Journal of Economic Literature
Vol. XXXIII (March 1995), pp. 132–163

Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?

By

ADAM B. JAFFE
Brandeis University and National Bureau of Economic Research

STEVEN R. PETERSON
Economics Resource Group

PAUL R. PORTNEY
Resources for the Future

and

ROBERT N. STAVINS
Harvard University and Resources for the Future

The authors thank Lawrence Goulder, Raymond Kopp, William Nordhaus, Richard Schmalensee, Martin Weitzman, David Wheeler, and participants in seminars at Harvard University and Resources for the Future for helpful comments. Funding for previous work on this subject from the U.S. Department of Commerce is gratefully acknowledged. The authors alone are responsible for any omissions or other errors.

1. *Introduction*

MORE THAN TWO DECADES ago, the first Earth Day in 1970 marked the beginning of the modern environmental movement. Since that time, the United States has spent more than $1 trillion to prevent or reduce environmental damages created by industrial and commercial activities. During the latter part of this period, the U.S. economy has moved from a position of approximate trade balance on a long-term basis to a position of chronic trade deficit. The coincidence of these two major trends has led many to suspect that environmental regulation may be playing a major causal role in impairing the "competitiveness" of U.S. firms.[1]

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. This loss of competitiveness is believed to be reflected in declining exports, increasing imports, and a long-term movement of manufacturing capacity from the United States to other countries, particularly in "pollution-intensive" industries.[2]

Under a more recent, revisionist view, environmental regulations are seen not only as benign in their impacts on international competitiveness, but actually as a net *positive* force driving private firms and the economy as a whole to become more competitive in international markets.[3] During the past few years, a heated debate has arisen in the United States revolving around these two views.[4] This paper assembles and assesses the evidence on these hypothetical linkages between environmental regulation and competitiveness.

The terms of the debate and the nature of the problems have not always been clear, but it is possible to sketch the general nature of the concerns. Much of the discussion has revolved around the fear that environmental regulation may reduce net exports in the manufacturing sector, particularly in "pollution-intensive" goods. Such a change in our trade position could have several effects. First, in the short run, a reduction in net exports in manufacturing will exacerbate the overall trade imbalance. Although we are likely to return toward trade balance in the long run, one of the mechanisms through which this happens is a decline in the value of the dollar. This means that imported goods become more expensive, thus reducing the standard of living for many people. Second, if those industries most affected by regulation employ less educated workers, then this portion of the labor force will be particularly hard hit, because those workers may have an especially hard time finding new jobs at comparable wages. Third, a diminishing U.S. share of world capacity in petroleum-refining, steel, autos, and other industries could endanger economic security. Finally, even in the absence of these income distribution or economic security concerns, the rearrangement of production from pollution-intensive to other industries creates a broader set of social costs, at least in the short run. Because the "short run" could last for years or even decades, these transition costs are also a legitimate policy concern.

[1] This argument is related but not identical to expressed concerns about the loss of "competitiveness" of the U.S. as a whole. For a trenchant criticism of the notion that countries "compete" in the same ways that individual firms do, see Paul Krugman (1994).

[2] The theoretical argument that ambitious environmental regulations could harm a nation's comparative advantage is well established, but our focus is exclusively on empirical evidence. On the former, see Rudiger Pethig (1975); Horst Siebert (1977); Gary W. Yohe (1979); and Martin C. McGuire (1982).

[3] These ideas, generally associated most with Michael E. Porter (1991), have become widely disseminated among policy makers. For example, a U.S. Environmental Protection Agency (EPA) conference recently concluded that environmental regulations induce "more cost-effective processes that both reduce emissions and the overall cost of doing business. . ." (U.S. Environmental Protection Agency 1992b).

[4] For an overview of the dimensions of this debate, see Richard B. Stewart (1993). Unfortunately, this debate has often been clouded by the very criteria chosen by proponents of alternative views. For example, there has been substantial debate *and* confusion among policy makers about whether environmental regulations create new jobs and whether such "job creation" ought to be considered a regulatory benefit or cost (if either). See Thomas D. Hopkins (1992).

TABLE 1
U.S. EMISSIONS OF SIX MAJOR AIR POLLUTANTS, 1970–1991[a]

Year	SO_2	NO_x	VOCs	CO	TSPs	Lead
1970	100[b]	100	100	100	100	100
1975	90	107	82	85	58	72
1980	84	124	79	81	48	34
1981	79	113	77	79	45	27
1982	75	107	71	73	40	26
1983	73	104	74	75	41	22
1984	76	106	77	71	43	19
1985	76	102	72	67	41	9
1986	74	99	67	62	38	3
1987	74	100	68	61	39	3
1988	75	104	68	61	42	3
1989	76	102	63	55	40	3
1990	74	102	64	55	39	3
1991	73	99	62	50	39	2

Source: U.S. Environmental Protection Agency (1992a).
[a] The six "criteria air pollutants[a] listed are: sulfur dioxide (SO_2); nitrogen oxides (NO_x); reactive volatile organic compounds (VOCs); carbon monoxide (CO); total suspended particulates (TSPs); and lead.
[b] Indexed to 1970 emissions, set equal to 100. Note that these are aggregate national emissions, not emissions per capita or emissions per unit of GNP; the latter two statistics would, of course, exhibit greater downward trends.

There are a number of reasons to believe that the link between environmental regulation and competitiveness could be significant. First, environmental regulation has grown significantly in the United States since 1970, and substantial gains have been achieved in reducing pollutant emissions (Table 1).

But according to the U.S. Environmental Protection Agency (EPA), the annual cost of complying with environmental regulation administered by EPA now exceeds $125 billion in the United States, or about 2.1 percent of gross domestic product (GDP).[5] Furthermore, EPA has projected that annual environmental compliance spending may reach $190 billion by the end of this decade. If that happens, the United States will be devoting nearly 2.6 percent of its GDP to environmental compliance by the year 2000.[6]

It is extremely difficult to compare this compliance cost burden with that borne by competing firms in other countries. Environmental requirements throughout most of the developing world are less stringent than ours, and related compliance costs are hence generally lower. On the other hand, some data suggest that other countries, such as Germany, have regulatory programs that give rise to regulatory costs roughly comparable to those imposed on U.S. firms (Table 2).[7]

Putting aside the potential effect of differences in regulatory stringency, there are other ways in which environmental regulations may affect competi-

[5] As we discuss later in some detail, these direct compliance costs represent only a share of the overall social costs of environmental regulation. For example, Weitzman (1994) estimates that the total "environmental drag" on the U.S. economy may be two to three times greater than these fractions of GNP dedicated to compliance spending would suggest.

[6] Figures are in constant 1992 dollars (throughout the paper, unless otherwise specified), assuming a seven percent cost of capital (U.S. Environmental Protection Agency 1990). These estimates include both capital and operating costs. Projections for compliance costs of existing regulations are based on historical extrapolations. Projections for the costs of new and proposed regulations are based on EPA regulatory analyses. EPA actually makes its projections in terms of gross national product (GNP), rather than gross domestic product (GDP), but any difference between the two is small compared to uncertainty over compliance costs.

[7] It is indicative of the data problems in this area that the OECD numbers in Table 2 differ in both level *and* trend from the EPA numbers cited above and presented in Table 4. It is our view that the data in the latter table more accurately reflect annual expenditures in the United States to comply with federal environmental regulations. It would be helpful if the environmental agencies of other nations made the same effort as the U.S. Environmental Protection Agency to keep track of and regularly report estimated compliance expenditures.

TABLE 2
POLLUTION ABATEMENT AND CONTROL EXPENDITURES FOR SELECTED OECD COUNTRIES AS A PERCENTAGE OF GROSS DOMESTIC PRODUCT

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
United States	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.4	1.4
France	0.9	0.9	0.9	0.8	0.9	0.8	1.0	1.0	1.0	1.0
West Germany	1.5	1.5	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.6
Netherlands	—	1.2	—	—	1.3	1.5	1.5	—	1.5	—
United Kingdom	1.6	—	—	—	1.3	1.3	—	—	—	1.5

Sources: Organization for Economic Cooperation and Development (1990, p. 40), for years 1981–1985; Organization for Economic Cooperation and Development (1993b, p. 11) for years 1986–1990.

tiveness. Holding constant the *stringency* of environmental standards, the *form* these rules take can potentially affect business location. For instance, U.S. environmental regulations often go beyond specifying numerical discharge standards for particular sources or source categories, and mandate, instead, specific control technologies or processes. If other countries tend to avoid such technological mandates and thus allow more flexibility in compliance, manufacturing abroad may be relatively attractive because sources will have the ability to use new, innovative, and low-cost ways to meet discharge standards.

Another difference between U.S. and foreign environmental regulation should also be recognized: namely, the adversarial approach to regulation typically taken in the United States. Regulatory decisions in the United States are time-consuming and characterized by litigation and other legal wrangling. By way of contrast, a more cooperative relationship is said to exist between regulator and regulatee in some other countries, with the United Kingdom offered as the definitive example (David Vogel 1986). Unfortunately, data on these aspects of respective costs are essentially unavailable.

In general, the studies that attempt to analyze directly the effects of environmental regulations on trade and competitiveness are limited in number. If one casts a wide enough net, however, by defining competitiveness rather broadly and by searching for indirect as well as direct evidence, it is possible to identify more than one hundred studies potentially capable of shedding some light on the relationship.[8] It is nearly the case, however, that no two of these studies ask the same question or even examine the same problem. This is one of the challenges of trying to assess the competing hypotheses of the environment-competitiveness linkage.

