THE EFFECTS ON INDUSTRY OF ENVIRONMENTAL PROTECTION REGULATIONS

Prepared for:

Environmental Protection Agency

Draft Report
October 24, 1991

Prepared by:

APOGEE RESEARCH

The Effects on Industry of Environmental Protection Regulations

Table of Contents

DISCLAIMER

Although prepared with EPA funding, this report has neither been reviewed nor approved by the U.S. Environmental Protection Agency for publication as an EPA report. The contents do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

1.0 Purpose and Report Format

Purpose

The Administrator and other groups within the Agency are being called upon increasingly frequently to demonstrate that the environmental protection regulations developed and monitored by the Agency have some positive effects beyond the well-recognized ones of improvements in the quality of the natural and built environments and in the reduction in the exposure of humans to health hazards.

The Administrator is particularly interested in determining whether there are positive effects of environmental protection regulations on what has been called the "environmental protection (ep) industry". In particular, do environmental protection regulations generate benefits to industry which serve to counterbalance somewhat the possible cost implications of the regulations?

The purpose of this project is to identify the possible range of industrial effects of interest to the Agency, to document the current state of knowledge about such effects, and to suggest a set of follow-on research plans which the Agency could carry out to document the case more fully.

Format of the Report

The remainder of this report consists of four sections.

- *Method and a Definition,* documenting the approach taken to identifying the issues of interest to the Agency and the current state of knowledge about them, and introducing a definition of the industry;
- *Issues Of Interest To The Agency,* in which we identify a set of 12 specific questions which are of potential interest to the Agency in determining the effects of its regulations on industry;
- *Hypothesized Effects And Empirical Research,* identifying and describing all of the hypothesized effects of environmental protection regulations on industry, and summarizing the state of knowledge concerning them;
- *A Research Agenda For The Agency,* presenting a set of research projects which the Agency could carry out to address the high priority questions and assist its management to respond to issues about the effects on industry of environmental protection regulations.

2.0 Method and a Definition

Method

The approach adopted in this study consisted of a sequence of three tasks:

1. an identification of the specific issues and questions concerning the environmental protection industry which are of greatest interest to the Agency,

2. a documentation of the current state of knowledge about the issues and current Agency and other research into them; and, finally,

3. the preparation of optional research agenda to address gaps between what the Agency would like to know and what is known currently.

The main research tools were literature reviews and personal interviews. Both Agency and external officials participated in the research, especially in the identification of the industry issues of interest to the Agency.

A Definition: The Environmental Protection Industry

An important definition is introduced here concerning this industry segment referred to as the "environmental protection industry."

It has been the practice, both within the Agency and elsewhere, to use the phrase "the environmental protection industry" to refer to companies which sell environmental protection goods and services, usually to other companies which are regulated by the Agency. Sometimes this definition is made explicit; in most cases, it is not explicit but rather is implicit in the finding which are then presented on what is purported to be the environmental protection industry.

We believe that this approach to the environmental protection industry is misleading and is at the heart of many of the difficulties encountered to date in trying to measure and assess the industry.

This approach views the environmental protection industry as something which is distinct from the regulated industries, and suggests that industrial benefits accrue largely to this supplying environmental protection industry while it is the costs which are borne largely by the regulated industries. It is certainly true that the costs are borne largely by the regulated industries, but it is unlikely to be true that the bulk of any benefits would accrue only to the supplying industries.

We define the environmental protection industry differently.

Specifically, by the phrase "the environmental protection industry" we refer to all firms which either spend resources complying with the Agency's regulations or are suppliers to firms which spend the resources to comply.

The first set of firms, ie. those which spend resources complying with the Agency's regulations, we refer to as the *internal environmental protection industry.* The firms which supply to the regulated firms, we refer to as the *external environmental protection industry.*

An example of the internal environmental protection industry would be the petrochemical sector. This sector must comply with a variety of Agency regulations. An example of the external environmental protection industry is the consulting engineering sector or the environmental audit sector. Both provide environmental protection goods and services to companies which fall under some of the Agency's regulations.

The relationship between the two sets of firms is illustrated in Exhibit #1.

Of course, some firms are members of both sets, ie. they both spend resources complying with the Agency's regulations in their own operations, and they supply to firms (including themselves) which are regulated by the Agency.

The distinction between these two sets of firms is an important one. It illustrates that not all demands for environmental protection goods and services turn into markets for external environmental protection companies. Some regulated companies meet their own demands for environmental protection goods and services, and even sell their environmental protection expertise to other regulated firms including other subsidiaries of their parent company. This is the classical "make v. buy" question.

To date, the Agency has usually referred only to this "external" industry when it ask about "the environmental protection industry". In the following discussion of questions of interest to the Agency, we distinguish as appropriate between the two groups of firms.

3.0 Issues of Interest to the Agency

The Agency has a number of questions of particular interest to it concerning the effects of its regulations on industry. We have identified a set of 12 priority questions, and present them below under four categories:

- *the environmental protection industry,* dealing with the effects of environmental protection regulations in creating opportunities for economic and industrial growth in America and around the globe;
- *the effects on regulated industries* of *the regulations,* dealing with the extent to which the regulated industries are affected by the regulations;
- *the actual costs and benefits* of *the environmental protection regulations,* as opposed to the predictions made during the rule-making stage; and
- *the future*, dealing with changing industry's approach to environmental protection and ensuring the competitiveness of American industry.

Each question is explained through a set of illustrative sub-questions and a brief description.

Group A: The Environmental Protection Industry

Q1: How Big is the External Industry, What Are Its Growth Trends and What are the Economic Spin-Offs From It?

What are the sales, employment, and technological sophistication of the American external environmental protection industry? Is it a services industry or a product industry? How quickly is it growing, and in what fields? Is it serving the domestic market only or is it succeeding in foreign markets also?

Recall that the "external" environmental protection industry has been defined to consist of those firms which supply goods and services to the industrial firms which are regulated by the EPA. In some cases, of course, regulated firms supply environmental protection goods and services either to themselves or to other firms.

The size and growth trends of this industry are of significant interest to the Agency. The environmental protection industry is potentially important in demonstrating positive industrial benefits which result from environmental protection. If an environmental protection industry can be shown to be arising in response to the demands for environmental protection, then it counterbalances somewhat the arguments that environmental protection regulations exerts a dragging force on American industrial growth.

That this external environmental protection industry has grown and become powerful in its own right is evidenced by the rise in interest in it and the emergence of specialized publications, such as *Environmental Business Journal,* catering specifically to it. Special stock listings are provided for publicly-traded environmental protection firms. A number of investment houses are targeting environmental protection as one of the growth industry sectors of the 90's. The Agency itself has

recognized the importance of this sector and is participating in efforts to encourage the domestic and international growth of the industry.

Yet it has proven to be an elusive industry to measure. The efforts to date to estimate its size and sophistication have all been rudimentary. In part, this failure has been due to a lack of data on the sector but also in part due to misunderstandings about the ways in which environmental protection regulations affect firms. The environmental protection industry is a creation of environmental protection regulations. Thus, to understand the environmental protection industry you must first understand how these regulations affect both the regulated industries and those firms which supply environmental protection goods and services to the regulated firms.

Q2: Which Generates Most Benefits for the American Economy: the Internal or External Industry? And Which Carries Out the Most Useful Technological Innovation?

Where do most of the technological innovations for pollution abatement and prevention come from: In-house research of the industries which are subject to environmental protection regulations, or innovation on the part of external firms which then supply their new products and services to the regulated firms? And which of these routes provides the most benefits to the American economy? Do the external sources of innovation generate the jobs and the value-added or is it the internal development route which generates these benefits?

The importance of these questions lies in the potential for the Agency to influence the growth of either of these industries in its selection of an approach to the regulation of environmental protection goals. If the regulated industries could be shown to be generally reactive to regulations with the external industry generally leading in technology development, then this might suggest different approaches to regulation development. On the other hand, if the regulated industries were generating most of the technological innovations then it might suggest a rule-making process which was more collaborative than the current adversarial one.

Some optional approaches to environmental protection are discussed in subsequent questions.

Q3: Which Regulatoy Approaches Facilitate the Growth of the Internal and External Industries?

Do some approaches to regulation development and implementation lead to greater industrial benefits than others, without sacrificing environmental protection?

The Agency has a variety of approaches it can take to developing, implementing and enforcing its rules. Some approaches might offer greater benefits to the environmental protection industry than others. For example:

- re-defining the basis for accepting a technology as “available” within the current notion of BAT and permitting processes might open the doors to more innovative solutions;

- focusing even more strongly in regulations on water quality goals as opposed to effluent standards could also facilitate the search for prevention strategies rather than end-of-pipe approaches; and

- a greater reliance on economic incentives and innovative financing schemes to meet the costs of abatement and prevention could improve the benefits to industry without compromising the goals.

Q4: How Competitive is America's Industry, Domestically and Globally?

Is America's environmental protection industry competing successfully domestically and around the world? Who is meeting the notion's demand for new technologies (including end-of-pipe, process changes, pollution prevention, etc.) to achieve environmental protection goals? Internationally, are American firms competing successfully against German, Japanese, Scandinavian and U.K. firms for the global environmental protection markets?

