separate environmental division within the firm, and placing environmental costs in overhead. Both actions tend to divorce environmental compliance from the production process and employees within the companies, where process expertise resides and pollution prevention responses would be best developed. As a consequence, "many firms overlook sources of savings such as energy reduction and pollution prevention, reorientation of materials flow, reduced inventory, and improved quality, in favor of either increased output or direct cost reductions related to production" (OTA 1994 at 247).

A major issue concerns the principal-agent problem, where the incentives of the employer differ from those of the employee, and the employer lacks the resources to monitor the employee effectively (Sinclair-Desgagné & Gabel 1997; Holmstrom & Milgrom1992). Some researchers have found that corporate structures are usually such that individuals within the corporation have no incentive to seek out and undertake pollution control measures. The Office of Technology Assessment identified that "responsibility for finding pollution prevention opportunities may not rest with those most capable of doing so," and they also found a general lack of organizational reward for reducing waste (OTA 1994 at 246; Roy 1992). They also found that "operating managers often emphasize output maximization, making it hard for them to give priority to pollution prevention investments" (OTA 1994 at 247). According to one author "waste reduction opportunities were seldom considered until circumstances virtually forced plants to review their waste management practices" (Sarokin 1985 at 143). The corporation thus fails to pick the "low-hanging fruit" (Gabel and Sinclair-Desgagné 1998) of cost savings achieved through pollution control.

Another problem pertains to the firm's limited ability to monitor the practices of those responsible for or capable of achieving pollution reduction. Limitations on staff time and attention are frequently-cited problems in identifying why profitable pollution prevention actions are not undertaken by firms until regulation forces attention to these

issues (OTA 1994). Thus, there arises a form of "bounded rationality," (Simon 1987) in which the desire of those at the top of the corporate hierarchy to achieve pollution reduction can be frustrated by inertia at the lower levels, where reduction can actually be accomplished. Some manufacturing firms have responded to the need to comply with environmental regulations by creating a separate environmental division within the firm, and placing environmental costs in overhead (Florida 1996 at 93). This still has the effect of divorcing environmental compliance from the production process and employees within the companies where process expertise resides, and pollution prevention responses best developed.

Another line of research has emphasized the coordination failure due to habits and procedures formed around production processes, and which keep a firm away from the global. According to Cyert and March (1992), "The way in which the organization searches for alternatives is substantially a function of the operating rule it has.... The organization uses standard business procedures and rules of thumb to make and implement choices. In the short run these procedures dominate the decisions made." By forcing a firm to reconsider its actual processes and re-engineer its existing routines, stricter environmental regulation might actually bring the firm closer to its own private optimum (Gabel and Sinclair-Desgagné 1998).

These problems have nevertheless been overcome in several instances. "Total quality environmental management" is an increasingly popular management technique, whereby production workers are involved in the product quality improvement process (Florida 1996 at 91). This technique directly addresses the organizational obstacles to pollution reduction inherent in corporate structures. Individual leadership on the part of committed individuals or a group of committed individuals can also compensate for poor organizational structure. One study of several differing industries identified the key role played by the CEO in firms' environmental initiatives (OTA 1994 at 247). A report by a steel company identified that one plant implementing profitable investments in pollution prevention did so primarily because the plant manager was individually motivated (ELI 1997a).

Another study of environmental compliance in the chemical industry found that several elements of firm organization played a key role in whether or not the plant carried out pollution prevention projects. "Plants that had one of three individual program features -- cost accounting, employee involvement and leadership from both environmental and other departments -- had statistically significantly more source reduction activities on average than plants lacking these features." The study also found that plant size was statistically significant - larger plants were generally able to do more (Dorfman 1992 at 31,35). Still, in the majority of cases in which environmental improvements are achieved, they are merely the "unintended consequence of broader efforts to improve industrial performance" (Florida 1996 at 94; Florida 1999).

3. Accounting information consistently under-represents the benefits of pollution reduction

A considerable literature has developed on business practices in accounting for environmental costs. This indicates that accounting systems often fail to capture the full cost of managing waste-streams, and hence understate the benefits of reducing those waste-streams through pollution prevention (Ditz 1995; Porter 1995b at 114; OTA 1994 at 247). Generally, whether an investment in pollution prevention is projected to be profitable depends largely on how the firm accounts for savings from pollution control. For example, accounting systems which have been designed for financial management and reporting typically fail to allocate environmental costs to the cost-creating activity (EPA 1992, Strasser 1996 at 47). Environmental costs, which are typically not large, tend to be treated as overhead, reducing perceived benefits from environmental projects (Ditz 1995). In one study, firms with some kind of environmental accounting system had three times the number of source reduction activities as plants with no cost accounting systems (Dorfman 1992 at 31).