Despite our relatively broad focus with regard to competitiveness, the scope of this review is somewhat limited in another respect. Specifically, we limit our attention here to studies shedding light on the effects of environmental regulation on manufacturing firms. This is not because of an absence of such regulation in natural resource industries such as forestry, agriculture, mining, and com-

[8] For a comprehensive review of the literature, see Jaffe et al. (1993). An earlier survey is provided by Judith M. Dean (1992). See, also U.S. Office of Technology Assessment (1992).

mercial fishing. Indeed, the controversy over the Northern Spotted Owl, the Endangered Species Act in general, and the effects of habitat preservation on the location of timber production is among the most visible U.S. environmental issues of recent times. Similarly, regulations pertaining to pesticide use in agriculture, the reclamation of land mined for coal or non-fuel minerals, or the equipment that can be used by commercial fishing fleets can clearly affect the costs faced by (and hence the international competitiveness of) U.S. firms in these industries.

Rather, we concentrate our attention on manufacturing industries for two reasons. First, that is where the research has been done. With a few exceptions, economists have paid little attention to the effects of environmental regulation on competitiveness in the natural resources sector. By way of contrast, there is a substantial and growing literature focused on the manufacturing sector, as suggested above. Second, the political and policy debate has centered around the possible "flight" of manufacturing from the U.S. to other countries with less stringent environmental standards.

To some extent, this distinction is a peculiar one. To be sure, environmental restrictions on pesticide use or habitat destruction cannot induce someone to move a farm or commercial forest to another country. Such natural capital is immobile, even in the long run. But if concern about competitiveness is primarily a "jobs" issue—and, to many, at least, it is—then it is relevant that environmental regulations pertaining to natural resource industries can affect *where* crops are grown, timber is harvested, fish are caught, or minerals are mined. Nevertheless, because the overwhelming share of attention by policy makers and academics has been devoted to the competitiveness of manufacturing, we concentrate our attention there, as well.

The remainder of this paper is organized as follows. Section 2 outlines an analytical framework for identifying the effects of environmental regulation on international trade in manufactured goods, discusses how different notions of competitiveness fit into that framework, and examines the major categories of environmental regulatory costs. In Section 3, we draw on the available evidence to examine the effects of environmental regulations on international trade in manufacturing. In Section 4, we turn to the empirical evidence regarding the linkage between environmental regulation and investment; and in Section 5, we look at links between regulation and more broadly defined economic growth. Finally, in Section 6, we draw some conclusions.

2. *Framework for Analyzing Regulation and Competitiveness*

2.1 *A Theoretically Desirable Indicator of Competitiveness*

The standard theory of international trade is based on the notion that trade is driven by comparative advantage—that countries export those goods and services that they make relatively (but not necessarily absolutely) more efficiently than other nations, and import those goods and services they are relatively less efficient at producing. Because of the anticipated international adjustments that occur when relative costs change, we could measure—in theory, at least—the real effects of regulation (or any other policy change, for that matter) on competitiveness by identifying the effect that the policy would have on net exports *holding real wages and exchange rates constant*.[9] We would wish to measure the

[9] This definition is closely related to those suggested by Laura D'Andrea Tyson (1988), and Organization of Economic Cooperation and Development (1993a).

reduction in net exports "before" any adjustments in the exchange rate (and hence in net exports of other goods) have taken place, because other industries whose net exports increase to balance a fall in exports should not be thought of as having become more competitive if their export increase is brought about solely by a fall in exchange rates. Similarly, we should not construe an increase in exports brought about solely by a fall in real wages as an increase in "competitiveness."

The unfortunate problem with this analytically clean definition of competitiveness is that it is essentially impossible to implement in practice. We simply are not presented with data generated by the hypothetical experiment in which regulations are imposed while everything else is held constant. In principle, one could formulate a structural econometric model in which net exports by industry, wages, and exchange rates are determined jointly as a function of regulatory costs and resource endowments. We have identified no study that has attempted to do so, and it is not clear that available data would support such an effort.[10] As a result, we are left with indicators of the effects on competitiveness that are not wholly satisfactory because they fail to take account of the complicated adjustment mechanisms that operate when regulations are imposed. Nevertheless, these indicators can be useful to sort through many of the policy debates regarding the environment-competitiveness linkage.

2.2 *Alternative Indicators of "Competitiveness"*

The indicators of "competitiveness" that are used in the existing literature can be classified into three broad categories.[11] One set of measures has to do with the change in net exports of certain goods, the production of which is heavily regulated, and with comparisons between net exports of these goods and others produced under less regulated conditions. For example, stringent environmental regulation of the steel industry should, all else equal, cause the net exports of steel to fall *relative* to the net exports of goods the production of which is more lightly regulated. Thus, the magnitude and significance of an econometric parameter estimate that captures the effect of regulatory stringency in a regression explaining changes in net exports across industries could be taken as an indicator of the strength of the effects of regulation on competitiveness.

A second potential indicator is the extent to which the locus of *production* of pollution-intensive goods has shifted from countries with stringent regulations toward those with less. After all, the policy concern about competitiveness is that the United States is losing world market share in regulated industries to countries with less stringent regulations. If this is so, then there should be a general decrease in the U.S. share of world production of highly regulated goods and an increase in the world share of production of these goods by countries with relatively light regulation.

Third, if regulation is reducing the attractiveness of the United States as a locus for investment, then there should be a relative increase in investment by U.S. firms overseas in highly regulated industries. Similarly, all else equal, new plants in these industries would be more likely to be located in jurisdictions with lax regulation.

Finally, in addition to research focusing on these aspects of competitiveness,

[10] Later we discuss the quantity and quality of available cross-country compliance-cost data.

[11] We henceforth drop the quotation marks around our use of the term "competitiveness" for convenience of presentation.

there exists one other set of important analytical approaches that can shed light on the environment-competitiveness debate. These are analyses focused on the more fundamental link between environmental compliance costs, productivity, investment, and the ultimate social costs of regulation. These analyses, including investigations of the productivity effects of regulation as well as general-equilibrium studies of long-term, social costs of regulation, have implications for both the conventional and the revisionist hypotheses concerning environmental regulation and competitiveness.

Because the economic adjustment to regulation is highly complex, and because there are a multiplicity of issues wrapped up in the term "competitiveness," it is not possible to combine estimates of these different aspects of the process into a single, overall quantification of the effects of regulation on competitiveness.[12] The best that can be done is to assess somewhat qualitatively the magnitude of estimated effects, based on multiple indicators. We return to that assessment shortly.

2.3 *A Framework for Analysis*

These diverse sets of indicators reflect the various routes through which regulation can conceivably affect competitiveness. First, environmental regulations affect a firm's costs of production, both directly through its own expenditures on pollution reduction and indirectly through the higher prices it must pay for certain factors of production that are affected by regulation. Both direct and indirect costs will affect competitiveness, including measures of trade and investment flows.[13]

It is also true that environmental regulations can reduce costs for some firms or industries, by lowering input prices or by increasing the productivity of their inputs. Such "benefits to industry" could take the form, for example, of reduced costs to the food processing industry when its supplies of intake water are less polluted; likewise, workers may become more productive if health-threatening air pollution is reduced (see Bart D. Ostro 1983). Such benefits would have positive effects on U.S. trade and investment through the same mechanisms by which increased costs would have negative effects. Additionally, firms in the environmental services sector typically benefit from stricter regulations affecting their clients and/or potential clients.[14]

In any case, the degree to which domestic regulatory costs (and benefits) affect trade will depend also on the magni-

[12] Having highlighted a theoretically desirable measure and a set of empirically practical means of assessing the link between environmental protection and economic competitiveness, we should also note the multiplicity of *inappropriate* means of examining this link. Indeed, the amount of published, muddled thinking on this subject seems to exceed the norm. Numerous studies have focused exclusively on "jobs created in the environmental services sector" and taken this to be a measure of net positive economic benefits of regulation (apart from any environmental benefits). A recent example of this approach is provided by Roger H. Bezdek (1993), with numerous citations to other such studies. See Hopkins (1992) and Portney (1994) for critiques of this approach.

[13] For the economy as a whole, there is, of course, no distinction between direct and indirect costs. To measure total industry expenditures for pollution compliance, it would be incorrect to add the increased costs of the steel industry and the increased costs in the auto industry resulting from higher steel prices; to do so would result in obvious double-counting. The necessity of tracking indirect costs arises, however, when the analyst wishes to estimate the impact of regulation on a particular industry, or to compare effects on different industries. We postpone discussion of another notion of "indirect costs," including transition costs and reduced investment, which we refer to for semantic clarity as "other social costs" of regulation. See Section 5, below.

[14] There are, of course, additional benefits of environmental regulation that accrue to society at large rather than to industry. We exclude these here, not because they are unimportant, but because they do not bear on the issue of competitiveness.

tude of the costs (and benefits) that other countries impose on the firms operating within their borders. Likewise, other nations' policies will also affect the investment decisions of their indigenous firms and of foreign firms, as well. Any changes in investment patterns that do occur ultimately affect trade flows as well, and both trade and investment effects interact with exchange rates.

2.4 *Measuring the Costs of Environmental Regulation*

In Table 3, we provide a taxonomy of the costs of environmental regulation, beginning with the most obvious and moving toward the least direct.[15] First, many policy makers and much of the general public would identify the on-budget costs to government of administering (monitoring and enforcing) environmental laws and regulations as *the* cost of environmental regulation. Most analysts, on the other hand, would identify the capital and operating expenditures associated with regulatory compliance as the fundamental part of the overall costs of regulation, although a substantial share of compliance costs for some federal regulations fall on state and local governments rather than private firms—the best example being the regulation of contaminants in drinking water. Additional direct costs include legal and other transaction costs, the effects of refocused management attention, and the possibility of disrupted production.

Next, one should also consider potential "negative costs" (in other words, nonenvironmental benefits) of environmental regulation, including the productivity impacts of a cleaner environment and the potential innovation-stimulating effects of regulation (linked with the so-called Porter hypothesis, which we discuss later). General equilibrium effects associated with product substitution, discouraged investment,[16] and retarded innovation constitute another important layer of costs, as do the transition costs of real-world economies responding over time to regulatory changes. Finally, there is a set of potential social impacts that is given substantial weight in political forums, including impacts on jobs and economic security.