How well American environmental protection firms are doing in the domestic and international markets is of primary interest to the Agency. Of special interest is the role of the Agency's regulations in this competitiveness.

If its regulatory requirements are being met by foreign suppliers, then a re-examination of the Agency's approach to both regulations and the regulated industry might be warranted On the other hand, if technologies developed in response to Agency regulations were being successful in both domestic and overseas markets, then the Agency can be credited with contributing to the resultant industrial growth.

Another factor of interest to the Agency is the export potential of the domestic environmental protection industry, again as a counterpoint to the possible depressing effects of its regulations on domestic industrial productivity.

Q5: What are Examples of Business Success Stories for Both the External and Internal Industries?

Are there examples of companies which have responded to Agency regulations by developing new technologies, products or processes which have been commercialized either within related subsidiaries or on the open market?

Specific examples of environmental protection companies which have succeeded in the market place would buttress the Agency's point that environmental protection generates positive business effects.

These examples could come from either the internal or external environmental protection industries, but should demonstrate the commercial success of products or services developed in response to, or in anticipation of, environmental protection regulations.

Journals such as *Harvard Business Review* (HBR) and *Environmental Business Journal* (EBJ) have examples of companies which are reported to have succeeded in the environmental protection market, but they tend to be once-off, anecdotal reports. There is no overall picture of:

- whether such success stories are the rare exception or can be found in all regulated industry sectors; or
- the relative importance of the external and internal environmental protection sectors in creating these successes.

Group B: Effects on the Regulated Industries of Regulations

Q6: What have been the Effects of Regulations on U.S. Industrial Productivity and Competitiveness?

Have the Agency's regulations had a depressing effect on the productivity and competitiveness of the regulated industries? If so, are there optional approaches to regulation which might be less damaging but which would achieve the desired goals?

This is one of the most hotly-debated and contentious issues concerning environmental protection regulations.

American manufacturing is coming under increasing pressure from both the developed and developing countries. Productivity is probably the single most important element in ensuring the competitiveness of American industry, and therefore regulations which are believed to hamper the productivity of America's domestic industry are bound to be criticized.

If there is evidence that environmental protection regulations have a depressing effect on domestic productivity and competitiveness, of interest to the Agency would be the identification of other approaches to regulation which might be less damaging. In specific cases, there might be alternative regulatory approaches which might preserve, or even enhance, productivity and competitiveness.

Examples of optional approaches include the following:

- an ambient environmental quality approach v. an effluent regulation approach;
- a technology-driven approach v. an end-results approach; and
- a command-and-control approach v. one of economic incentives.

This last question becomes particularly important to the Agency given the changing nature of the environmental pollution challenges (greater emphasis on diffuse sources, toxics and global problems such as climate change) and the recent initiatives of the Administrator to broaden the approaches being taken to environmental protection.

Q7: How do U.S. Regulations Compare with America's Major Industrial Competitors? What have been the Impacts of their Regulations on Productivity and Competitiveness of America's Competitors?

How do America's environmental protection regulations compare to those of its major industrial competitors? And what have been the relative effects, in each of these countries, of its regulations on the productivity of its domestic industries?

If environmental protection regulations are shown to have had a dampening effect on U.S. industrial productivity, the question still remains as to the impact of such an effect. If all other comparable industries around the world have been subject to similar regulations, then the competitiveness of American industry might remain unchanged.

This is a complex question. Comparing the stringency of different approaches to environmental protection requires an examination of the rules themselves, the enforcement measures, the technological development stage of the affected industries, and the overall effects of the regulations on the productivity of the various industry sectors. Yet it is an important question.

If America's major industrial competitors are implementing regulations similar to the Agency's, then U.S. industry is not necessarily being forced to play on a tilted field; rather, it and its competitors are part of a global concern about protecting the environment.

Of course, the real situation is Likely to be more complex than this. Timing, for example, becomes an important issue. Common concerns about environmental protection can still yield competitive disadvantage if one country is moving much faster than its competitors.

Group C: The Realized Costs and Benefits of Environmental Regulations

Q8: What have been the Realized Costs to Industry of Complying with the Agency's Regulations?

What has been the real experience of regulated industries? Have the realized costs been close to the costs forecast by the Agency and the affected industries during the rule-making stage? Or have the costs been smaller or larger If so, how could the Agency's cost estimation methods be improved to provide a more realistic estimate of the burden of its regulations on industry? If the costs have been much less than predicted were them particular features of the Agency's approach to regulation which contributed to this benefit? What have been the real effects on financial performance of these realized costs?

The forecasted costs of complying with an Agency regulation become one of the major issues in setting both the details of the regulation and the time period over which compliance is to be achieved. The regulated groups typically argue that the costs of compliance are large and will have serious consequences for the sector's financial health. Yet there is little codified knowledge about how the realized costs compare to the forecast costs, and how the realized costs affected the financial

performance of the affected firms. Some arguments suggest that the Agency's approach to forecasting costs Likely leads to over-estimation of costs; others suggest that the Agency misses many of the less-obvious cost elements.

Q9: What have been the Transaction Costs of Complying with EPA Regulations? Is there a Cheaper Way?

Are the transaction costs (legal, communications, coordination, etc) of the EPA'S approach to regulation too high? Are there other, perhaps less adversarial, approaches especially in rule development and monitoring/enforcement which might lessen these transaction costs?

It has been argued frequently that lawyers are the most immediate beneficiaries of environmental protection regulations. From the rule development stage through to enforcement, the transaction costs to the regulated industries may be significant. Other approaches may offer the potential to reduce these costs.

Q10: What Benefits have Industries Realized from Complying with Environmental Regulations?

What have been the benefits accruing to the regulated firms? Has technological development been spurred? Have new or changed processes and products resulted from the regulations?

It is important for the Agency to demonstrate that environmental protection concerns are not just a cost to the regulated firms, but rather that pollution prevention and abatement is a necessary component of successful business planning. Ideally, the Agency would like to be able to demonstrate that prevention and abatement of pollution can be counted upon to lead to benefits which lessen the impact of the costs.

Business and environmental protection journals contain anecdotal evidence of individual companies which have shown benefits, sometimes significant, from their compliance efforts. But there is little codified evidence of such benefits, for example, across a sector or in response to a particular Agency regulation.

Group D: The Future

Q11: Are There Useful Blueprints for Companies to Internalize Environmental Protection Concerns?

Are there detailed examples upon which companies could draw to design a more anticipatory approach to environmental protection? How can environmental protection become an integral part of a company's decision processes, rather than after-the-fact, forced by regulation?

The Agency's long-term goal goes beyond end-of-pipe regulations. An ultimate goal of the Agency is to instill in industry the need to anticipate environmental concerns, rather than having to react subsequently to regulations.

Some companies have seen the future and have committed to internalizing environmental protection concerns into their planning of r&d, products, capital investments, etc by the end of this century. In other cases, Agency staff are participating in projects with firms to design planning processes which are more forward-looking and sensitive to environmental concerns. Lessons learned from these experiences, and in particular blueprints for other firms to follow, would be useful and would demonstrate that this long-term approach is feasible and profitable.

The potential long-term savings to the Agency, and to the nation, from this type of approach to environmental protection are believed to be substantial. It represents nothing short of a major paradigm shift in our thinking about natural resources and environmental protection.

Q12: Will Differential EP Regulations Affect Plant Locations in: North America? Elsewhere?

Will enhanced trading arrangements in North and Central America lead to investment decisions being affected by the different environmental protection standards of *the partners? Will American jobs be lost* to *countries with lower environmental protection standards ? Globally, will environmental protection standards become an element in investment location decisions?*

Concern with environmental protection is a global issue, but the rate of acting on the concern varies widely. The question here is whether or not environmental protection standards will become a factor in the investment location decisions of industries.

The enhanced trading arrangements being negotiated among the U.S., Mexico and Canada are of immediate interest here. Environmental protection standards differ among the three countries, and indeed among the states, provinces etc. of each of the three countries. There is the potential for environmental protection to become a factor in investment decisions. On a larger scale, there is a similar concern about investments in Latin America, Asia and Europe. While Europe 92 is supposed to have eliminated the use of lax environmental protection standards as an investment promotion vehicle, in practice the slow pace of implementation of the accords may mean that that result is not achieved

4.0 Hypothesized Effects and Empirical Research

Introduction

Modeling firm and industry behaviour has occupied, if not most, then at least a large part of economists' time. Theoretical and empirical models have been developed for almost all aspects of firm behaviour. As concern over environmental degradation has mounted, and regulations designed to protect or restore environmental quality have been enacted, much debate has occurred over the economic effects upon industry of such measures. These effects have been incorporated into many of the traditional economic models of firm behaviour, and new models have been developed to more accurately capture the exact relationships between EP regulations and industrial activities.

Environmental protection regulations have been hypothesized to affect nearly all decisions made by firms of the internal EP industry, including those related to employment, investment, R&D, production technology, waste disposal and plant location. These effects may in turn have an impact upon measures of firm performance, such as productivity and competitiveness. When these changes are aggregated across firms, effects in these variables at the industry or economy-wide level may occur.