OTA found that a large portion of firms do not perform discounted cash flow analysis on pollution prevention projects, which are often regarded simply as mandatory environmental projects that historically have cost the firm money; in addition, conventional accounting underestimates longer-term benefits of pollution prevention projects (OTA 1994 at 248; see also Sinclair-Desgagné & Gabel 1997).

4. Overcoming static mind-set and industry inertia

Perhaps the most important, yet difficult to quantify factor contributing to the Porter hypothesis is the issue of static mind-set and industry inertia. However, the firm and sector based studies above that reveal, albeit anecdotally, win-win responses to environmental regulation, consistently point to this issue. Firm management did not regard waste reduction as within their priority concerns. Their training concerned other issues, and there was little institutional focus on the issue absent regulation. "Pollution prevention efforts within business organizations today are more limited by organizational culture than by available technology" (Strasser 1996 at 44). This is not wholly irrational — firms invest heavily in developing routines to handle their day-to-day business, and changing routines can not only be difficult but also costly (Gabel and Sinclair-Desgagné 1998 at 100). Moreover, firms may face disincentives to environmental self-auditing by having the disclosed information used against them by a regulator to assess fines and penalties (Pfaff and Sanchirico 1998).

A relevant literature here is that concerning industry behavior in response to technology change. This literature supports the finding that there is considerable rigidity in business response to potential opportunities for change. Although these are considerable differences between sectors, one finding is that mature firms tend to

become rigid in response to technology change opportunities. Another is that radical technology changes are likely to come from sources outside the industry. (Strasser 1998 at 19-23; Ashford and Heaton 1983 at 126; Utterback 1994). Porter's broader research on competitiveness also highlights the importance of outside pressure in overcoming organizational inertia and fostering creative thinking (Porter 1995a; Roy 1992; Rejeski 1995).

C. Reasons arising from factors from without firm

1. Cross-industry gains - some costs won't be borne by firms until all must do so

Environmental regulation may stimulate research and other action that makes economic sense only if all firms in the industry must participate in the activity together, or if the benefits of the activity are spread over all firms. This is especially true of research, as though individual firms must pay for the research, all firms in the sector may benefit over time as the results of the research become diffused (Jaffee 1995 at 156). To the extent research is important to maintaining a nation's competitive advantage in an industry, environmental regulation has a positive effect by requiring more research than a private firm optimum.

2. Industry structure may preclude innovation.

The structure of some industries creates significant barriers to research and action to take advantage of innovations. These include industrial sectors dominated by small businesses, which lack the capacity and finance to mount significant research efforts, and sectors such as public utilities which have been insulated from competitive pressures and are slow to innovate (OTA 1994 at 246-247).

Industries dominated by small business lack both the technical and financial capacity to conduct the necessary research efforts to identify new opportunities. One example is the fragmented U.S. printed wiring board industry, which lost global market share because of its failure to innovate competitively (MIEB 1995). Another such industry is the dry cleaning industry, dominated by very small firms, and where the industry has financed little research on alternative processes. The most significant research on several viable alternative technologies for dry cleaning that promise win-win solutions has been financed by sources outside the industry (ELI 1997a).

Public utilities are another sector where barriers to innovation stem in part from the nature of the industry. Since these have traditionally been public monopolies with defined service areas, they are insulated from commercial pressures and have been slow to innovate. According to one former professor of waste-water engineering, "The stuff I was looking at in the 1970's was just improving on what the Egyptians did 5,000 years

ago. But that's changing now" (Environmental Business International 1995). A market structure that supports rivalrous behavior among firms within the industry and new entrants is an important condition supporting innovation (Strasser 1997).

3. Outside experts tend to promote end-of-pipe solutions

Another factor cited for the slowness to innovate in utility sectors has been the structural problems in the consulting industry which municipal utility plant owners rely on to identify and install technologies. Outside consultants play a significant role in the technology compliance of many firms. This is especially true of public utilities, where municipal owners have no research capacity, and small business (OTA 1994 at 247). These outside experts have only limited capacity or incentive to promote low-cost process changes for numerous reasons, including their lack of familiarity with a client's particular process, their ties to particular vendors or technologies, their readiness to promote end-of-pipe solutions due to adversarial USA permit process, or simply because their fees are higher with higher cost solutions. Also, there are economic drivers for these outside consultants to prescribe traditional treatment methods, instead of lower-cost alternative treatments which are widely available, as their fees are higher and risks are lower.

4. Regulation may eliminate inefficient plants

Economists would agree that environmental regulation may force the less efficient plants in an industry to close, which may boost overall productivity. Jaffee (1995) suggests this happen in the steel industry in the 1970s. A related argument is that environmental regulation leads to "upgrade production facilities or invest in new, more productive facilities" (OTA 1994 at 85).

An unintended consequence of environmental regulation may be that it favors the success of large plants with greater research and adaptations capacity than smaller entities. This contributes to increased economic efficiency in situations where the larger firms are also more economically efficient than the smaller ones.