TABLE 3
A TAXONOMY OF COSTS OF ENVIRONMENTAL REGULATION

Government Administration of Environmental Statutes and Regulations
Monitoring
Enforcement
Private Sector Compliance Expenditures
Capital
Operating
Other Direct Costs
Legal and Other Transactional
Shifted Management Focus
Disrupted Production
Negative Costs
Natural Resource Inputs
Worker Health
Innovation Stimulation
General Equilibrium Effects
Product Substitution
Discouraged Investment
Retarded Innovation
Transition Costs
Unemployment
Obsolete Capital
Social Impacts
Loss of Middle-Class Jobs
Economic Security Impacts

[15] For a very useful decomposition and analysis of the full costs of environmental regulation, see Schmalensee, (1994). Conceptually, the cost of an environmental regulation is equal to "the change in consumer and producer surpluses associated with the regulations and with any price and/or income changes that may result" (Maureen L. Cropper and Wallace E. Oates 1992, p. 721).

[16] For example, if a firm chooses to close a plant because of a new regulation (rather than installing expensive control equipment), this would be counted as zero cost in typical compliance-cost estimates.

TABLE 4
TOTAL COSTS OF POLLUTION CONTROL[a]
(millions of 1992 dollars)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Toatl Air & Radiation	9,915	11,995	12,725	13,942	15,854	18,071	19,993	21,413	22,313	22,992	23,550
Total Water	12,387	14,352	16,795	18,940	21,769	24,234	26,342	28,707	30,925	33,149	34,832
Total Land	10,543	11,120	11,683	12,235	12,984	14,160	14,897	16,223	17,011	17,660	16,502
Total Chemicals	115	179	229	226	436	510	729	1,066	1,111	989	890
Multi-Media	135	174	576	734	911	1,149	1,129	1,107	1,085	869	757
Total Costs	33,094	37,818	42,009	46,043	51,954	58,124	63,089	68,516	72,446	75,658	76,530
Percentage of GNP	0.88	0.96	1.07	1.19	1.28	1.37	1.41	1.49	1.58	1.62	1.68
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	2000
Toatl Air & Radiation	25,970	27,899	31,885	31,782	33,751	34,482	35,326	35,029	36,852	37,763	46,859
Total Water	37,199	39,099	41,418	44,197	46,904	48,104	50,317	52,604	55,114	57,277	72,705
Total Land	17,034	18,711	19,881	21,884	23,860	25,392	28,760	33,177	37,184	41,186	57,673
Toatl Chemicals	762	856	966	1,027	1,024	1,137	1,531	1,973	2,356	2,662	3,614
Multi-Media	865	821	859	1,147	1,052	1,475	1,853	2,003	2,493	2,486	2,872
Total Costs	81,829	87,388	92,507	100,037	106,590	110,590	117,826	124,787	133,999	141,375	184,842
Percentage of GNP	1.74	1.74	1.78	1.87	1.92	1.91	1.98	2.13	2.24	2.32	2.61

Source: U.S. Environmental Protection Agency (1990, pp. 8–20 to 8–21).
[a] Assuming present implementation annualized at 7 percent.

Within the category of direct compliance costs, expenditures for pollution abatement in the United States have grown steadily over the past two decades, both absolutely and as a percentage of GNP (Table 4), reaching $125 billion (2.1 percent of GNP) by 1990. EPA estimates these costs will reach 2.6 percent of GNP by 2000.[17]

Even estimates of direct, compliance expenditures vary greatly. For example, Gary L. Rutledge and Mary L. Leonard (1992) estimate that pollution abatement costs for 1990 were $94 billion, rather than $125 billion as estimated by EPA.[18]

There are a number of potential problems of interpretation associated with these data. The questionnaire used by the U.S. Department of Commerce (1993) to collect data for its *Pollution Abatement Costs and Expenditures* (*PACE*) survey asks corporate or government officials how capital expenditures

[17] Recall that these estimates capture, at most, only what we have labelled private sector compliance expenditures in Table 4. As is shown in Table 5, business pollution-abatement expenditures represented about 61 percent of total *direct* costs in 1990. The remainder consisted of: personal consumption abatement (11%); government abatement (23%); government regulation and monitoring (2%); and research and development (3%).

[18] The primary difference between the estimates is due to the fact that EPA includes the cost of all solid waste disposal, while Rutledge and M. L. Leonard exclude some of these costs. See, also: Rutledge and Leonard 1993. The EPA data, however, exclude a significant portion of other expenditures mandated at the state and local level.

TABLE 5
EXPENDITURES FOR POLLUTION ABATEMENT AND CONTROL BY SECTION[a]
(millions of 1992 dollars)

Sector	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Personal Consumption Abatement	10,278	10,307	12,119	13,270	14,254	15,349	13,159	14,316	12,278	10,485
Business Abatement	48,969	45,726	46,031	49,825	51,314	52,994	53,846	55,615	57,784	60,122
Government Abatement	16,446	15,912	15,504	16,760	17,684	18,974	20,727	20,559	21,560	23,122
Regulation & Monitoring	2,190	2,068	1,946	1,823	1,647	1,923	1,838	1,988	2,005	1,980
Research & Development	2,626	2,484	3,115	2,998	3,017	3,186	3,204	3,216	3,303	3,303
Total	80,509	76,495	78,713	84,677	87,914	92,425	92,773	95,694	96,928	99,024

Source: Rutledge and Leonard (1992), pp. 35–38.
[a] Excludes expenditures for solid waste collection and disposal; excludes agricultural production except feedlot operations.

compared to what they would have been in the absence of environmental regulations. This creates two problems. The first involves the determination of an appropriate baseline. Absent any regulation, firms might still engage in some—perhaps a great deal of—pollution control to limit tort liability, stay on good terms with communities in which they are located, maintain a good environ-

TABLE 6
POLLUTION ABATEMENT EXPENDITURES FOR SELECTED INDUSTRIES, 1991
(Monetary amounts are in millions of 1992 dollars.)

Industry	Total Capital Expenditures	Pollution Abatement Cap. Exp. (PACE)	PACE as Percentage of Total Cap. Exp.	Total Value of Shipments	Abatement Gross Annual Cost (GAC)	GAC as Percentage of Value of Shipments
All Industries	$101,773	$7,603	7.47%	$2,907,848	$17,888	0.62%
Industries with High Abatement Costs						
Paper and Allied Products	$9,269	$1,269	13.68%	$132,545	$1,682	1.27%
Chemical and Allied Products	$16,471	$2,126	12.91%	$300,770	$4,164	1.38%
Petroleum and Coal Products	$6,066	$1,505	24.81%	$162,642	$2,931	1.80%
Primary Metal Industries	$6,049	$692	11.45%	$136,674	$2,061	1.51%
Industries with Moderate Abatement Costs						
Furniture and Fixtures	$750	$25	3.29%	$41,183	$140	0.34%
Fabricated Metal Products	$4,190	$182	4.35%	$161,614	$867	0.54%
Electric, Electronic Equipment	$8,356	$241	2.88%	$203,596	$857	0.42%
Industries with Low Abatement Costs						
Printing and Publishing	$5,187	$38	0.73%	$161,211	$235	0.15%
Rubber, Misc. Plastics Products	$4,337	$84	1.95%	$103,576	$454	0.44%
Machinery, except Electrical	$7,546	$132	1.75%	$250,512	$591	0.24%

Source: U.S. Department of Commerce (1993), pp. 12–13.

mental image, etc. Should such expenditures be included or excluded in the no-regulation baseline?

Second, when additional capital expenditures are made for end-of-the-pipe abatement equipment, respondents have relatively little difficulty in calculating these expenditures. But when new capital equipment is installed, which has the effect of both reducing emissions and improving the final product or enhancing the efficiency with which it is produced, it is far more difficult to calculate how much of the expenditures are attributable to environmental standards. Furthermore, it is not always clear whether a regulation is an "environmental regulation." The *PACE* data do not include expenditures for worker health and safety (U.S. Department of Commerce 1993, p. A4), but some expenditures for health and safety essentially control the working environment. Determining precisely which regulatory costs should be included in the costs of environmental regulations is ultimately somewhat arbitrary.[19]

The most striking feature of either annual capital or annual total expenditures for pollution abatement is the degree of variation across industries.[20] For all manufacturing industries combined, 7.5 percent of new capital expenditures in 1991 were for pollution control equipment, and gross annual operating costs for pollution control were 0.62 percent of the total value of shipments. For the highest abatement-cost industries, however, the costs of complying with environmental regulations were dramatically higher (Table 6).

[19] For a detailed discussion of environmental compliance cost measurement problems, see U.S. Congressional Budget Office (1985).

[20] Gross annual costs for pollution abatement are equal to the sum of operating costs attributable to pollution abatement and payments to the government for sewage services and solid waste collection and disposal.

In particular, for the chemicals, petroleum, pulp and paper, and primary metals industries, new capital expenditures for pollution abatement ranged from 11 to 25 percent of overall capital expenditures, and annual abatement (operating) costs ranged from 1.3 to 1.8 percent of the total value of shipments.

3. *Environmental Regulations and International Trade*

3.1 *Effects of Regulation on Net Exports*

Natural resource endowments have been a particularly important determinant of trading patterns (see, for example, Edward E. Leamer 1984). Having recognized this, we note that when a firm pollutes, it is essentially using a natural resource (a clean environment), and when a firm is compelled or otherwise induced to reduce its pollutant emissions, that firm has, in effect, seen its access to an important natural resource reduced. Industries that lose the right to pollute freely may thus lose their comparative advantage, just as the copper industry in developed countries lost its comparative advantage as copper resources dwindled in those regions. The result is a fall in exports.