In addition to firms in the internal EP industry, other firms are also affected. Of these, firms in the external EP industry have been much discussed. The impact results from the fact that EP regulations shape the demand for these firms' primary products, EP goods and services. The focus of these effects is generally upon the magnitude of the EP industry. How many people does it employ? How much output does it produce? How much trade does it generate?

This approach, however, neglects many other effects EP regulations may have upon the external EP industry. Not only may regulations shape the demand for EP goods and services but they may also influence the entire incentive structure facing the industry. Thus, regulations may also affect decisions made by EP firms regarding such activities as investment, R&D, and plant location. Industry characteristics such as market structure and competitiveness may also be impacted.

Finally, no sector of the economy is immune from major shocks occurring in other sectors. Therefore, the economic effects of EP regulations upon industries are not limited to the internal and external EP industries. Firms which buy the output of regulated firms, buy inputs from the same factor markets as regulated firms, face demand curves determined by environmental quality, or sell to the owners of factors employed by regulated industries may all feel the impact of environmental regulations.

To make sense of such a diverse, yet interconnected, set of industrial effects is a daunting task. As a first step, this project's purpose is to suggest a research plan to guide the work. Two inputs to this research plan are a compilation and taxonomy of hypothesized effects, followed by a review of the empirical research done to date on each effect. The results of these two tasks are discussed in sections 4.1 and 4.2 respectively

4.1 A Taxonomy of Possible Effects on Industry of (EP) Regulations

From the brief overview provided above, it is clear that the industrial effects of EP regulations are exceedingly complex, interconnected and yet diverse. Therefore, the task of organizing them is very important and difficult.

Several ways of organizing effects, each with its own strengths and weaknesses, were examined. These included trying to classify effects according to the following criteria:

- distributional effects versus efficiency effects;
- static effects versus dynamic effects; and
- by agent affected, namely external EP industry, internal EP industry and other industries.

Serious problems arose with the first two criteria. Many hypothesized effects cannot clearly be classified under one or the other categories. For example, in order to classify an effect as an efficiency gain requires knowledge of the cost-benefit tradeoff of the activity. Theoretical and empirical models can examine the same basic impact in both static and dynamic settings. Therefore, it was decided to classify impacts according to the economic sector which is being directly affected.

Finally, it is worthwhile repeating that the industrial effects of EP regulations are all interconnected. Although for research purposes each effect tends to be examined separately, this is not meant to imply that each channel whereby EP regulations affect industry is isolated.

This can clearly be seen with one example. Productivity is often studied as an entity to itself. Yet productivity is determined by factors such as R&D and economies of scale, which are examined separately. In this way, productivity can be thought of as a higher order" impact. Similarly, competitiveness, as measured by trade performance, is also studied separately, even though productivity is clearly a major determinant of competitiveness.

We now present summary charts outlining the various hypothesized effects of EP regulations upon industry. These are followed by section 4.2 which provides detailed explanations of each hypothesis and brief summaries of relevant empirical research.

Potential Industrial Impacts of EP Regulations

Internal EP Industry (Regulated Firms)

Employment
- job loss
- job creation

Investment Effects
- displacement of "productive" investment
- compliance strategy may quicken capital turnover
- old/new source distinction may retard capital turnover

R&D Effects
- diversion of R&D from product innovation
- product reformulation and process redesign lead to cost savings

Economies of Scale Effects
- ep regs act as an entry barrier
- economies of scale exist in control activities
- firms with low control costs increase market share
- emissions per unit of output change with output levels

Market Structure Effects
- significant changes to the number of firms in an industry
- firms' market shares are significantly altered

Waste Recovery
- for reuse within original plant
- for sale as inputs to other industries

Potential Industrial Impacts of EP Regulations

Internal EP Industry (Regulated Firms)

Productivity Effects

- if inputs are diverted from activities which contribute to measured output
- if changes occur in the efficiency of capital devoted to production of output
- if "cleaner," but more expensive, inputs are substituted for "dirty" inputs
- if economies of scale are changed

Industrial Relocation

- away from regions of stringent ep regulations

International Competitiveness

- deterioration
- improvement
- change in the composition of international trade

Exports of Control Technology

- to foreign subsidiaries
- to other foreign firms

Potential Industrial Impacts of EP Regulations

Other Industries

General Equilibrium Price Effects

- Increased production costs to industries which consume the output of regulated industries

General Equilibrium Output Effects

- substitution away from output of regulated industries

Environmental Quality of Inputs

- reduce maintenance costs for structures
- change agricultural, fishing and forestry yields
- reduce water purification costs

Environmental Quality as a Determinant of Demand

- for health care services
- for recreational goods and services
- for real estate

Potential Industrial Impacts of EP Regulations

External EP Industry (Traditional EP Industry)

Employment Effects
- job creation

International Competitiveness Effects
- exports of EP goods and services

R&D Effects
- technology-based standards discourage innovation
- lengthy permitting system discourages R&D

Market Structure
- technology-based standards create monopolies for some firms
- fluctuating regulations increase firms risk

4.2 Empirical Research

One of the most obvious shortcomings to classifying impacts according to what type of agent is being affected is that some of the empirical work has been undertaken at the macroeconomic level and hence is not disaggregated by sector. Many other studies which do include sectoral detail are conducted within a general equilibrium framework. While this is desirable from a theoretical perspective, it makes it difficult to summarize results. These problems have been dealt with by including a separate section of macroeconomic studies. All other empirical research is summarized under the relevant effect.

Although over 75 studies were reviewed, definitive conclusions on the magnitude, and in some cases direction, of any effect are rarely possible. Each methodological framework neglects some aspects of EP regulations and firms' responses to them. Whether these shortcomings seriously impair results can only be hypothesized at this tune. A comprehensive research plan should address these weaknesses.

42.1 Effects of EP Regulations on the Internal EP Industry

Employment Effects

- Job loss
- Job creation

Regulated firms may experience changes in employment in several ways (Haveman and Christiansen, 1979). Most commonly, regulatory impact analyses examine the impact upon firms in terms of plant closings and resulting job losses. Job losses could also occur if plants simply reduced output in order to decrease pollutant emissions to regulatory standards, or if regulations reduced the competitiveness of firms such that output and employment were reduced. Plant closings, of course, is merely the most extreme form of the latter.

Christainsen and Tietenberg (1985) outline the factors which determine the magnitude of this effect. First, employment effects will be influenced by the output demand elasticity in the regulated industry. If the elasticity is high, then a small increase in output price to cover compliance costs will result in large decreases in demand. This in turn will force firms to reduce output, and hence employment, to a greater degree than an industry exhibiting low demand elasticities. Second, firms' response to increased costs resulting from EP regulations will be different depending upon the market structure of the industry. In particular, the same compliance costs will result in smaller output and employment decreases if the industry is highly monopolized Finally, employment effects will be influenced by the labour intensity of the regulated firm or industry. For example, the same decrease in output will result in higher levels of unemployment if a firm or industry is labour-intensive.

Renner (1991) summarizes the empirical literature on plant closings as a result of EP regulations. These studies find that five percent or less of plant closings across all sectors can be, at least partly, attributed to EP regulations. Resulting job losses are dwarfed by job losses and layoffs due to other economic factors.

A second source of information on job losses in regulated industry is the EPA's Economic Dislocation Early Warning System (EPA, 1982). Between 1971 and 1983, 155 plant closures 33,000 job losses were, at least partially, attributed to EP regulations. Of the job losses, 34 percent were from the primary metals industries, while a further 20 percent were lost in the chemicals and allied products industries.

The economic impact analyses commissioned by the EPA for each proposed regulation also provide estimates of the employment impact on a sector-by-sector basis. For example, it was estimated that, under different definitions of BAT effluent standards on the organic chemicals, plastics and synthetic fibres (OCPSF) industry, reductions in employment would range from 1,335 to 6,475 jobs (EPA, 1987). Of course, these represent ex ante forecasts. Actual changes in employment may differ somewhat.

Researchers outside the EPA have also studied the employment effects of EP regulations. For example, Hartman, Bozdogan and Nadkarni (1979) developed a model of the U.S. copper industry. Simulating the effects of EP regulations from 1974 to 1987 yielded estimated losses of between 21,300 and 28,200 jobs. This represents 25% and 33% of total employment by the copper industry.

On the other hand, some positive employment effects may occur in regulated industries. It has been suggested that regulations may force firms to increase employment levels if labour is a significant input to their compliance strategy. This may be especially true if environmental engineers are needed to develop a compliance strategy, pollution abatement capital requires frequent maintenance, or significant reporting activities are mandatory.

These increases in employment are generally ignored by the regulatory impact analyses conducted for the EPA. Although these studies estimate operating and maintenance costs, they do not indicate whether these expenditures will result in the hiring of new technicians, engineers, clerical staff, etc. No other studies were found which specifically estimated the employment requirements of regulated firms for complying with EP regulations.

It is also worth noting that Crandall (1981) finds some empirical evidence that the industries which have incurred the highest costs as a result of EP regulation are some of the most highly capital-intensive industries in the economy. However, the impact this influence has had upon employment levels has not been empirically established.