In addition, older technology tends to be less efficient and therefore more polluting, so additional environmental regulation may discriminate selectively against such older equipment, forcing its retirement by the firm. Although this may raise average productivity of the industry, an economist could point out that the older equipment had remaining useful economic life absent the regulation, so its retirement in favor of investment in newer equipment is not necessarily efficient.

5. Regulation adds green market

Another area where economists would agree is that environmental regulation can give a nation's industry first mover advantages in situations where international environmental regulation is also expected to become more stringent in the future (Jaffee 1995; OTA 1994 at 86). According to Porter, "innovation that US environmental regulation spurred is allowing it to gain position in international markets where similar needs are growing" (Porter 1995 at 127). Put another way, regulation often creates the emerging markets for environmentally cleaner products and processes. The far-sighted company can anticipate impending regulation and gain a competitive advantage by beginning development of cleaner products and processes earlier. This is especially true in cases where these products or processes are patentable or otherwise protectable as intellectual property. On the other hand, this company may lose if green demand is not forthcoming, and the company cannot charge a premium for its product.

In addition, early compliance may allow the company to sell its compliance technology to others. Examples can be found in the pulp and paper sector (MIEB 1995), in distilling and brewing where Bacardi and Anheuser-Busch both successfully market waste processing technologies originally designed for environmental compliance (ELI Forum 1993; Beers 1993).

The opportunity to market green products is widely promoted by advocates of sustainable development, who suggest that demand for green products may be important (Hart 1997). The U.S. Environmental Protection Agency's initiative to induce computer manufacturers to build more energy-efficient computers for example was particularly effective, as it applied to all computers purchased by any U.S. governmental agency. The refrigerator market in Germany may have been driven by desires of German consumers to purchase more energy-efficient refrigerators that also avoid the use of ozone layer-depleting chlorofluorocarbons (MIEB 1995). Although this may provide a boost to competitiveness of firms in industries where international demand in greener products is growing, it may not be significant for most industries.

6. Timing in regulation life cycle

Few studies have focused on the relevance of the timing of regulation on compliance cost. The opportunities to develop cost-saving approaches or win-win solutions are not equal at all times during the life cycle of regulation of a pollutant. With many pollutants there are more opportunities for such low-cost abatement actions when a pollutant is first being regulated, due to the lack of focus on the problems and lack of any previous action. In contrast, there may be expected to be relatively few undiscovered cost-effective actions in a traditionally regulated pollutant where standards are being raised to close to 100% abatement.

This situation can be empirically described for several regulated or potentially regulated substances. One is carbon dioxide (CO_2), where The National Academy of Sciences estimates that using existing technology, the United States could reduce emissions of CO_2 by an initial 25% at a profit, a second 25% at low or not cost, and thereafter with a steadily rising cost curve for the remaining 50% (NAS 1991 at 61). A similar scenario exists for reducing NO_x emissions from vehicles. Initially, emissions of existing fleets can be reduced at a profit by such basic actions as improving maintenance, especially of diesel engines, where reductions of up to 60% can be achieved with little net cost. After this point costs increase steadily, with the costs of current efforts to move from roughly 95% to 98% control requiring such expensive technologies as the addition of a second catalytic converter (International Bank for Reconstruction and Development 1996).

However, other studies indicate "efficiency-oriented opportunities continue to be found by plants that had previously achieved significant reductions in waste generation" (Dorfman 1992 at 90). The literature regarding total quality control and compliance with International Standard Organization (ISO) standards for total quality control and environmental quality also indicate that firms find it in their interests to continually seek improvement in total quality.

7. There may be net economic gains to society due to market imperfections

It is widely acknowledged that net social benefit may rise with greater environmental regulation, although there is a vigorous debate as to whether specific regulations have net benefits. In general, several economic analyses have concluded that, leaving aside aesthetic and other purely qualitative benefits, US air regulations have had significantly positive net benefits, whereas water regulations have had marginal or negative net benefits (Davies 1998 at 135; Hahn 1996).

Social return rates from environmental quality investments are often higher than private, especially because of the externality cost of pollution. Lower levels of pollution may lead to lower health care costs, increased labor productivity and lower costs in other parts of the economy resulting from reduced pollution (OTA 1994 at 83; OECD 1989). Lower pollution can also improve water quality, lowering costs to firms using process water, and has significant positive benefits to agriculture and aspects of our economic infrastructure such as buildings (Davies 1998). Regulation may also confer industry- or society-wide economic benefits, some of which would accrue to firms, reduce production costs or enhance factor productivity (Stewart 1993).

Studies by Repetto have shown how the productivity of specific industries can be dramatically altered by including measurement of environmental externalities. For example, conventional measurement of productivity in the electric power sector

declined 0.35% per year from 1970 to 1991; after taking into account benefits of pollutant reductions on the economy in general, the sector's productivity rose by as much as 0.68% per year.