This suggests an analytical approach to investigating the environmental protection-competitiveness connection. The primary difficulty in implementing this approach, however, is the limited availability of data on environmental regulatory compliance expenditures, particularly for foreign (and especially for developing) countries. Because such comparative data are generally unavailable, we must rely instead on studies that either examine the effect of environmental controls on U.S. net exports (without considering more general trading patterns) or those that examine international trading patterns (but rely

TABLE 7
EFFECTS OF ENVIRONMENTAL REGULATIONS ON NET EXPERTS

Study	Time Period of Analysis	Industrial Scope	Geographic Scope	Results[a]
Grossman and Krueger 1993	1987	Manufacturing	U.S.-Mexico Trade	Insignificant
Kalt 1988	1967–1977	78 industry categories	U.S. Trade	Insignificant
		Manufacturing		Significant
		Manufacturing w/o Chemicals		More Significant
Tobey 1990	1977	Mining, Paper, Chemicals, Steel, Metals	23 Nations	Insignificant

[a] See the text for descriptions of the results of each study.

on qualitative measures of environmental control costs in different countries).

First, we can ask whether (all else equal) net exports have been systematically lower in U.S. industries subject to relatively stringent environmental regulations. The evidence pertaining to this question is not conclusive (Table 7). Employing a Heckscher-Ohlin model of international trade, Joseph P. Kalt (1988) regressed changes in net exports between the years 1967 and 1977 across 78 industrial categories on changes in environmental compliance costs and other relevant variables, and found a statistically insignificant inverse relationship. On the other hand, when the sample was restricted to manufacturing industries, the predicted negative effect of compliance costs on net exports became significant. It is troubling, however, that the magnitude and significance of the effect was increased even further when the chemical industry was excluded from the sample, because this is an industry with relatively high environmental compliance costs (Table 6).[21]

Gene M. Grossman and Alan B. Krueger (1993) found that pollution abatement costs in industries in the United States have apparently not affected imports from Mexico or activity in the maquiladora sector[22] along the U.S.-Mexico border.[23] Using 1987 data across

[21] The explanation appears to be the relatively strong net export performance of the chemical industry (at the same time that it was heavily regulated).

[22] The maquiladora program was established by Mexico in the 1960s to attract foreign investment. Under the program, qualified firms are exempt from national laws that require majority Mexican ownership and prohibit foreign ownership of border and coastline property. Also inputs for production processes can be imported duty-free, as long as 80 percent of the output is re-exported. For further discussion of the maquiladoras sector in the context of the environmental protection—competitiveness debate, see Robert K. Kaufmann, Peter Pauly, and Julie Sweitzer (1993).

[23] As Grossman and Krueger (1993) point out, however, there is evidence from one government survey suggesting that a number of U.S. furniture manufacturers relocated their California factories across the Mexican border as a result of increases in the stringency of California state air pollution

industry categories and three different measures of economic impacts—total U.S. imports from Mexico, imports under the offshore assembly provisions of the U.S. tariff codes, and the sectoral pattern of maquiladora activity—they examined possible statistical relationships with: industry factor intensities, tariff rates, and the ratio of pollution abatement costs to total value-added in respective U.S. industries. With all three performance measures, they found that "traditional determinants of trade and investment patterns"—in particular, labor intensity—were very significant, but that cross-industry differences in environmental costs were both quantitatively small and statistically insignificant.[24] Given the physical proximity of Mexico, the large volume of trade between the two countries, and the historically significant differences between Mexican and U.S. environmental laws, these findings cast doubt on the hypothesis that environmental regulations have significant adverse effects on net exports.

Finally, environmental regulations in other nations are, of course, also important in determining trade patterns, but here the available evidence again indicates that the relative stringency of environmental regulations in different countries has had no effect on net exports (James A. Tobey 1990). Using a qualitative measure of the stringency of national environmental policies (Ingo Walter and J. Ugelow 1979), Tobey applied what is otherwise a straightforward Hecksher-Ohlin framework to test empirically for the sources of international comparative advantage. In an examination of five pollution-intensive industries—mining, paper, chemicals, steel, and metals—Tobey found that environmental stringency was in no case a statistically significant determinant of net exports. The results could theoretically be due to no more than the failure of the ordinal measure of environmental stringency to be correlated with true environmental control costs,[25] but Tobey's results are essentially consistent with those from other, previous analyses that employed direct cost measures (Walter 1982; Charles S. Pearson 1987; and H. Jeffrey Leonard 1988).

3.2 *International Trade in Pollution-Intensive Goods*

We can also search for evidence on the impact of environmental regulations on international competitiveness by examining temporal shifts in the overall pattern of trade in pollution-intensive goods.[26] Defining such goods as those produced by industries that incur the highest levels of pollution abatement and control expenditures in the United States, shifts in trade flows can be examined to determine whether a growing proportion of these products in world trade originate in developing countries, where regulatory standards are often (but not always) relatively lax (Patrick Low and Alexander Yeats 1992). The results for the period 1965–1988 show that: (i) the share of pollution-intensive products in total

standards affecting paints and solvents (U.S. General Accounting Office 1991).

[24] As we discuss later, this result is consistent with something else the data reveal—international differences in environmental costs (as a fraction of total production costs) are trivial compared with apparent differences in labor costs and productivity.

[25] For example, a nation might have strict regulations but not enforce them.

[26] Unfortunately, a major constraint faced by any such analysis is a lack of sufficient data on environmental costs and regulations in foreign countries to permit a direct link to be established between observed changes in trade flows and differences in environmental regulations across various countries. Not only are data on environmental regulations sparse, but a further difficulty is separating the impact of environmental costs on trade from shifts in natural resource advantages or other factor endowments, such as labor costs.

world trade fell from 19 to 16 percent; (ii) the share of pollution-intensive products in world trade originating in North America fell from 21 to 14 percent;[27] (iii) the share of pollution-intensive products originating in Southeast Asia rose from 3.4 to 8.4 percent; and (iv) developing countries gained a comparative advantage in pollution-intensive products at a greater rate than developed countries.[28]

These results may be less meaningful than they may seem at first glance. First of all, Low and Yeats found that industrialized countries accounted for the lion's share of the world's exports of pollution-intensive goods from 1965 to 1988, contradicting the notion that pollution-intensive industries have fled to developing countries. Second, to the extent pollution-intensive industries *have* moved from industrialized to industrializing countries, this may be due simply to increased demand within the latter for the products of pollution-intensive industries. Third, natural resource endowments may partly or largely explain the pattern of pollution-intensive exports.[29]

In general, it would be preferable to examine individual nations' production of pollution-intensive goods relative to world production rather than their share of world trade or the proportion of their exports that are pollution intensive. This is because as world demand grows for pollution-intensive goods, production facilities will be built in new locations close to sources of product demand, and trade in these goods may shrink. A declining volume of world trade in such goods would result in a drop in U.S. exports, even if the United States maintained its *share* of such trade. The drop in overall trade could indicate that other countries were developing expertise in making these goods for domestic consumption, and that the U.S. competitive advantage was shrinking.

The evidence that developing countries are more likely to gain a comparative advantage in the production of pollution-intensive goods than in clean ones[30] is consistent with the change in U.S. trading patterns identified by H. David Robison (1988; see also Ralph D'Arge 1974 and Organization for Economic Cooperation and Development 1985). He found that the abatement content of U.S. imports[31] has risen more rapidly than the abatement content of exports as U.S. environmental standards have grown relatively more stringent than those in the rest of the world. However, the U.S.-Canadian trade pattern has not shifted in this way, presumably because of the similarity of Canadian and U.S. environmental standards and costs. While this result suggests that U.S. environmental regulations have had an affect on trading patterns, Robison's model indicates that, relative to domestic consumption, the effects of increased abatement costs of U.S. trade are quite small, even when no mitigating general equilibrium effects are taken into account.

[27] This result is consistent with a parallel finding by Kalt (1988) that in 1967 U.S. exports were more pollution-intensive than its imports while the opposite was true by 1977.

[28] These results are consistent with the findings of Robert E. B. Lucas, Wheeler, and Hemamala Hettige (1992), who also found evidence that pollution-intensive industries had migrated from the United States to developing countries, in a study of 15,000 plants (from Census Bureau data) for the period, 1986–1987.

[29] The data suggest that countries that export a high proportion of pollution-intensive goods may do so because their natural resource base makes them efficient producers of particular pollution-intensive products. Finland exports paper products, while Venezuela and Saudi Arabia export refined petroleum products.

[30] This result is based primarily on an analysis of one industry, iron and steel pipes and tubes (Low and Yeats 1992).

[31] The abatement content of imported goods is the cost of abatement that would be embodied in those goods had they been produced in the United States.

TABLE 8
EFFECTS OF ENVIRONMENTAL REGULATIONS ON TRADE PATTERNS IN ABATEMENT-INTENSIVE GOODS

Study	Time Period of Analysis	Industrial Scope	Geographic Scope	Results[a]
Low and Yeats 1992	1965–1988	"Dirty" Industries[b]	World Trade	Generally consistent with migration of dirty industries
Robison 1988	1973–1982	78 Industry categories	U.S. Trade	Increased U.S imports of relatively abatement-intensive goods
			Canadian Trade	No change in relative abatement-intensity of trade

[a] See the text for descriptions of the results of each study.
[b] Dirty industries are those incurring the highest level of abatement expenditure in the U.S.

Observed changes in international trading patterns over the past thirty years thus indicate that pollution-intensive industries have migrated, but the observed changes are small in the overall context of economic development (Table 8). Furthermore, it is by no means clear that the changes in trade patterns were caused by increasingly strict environmental regulations in developed countries. The observed changes in international trading patterns are consistent with the general process of development in the Third World. As countries develop, manufacturing accounts for a larger portion of their economic activity.