Table 1 summarizes past estimates of the effect of EP regulations upon employment in regulated industries. These studies do not attempt to capture any positive employment effects.

Table 1
Impact of EP Regulation Upon Employment in Regulated Industries

Study	Sector	Change in Labour Employed
Environmental Protection Agency (1982)	all	-32,749
Environmental Protection Agency (1987)[1]	OCPSF	-1,335 to -6,475
Hartman, Bozdogan and Nadkarni (1979)	copper	-21,300 to -28,200
Rennet (1991)	all	small reduction

Notes:

1. EPA (1987) is listed only as an example of the economic impact analyses commissioned by the Agency. The employment impact is for proposed BAT effluent standards.

Investment Effects

- Displacement of "productive" investment
- Compliance strategy may quicken capital turnover
- Old/new source distinction may retard capital turnover

Environmental protection regulations may affect investment behaviour in three ways. The first hypothesizes that regulations force firms to change the purpose of investment. Specifically, regulations force firms to divert scarce capital resources from investment which raises measured output to pollution abatement capital which does not contribute to measured output. This in turn reduces productivity and competitiveness.

There is a large body of empirical literature which incorporates this hypothesis into its analysis. Most notably, the growth accounting framework used by Denison (1988), Norsworthy et al (1979), and others measures the change in productivity growth under the assumption that pollution control inputs fully displace "productive" investment. The measure used of the investment effect is generally the series of pollution abatement and control capital expenditures compiled by the Bureau of Commerce.

The hypothesis that investment to comply with regulations fully displaces other investment has been challenged by other research Estimation of cost functions have found that there is usually some substitutability between pollution abatement inputs and other inputs (see Barbera and McConnell, 1986, 1990; Gollop and Roberts, 1983; Kopp and Smith, 1981; Pittman, 1981; Sims

and Smith 1981). Therefore, some investment attributed to EP regulation also contributes to firms' measured output.

The second hypothesized relationships between EP regulations and investment is that EP regulation forces firms to investment in new capital equipment which, not only results in lower pollutant emissions, but is also more efficient. Increasing the turnover rate of equipment and machinery means that older capital is replaced by new capital which embodies the latest technological advances. Hence productivity may be increased. This of course assumes that firms' compliance strategies involve altering their production capital rather than simply investing in end-of-pipe treatment facilities (Boyd and Uri, 1991).

The third hypothesis examines the effects of differential treatment of old and new point sources. Since EP regulations are typically most stringent for new plants, then investment may be discouraged. Potential entrants into the industry may be delayed and existing firms may not undertake new investment. Such a slowdown in capital turnover may lengthen the lifespan of older, less efficient capital (Christainsen and Tietenberg, 1985; Crandall, 1981).

No empirical research examining the last two hypotheses was found Therefore, the only conclusion which can be drawn is that capital expenditures necessitated by EP regulations probably displace "productive" investment on a less than one-to-one basis. This, however, has serious implications. Since many productivity and macroeconomic studies assume full displacement, these studies would tend to overestimate the adverse effects of EP regulations.

R&D Effects

- Diversion of R&D from product innovation
- Product reformulation and process redesign lead to cost savings

Some evidence has attributed the slowdown in productivity growth to changes in the magnitude of R&D expenditures. Griliches (1979), however, has suggested that there has also been a "collapse" in the productivity of R&D, that is R&D expenditures are also not producing as big a bang for the buck as they once did. Environmental protection regulations may force some firms to devote their R&D efforts, not to product innovation and process redesign, but rather to developing waste treatment technology. Magat (1978, 1979) added EP activities to theoretical models of technological advance and obtained this theoretical result.

Link (1982) tested the hypothesis and found that this was indeed the case. Estimating a single-equation productivity model, Link found that the relationship between productivity and total R&D expenditures was positive but weak. When R&D expenditures were disaggregated by purpose, there was a strong, positive relationship between productivity growth and traditional, innovative R&D. R&D expenditures on environmental protection, however, were found to reduce productivity growth Link, however, admitted that his model was quite simple, that only a small sample of firms were used, and that therefore his results were not definitive.

This is especially true in light of the second hypothesis, that R&D devoted to compliance activities may result in cost-saving process redesign or product innovation. Since EP regulations

The efficiency with which inputs are transformed into outputs may change as a plant, firm or industry increases or decreases its output. This relationship between the cost per unit of output and the output level itself is referred to as economies of scale.

Environmental protection regulations are hypothesized to affect economies of scale in four ways. First, EP regulations may act as a barrier to new firms wishing to enter an industry by raising entry costs. Entry costs will rise as a result of EP regulations if regulations require firms to undertake costly pollution control programs. This in turn may prevent firm entry if potential entrants have limited start-up capital or if a larger initial market share would have to be "pirated" from existing firms in order to make entry profitable (Pittman, 1981). Since firms often expand into new industries on the basis of innovations in products or production processes, regulations may also serve as an entry barrier if, as discussed above, regulations reduce the returns to R&D (Davies, 1983).

The second hypothesis holds that economies of scale may exist in pollution control activities. For example, if control requires a large fixed cost for end-of pipe treatment facilities which is invariant to waste volume, then plants which operate at high output levels will have lower abatement costs per unit of output. This would increase plants' optimal output levels and thus change economies of scale in production activities.[2] It has been noted, however, that this effect may be offset if there is a tendency to concentrate enforcement on larger firms (Christainsen and Tietenberg, 1985).

Some empirical evidence suggests that there are economies of scale in pollution control. For example, Hanke and Gutmanis (1975) found that, for both private and public wastewater treatment plants, the treatment cost per unit of wastewater declined as more water was treated. Similar economies of scale were found for in-plant process changes for fruit and vegetable processing plants. Kohn (1988) cites further evidence of economies of scale in abatement activities.

The third hypothesis results from the fact that EP regulations do not impose the same pollution control costs per unit of output across firms (Pashigian, 1984).[3] This results in increased competitiveness for firms with low control costs relative to firms with high control costs. Hence the market share and output of low-cost firms may increase and change the level of economies of scale present within that firm.

---

1 In their most extreme form, EP regulations may prohibit firm entry if new plants increase pollutant emissions at all. This might be the case if a potential entrant would increase regional emissions beyond levels allowed under PSD regulations.

2 Of course, changes in plants' output levels are dependent upon additional market factors. For example, increased output levels at the plant level may necessitate: i) growing demand, despite possible rises in output price due to control costs; or ii) the exit of plants not able to take advantage of these economies of scale, allowing demand to be met by fewer suppliers.

3 This does not imply that the regulator *should* attempt to equate average control costs per unit of output across firms. Clearly this may violate first-order efficiency conditions: equal marginal abatement costs across pollutant sources.

Finally, Kohn (1986, 1988) offers a fourth hypothesis. In examining emissions per unit of output produced by diesel-powered generators in vessels, he finds evidence that they first decline as output increases and then increase with output. Once regulations make it costly to produce uncontrolled pollutants, output can be altered to take advantage of changes in emissions per unit of output. This shift in optimal output could result in changes to scale economies.

No empirical work was found relating these hypotheses to the actual impact of EP regulations upon economies of scale. Two studies, however, do test whether or not pollution control expenditures are related to changes in economies of scale. First, Pittman (1981) estimated a translog production function for a set of U.S. pulp and paper plants and found a strong, positive correlation between scale economies and pollution control intensity. Hence he concluded that "[waste] treatment requirements increase the minimum efficient size of plant, thus increasing barriers to entry and exacerbating any lack of competition in the industry."

Second, Pashigian (1984), using a single-equation regression framework, found that EP regulations were responsible for an increase in average plant size across 319 industries. His results, however, have been challenged by Evans (1986).

Given that Pittman studied only one industrial sector and that Pashigian's conclusions have been disputed, there are no general conclusions which can be drawn regarding the effect of EP regulations upon the economies of scale in regulated industries.

Market Structure Effects

- Significant changes to the number of firms in an industry
- Firms' market shares are significantly altered
- EP regulations have different effects according to size of firm

Market structure is defined here as the degree of competitiveness of a market, that is the extent to which firms have power to influence the price for which their output is sold. This power is determined by, among other factors, the number of producers in an industry, similarity of products, firms' ease of entering and exiting the industry, the nature and size of consumers, etc.

The number of firms in an industry may be affected by EP regulations in several ways. First, as discussed above, regulations can act as an entry barrier. This would tend to reduce the number of firms in an industry and hence may alter the structure of the market by reducing competition (Kohn, 1985). Second, by imposing costs upon polluting firms, relative output prices across industries are affected. In particular, changes in relative prices may result in decreased consumption of goods produced by industries incurring high pollution control costs. This decline in demand may result in firms leaving the high-cost industry and a possible shift in the market structure of this industry.

It is also possible that EP regulations could change a market's structure by altering the share of industry output accounted for by each firm within the industry. This could result if pollution

control costs vary between firms. Firms with low compliance costs may be able to increase their market share at the expense of competitors with high compliance costs.