However, while the net benefits of environmental regulations increase overall social welfare, the marginal contribution of one regulation to social welfare is not likely to be so significant to a particular firm that it overcomes the private cost to the firm of complying with that regulation. However, the overall cost to the firm of complying with all environmental regulations may be reduced by improvements to worker health and productivity, and other benefits that result from environmental regulation. Also, regulation of downstream processes and finished products can create emerging markets for upstream suppliers to the regulated industry. This is generally only true, however, when the downstream market is sufficiently large and important to the upstream industries (MIEB 1995).

IV. Conclusion

The overview given by this paper reveal many considerations affecting the achievement of win-win environmental solutions, and issues that require further research. External to firms, the design of environmental regulations is shown to play a major role in the extent to which firms may seek innovative solutions, and the consequent costs of compliance. This may overshadow strictly economic considerations today in the United States. Studies of strict but flexible regulatory programs, such as cap-and-trade programs, show that unexpected innovation may generally be expected to reduce significantly the cost of compliance.

Within industries and firms, a large variety of factors, including management, communications and accounting structures, are identified that may preclude efficient attainment of pollution prevention practices. Alternately, they show that considerations of risk, strategy and other business factors may discourage otherwise beneficial pollution abatement options. These factors help to explain why Porter's hypothesis may be realized in certain instances, although their richness and complexity also indicates the need for greater understanding and analysis.

Sources

Arnold, M. & R. Day, 1998. THE NEXT BOTTOM LINE: MAKING SUSTAINABLE DEVELOPMENT TANGIBLE. World Resources Institute, Washington, D.C.

Ashford, N., 1994. *An Innovation Based Strategy for the Environment*, in WORST THINGS FIRST. Resources for the Future, Washington, D.C.

Ashford, N., C. Ayers & R. Stone, 1985, *Using Regulation to Change the Market for Innovation*, 9 Harvard Env. Law Rev, 419.

Ashford, N. & G. Heaton, 1983. *Regulation and Technological Innovation in the Chemical Industry* 46 Law and Contemporary Problems, 109.

Beers, Allen, 1993. *First year Operation of Two Brewery Anaerobic Treatment Systems.* Unpublished document, Anheuser Busch Companies, Inc.

Bolton, P. and M. Dewatripont, 1994. *The Firm as a Communication Network*, 109 Quarterly Journal of Economics 809.

Boyd, James, 1998a. *Searching fr the Profit in Pollution Prevention: Case studies in the Corporate Evaluation of Environmental Opportunities*. Resources for the Future, Discussion Paper 98-30 (April).

Boyd, James, 1998b. *The Benefits of Improved Environmental Accounting: An Economic Framework to Identify Priorities.* Resources for the Future, Discussion Paper 98-49 (September).

Burtraw, D. and B. Swift, 1996. *A New Standard of Performance: An Analysis of the Clean Air Act's Acid Rain Program*. 26 Envir. Law Rep. 10411 (August).

Cyert, R. and J. March, 1992. A BEHAVIORAL THEORY OF THE FIRM (Blackwell).

Davies, C. and J. Mazurek, 1998. POLLUTION CONTROL IN THE UNITED STATES: EVALUATING THE SYSTEM. Resources for the Future, Washington, D.C.

Ditz, D. et al., 1995. GREEN LEDGERS: CASE STUDIES IN CORPORATE ENVIRONMENTAL ACCOUNTING. World Resources Institute, Washington, D.C.

Dorfman, M., W. Muir, & C. Miller, 1992, ENVIRONMENTAL DIVIDENDS: CUTTING MORE CHEMICAL WASTES (INFORM, New York).

Environmental Business International, 1994. *Innovative Technologies Poised for Growth in Water/Wastewater*. X Environmental Business Journal, Vol. VII (Nov / Dec).

Environmental Law Institute, 1997a. PROCEEDINGS OF THE WORKSHOP ON SPENT PICKLE LIQUOR. Washington, D.C. (April).

Environmental Law Institute, 1997b. RESEARCH AND DEVELOPMENT PRACTICES IN THE ENVIRONMENTAL TECHNOLOGY INDUSTRY. Washington, D.C.

Environmental Law Institute, 1998. BARRIERS TO ENVIRONMENTAL TECHNOLOGY INNOVATION AND USE. Washington, D.C. (January).

Environmental Law Institute Forum, 1993. *A Remarkable Process.* ELI Forum at 10 (July / August).

Florida, Richard (1996) *Lean and Green: The Move to Environmentally Conscious Manufacturing.* 39 California Management Review 39:80-105.

Florida, R., M. Atlas & M. Cline, 1999. *What Makes Companies Green? Organizational Capabilities and the Adoption of Environmental Innovations.* Carnegie Mellon University (Feb.)

Gabel, H.L., and B. Sinclair-Desgagné (1998) *The Firm, its Routines and the Environment,* Chapter 3 in the International Yearbook of Environmental and Resource Economics.