4. *Environmental Regulations and Investment*

The spatial pattern of economic activity is partly a function of resource endowments and the location of markets; but, to some degree, it is also an accident of history. Although firms may locate where production costs are low and market access is good, there are benefits to firms that locate where other firms have previously located (in terms of existing infrastructure, a trained work force, potential suppliers, and potential benefits from specialization).[32] Under this latter view, productivity and competitiveness arise, at least in part, from the existence of a large industrial base; the ability to attract capital is also an important determinant of competitiveness.

In any case, the choice of a new plant location is obviously a complex one. When choosing between domestic and foreign locations, firms consider the market the plant will serve, the quality of the work force available, the risks associated with exchange rate fluctuations, the political stability of foreign governments, and the available infrastructure, among other factors. Hence, isolating the effect of environmental regulations on the decision will inevitably be difficult. Two sources of evidence can be used to investigate the sensitivity of firms' investment patterns to environmental regulations:

[32] See Wheeler and Ashoka Mody (1992) for a brief discussion of these issues in the context of the effects of regulation. For a more general discussion of agglomeration effects, see Krugman (1991).

changes in direct foreign investment and siting decisions for domestic plants.

4.1 *Direct Foreign Investment*

Although there has been little focus on the direct effects of environmental regulations on foreign investment decisions,[33] the results from more general studies can be informative. Wheeler and Mody (1992) found that multinational firms appear to base their foreign investment decisions primarily upon such things as labor costs and access to markets, as well as upon the presence of a developed industrial base. On the other hand, corporate tax rates appear to have little or no appreciable effect on these investment decisions. To the extent that environmental regulations impose direct costs similar to those associated with taxes, one could infer that concerns about environmental regulations will be dominated by the same factors that dominate concerns about taxes in these investment decisions.[34]

General trends in direct investment abroad (DIA) can also provide insights into the likely effects of environmental regulations. If environmental regulations cause industrial flight from developed countries, then direct foreign investment by pollution-intensive industries should increase over time, particularly in developing nations. In fact, from 1973 to 1985, overall direct foreign investment by the U.S. chemical and mineral industries *did* increase at a slightly greater rate than that for all manufacturing industries.[35] Over the same period, however, there was an increase in the proportion of DIA made by all manufacturing industries in developing countries, while the proportion of DIA made by the chemicals industry in developing countries actually fell.[36]

Information is also available on the capital expenditures of (majority-owned) foreign affiliates of U.S. firms. The evidence indicates that those affiliates in pollution intensive industries, such as chemicals, did not undertake capital expenditures at a rate greater than manufacturing industries in general. Majority-owned affiliates in pollution-intensive industries in developing countries, however, did increase their capital expenditures at a slightly greater rate than did all manufacturing industries (H. J. Leonard 1988).[37] Overall, the evidence

[33] There is abundant anecdotal evidence in the press and at least one survey of 1,000 North American and Western European corporations regarding their attitudes toward investing in Eastern and Central Europe (Anthony Zamparutti and Jon Klavens 1993).

[34] Wheeler and Mody (1992) included a composite variable in their analysis designed to measure the effects of a variety of risks associated with various countries. One of the ten components of this composite variable reflects the bureaucratic "hassle" associated with doing business in the countries examined. If this variable had been entered separately, the analysis might have shed more light on the nonpecuniary effects of regulation on location decisions.

[35] Direct investment abroad (DIA) made by the chemical and mineral industries as a proportion of DIA by all manufacturing industries increased from 25.7 percent to 26.5 percent between 1973 and 1985 (H. J. Leonard 1988). Of course, this statistic may simply indicate that markets for these products were growing in developing countries.

[36] The proportion of DIA made by mineral processing industries in developing countries increased from 22.8 to 24.4 percent between 1973 and 1985. This shift could have been caused by changes in comparative advantage due to natural resource endowments (Leonard 1988).

[37] A preliminary study by Charles D. Kolstad and Yuqing Xing (1994) has examined the relationship between the laxity of various countries' environmental regulations and the level of investment by the U.S. chemical industry in those nations. The authors used two proxies for the laxity of environmental regulation: emissions of sulphur dioxide (SO_2) per dollar of GDP, and the growth rate of SO_2 emissions. They found that both measures were positively and significantly related to the amount of inbound direct investment by the chemical industry, and they interpreted this as evidence that strict regulation discourages investment. It seems equally likely, however, that these empirical results are due to omitted variables or causality running in the opposite direction, from investment to pollution.

of industrial flight to developing countries is weak, at best.[38]

4.2 *Domestic Plant Location*

As suggested above, data on required pollution-control expenditures in foreign countries are insufficient to permit plant-level analyses of the effects of environmental regulations on international siting of plants. Nevertheless, such analyses have been conducted for plant location decisions in the United States in an effort to link such decisions to environmental regulatory factors. Despite the fact that new environmental regulations typically will not cause firms to relocate *existing* plants (due to significant relocation costs), firms have more flexibility in making decisions about the siting of new plants. Indeed, some environmental regulations are particularly targeted at new plants—so-called, "new source performance standards."

There appears to be widespread belief that environmental regulations have a significant effect on the siting of new plants in the United States. The public comments and private actions of legislators and lobbyists, for example, certainly indicate that they believe that environmental regulations affect plant location choices. Indeed, there is evidence that the 1970 Clean Air Act and the 1977 Clean Water Act Amendments were designed in part to limit the ability of states to compete for businesses through lax enforcement of environmental standards (Portney 1990). The House Committee Report on the 1970 Clean Air Act amendments claims that "the promulgation of Federal emission standards for new sources . . . will preclude efforts on the part of States to compete with each other in trying to attract new plants and facilities without assuming adequate control of large scale emissions therefrom" (U.S. Congress 1979). Likewise, environmental standards became a major obstacle to ratification of the North American Free Trade Agreement (NAFTA) in 1993, largely because of concerns that U.S. companies would move to Mexico to take advantage of relatively lax environmental standards there.

The evidence from U.S. studies suggests that these concerns may not be well founded. Timothy J. Bartik (1985) examined business location decisions as influenced by a variety of factors. While he did not take the stringency of states' environmental regulations into account, his findings are helpful in identifying factors that can affect business location decisions. First, Bartik found that both state taxes and public services are important determinants of location choice;[39] second, he found that unionization of a state's labor force has a strongly negative effect on the likelihood that firms will locate new plants within a given state. Third, he found that the existing level of manufacturing activity in a state seems to have a positive effect on the decision to locate a new plant, consistent with other findings in the international context (Low and Yeats 1992).

While these results indicate that firms are sensitive, in general, to cost variations among states when deciding where to locate new facilities, there is little direct evidence of a relationship

[38] It has been suggested in the popular press that multinational companies install pollution control equipment in their foreign plants for a variety of reasons—including public relations and stockholders demands—even where and when not required by local laws and regulations (see, for example, "The Supply Police," *Newsweek*, Feb. 15, 1993, pp. 48–49). If true, this could help explain why investment patterns have been relatively unaffected by regulatory stringency.

[39] The effect of state taxes was statistically significant, but not particularly large in Bartik's (1985) analysis. A 10 percent increase in the corporate tax rate (from 5 to 5.5%, for example) will cause a 2 to 3 percent decline in the number of new plants.

TABLE 9
EFFECTS OF ENVIRONMENTAL REGULATIONS ON DOMESTIC PLANT LOCATION DECISIONS

Study	Time Period of Analysis	Industrial Scope	Results[a]
Bartik 1988	1972–1978	Manufacturing branch plants of Fortune 500 companies	No Significant Effects[b]
Bartik 1989	1976–1982	New small businesses in 19 manufacturing industries	Significant but Small Effects[c]
Friedman, Gerlowski, and Silberman 1992	1977–1988	Foreign multinational corporations	No Significant Effects[d]
Levinson 1992	1982–1987	U.S. Manufacturing	No Significant Effects[e]
McConnell and Schwab 1990	1973, 1975, 1979, 1982	Motor-Vehicle Assembly Plants (SIC 3711)	Mostly Insignificant Effects[f]

[a] See the text for descriptions of the results of each study.
[b] In a previous study, Bartik (1985) found significant impacts of state corporate tax rates, suggesting that differences in the costs of doing business matter.
[c] A one standard deviation change in environmental stringency yielded a 0.01 standard deviation change in the start-up rate of small businesses.
[d] An exception is that when the sample was restricted to new branch plants built by Japanese firms alone, the environmental variable was both negative and significant.
[e] Although the results are insignificant when the entire sample is considered, state-level environmental regulations exhibit significant effects when the sample is restricted to firms in the most pollution-intensive industries (chemicals, plastics, and electronics).
[f] The insignificance of regional differences in environmental regulation held across a substantial number of alternative measures of environmental regulatory strinency. They found significant effects in the case of countries that were exceptionally far out of compliance with air quality standards.

between stringency of environmental regulations and plant location choices (although the fact that state taxes were significant could be taken to infer that environmental regulations ought to be significant as well).[40] In a more recent analysis that included measures of environmental stringency, Bartik (1988) found that state government air and water pollution control expenditures, average costs of compliance, and allowed particulate emissions all had small[41] and insignificant effects on plant location decisions.[42] In a subsequent analysis, Bartik (1989) detected a significant, negative impact of state-level environmental regulations on the start-up rate of small businesses, but the effect was substantively small.[43] These results are essentially consistent with those of Arik Levinson (1992), who found that large differences in the stringency of environ-

[40] In any event, the magnitude of the two effects could be dramatically different, because state taxes may impose a burden that is large relative to the monetary-equivalent regulatory burden.

[41] In the case of highly polluting industries, Bartik (1988) could not reject the possibility of a substantively large effect of environmental regulation, although the estimated effect was statistically not significant.