This may be especially relevant to market structure if the impact of EP regulations varies systematically across. Most importantly, much discussion has focused upon whether or not compliance costs differ by size of firm. For example, if large firms are better able to raise investment funds for pollution abatement capital, then the competitiveness of firms with access to only small pools of investment capital may decline. It is also possible that larger firms have the lobbying resources to fight undesirable regulations more effectively than smaller firms (Farber and Martin, 1986). Alternatively, it has been suggested that political concerns regarding the regulatory impact upon "small business" has resulted in higher compliance costs being imposed upon larger firms (Farber and Martin, 1986).

In a related effect, old/new source distinctions in EP regulations have been hypothesized to delay entry of new firms (Koch and Leone, 1979). Furthermore, firms who do enter the market may do so with lower shares of total industry output (Christainsen and Tietenberg, 1985).

Little empirical research relating to the effects of EP regulations upon market structure has been conducted. What has been done does not allow any definitive conclusions. Rather existing studies suggest ways in which future comprehensive work might be undertaken. Brief summaries of the existing empirical research are presented below.

- Farber and Martin (1986) used average size of establishment and number of establishments per firm as a *determinant* of pollution control effort across 388 four-digit SIC manufacturing industries. Their model yielded the result that pollution control efforts are inversely related to the degree of firm rivalry in a market. If markets are more competitive, then firms can achieve compliance at lower cost by reducing output rather than incurring abatement expenditures. Increasing the number of firms in an industry will, ceteris paribus, reduce the output of a representative firm. Thus, for the same waste control inputs, effluent loadings will be diminished, and firms will reduce their EP expenditures.

- Koch and Leone (1979) found that, for the tissue industry, the long-term increase in output price exceeded the increase in average cost imposed by the 1972 Federal Water Pollution Control Act. This implies that firms with the lowest compliance costs actually profited from the regulations and was presumably accompanied by shifts in market shares between low- and high-cost producers.

- Maloney and McCormick (1982) found that the judicial upholding of PSD regulations increased the stock value of existing smelting firms due to the regulations' potential to prevent market entry of new smelters.

- Pashigian (1984) compared the burden of EP regulations by size of firm using a cross-section of industries. A single-equation regression analysis yielded the result that EP regulations decreased the market share of smaller firms relative to larger firms.

Waste Recovery Effects

- For reuse within original plant
- For sale as inputs to other industries

One compliance strategy available to regulated firms is to reduce waste by recovering and recycling efforts. In addition to reducing waste disposal costs, this could generate revenues from the sale of by-products or reducing disposal costs or reduce expenditures on virgin materials. Much anecdotal evidence exists that some firms have adopted this strategy, including:

- Dow Chemical developed saleable ferric chloride from steelmaker's waste dust, and consequently eliminated the need to landfill more than 10 million pounds of steelmaker's dust annually. (Campbell and Glenn, 1982)
- Westvaco began converting its mill wastes into chemicals, eventually establishing a chemical products subsidiary which turns former waste by-products into chemical sales worth $45 million in 1980. (Royston, 1980)
- One plant of Quaker Oats reported $1 million in annual savings due to recycling what were formerly considered to be waste products. The same report cites savings of $40 per ton by recycling waste products rather than hauling to landfill sites. (McKenney, 1991)
- 3M's U.S. facilities reported net savings of $17.4 million over a three-year period due to its pollution prevention program, while its overseas subsidiaries netted an additional $3.5 million. (Campbell and Glenn, 1982)

Anecdotal evidence such as this has yet to be analyzed in a rigorous manner. Several obstacles will need to be overcome in order to accomplish this. First, recycled inputs within a plant do not pass through a market and so do not register as production of an intermediate good. Second, aggregate output may actually be reduced if using recycled inputs reduces expenditures on virgin inputs. Third, it may be difficult to prove causal relationships between EP regulations and sales of recycled "waste."

Productivity Effects

- If inputs are diverted from activities which contribute to measured output
- If changes occur in the efficiency of capital devoted to production of output
- If "cleaner," but more expensive, inputs are substituted for "dirty" inputs
- If economies of scale are changed

Productivity, as defined by some measure of output per unit of input, has been of the most widely examined industrial variables. Its importance originates in the belief that it is a primary determinant of competitiveness and an essential factor in economic growth and improved standards of living.

The impact of EP regulations upon productivity is usually thought of as being direct. In fact, changes in output per unit of input result from the net effect of many of the factors discussed above. Since it is affected through these intermediate channels, productivity can be thought of as a higher order" variable.

For example, the most commonly discussed effect is through the diversion of inputs -- EP regulations force firms to devote inputs to abatement activities rather than producing measured output. These inputs include:

- investment diverted to pollution abatement capital;
- labour used on operating and maintaining pollution abatement capital, and monitoring and reporting pollutant emissions; and
- R&D expenditures upon control technology.

Second, regulations may affect productivity if they change the efficiency of the those inputs which are devoted to "productive" activities. For example, the efficiency of productive capital may decline if regulations slow capital turnover (see under investment effects for a more detailed discussion).

Third, productivity may be affected if EP regulations result in the substitution of more expensive inputs for cheaper inputs. One prominent example of this impact of regulation is provided by electricity generating plants replacing high-sulphur fossil fuels with low-sulphur fossil fuels (Gollop and Roberts, 1983).

Finally, as discussed above, regulations may affect the average size of plant in an industry. This would result in productivity changes if different economies of scale obtained at the new output level.

Most studies of the impact of EP regulations upon productivity employ frameworks which only account for one of these channels. In addition, the frameworks generally focus upon the negative impact of regulations to the point where positive effects are, by construction, impossible. For example, growth accounting focuses upon input diversion, while not attributing any increases in measured output to regulations. Therefore, it is important in interpreting empirical studies of productivity and EP regulations to assess each study for the channels it is designed to capture.

With these points in mind, Table 2 summarizes the empirical research relating EP regulations to changes in productivity growth.

Table 2
Impact of Environmental Protection Regulations Upon Productivity Growth

Study	Framework	Impact Upon Productivity Growth (+ or -)
Barbera and McConnell (1986)	production function	-
Barbera and McConnell (1990)	cost function	-
Chase Econometrics (1972)	macroeconometric	-
Congressional Budget Office (1985)	small-systems model	-
Crandall (1981)	single-equation regression	-
Denison (1984)	growth accounting	-
Farber, Dreiting and Rutledge (1984)	growth accounting	-
Gallop and Roberts (1983)	cost function	-
Gray (1987)	econometric	-
Haveman and Christainsen (1981)	single-equation regression	-
Kopp and Smith (1981)	cost function	-
Kendrick (1981)	growth accounting	-
Kutscher, Mark and Norsworthy (1977)	growth accounting	-
Link (1982)	single-equation regression	-
Norsworthy, Harper and Kunze (1979)	growth accounting	-
O.E.C.D. (1985)	macroeconometric	-
Sims and Smith (1981)	cost function	-
Thurow (1980)	single-equation regression	-

Industrial Relocation

- Away from regions of stringent EP regulations

Environmental protection regulations raise production costs for some firms. Since firms are assumed to operate by cost-minimization criteria, then some firms have an incentive to locate their production facilities in regions with less stringent or no EP regulation.

The strength of this incentive depends upon a variety of factors (Walter, 1982a). First, the incentive for firms to relocate increases as pollution control costs comprise a greater proportion of total costs. Second, the incentive increases as inter-regional differences in regulatory burden increase. Third, inter-regional differences in the availability and quality of inputs will influence whether or not a firm relocates due to EP regulations. Fourth relocation decisions will also depend upon firms' market strategy (for example, if it is important to produce in areas where the good is consumed, EP regulations may have little effect upon location decisions).

The hypothesis that EP regulations may induce firms to relocate has been of increasing concern due to the "globalization" of the world economy. With the lowering of tariff trade barriers and the growing importance of multinational corporations, plant location decisions may be becoming more sensitive to regional differences in production costs. Nowhere has this hypothesis been more prominent than in the recent U.S.-Canada free trade talks and the current U.S.-Mexico-Canada negotiations.

To date, little empirical research on this hypothesis has been undertaken. Walter (1982b) reports one survey of 43 corporations, most of them multinational. In discussing their concerns surrounding EP regulations, only three (eight percent) believed that industrial relocation was at stake.

Walter also attempts some empirical testing of the hypothesis, though his method is far from illuminating. First, he collects data upon overseas data investment by U.S firms and finds no shift over time in foreign direct investment by pollution-intensive U.S. industries. This, of course, does not prove that EP regulations has no impact upon international direct investment flows.

Second, he also examines inter-state location decisions and finds that they are not highly correlated with a "quality-of-life" indicator which includes environmental quality as a determinant. However, this indicator does not necessarily reflect the regulatory burden imposed upon firms in each state.

An earlier study of induced locational shifts by multinational corporations is reported in Gladwin and Welles (1976). Basing their analysis on a survey of trade journals, they find little evidence to suggest that EP regulations affect location decisions of firms based in any country. The only examples they were able to find of such an impact consisted of certain copper smelters and petroleum refineries in the U.S., some chemical plants in a few European countries, and some heavy industry in Japan as part of its industrial decentralization.