Gibbons, R., *1998. Incentives in Organizations,* 12 Journal of Economic Perspectives 115.

Gray, W. & R. Shadbegian, 1995. *Pollution Abatement Costs, Regulation and Plant-level Productivity*. National Bureau of Economic Research, Working Paper #4994 (Cambridge, MA).

Hahn, R. & R. Stavins, 1991. Incentive-based Environmental Regulation: A New Era from an Old Idea, *Ecology Law Quarterly* 1991, pp. 1-42.

Hahn, Robert. 1996. *Regulatory Reform: What do the Government Numbers Tell US?* in Robert W. Hahn (ed.), RISKS, COSTS, AND LIVES SAVED: GETTING BETTER RESULTS FROM REGULATION. New York: Oxford University Press.

Harrington, W., R. Morgenstern. & P. Nelson, 1999. *On the Accuracy of Regulatory Cost Estimates.* Resources for the Future, Discussion Paper 99-18 (January) (available at www.rff.org).

Hart, Stuart. 1997. *Beyond Greening: Strategies for a Sustainable World,* Harvard Business Review 66 (January / February 1997).

Holmstrom, B. & P. Milgrom, 1992. "Multi-Task Principal-Agent Analysis: Incentive Contract, Asset Ownership and Job Design," 7 *Journal of Law, Economics and Organization* 24.

Jaffee, A., S. Peterson, & P. Portney, 1995. *Environmental Regulation and the Competitiveness of U.S. Manufacturing: What does the Evidence Tell Us?* XXXIII Journal of Econ. Lit.132 (March).

International Bank for Reconstruction and Development, 1996. AIR POLLUTION FROM MOTOR VEHICLES: STANDARDS AND TECHNOLOGIES FOR CONTROLLING EMISSIONS. (Washington, D.C.)

The Management Institute for Environment and Business. 1996. COMPETITIVE IMPLICATIONS OF ENVIRONMENTAL REGULATION: A STUDY OF SIX INDUSTRIES (Washington, D.C.).

Meyer, S., 1993. ENVIRONMENTALISM AND ECONOMIC PROSPERITY (MIT, Cambridge, MA).

Morgenstern, R., W. Pizer & J. Shih, 1998. *The Cost of Environmental Protection*. Resources for the Future, Discussion Paper 98-36 (May) (available at www.rff.org).

National Academy of Sciences, 1995. ALLOCATING FEDERAL FUNDS FOR SCIENCE AND TECHNOLOGY. (Washington, D.C.)

National Academy of Sciences, 1991. POLICY IMPLICATIONS OF GREENHOUSE WARMING. (Washington, D.C.)

Nelson, Tietenberg and Donihue, 1993. Differential Environmental Regulation: Effects on Electric Utility Capital Turnover and Emissions. *Review of Economics and Statistics* 77(2), 368-373.

Organization for Economic Cooperation and Development, 1989. ENVIRONMENTAL POLICY BENEFITS: MONETARY VALUATION (Paris).

Pfaff, A.S.P., and C.W. Sanchirico (1998) *Environmental Self-Auditing: Setting the Proper Incentives for Discovering and Correcting Environmental Harm.* Working Paper, Department of Economics, Columbia University.

Porter, Michael & van der Linde, Claas, 1995a, Green and Competitive: Ending the Stalemate, Harvard Business Review, 120 (Sep-Oct 1995).

Porter, Michael & van der Linde, Claas, 1995b, Toward a New Conception of the Environmental-Competitiveness Relationship, J. Econ Perspectives (Fall 1995) pp. 97-118.

Portney, Paul, 1994, Does Environmental Policy Conflict with Economic Growth?, Resources (Spring 1994) pp. 21-23.

Rejeski, David, 1995. *The Forgotten Dimensions of Sustainable Development: Organizational Learning and Change*, 3 Corp. Envtl. Strategy 19 (Summer 1995).

Repetto, Robert, Environmental Productivity and Why it is so Important, 33 Challenge No. 5, 33-38 (Sept.-Oct. 1990). (utility sector social productivity + with envir.)

Roy, Manik, 1992. *Pollution Prevention, Organizational Culture, and Social Learning*, 22 Environmental Law 189.

Sarokin, D., W. Muir, C. Miller & S. Sperber, 1985, CUTTING CHEMICAL WASTES (INFORM, New York).

Simon, H.A. (1987) *Bounded Rationality*, in J. Eatwell, M. Milgate and P. Newman (eds), The New Palsgrave Dictionary of Economics, Vol. 1. Macmillan, London.

Sinclair-Desgagné, B. and H.L. Gabel, 1997. *Environmental Auditing in Management Systems and Public Policy*. Journal of Environmental Economics and Management 33:331-346.

Smart, Bruce, ed. 1992. BEYOND COMPLIANCE: A NEW INDUSTRY VIEW OF THE ENVIRONMENT. World Resources Institute, Washington, D.C.)