[42] State spending on pollution control is meant to be a proxy for the likelihood that a plant will face inspection. Bartik experimented with a variety of variables and specifications, and the general results were quite robust to these changes.

[43] A change of one standard deviation in the environmental stringency variable—the Conservation Foundation's rating of state environmental laws and regulations (from Christopher Duerksen 1983)—yielded a 0.01 standard deviation change in the state start-up rate of small businesses.

mental regulations among states had no effect on the locations of most new plants; but the locations of new branch plants of large multi-plant companies in pollution-intensive industries were found to be somewhat sensitive to differences in pollution regulations.[44]

In another plant-location study, Virginia D. McConnell and Robert M. Schwab (1990) found no significant effects of regional differences in environmental regulation on the choice of location of automobile industry branch plants.[45] This finding held across a variety of alternative measures of environmental stringency. Finally, Joseph Friedman, Daniel A. Gerlowski, and Jonathan Silberman (1992) analyzed the determinants of new manufacturing branch plant location in the United States by foreign multinational corporations. Among the independent variables they used to explain location choice was a measure of regulatory intensity—the ratio of pollution abatement capital expenditures in a state to the gross product in the state originating in manufacturing. When the investment decisions of all foreign companies were considered together, the measure of environmental stringency—while negative—did not exert a statistically significant effect on new plant investment (Table 9).[46]

5. *Environmental Regulations and Economic Growth*

The evidence reviewed above does not provide much support for the proposition that environmental regulation has significant adverse effects on competitiveness. This can be placed in perspective by scrutinizing what may be more fundamental, though possibly less direct, evidence related to the overall social costs of environmental regulation.[47]

5.1 *Productivity Effects*

If firms are operating efficiently before environmental regulations are imposed, new regulations will theoretically cause firms to use more resources in the production process. We can posit five ways in which environmental regulations could negatively affect productivity (see Robert H. Haveman and Gregory B. Christiansen 1981; Robert W. Crandall 1981; and U.S. Office of Technology Assessment 1994). First, by definition, the *measured* productivity of the affected industry will fall because measured inputs of capital, labor, and energy are being diverted to the production of an additional output—environmental quality—that is not included in conventional measures of output and hence productivity (Robert

[44] In work in progress, Wayne B. Gray (1993) uses data from six Censuses of Manufacturing between 1963 and 1987 to examine how the births and deaths of plants are related to a set of state characteristics, including: factor prices, population density, unionization, taxes, education, and various measures of environmental regulation, such as enforcement activity by state and federal regulators, pollution abatement costs, and indices of state-level environmental policy stringency. In this preliminary work, Gray finds significant effects for two of his measures of regulatory stringency—air pollution enforcement and state-level laws—but the respective parameters have opposite signs.

[45] An exception was found in the case of counties that were exceptionally far out of compliance with air quality standards.

[46] When the sample was restricted to new branch plants built by Japanese firms alone, however, the environmental variable was both negative and significant. In other words, ceteris paribus, states with more stringent regulation were less likely to attract new Japanese-owned branch plants in manufacturing.

[47] One way to gain a perspective on this issue is to ask: Are environmental regulations more costly to a society with an open economy or one with a closed economy? On the simplest possible level, the existence of trade *reduces* the social cost of regulation. Rather than invest in pollution control equipment for its pollution-intensive industries, a country might specialize in the production of cleaner goods and stop producing pollution-intensive goods, choosing to import these goods rather than produce them domestically. Essentially, a country open to international trade has available a means of cleaning up its environment that is not available to countries closed to trade.

TABLE 10
EFFECTS OF ENVIRONMENTAL REGULATIONS ON TOTAL FACTOR PRODUCTIVITY DECLINE[a]

Study	Time Period of Analysis	Industrial Scope	Results:[b] Percentage Share Due to Environmental Regulation
Barbera and McConnell 1990	1970–1980	Chemicals; stone, clay, and glass; iron and steel	10%–12%
Barbera and McConnell 1990	1970–1980	Paper	30%
Dension 1979	1972–1975	Business sector	16%
Gallop and Roberts 1983	1973–1979	Electric utilities	44%
Gray 1987	1973–1978	240 manufacturing sectors	12%
Haveman and Christainsen 1981	1973–1975	Manufacturing	8%–12%
Norsworthy, Harper, and Kunze 1979	1973–1978	Manufacturing	12%[c]

[a] Based upon Table A-1 in U.S. Office of Technology Assessment 1994.
[b] See the text for descriptions of the results of each study.
[c] Share of labor productivity decline due to environmental regulation.

Repetto 1990; Robert M. Solow 1992). Second, when and if firms undertake process or management changes in response to environmental regulations, the new practices may be less efficient than old ones (although, as we discuss below, there are those who suggest that this factor operates in the opposite direction, i.e., regulation-induced process and management shake-ups may increase productive efficiency). Third, environmental investments could conceivably crowd out other investments by firms.[48] Fourth, many environmental regulations exempt older plants from requirements, in effect mandating higher standards for new plants. This "new-source bias" can be particularly harmful by discouraging investment in new, more efficient facilities. Fifth, requirements that firms use the "best available control technology" for pollution abatement may increase the adoption of these new technologies *at the time* regulations go into effect, but subsequently blunt firms' incentives to develop new pollution control or prevention approaches over time. This is because their emission standard may be tightened each time the firm innovates with a cost-saving approach.

Empirical analyses of these productivity effects have found modest adverse impacts of environmental regulation. A number of studies focused on the 1970s, a period of productivity decline in the United States (Table 10), attempting to determine what portion of the decline in productivity growth rates could be attributed to increased regulatory costs. When the scope of the analysis is most or all manufacturing sectors, the estimates of the fraction of the decline in the total factor productivity growth rate due to environmental regulations range from 8 percent to 16 percent (Edward Denison 1979; Gray 1987; Haveman and Christiansen 1981;[49] and J. R. Norsworthy,

[48] The empirical evidence here is mixed. Adam Rose (1983) finds that pollution-control investments reduce other investments by firms, but on less than a one-for-one basis; Gray and Ronald J. Shadbegian (1993) actually found a positive correlation of environmental investments and "productive investments" for some sectors, such as pulp and paper mills.

[49] Haveman and Christiansen (1981) examine the contribution of environmental regulation to the observed decline in labor productivity, not total factor productivity.

Michael J. Harper, and Kent Kunze 1979). Thus, regulation cannot be considered the primary cause of the productivity slowdown. There is, however, substantial variation by industrial sector: 10 percent for the chemical industry; 30 percent percent for paper producers (Anthony J. Barbera and McConnell 1990); and 44 percent for electric utilities (Frank M. Gallop and Mark J. Roberts 1983).

Gray and Shadbegian (1993) merged plant-level input and output data from the Census and Survey of Manufactures with plant-level data from the PACE surveys. They estimated equations for productivity at the plant level as a function of pollution control expenditures. If the only effect of pollution control expenditures on productivity were that they do not contribute to measured output, then their coefficient in such a regression ought to be minus one, because, holding inputs (including pollution control expenditures) constant, there ought to be $1 less output for every $1 diverted to pollution control. They found, however, that output fell by $3–$4 for every dollar of PACE spending, suggesting extremely large adverse productivity effects. In subsequent work (Gray and Shadbegian 1994), however, the same authors showed that these results were extremely sensitive to econometric specification, and that the large negative effects in the first paper were largely an artifact of measurement error in output.[50] In a specification that is robust to the measurement error problem, they found that the coefficient on PACE expenditures fell to about 1.5 in pooled time-series/cross section regressions, and was not significantly greater than one in fixed-effect regressions. Thus, there remains some evidence of a productivity penalty, but it has to be regarded as weak because the pooled regression is likely to be subject to spurious negative correlation between productivity levels and pollution control expenditures.[51]

Any discussion of the productivity impacts of environmental protection efforts should recognize that not all environmental regulations are created equal in terms of their costs or their benefits.[52] So-called market-based or economic-incentive regulations, such as those based on tradeable permits or pollution charges, will tend to be more cost-effective than regulations requiring technological adoption or establishing conventional performance standards. This is because under the market-based regulatory regime, firms are likely to abate up to the point they find it profitable, and firms that find it cheapest to reduce their levels of pollution will clean up the most. With such incentive-based regulatory systems, regulators can thus achieve a given level of pollution control more cheaply than by imposing fixed technological or performance standards on firms (Robert W. Hahn and Stavins 1991). Furthermore, market-based environmental policy instruments provide ongoing incentives for firms to adopt new and better technologies and processes, because under these systems, it always pays to clean up more if a suffi-

[50] The specification in Gray and Shadbegian (1993) is to regress productivity levels (the ratio of value-added to a weighted average of inputs) on the ratio of PACE expenditures to value-added. If value-added is measured with error, this introduces a downward bias in the coefficient on the PACE/Value-added ratio.

[51] If some plants are generally inefficient relative to others, then it would not be surprising if they had both higher control costs and lower productivity, even if there were no causal relationship between the two.

[52] Stewart (1993) attributes observed differences in the productivity effects of environmental regulations in the U.S., Canada, and Japan (U.S. Congressional Budget Office 1985) to differences in legal and administrative systems, although he notes that the CBO study did not attempt to control for regulatory stringency.

ciently cheap way of doing so can be identified and adopted.[53]

5.2 *General Equilibrium Effects*

To quantify the overall, long-run social costs of regulation (where costs are measured by the compensation required to leave individuals as well off after a regulation as before—ignoring environmental benefits), a general equilibrium perspective is essential, in order to incorporate interindustry interactions and cumulative effects of changes in investment levels. In general, the overall social costs of environmental regulation will exceed direct compliance costs because regulations can cause reductions in output, inhibit investments in productive capital, reduce productivity, and bring about transitional costs (Schmalensee 1994).