Gladwin and Welles conclude that much of the concern over industrial relocation is based upon a lack of understanding of the determinants of direct foreign investment. They stress that industrial organization considerations continue to dominate investment location decisions. Furthermore, lower control costs in most "pollution havens" are more than offset by higher political risks and poor availability of inputs.

Judging from these few studies, it would appear that EP regulations have had little impact upon industrial location. However, their methodological frameworks are quite simplistic and they were conducted about 10 years ago. Since international economic conditions are rapidly changing, further research is recommended.

International Competitiveness

- Deterioration
- Improvement
- Change in the Composition of International Trade

International competitiveness is defined as "success in the world market." It is a relative variable comparing market success of one country to its foreign competitors. Many measures of competitiveness have been developed, including relative profitability, world market shares, and current account balances.

Whereas in the 1970s and early 1980's, inflation and unemployment were the primary concerns of public policy-makers, international competitiveness has fast become the yardstick by which policy options are being evaluated. As with the concern over the plant relocation incentives provided by EP regulations, concern over international competitiveness has risen to prominence with increased globalization. In fact, plant relocation could be analyzed as international competitiveness in the market for direct foreign investment.

It is important to realize that competitiveness is not independent from the other industrial effects discussed above. Since most of the factors discussed are *determinants* of competitiveness, it should be thought of as another "higher order" effect. Productivity or unit labour costs, economies of scale, R&D patterns, etc are integral to any discussion of competitiveness. For example, if EP regulations reduce productivity, then ceteris paribus competitiveness may decline. If regulations result in cost-reducing process redesign or innovative product reformulation, then competitiveness may improve. Since different industries are subject to varying degrees of regulation, changes in competitiveness should be heterogeneous across industries.

There is an abundant literature discussing competitive *strategies*, that is ways to influence the *determinants* of competitiveness (e.g., Porter, 1980). Much less empirical work has been undertaken. The empirical work which has been done on the relationship between EP regulations and competitiveness has used trade performance as the measure of competitiveness. Trade effects have been estimated using macroeconometric models, as well as import-export

demand models.[4] Many use input-output matrices to capture both the direct effects on the output of regulated industries and the indirect effects on the output of industries which use the former as intermediate inputs.

Table 3 summarizes the findings of these studies. Overall, the results are quite mixed and no conclusions emerge. Special note should be made of the work of Robison (1988). In addition to estimating the net trade effects for the country as a whole, this study also provided confirmation that EP regulations have altered the composition of U.S. trade. Goods with lower abatement costs had increased their share of U.S. trade at the expense of goods with higher abatement costs.

Table 3
Impact of Environmental Protection Regulation
Upon the Balance of Trade

Study	Change in Net Exports
D'Arge (1974)	+
Chase Econometric Assoc. (1972)	-
Kalt (1988)	-
O.E.C.D. (1985)	+
Robison (1988)	-
Tobey (1990)	nil
Walter (1973)	-

Exports of Control Technology

- To foreign subsidiaries
- To other foreign firms

Trade effects have been discussed above as a measure of the impact of EP regulations upon international competitiveness. It is worthwhile, however, to discuss separately the hypothesis that regulated firms may develop export markets for

[4] Many theoretical models of the impact of EP regulations upon international trade have also been developed. See, for example, Ford and Magee (1972), Richardson and Mutti (1976) and McGuire (1982)

Trade journals and, in particular, publications relating specifically to environmental issues contain much anecdotal evidence that some firms have generated foreign revenue from its expertise in pollution control. For example, by 1980 many major U.S. regulated firms, including Exxon, Dow Chemical and 3M, had added divisions which sell environmental protection goods and services (Royston, 1980). As a result of pollution control innovations developed in its U.S. facilities, 3M generated further net savings of $3.5 million in overseas subsidiaries.

Caution, however, is necessary in interpreting this evidence. Publication of such stories may be more politically motivated than a true indicator of significant export by regulated firms of control technology. Since no empirical research has been published on the issue, conclusions are impossible.

Current research may shed some light on the matter. Dr. Carl Pasurka of the Office of Policy, Planning and Evaluation, Environmental Protection Agency is undertaking a comprehensive search of trade statistics in order to estimate exports of control technology. Since many pollution control devices are deeply hidden within the Standard Industrial Classification system, the work is being conducted at a highly disaggregated level. Once complete, a clearer picture of trade in pollution abatement and control goods and services should be available.

4.22 Effects of EP Regulation on the External EP Industry

One of the most obvious positive effects upon measured output resulting from EP regulations has been the growth of companies producing environmental protection goods and services. Although conflictin finitions of the external EP industry exist, at a minimum it encompasses developers and manufacturers of pollution control technology, waste disposal, recovery, and recycling firms, and environmental consultants.

There are many studies which attempt to measure the size of the external EP industry. These are usually of a primitive nature. After defining the industry -- often dictated by what data is available, the firms designated as part of the EP industry are simply summed to produce aggregate measures of the industry's size. Output and employment levels have tended to be the focus of such studies. Although exports of EP goods and services have also been the subject of much discussion, data constraints have prevented accurate quantification of this aspect of the industry. Table 4 below presents some representative examples of external EP industry studies.

These studies can be criticized on a variety of grounds. First, little analysis is typically offered. While summing output and employment across firms designated as the external EP industry may have some limited uses, it says little about the interdependency between regulators, the external EP industry and the internal EP industry. All three agents play key roles in achieving environmental protection objectives, but the way they interact to determine the size of the external EP industry remains largely unknown.

Second, by focusing upon output and employment, many of the most interesting questions regarding the external EP industry are neglected. Regulations do not merely determine the demand for EP goods and services, but they also shape the nature of that demand. Therefore, it is reasonable to hypothesize that fundamental characteristics of the industry can be influenced

by the design, monitoring and enforcement of the regulations. Just as regulations may affect all aspects of decision-making in regulated firms, so too might the behaviour of external EP firms be affected.

The following are specific examples of hypothesized effects of EP regulations upon the external EP industry which have been neglected.

- **Trade Effects**

  Can regulations be designed so as to encourage the export of EP goods and services? Are exports of EP goods and services encouraged by having similar regulations across countries? As Porter (1991) suggests, does early introduction of EP regulations create a dynamic domestic external EP industry which can export their products to countries introducing regulations at later dates?

- **R&D/Innovation Effects**

  Do EP regulations encourage regulated firms to try innovative compliance strategies, or do regulations encourage regulated firms to utilize traditional control technology? Does the permitting system for new technology raise the cost of innovation by imposing long pre-market testing requirements?

- **Market Structure Effects**

  Do engineering-based standards create monopolies for firms producing control equipment designated as BAT or BPT? Do changes in regulations create extreme fluctuations in the market conditions faced by the external EP industry? Do such fluctuations make firms more susceptible to closure or foreign takeover?

- **Implications for Regulators**

  Do the magnitudes of the above effects justify using impact upon the external EP industry as one criterion in decisions regarding regulation design, monitoring and enforcement? Might development of a strong EP industry be essential to meeting long-term environmental protection objectives?

A final issue which is neglected by most studies of the EP industry is the contribution of the industry to economic efficiency. Many analysts argue that, although the industry is measured within the national accounts, it represents a distributional effect only. Industrial inputs are being re-allocated from the production of consumer goods to the production of non-marketed goods in the form of improved environmental quality. Therefore, improved environmental quality is the true measure of the benefits of EP regulations and not the output of the EP industry.

Table 4
Estimates of the Size of the EP Industry

Study	Employment	Output	Exports
A.D. Little (1972)	43,000[1]	na	na
Environmental Business Journal (1991)	na	$132 billion	na
Hannon and Bezdek (1974)	73,400[2]	na	na
Lorenz et al. (1987)3	na	$2 billion	na
Lyman and Clarke (1991)	960,000	$118 billion	na
Management Information Services[4]	2,963,400	$106 billion	na
U.S. Department of Labor (1975)[5]	33530	na	na

Notes:

1. The difference in 1980 employment levels in the pollution-abatement equipment industry with and without 1972 U.S. Federal air and water pollution control regulations.

2. This is the number of jobs created for *each* $1.13 billion worth of expenditures on water resource investments. The same expenditure on the construction of waste treatment plants would generate 95,600 jobs.

3. Lorenz et al. (1987) examine the commercial hazardous waste industry only.

4. As reported in Lyman and Clark (1991). This includes both the direct jobs created within the EP industry, as well as the spinoff jobs generated in local economies.

5. From expenditures on pollution control and abatement by the Federal government only, that is jobs resulting from expenditures of private firms are excluded. Of these 33,530 jobs, 53 percent were direct public sector jobs, while the remaining were created indirectly through the purchase of goods and services. This implies that an average of 66.9 jobs were generated for each million dollars spent by the Federal government for pollution control and abatement.

4.2.3 Effects of EP Regulations on Other Industries

Firms which incur compliance costs and firms which produce primarily EP goods and services are affected most directly by EP regulations. However, these firms are not isolated from the rest of the economy. The many ways in which firms and sectors are interconnected ensure that the effects of EP regulations are felt throughout the economy.