Strasser, Kurt, 1996. *Preventing Pollution*, VIII Fordham Environmental Law Journal 1-47 (Fall).

Strasser, Kurt, 1997. *Cleaner Technology, Pollution Prevention, and Environmental Regulation*, IX Fordham Environmental Law Journal 1-106 (Fall).

Stewart, Richard Environmental Regulation and International Competitiveness, 102 *Yale Law J.* 2039 (June 1993).

UCLA Pollution Prevention Education and Research Center, UCLA WET CLEANING DEMONSTRATION PROJECT, INTERIM PROGRESS REPORT (Univ. Calif at Los Angeles, Nov. 1, 1996).

U.S. Environmental Protection Agency, 1998. STAKEHOLDER ATTITUDES ON THE BARRIERS TO INNOVATIVE ENVIRONMENTAL TECHNOLOGIES. EPA 236-R-98-001.

U.S. Environmental Protection Agency, 1993. REMOVING BARRIERS AND PROVIDING INCENTIVE TO FOSTER TECHNOLOGY INNOVATION, ECONOMIC PRODUCTIVITY AND ENVIRONMENTAL PROTECTION. EPA 100-R-93-004 (April).

U.S. Environmental Protection Agency, 1992. FACILITY POLLUTION PREVENTION GUIDE. EPA 600-R-92-088.

U.S. Environmental Protection Agency, 1991. PERMITTING AND COMPLIANCE POLICY: BARRIERS TO U.S. ENVIRONMENTAL TECHNOLOGY INNOVATION. (EPA 101/N-91/001.

U.S. Environmental Protection Agency, 1990 ENVIRONMENTAL INVESTMENTS: THE COST OF A CLEAN ENVIRONMENT.

US Office of Technology Assessment, 1994. INDUSTRY, TECHNOLOGY, AND THE ENVIRONMENT: COMPETITIVE CHALLENGES AND BUSINESS OPPORTUNITIES. US GPO, Washington, D.C.

US Office of Technology Assessment, 1995. GAUGING CONTROL TECHNOLOGY AND REGULATORY IMPACT IN OCCUPATIONAL SAFETY AND HEALTH - AN APPRAISAL OF OSHA'S ANALYTIC APPROACH. (OTA-ENV-635) US GPO, Washington, D.C.

Utterback, James, 1994. MASTERING THE DYNAMICS OF INNOVATION.

Weitzman, Martin, 1994. *On the Environmental Discount Rate.* 26 J. Environ. Econ. Management 200 (March).

White House Office of Science and Technology Policy, 1994. TECHNOLOGY FOR A SUSTAINABLE FUTURE. (Washington, D.C.).

Appendix

Summary of the Workshop on
Innovation, Cost and Environmental Regulation

Help on April 30th, 1999
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Carnegie Mellon University

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Nearly 100 people filled conference rooms at the Resource and Conservation Center in Washington, D.C. to hear a research and policy update on expected compliance cost and innovation resulting from environmental regulation. The issue, popularized as the Porter Hypothesis, is whether tighter environmental regulation causes an industry to become more instead of less competitive in today's global economy.

David Rejeski of the Council on Environmental Quality opened the meeting by summarizing the intellectual history of the issue that from the first has seemed to pit skeptical economists against more receptive representatives of business. That division, with only modest middle ground, continues to the present. Mr. Rejeski identified several key issues to be addressed. What is the empirical evidence that there is a competitive penalty to regulation? If so, what does it look like? Are their certain behavioral and structural factors in firms and sectors that tend to mitigate the penalties? Is there a way to regulate that reduces competitive impacts, enhances environmental performance, and increases innovation? Mr. Rejeski concluded by challenging the workshop to produce a list of policy conclusions, research recommendations, and to determine whether a shift in perspective has occurred about the hypothesis.

Panel I: Perspectives on the Economic Costs of Environmental Regulation

Scott Farrow of the Center for the Study and Improvement of Regulation at Carnegie Mellon University moderated the first panel on studies of the costs impacts of environmental regulation. He pointed out that regulatory analysis is proceeding to a deeper examination of the linkages among regulatory design, organizational behavior and performance.

Professor Adam Jaffe of Brandeis University opened the discussion by surveying seven dimensions of competitiveness, including cost, balance of trade, foreign direct investment, plant location, innovation, productivity growth and economic growth. Updating earlier work, Jaffee noted that there was substantial agreement among

economists that environmental regulation is likely to stimulate research, and that innovation may make regulation less costly. Overall, however, there remains little evidence to support either claims that environmental regulations causes either large adverse effects on competitiveness, or large positive impacts on innovation and competitiveness. He noted that some of the most recent econometric evidence indicated that regulation resulted in statistically significant but very small reductions in economic growth.