Michael Hazilla and Kopp (1990) compared projected costs for compliance with the Clean Air and Clean Water Acts, with and without allowing for general equilibrium adjustments in labor input and investment by industry. They found that the annual social costs allowing for general equilibrium adjustments were smaller than projected pollution control expenditures in early years, but eventually came to exceed greatly the partial equilibrium projection (because of reductions in investment and labor supply).

Dale W. Jorgenson and Peter J. Wilcoxen (1990) used a model with 35 industry sectors (including government enterprises), a representative consumer, and an exogenous current account balance. Each sector's demand for inputs responds to prices according to econometrically estimated demand functions. There is a single malleable capital good, whose quantity is based on past investment and whose service price is determined endogenously. Investment is determined by the consumer's savings, which is given by the solution to a perfect foresight intertemporal optimization of consumption. They model the dynamic effects of operating costs associated with pollution control, pollution control investment, and compliance with motor vehicle emissions standards. They find that over the period 1974–1985, the combined effect of these mandated costs was to reduce the average growth rate of real GNP by about 0.2 percentage points per year, with required investment having the biggest effect and operating costs the smallest.[54] By 1985, the cumulative effect of this reduced growth is that simulated GNP without environmental regulation would be about 1.7 percent more than the actual historical value. This lost output is of roughly the same magnitude as the direct costs of compliance (Table 4).[55]

The results of any simulation model are, of course, somewhat sensitive to the structure and parameter values employed. This can be a particular concern with computable general equilibrium models because of their size and complexity. Nevertheless, the results examined in this section suggest that there are significant dynamic impacts of environmental regulation in the form of costs associated with reduced investment.

5.3 *Economic Growth Enhancement*

The vast majority of economic analyses of regulation and competitiveness are

[53] See Jaffe and Stavins, forthcoming. Some types of market-based instruments can raise special problems in the context of international trade, however, if the policy instruments are not harmonized across nations (Harmen Verbruggen 1993).

[54] Because the compliance expenditures are included in GNP, this reduction in growth is a cost over and above the direct costs.

[55] Jorgenson and Wilcoxen (1992) estimate that the 1990 amendments to the Clean Air Act will impose incremental losses in economic growth that are approximately one-fifth as large as the losses they estimated for regulation in place during the 1974–1985 period.

based upon the assumption that regulations increase production costs. Nevertheless, there have been some recent suggestions in the literature that regulations may actually stimulate growth and competitiveness. This argument—articulated recently by Porter (1991)[56]—has generated a great deal of interest and enthusiasm among some influential policy makers (see, for example, Senator Al Gore 1992).

There are several levels on which the so-called Porter hypothesis may be interpreted. First of all, it can be taken simply to mean that some sectors of private industry, in particular, environmental services, will benefit directly from more stringent environmental regulations *on their customers* (but not on themselves). Thus, the acid-rain reduction provisions of the Clean Air Act amendments of 1990, which call for significant reductions in sulfur dioxide (SO_2) emissions from electric utilities, are unambiguously good news for the manufacturers of flue-gas purification equipment (scrubbers) and producers of low-sulfur coal.

To push this argument slightly further, it would also not be surprising if environmental regulation induced innovation with respect to technologies to achieve compliance. Surely, catalytic converter technology today is superior to what it would have been if auto emissions had never been regulated. Internationally, it has been suggested that German firms possess some competitive advantage in water-pollution control technology and U.S. firms dominate hazardous waste management, because of relatively stricter regulations (Organization for Economic Cooperation and Development 1992; U.S. Environmental Protection Agency 1993). Jean Lanjouw and Mody (1993) looked at patents originating from inventors in different countries, in patent classes deemed to be environmental technologies, and found that increases in environmental compliance costs were related to increases in patenting of such technologies with a one to two year lag. The existence of such "induced innovation" suggests that projections of compliance costs made *before* regulatory implementation may be biased upwards, because they will inevitably take existing technology as given to some extent. On the other hand, this effect does *not* necessarily suggest that measured compliance costs overstate actual costs, because measured costs will reflect technology as it actually evolved.[57]

Second, putting aside the obvious gainers in the environmental services sector, the Porter hypothesis can be taken to imply that, under stricter environmental regulations, *some* regulated firms will benefit competitively, at the expense of *other* regulated firms. If, for example, larger firms find it less costly to comply than smaller firms, then the former might actually benefit from regulation, if higher prices from reduced competition more than offset *their* increased costs. Similarly, the Chrysler Corporation may have benefitted—relative to General Motors and Ford—from the imposition of automobile fuel-efficiency standards[58] in 1975, because its fleet consisted of smaller-sized models. Somewhat related to this, the hypothesis can be thought of as referring dynamically to the reality that environmental regulation

[56] The idea goes back, at least, to Nicholas A. Ashford, C. Ayers, and R.F. Stone (1985). For a recent explication, see Claas van der Linde (1993).

[57] One could argue that measured costs understate the social cost, because they generally do not include the cost of R&D to develop new control technologies. On the other hand, if, as discussed further below, R&D has large positive externalities, then the net mismeasurement is ambiguous.

[58] Energy Policy and Conservation Act of 1975 (89 Stat. 902), amending the Motor Vehicle Information and Cost Savings Act (86 Stat. 947).

can provide some firms with "early mover" advantages by pushing them to produce products that will in the future be in demand in the marketplace.

The proponents of the Porter hypothesis—in public policy circles—have asserted some significantly stronger interpretations, however, namely that the competitiveness of the U.S. as a whole can be enhanced by stricter regulation.[59] It has been suggested that induced innovation can create lasting comparative advantage for U.S. firms, if other countries eventually follow our lead to stricter regulations and there are strong "first-mover" advantages enjoyed by the first firms to enter the markets for control equipment (see, for example, David Gardiner 1994). Even ignoring export possibilities, it has been suggested that environmental regulation can increase domestic efficiency, either by wringing inefficiencies out of the production process as firms struggle to meet new constraints or by spurring innovation in the long term through "outside-of-the-box thinking."[60] The notion is that the imposition of regulations impels firms to reconsider their production processes, and hence to discover innovative approaches to reduce pollution *and* decrease costs or increase output. If this happened widely enough, total social costs of regulation could be no greater than measured compliance costs. Indeed, if the innovation-stimulating effect of regulation were large enough, then regulation would offer the possibility of a "free lunch," that is, improvements in environmental quality without any costs.[61]

Economists generally have been unsympathetic to these stronger arguments, because they depend upon firms being systematically ignorant of profitable production improvements or new technologies that regulations bring forth. (For a more detailed explication of economists' skepticism, see Karen L. Palmer and R. David Simpson 1993, and Oates, Palmer, and Portney 1993.) Nevertheless, specific instances of "cheap" or even "free lunches" may occur. For example, Barbera and McConnell (1990) found that lower production costs in the nonferrous metals industry were brought about by new environmental regulations that led to the introduction of new, low-polluting production practices that were also more efficient.[62] One way in which environmental regulation could theoretically have a positive impact on measured productivity at the industry level is by forcing exceptionally inefficient plants to close. To the degree that production is shifted to other domestic plants with higher productivity, the industry's overall productivity could actually increase. One study suggests that this is what happened when environmental regulations in the 1970s unintentionally accelerated

[59] Scott Barrett (forthcoming) calls this notion "strategic standard-setting."

[60] Porter (1990) emphasizes that a number of industrial sectors subject to the most stringent domestic environmental regulations have become more competitive internationally: chemicals, plastics, and paints.

[61] Note that the suggestion of proponents of the Porter hypothesis is *not* that the benefits of environmental regulation (in terms of reduced health and ecological damages) exceed the costs of environmental protection. This is obviously possible, and it is an empirical issue. Rather, the notion of a "free lunch" is that—putting aside the benefits of environmental protection—the costs of regulatory action can be zero or even negative (a "paid lunch"). For an example of "free lunch" arguments —both theoretical and empirical—in the context of energy efficiency and global climate change, see Robert Ayers (1993).

[62] Two of five industries studied experienced induced savings in conventional capital costs and operating costs as a result of stricter environmental regulations and consequent increases in environmental capital investment. But, even for these two industries, the indirect effects were not sufficient to offset the direct cost increases. In the other three industries studied, environmental regulations caused both direct increases in environmental capital investments *and* increases in conventional capital costs and operating costs.

the "modernization" of the U.S. steel industry (U.S. Office of Technology Assessment 1980).[63]

Even if firms are systematically ignorant of potential new processes that are both cleaner and more profitable than current methods of production, there is considerable doubt as to whether regulators would know more about these better methods of production than firm managers, or that continually higher regulatory standards would lead firms regularly to discover new clean and profitable technologies.[64] Moreover, one must be careful when claiming that firms are not operating on their production frontiers: if there are managerial costs to investigating new production technologies, then firms may be efficient even if they do not realize that new, more efficient processes exist until regulations necessitate their adoption.[65] In other words, there may be many efficiency-enhancing ideas that firms could implement if they invested the resources required to search for them. If firms do successfully search in a particular area for beneficial ideas, it will appear ex post that they were acting suboptimally by not having investigated this area sooner. But with limited resources, 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.[66]

Finally, one could argue that regulation, by forcing a re-examination of products and processes, will induce an overall increase in the resources devoted to "research," broadly defined. Even if firms were previously choosing the (privately) optimal level of research investment, this inducement could be (socially) desirable, if the social rate of return to research activities is significantly greater than the private return.[67] Jaffe and Palmer (1994) examined the PACE expenditure data, R&D spending data, and patent data, in a panel of industries between 1976 and 1989. They found some evidence that increases in PACE spending were associated with increases in R&D spending,

[63] While the premature scrapping of "obsolete" capital will raise measured industry productivity, this does not mean that it is socially beneficial. Such plants were, presumably, producing output whose value exceeded variable production costs.