Indirect effects upon firms and industries can occur through a variety of channels. Examples of these links include the following.

- Many regulated firms produce intermediate inputs such as iron, steel, non-ferrous metals and chemicals. These are then bought by other firms to produce final consumption goods. If regulations result in increased prices of intermediate inputs, then pollution control costs are in effect transmitted to other industries which do not necessarily produce regulated contaminants.

- Regulations may also change the demand for various factors of production. Regulations may result in regulated firms decreasing their output, hence requiring fewer inputs. Alternatively, compliance activities may require certain inputs, thus increasing factor demand. Therefore the production costs f any firm buying from these factor markets may be affected by EP regulations.

- Owners of factors of production are also consumers. To the extent that environmental regulations affect factor markets, such as increasing or decreasing the unemployment rate, the demand for most products may be affected.

- Many firms operate in markets in which demand is affected by environmental quality. Since EP regulations are (hopefully) effective in improving environmental quality or reducing environmental deterioration, these firms will be affected.

Recognizing that the impact of EP regulations may be felt throughout the economy, and that this impact would likely differ widely across industrial sectors, some attempts have been made to estimate these cross-industry effects. These studies also include regulated industries. However, because they are intended to encompass many or all sectors of the economy, they have not been discussed above.

We now elaborate upon the hypothesized effects on other industries and review existing, relevant empirical research.

General Equilibrium Price Effects

- Increased production costs to industries which consume the output of regulated industries

Many of the regulated industries which incur the greatest pollution control costs do not produce goods for final consumption. Rather the output of these industries are used as intermediate inputs by other industries. A clear example is the use of iron and steel by auto manufacturers. Since EP regulations may raise the price of intermediate inputs produced by regulated industries, the production costs of other industries may rise.

There have been many studies which trace the spread of pollution control costs incurred by regulated industries through other industries. The input-output framework is the most common analytic device used for such studies. By assuming that the production technology of all industries is linear and constant over time, control costs are allocated across all production. Examples of this type of analysis include Giarratani (1974), Pasurka (1984) and Lieu (1986).

Table 5 summarizes the results of these studies. Percentage price increases are provided for the industries which register the highest and lowest effects.

The highest price increases are about 10 percent and occur in industries which incur large direct costs as a result of EP regulations or those which are heavy users of intermediate inputs from regulated industries. Lowest price increases indicate that some industries are not affected at all.

Note that these do not always concur with each other. Significant differences in methodology can yield quite different results. This implies that caution should be used in interpreting these empirical studies, and that quoting figures without mentioning assumptions behind their derivation may be misleading.

Table 5
Effects of EP Regulations on Output Prices Across All Industries

Study	Regulation (effect on national economy unless stated otherwise)	Highest Price Increase		Lowest Price Increase	
		Sector	Price Increase	Sector	Price Increase
Evans (1973)	All	Auto	10.8%	Food	0.9%
Giarratani (1974)	Federal Particulate Stds. in West Virginia	Primary Metals	11.2%	Instruments & Products	0.1%
Hollenbeck (1979)	1970 CAA Amendments[1]	Public Utilities	7.0%	Industrial Machinery	-0.7%
Jorgenson and Wilcoxen (1990)	All	Motor Vehicles	8.8%	Crude Petroleum & Natural Gas	0.9%
Lieu (1986)	NO_x iin Southern CA	Petroleum Refining	0.5%	Paving Mixtures	0.0%
Pasurka (1984)	All	Electric, Gas, Water & sanitary Services	6.6%	Real estate	0.1%
Richardson and Mutti (1976)	All[2]	Electric, Gas, Water & Sanitary Services	5.2%	Crude Petroleum & Natural Gas	0.1%

Notes:

1. "Steady state" simulation uses compliance capital recovery costs.

2. Results reported assume industries respond to demand changes resulting from initial price increases.

General Equilibrium Output Effects

- Substitution away from output of regulated industries

The initial price effect of EP regulations occurs in the regulated firms. This will result in relative price shifts favouring industries which incur few or no pollution control costs. Consumers, whether they be buyers of final goods or buyers of intermediate outputs, are expected to decrease their demand for goods produced by high-cost industries.

As described in the previous section, indirect price increases may also occur in industries using intermediate inputs produced by regulated firms. This will induce shifts in demand away from non-regulated industries which buy the output of regulated firms. Non-regulated industries will then require fewer inputs including those produced by the regulated industry, thus decreasing demand in the regulated industry even further.

In this way, the entire pattern of production and consumption may change as a result of EP regulations. The magnitude of these shifts depend upon the demand elasticities of the various industries and the size of the original pollution control costs.

Studies which estimate output effects across industries are summarized in Table 6. Similar to Table 5 above, findings are quite varied due to methodology and general conclusions are difficult to draw.

Table 6
Effects of EP Regulations on Output Across All Industries

Study	**Regulation** (effect on national economy unless stated otherwise)	**Largest Decrease in Output**		**Smallest Decrease (Largest Increase) in output**	
		Sector	Change	Sector	Change
Evans (1973)	All which were to be met by 1976	Auto	-5.4%	Food (Baking)	-0.1%
Hollenbeck (1979)	1970 CAA Amendments[1]	Public Utilities	-1.9%	Primary Steel & Iron[2]	+ 1.2%
Jorgenson and Wilcoxen (1990)	All	Motor Vehicles	-15.0%	Furniture & Fixtures	+ 2.0%
Richardson and Mutti (1976)	All3	Electric, Gas, Water & sanitary Services	-5.2%	Crude Petroleum & Natural Gas	-0.1%

Notes:

1. "Steady state" simulation uses compliance capital recovery costs.

2. The rise is due to increased demand for iron from the industrial machinery sector in order to produce pollution control equipment.

3. Results reported assume industries respond to demand changes resulting from initial price increases and that control programs are financed by the polluter pays principle.

Environmental Quality of Inputs

- Reduce maintenance costs for structures
- Change agricultural, fishing and forestry yields
- Reduce water purification costs

Environmental quality may influence production costs for many firms. Many studies have estimated the costs of repairing soiling and structural deterioration resulting from airborne particulates and sulfur dioxides. Crop yields and forestry growth rates may depend upon the content of sulfur and nitrogen oxides in rain water. Similarly, fishing yields in areas such as the Great Lakes have been affected by pollutant contamination levels. Finally, the costs of water purification by both public and private facilities may also fluctuate with pollution levels.

These effects are effects upon industry, and hence should be included in this report. However, they do differ in that they are not the results of the cost of pollution control working its way through the economy. Typically the impact of increased environmental quality is estimated as part of benefits calculation, and as such are not discussed in detail here.

Environmental Quality as a Determinant of Demand

- For health care services
- For recreational goods and services
- For real estate

The previous impact briefly discussed cases where environmental quality appeared in firms' cost functions. Now we turn to an equally brief overview of the case where environmental quality appears in certain industries' *demand* functions.

That environmental quality should have an effect upon the health care industry is no surprise. Since protection of public health is one of the primary motivations behind EP regulations, environmental quality is obviously a determinant of the demand for health care services. This example has been widely, though most certainly not conclusively, studied for a variety of health problems and pollutants.

Environmental quality has also been examined as a determinant of demand in the recreational and real estate industries. This forms the basis of hedonic pricing studies. This approach to measuring consumers' willingness-to-pay for improved environmental quality estimates the contribution of differences in environmental quality to differences in the costs people incur for housing and recreational activities.

Similar to the previous discussion, these effects are generally considered user benefits rather than an impact of compliance costs upon the economy.

4.2.4 Effects of EP Regulation Upon the Aggregate Economy

The effects discussed above have focused upon the details of how firms and industries function. By examining the impacts of EP regulations upon individual activities of firms, such as factor substitution, R&D, and waste recovery, sector impacts could be estimated by aggregation over firms. This has been termed a "bottom-up" approach by Haveman and Christainsen (1979).

An alternative approach has been to estimate aggregate impacts using aggregate models directly. This "top-down" is most clearly displayed by macroeconometric simulations. The general methodology employed by such studies is fairly simple. The models are examined to determine where pollution control expenditures might manifest themselves in the economy and what might occur in their absence. This is largely done by netting out the employment and investment requirements of EP regulations from the non-regulation scenario.

Macroeconometric simulations possess a number of advantages over other approaches to measuring the impacts of EP regulations. These include:

- the general equilibrium nature of their results;
- their ease at modelling different regulatory implementation schedules; and
- the diverse set of variables for which effects are determined.

These advantages are offset by the following shortcomings:

- pollution control costs are pre-determined and hence are independent of output;
- the impacts of costs are assumed to be the same regardless of by which industry they are incurred; and
- many of the hypothesized effects previously discussed are ignored.

With these points in mind, Table 7 summarizes some of the key findings of macroeconomic studies on key aggregate variables. Ignoring differences in variable definitions and methodologies, these studies indicate that on average EP regulations tend to increase the aggregate price level and lower productivity. The effects on employment, output and the balance of trade are indeterminate.