In concluding, Professor Jaffee proposed the "Jaffe Hypothesis" that second-order effects of regulation (good or bad) are small relative to first-order effects. This implies that measured costs are reasonably accurate, and that innovation does not make regulation free, just cheaper than industry says in advance. He further noted that despite the disagreement about the extent of innovation, there is widespread agreement that the current regulatory system uses inflexible mechanisms likely to stifle innovation and escalate costs. He proposed that instead of arguing about differences we focus on reforms that would replacing inflexible regulations with incentive-based approaches to make them less stifling or positively innovation-enhancing.

Professor Richard Florida of Carnegie Mellon University presented the results of a series of structured surveys and case studies carried out to assess the linkages between elements of green management, such as pollution prevention or environmental management systems, and innovation practices focused on company core capabilities. This research has found that companies that achieve innovative management and high levels of resource productivity are also the ones achieving positive environmental performance. Roughly 40% of companies in a field are leaders, whereas 15-20% are doing little. The green innovators tend to be larger, spend more on research and development, and in general are also innovators in their core business. They found a company's ability to innovation strongly mattered to all performance measures, as did its use of systems to measure results. Other major determinants of innovation were barriers and resource constraints, and not lack of information.

Professor Florida suggested that a problem with environmental regulation is that it treats all firms equally. A major policy recommendation would be to achieve more flexible regulations, that set standards but do not impose the remedy as the current system tends to. He endorsed the recommendation in the background paper, and noted he had repeatedly witnessed the problems caused by inflexible regulations within innovative firms. In a sense the current regulatory system penalizes the innovators and rewards the laggards. A forward-looking research agenda would stress a multi-disciplinary approach, and focus on environmentally conscious manufacturing. He expressed his hope that the government and foundations would fund research on this subject.

The morning session concluded with two presentations by Billy Pizer and Winston Harrington of Resources for the Future. Dr. Pizer presented statistical results for environmental costs borne by about 550 manufacturing plants observed over time. The results indicated that the impact of a reported dollar increase in environmental spending caused somewhat less than a dollar increase in total spending, or about 82 cents, due to cost-reducing offsets. There was considerable variety within industries, but at worst, environmental cost increases in an industry led to total cost increases of more than a dollar, but generally less than two dollars. He noted that the estimates of costs in their study would be much higher if they had not controlled for inter-plant differences. He felt this might explain why some other studies find very high environmental costs, as they do not control for such differences. While their study indicates that our present form of environmental regulation does impose costs, it indicates innovation to some extent offsets costs, and rejects the notion that environmental regulation causes dramatically escalating costs.

Winston Harrington concluded the morning session with a study of *ex-ante* and *ex-post* estimates of the cost of 25 specific federal regulations. Overall, their research found that *ex-ante* estimates tend to overstate both total costs and environmental efficacy, while estimates of costs per unit of reduction were about right. A variety of factors is believed responsible that includes innovation that reduces costs, but also other factors as the tendency for final regulations to be weaker than those proposed, when the cost estimates had been made. One of the interesting findings is that the implication of the Porter hypothesis hold true most strongly for the 7 regulations implementing market-based approaches. For these, the actual results showed that total and per-unit costs were consistently less than estimates, and environmental effectiveness greater, a much stronger correlation than for other types of regulation.

The audience, with members from industry, government, environmental groups, and trade associations, raised numerous questions throughout the presentations. No formal conclusions were drafted during the workshop though sentiment in the morning seemed to coalesce around the win-win returns from regulatory flexibility and innovation if other objectives can be met, the potential to distinguish different categories of those regulated, and remaining uncertainties in the links between specific regulatory designs, the response of industry, and various aspects of environmental, social, and economic performance.

Panel II: Incentives and Barriers to Innovation

Byron Swift of the Environmental Law Institute introduced the next panel, consisting of Prof. Kurt Strasser of the University of Connecticut Law School, Dr. Bernard Sinclair-Desgagné of the Inter-University Center for Research and Analysis of Organizations, and Robert Day of World Resources Institute. These panelists would attempt to identify

the practical legal and organizational barriers that could prevent a firm from developing and implementing cost -effective pollution prevention solutions.

Mr. Swift noted that research done by ELI indicates that regulatory barriers constrain innovative and prevention-oriented approaches in the environmental field. These stem from the way environmental laws are written and enforced, and possibly more than fundamental economics explain why compliance costs may be high in some industries. In particular he noted that rate standards such as those based upon "achievable control technologies"cause significant problems as they restrain flexibility and lead to governmental review of technology choices. Wherever possible, such as for area-wide pollutants, these rate standard should be replaced by mass standards that are equally effective and much friendlier to innovation.