[64] The optimal timing of the adoption of a new technology is obviously a complicated issue. Although early adoption can be better than waiting, if technology advances quickly, it may be optimal for firms to wait to invest until even better processes are available. Regulation may cause firms to invest in clean technologies today, but then discourage investment in still cleaner technologies later. See Jaffe and Stavins (1994).

[65] As contrary anecdotal evidence, we should recognize that many business people find economists' skepticism about businesses not operating on their frontiers to be, at best, an indication of the naivete of academic economists, and, at worst, a special case of the joke about the economist who fails to pick up a twenty-dollar bill from the sidewalk because he assumes that if it were not counterfeit someone else would surely have taken it.

[66] As noted above, environmental regulations may lower some firms' costs and increase their productivity by cleaning the environment. Some studies find that environmental regulations are productive when one takes into account the cost of the "environmental inputs" into the production process (Repetto 1990). Studies of this type are tangential to the "Porter hypothesis," because such studies focus on situations where the benefits of environmental regulations are not sufficient to make individual firms undertake cleanup, but are substantial enough that industry as a whole may benefit. For example, it is unlikely that any single firm has an incentive to reduce its smokestack emissions solely to improve its own workers' health, but if every firm lowered its emissions, industry might find that, as a result of the change, fewer work days were lost due to illness. See Lester B. Lave and Eugene Seskin (1977); U.S. Environmental Protection Agency (1982); and Douglas W. Dockery et al. (1993).

[67] A priori, private incentives to engage in research could be either too low (because research generates knowledge externalities enjoyed by other firms) or too high (because research creates negative externalities by destroying quasi-rents being earned by other firms). Empirical evidence seems to confirm that social returns exceed private returns (Edward Mansfield et al. 1977; Jaffe 1986; and Zvi Griliches 1990).

but no evidence that this increased spending produced greater innovation as measured by successful patent applications.

One empirical analysis that is frequently cited in support of the Porter hypothesis is Stephen M. Meyer (1992), which examines whether states with strict environmental laws demonstrate poor economic performance relative to states with more lax standards. Meyer (1992, p. iv) finds that

> *at a minimum* the pursuit of environmental quality does not hinder economic growth and development. Furthermore, there appears to be a moderate yet consistent positive association between environmentalism and economic growth.

Unfortunately, his statistical analysis sheds very little light on a possible causal relationship between regulation and economic performance.[68] His approach does not control for factors other than the stringency of a state's environmental laws that could affect the state's economic performance. Consequently, it is quite possible that he has merely found a spurious positive correlation between the stringency of a state's environmental standards and its economic performance. His results are consistent with the hypothesis that poor states with no prospect for substantial growth will not enact tough environmental regulations, just as developing countries are less likely than rich countries to enact tough environmental regulations.[69]

Thus, overall, the literature on the "Porter hypothesis" remains one with a high ratio of speculation and anecdote to systematic evidence. While economists have good reason to be skeptical of arguments based on nonoptimizing behavior where the only support is anecdotal, it is also important to recognize that if we wish to persuade others of the validity of our analysis we must go beyond tautological arguments that rest solely on the postulate of profit-maximization. Systematic empirical analysis in this area is only beginning, and it is too soon to tell if it will ultimately provide a clear answer.

6. *Conclusions*

Overall, there is relatively little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competitiveness, however that elusive term is defined. Although the long-run social costs of environmental regulation may be significant, including adverse effects on productivity, studies attempting to measure the effect of environmental regulation on net exports, overall trade flows, and plant-location decisions have produced estimates that are either small, statistically insig-

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[68] This has not kept a number of authors from describing Meyer's analysis as absolutely conclusive: "Meyer's study does repudiate the hypothesis that environmental regulations reduce economic growth and job creation" (Bezdek 1993, p. 10).

[69] For some environmental problems, such as inadequate sanitation and unsafe drinking water, there is a monotonic and *inverse* relationship between the level of the environmental threat and per capita income (International Bank for Reconstruction and Development 1992). This relationship holds both cross-sectionally (across nations) and for single nations over time. For other environmental problems, the relationship with income level is not monotonic at all, but an inverted *u*-shaped function in which at low levels of income, pollution increases with per capita income, but then at some point begins to decline with further increases in income. This is true of most forms of air and water pollution (Grossman and Krueger 1994), some types of deforestation, and habitat loss. Pollution increases from the least developed agricultural countries to those beginning to industrialize fully—such as Mexico and the emerging market economies of Eastern Europe and parts of the former Soviet Union. After peaking in such nations, pollution is found to decline in the wealthier, industrialized nations that have both the demand for cleaner air and water and the means to provide it. Finally, for another set of environmental pollutants, including carbon dioxide emissions, there is an *increasing* monotonic relationship between per capita income and emission levels, at least within the realm of experience.

nificant, or not robust to tests of model specification.

There are a number of reasons why the effects of environmental regulation on competitiveness may be small and difficult to detect. First, the existing data are severely limited in their ability to measure the relative stringency of environmental regulation, making it difficult to use such measures in regression analyses of the effects of regulation on economic performance. Second, for all but the most heavily regulated industries, the cost of complying with federal environmental regulation is a relatively small fraction of total cost of production. According to EPA, that share for U.S. industry as a whole averages about two percent, although it is certainly higher for some industries, such as electric utilities, chemical manufacturers, petroleum refiners, and basic metals manufacturers. This being the case, environmental regulatory intensity should not be expected to be a significant determinant of competitiveness in *most* industries. Labor cost differentials, energy and raw materials cost differentials, infrastructure adequacy, and other factors would indeed overwhelm the environmental effect.

Third, although U.S. environmental laws and regulations are generally the most stringent in the world, the difference between U.S. requirements and those in other western industrial democracies is not great, especially for air and water pollution control.[70] Fourth, even where there are substantial differences between environmental requirements in the United States and elsewhere, U.S. firms (and other multinationals, as well) are reluctant to build less-than-state-of-the-art plants in foreign countries. If such willingness existed before the accident at the Union Carbide plant in Bhopal, India, it does not now. Thus, even significant differences in regulatory stringency may not be exploited. Fifth and finally, it appears that even in developing countries where environmental standards (and certainly enforcement capabilities) are relatively weak, plants built by indigenous firms typically embody more pollution control—sometimes substantially more—than is required. To the extent this is true, even significant *statutory* differences in pollution control requirements between countries may not result in significant effects on plant location or other manifestations of competitiveness.

Having stated these conclusions, it is important to emphasize several caveats. First, in many of the studies, differences in environmental regulation were measured by environmental control costs as a percentage of value-added, or some other measure that depends critically on accurate measurement of environmental spending. Even for the United States, where data on environmental compliance costs are relatively good, compliance expenditure data are notoriously unreliable. The problem is more pronounced in other OECD countries, whose environmental agencies have not typically tracked environmental costs. Thus, we may have found little relationship between environmental regulations and competitiveness simply because the data are of poor quality.

In an era of increasing reliance on incentive-based and other performance-based environmental regulations, accurate accounting for pollution control will become an even more pronounced problem. This is because pollution control expenditures increasingly are taking the form of process changes and product reformulations, rather than installation of end-of-pipe control equipment. It will be

[70] See Kopp, Diane Dewitt, and Portney (1990) for empirical evidence, and Barrett (1992) for a theoretical argument of why governments should *not* be expected to adopt relatively weak pollution standards for competitive reasons.

increasingly difficult (perhaps even impossible) to allocate accurately that part of the cost of a new plant that is attributable to environmental control (Hahn and Stavins 1992). Ironically, in ten years we may know less about total annual pollution control costs than we do now, in spite of increased concern about these expenditures and their possible effects on competitiveness.

A second caveat is that only two of the studies we reviewed controlled for differences in "regulatory climate" between jurisdictions. If the delays and litigation surrounding regulation are the greatest impediments to exporting or to new plant location, these effects will not be picked up by studies that look exclusively at source discharge standards or traditional spending for pollution control equipment as measures of regulatory intensity, unless these direct compliance costs are highly correlated with the costs of litigation and delay.

A third factor that tempers our findings is the difficulty of measuring the effectiveness of enforcement efforts. Subtle differences in enforcement strategies are very difficult to measure, but these differences can lead to variations from country to country that *could* influence competitiveness. Finally, it is important to recall that any comprehensive effort to identify the competitiveness effects associated with regulation must look at both the costs *and* benefits of regulation. To the extent that air or water pollution control efforts reduce damages, they may reduce costs for some businesses and thus make them more competitive. Similarly, pollution control can reduce labor costs and enhance competitiveness in some locations under certain conditions.

Just as we have found little consistent empirical evidence for the conventional hypothesis regarding environmental regulation and competitiveness, there is also little or no evidence supporting the revisionist hypothesis that environmental regulation stimulates innovation and improved international competitiveness. Given the large direct and indirect costs that regulation imposes, economists' natural skepticism regarding this free regulatory lunch is appropriate, though further research would help to convince others that our conclusions are well grounded in fact.

Overall, the evidence we have reviewed suggests that the truth regarding the relationship between environmental protection and international competitiveness lies in between the two extremes of the current debate. International differences in environmental regulatory stringency pose insufficient threats to U.S. industrial competitiveness to justify substantial cutbacks in domestic environmental regulations. At the same time, such regulation clearly imposes large direct and indirect costs on society, and there is no evidence supporting the enactment of stricter domestic environmental regulations to stimulate economic competitiveness. Instead, policy makers should do what they can to establish environmental priorities and goals that are consistent with the real tradeoffs that are inevitably required by regulatory activities; that is, our environmental goals should be based on careful balancing of benefits and costs. At the same time, policy makers should seek to reduce the magnitude of these costs by identifying and implementing flexible and cost-effective environmental policy instruments, whether they be of the conventional type or of the newer breed of market-based approaches.

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