Kurt Strasser opened his remarks by posing the question why the current regulatory system has a marked preference for familiar technologies. He suggested one answer is that today's regulatory approach stresses a law enforcement mentality that grew out of legitimate public health concerns. His research reveals many causes for such a bias, especially in the permitting and enforcement process. Familiar technologies are readily evaluated by permit writers, and because they are, offer less delay to the company. The enforcement system also creates high risks to both permit writers and industry officers who support a new technology effort that may not attain its goals. In addition, the regulatory process creates monstrous records, and almost always generates a court case, reinforcing conservative decisions.

As a result, adopting new technologies has many risks, especially for process changes that may be environmentally preferable, but may change waste streams and so trigger the need for new permits. It usually takes time and occasional failures to make new technologies to work, and the inhospitality of our present regulatory system to this process is evidenced in the woefully small financial investment into development of new environmental technologies today.

In closing, Professor Strasser offered several pointers towards a robust technology policy. First, he would target incentives on those likely to do the innovating that are greater than economic incentives. Doing this requires an evaluation of (1) the industry context; (2) technology options for the whole industry, (3) firm specific factors such as were discussed by Dr. Florida, and (4) regulatory options. A second is to adopt a cross-media approach. This has been attempted in a few instances, most notably in the pulp and paper sector, but appears difficult under current air and water laws that operate in almost isolation. Finally, he noted that while innovative pilot programs were good, they seldom addressed root causes and rarely developed a life after the program's end.

Unfortunately, it appears that implementing such an agenda may require changes in existing law. If we were to reform our environmental laws, Professor Strasser urges a

consideration of a regulatory structure that would proceed industry by industry instead of medium by medium. Possibly this could be started at the state level, such as through partnership grants.

Bernard Sinclair-Desgagné suggested there are three kinds of innovation; incremental innovation, which typically comprises the bulk of industrial innovation, innovation oriented towards risk reduction, and radical innovation. The most controversial aspect of the Porter principal is its assertion that regulations could create radical innovations that lead to net profits. As it is difficult to address this issue using traditional economics, another ways to investigate this assertion is to open up some of the filed's "black boxes", such as innovation or the management of the firm, his area of research.

His studies of the operations within firms revealed several instances why so-called "low hanging fruit" might be available with win-win characteristics. One rationale is provided by the principle-agent problem, in which incentives may be poorly designed. Low-hanging fruits can also derive from coordination failures within a firm, such as communications failures. His work with Landis Gabel investigates how a firm's production habits and routines may keep it from acting optimally. Firms attempt to maximize efficiency by promoting routines. Although this is a sensible and necessary approach, it can lead to the oversight of possible changes and to the kinds of win-win situations Porter predicts. By forcing a firm to reconsider its actual processes and re-engineer its existing routines, stricter environmental regulation might actually push firm to revise its procedures and bring it closer to an operating optimum

This theory might suggest that re-engineering, defined as tracing down elementary inputs and bunching them back into better routines, may always deliver low-hanging fruits. However, there will be associated costs to do this, and there may be complementarities in the production process that require many changes once one is made. Therefore, firms may not implement such changes due to such complementarities or to higher cost than benefits, as well as from inertia generated by political factors within the firm or by management systems.

Dr. Sinclair concluded by suggesting research into the following policy elements:

1) the role of regulation to tackle inertia with a firm; such regulation should be crafted to fit the type of innovation that is pursued - incremental (low-hanging fruits), risk reducing or radical;

2) the governmental role in harmonizing practices and norms, such as support of audit procedures, environmental management strategies, as well imposing penalties for non-compliance.

3) the use of credible threats of regulation, such as in the European Community, where a governmental threat to adopt common emerging regulations may be quite credible.. The purpose here is to promote industry research into better solutions without giving them strict time frames which might force a more rapid but less innovative pollution control response.

Robert Day next discussed recent research by World Resources Institute that reveals several factors determine superior corporate performance. These included the regulatory structure, reinforcing what had been said so far on the need for stringent but flexible performance-based regulation; the structure of the industry; an understanding of the role of the pollutant within the industrial process; and an understanding of the investment life-cycle relevant to the pollutant in question.

Their work emphasized a business value model that identifies the reasons for business successes and failures. In this context Mr. Day emphasized the importance of radical innovation to firms. A study by INSEAD in France showed that 86% of innovation was incremental, and only 14% could be classified as radical, but that 38% of firm revenues and 61% of profits derived from those radical innovations. There are many current barriers though to achieving this model, such as the lack of entrepreneurship in the Environmental Health and Safety divisions of firms. Also, despite the evident attractiveness of market-based standards, some research has revealed existing firms may prefer the present regulatory system they have learned to live with.

In conclusion, his policy recommendations included: (a) emphasizing overall performance standards in government regulation; (b) collaborative development between government and industry; (c) an emphasis on management issues, and (d) identifying how non-governmental efforts could support a clean production agenda, such as the release of information on pollutants, certification and green labeling, and pressure imposed by buyer collaboratives.

[Summaries of the presentations of each speaker can be found at the website of the Economics and Environment Division of EPA's Office of Policy, at www.epa.gov/economics.]

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