Table 7
Effects of EP Regulations upon Selected Aggregate Economic Variables

Study	Employment	Output	Productivity	Price Level	Trade Balance
CBO (1985)	+	+	na	-	na
Chase (1972)	-	-	na	+	na
DRI (1978)[1]	+	+,-	-	+	-
DRI (1981)[1]	+	+,-[2]	-	+	-
Evans (1973)	nil	+,-[2]	na	+	-
Hollenbeck (1979)	-	+,-[3]	na	+	na
Jorgenson and Wilcoxen (1990)	na	+	na	+	na
OECD (1985)	+	+,-[2]	na	+	+

Notes:

1. As discussed in Portney (1981).

2. Initial increases are followed by future decreases. For Evans (1973), real GNP is reported.

3. Gross output decreased when full pollution abatement capital expenditures were incurred in one year, but increased if pollution abatement capital recovery expenditures were used. Only the impact of the 1970 Clean Air Act Amendments were simulated.

5.0 A Research Agenda for the Agency

(to be completed)

Appendix A

Bibliography

Allison, G. (1977) Are Jobs Really the Price of a Clean Environment? Washington: League of Women Voters.

Ashford, N. et al. (1979) “Environmental/Safety Regulation and Technological Change in the U.S. Chemical Industry" Report to the National Research Foundation, Grant No. PRA 76-21368.

Barbera, A. and V. McConnell (1986) “Effects of Pollution Control on Industry Productivity” Journal of Industrial Economics 35:2 (December):161-172.

Barbera, A. and V. McConnell (1990) “The impact of Environmental Regulations on Industry Productivity: Direct and Indirect Effects” Journal of Environmental Economics and Management 18:1 (January):50-65.

Boyd, R. and N.D. Uri (1991) “The Cost of Improving the Quality of the Environment” Journal of Policy Modeling 13:1, 115-140.

Brashares, E. et al. (1980) “Industrial Air and Water Pollution Regulations and Innovation” Report prepared for the Office of Technology Assessment, Resources for the Future, Washington.

Campbell, M. and W. Glenn (1982) Profit from Pollution Prevention Toronto: Pollution Probe.

Chase Econometric Associates (1972) "The General Economy" in The Economic Impact of Pollution Control: A Summary of Recent Studies Washington D.C.: Council on Environmental Quality.

Christainsen, G.B. and T.H. Tietenberg (1985) “Distributional and Macroeconomic Aspects of Environmental Policy" in Handbook of Natural Resource and Enerey Economics Vol. 1, A.V. Kneese and J.L. Sweeney, eds. New York: North-Holland.

Congressional Budget Office (1985) Environmental Regulation and Economic Efficiency Washington, D.C.: CBO.

Crandall, R.W. (1981) “Pollution Controls and Productivity Growth in Basic Industry” in Productivity Measurement in Regulated Industries, T.G. Cowing and R. Stevenson eds. New York Academic Press.

D’Arge (1974) “International Trade, Domestic Income and Environmental Controls: Some Empirical Estimates" in Managing the Environment: International Economic Cooperation for Pollution Control A.V. Knees, ed.

Davies, J. (1983) "The Effects of Federal Regulation on Chemical Industry Innovation” Law and Contemporary Problems 46:3 (Summer):41-58.

Denison, E.F. (1984) “Accounting for Slower Growth: An Update” in International Comparisons of Productivity and Causes of the Slowdown J.W. Kendrick, ed. Cambridge, Mass.: Ballinger.

Environmental Business Journal “The Industry Takes Shape” Environmental Business Journal 4:4 (April):1-8.

Environmental Protection Agency (1982) "Third Quarter Report of the Economic Dislocation Warning System” Washington, D.C.: EPA.

Environmental Protection Agency (1987) “Economic Impact Analysis of Effluent Limitations and Standards for the Organic Chemical, Plastics and Synthetic Fibres Industry" Washington: EPA.

Evans, D. ‘The Differential Effect of Regulation Across Plant Size: Comment on Pashigian” Journal of Law and Economics 29:1 (April):187-199.

Koch, C. and R. Leone (1979) “The Clean Water Act: Unexpected Impacts Upon Industry" Harvard Environmental Law Review 3 (May):84-111.

Kohn, R. (1985) “A General Equilibrium Analysis of the Optimal Number of Firms in a Polluting Industry” Canadian Journal of Economics 18:2 (May):347-354.

Kohn, R. (1986) "The Rate of Emission and the Optimal Scale of the Polluting Film” Canadian Journal of Economics 14:3 (August):574-581.

Kohn, R. (1988) “Efficient Scale of the Pollution Abating Firm” Land Economics 64:1 (February):53-61.

Kopp, R. and V.K. Smith (1981) “Productivity Measurement and Environmental Regulation: An Engineering-Econometric Approach” in Productivity Measurement in Regulated Industries Thomas Cowing and Rodney Stevenson eds. New York: Academic Press.

Kutscher, R., J. Mark and J. Norsworthy (1977) “The Productivity Slowdown and the Outlook to 1985" Monthly Labour Review 100:5 (May):3-8.

Lieu, T. (1986) “Impacts of Air Pollution Costs: An Input-Output Approach” Annals of Regional Science 20:2 (July):55-65.

Link, A. (1982) “Productivity Growth, Environmental Regulations and the Composition of R&D” Bell Journal of Economics 13:2 (Autumn):548-554.

Little, Arthur D. (1972) "The Impact of the Pollution Abatement Equipment Industry" Report prepared for the U.S. Environmental Protection Agency, Washington, D.C., December.

Lorenz, John, William Lorenz and Allison Ropes (1987) 1987 Update - Hazardous Waste Control Industry Outlook Concord, N.H.: William T. Lorenz & Co.

Lyman Clark, Environmental Economics Associates (January, 1991) "The Environmental Industry in the United States” Report to the Economic Analysis and Research Branch, Office of Regulatory Management and Evaluation, Environmental Protection Agency, Washington D.C.

Magat, W. (1978) “Pollution Control and Technological Advance: A Dynamic Model of the Film” Journal of Environmental Economics and Management 5:1 (March):1-25.

Magat, W. (1979) "The Effects of Environmental Regulation on Innovation” Law and Contemporary Problems 43:1 (Winter-Spring):4-25.

Maloney, M. and R. McCormick (1982) “A Positive Theory of Environmental Quality Regulation” Journal of Law and Economics 25:1 (April):99-123.

McGuire M. (1982) “Regulation, Factor Rewards and International Trade” Journal of Public Economics 17, 335-354.

McKenney, M. (1991) “Recycling for Money "Canadian Business 11:3 (July):26-7.

Norsworthy, J.R., M.J. Harper and K. Kunze (1979) "The Slowdown in Productivity Growth: Analysis of Some Contributing Factors” Brookings Papers on Economic Activity 2, 423-431.

O.E.C.D. (1985) The Macroeconomic Impact of Environmental Regulation Paris: O.E.C.D.

Organization for Economic Cooperation and Development (1985) The Macroeconomic Impact of Environmental Regulations Paris: OECD.

Pashigian, B. (1984) “The Effect of Environmental Regulation on Optimal Plant Size and factor Shares” Journal of Law and Economics 27 (April):1-18.

Pasurka, C. (1984) "The Short-Run Impact of Environmental Protection Costs to U.S. Product Prices” Journal of Environmental Economics and Management 11:4 (December):380-390.

Pittman, R. (1981) “Issues in Pollution Control: Interplant Cost Differences and Economies of Scale” Land Economics 57:1 (February):1-17.

Portney, P. (1981) "The Macroeconomic Impacts of Federal Environmental Regulation” Natural Resources Journal 21:3 (JuIy):459-488. Porter, M. (1980) Competitive Strategy New York Free Press.

Renner, M. (1991) Jobs in a Sustainable Economy Worldwatch Paper 104. Washington: Worldwatch Institute.

Richardson, J. and J. Mutti (1976) “Industrial Displacement Through Environmental Controls: The International Competitive Aspect” in Studies in International Environmental Economics I. Walter, ed. New York: John Wiley & Sons. .

Robison H.D. (1988) “Industrial Pollution Abatement: The Impact on Balance of Trade” Canadian Journal of Economics 21:1 (February):187-199.

Royston, M. (1980) “Making Pollution Prevention Pay” Harvard Business Review 58:6 (Nov.-Dec.):6-22.

Sims, W. (1979) "The Response of Firms to Pollution Charges” Canadian Journal of Economics 12:1 (February):57-74.

Sims, W. and J.B. Smith (1983) “The Impact of Environmental Regulations on Productivity Growth" Discussion Paper No. 241, Economic Council of Canada

Tobey (1990) "The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test” Kyklos 43:2, 191-209.

Thurow, L. (1980) "The Productivity Problem” Technology Review 83:2 (November/December):40-51.

Walter (1973) "The Pollution Content of U.S. Trade” Western Economic Journal

Waker, I. (1982a) “International Economic Repercussions of Environmental Policy: An Economist’s Perspective” in Environment and Trade S.J. Rubin and T.R. Graham, eds. Totowa, N.J.: Allanheld, Osum & Co.

Walter, I. (1982b) “Environmentally Induced Industrial Relocation to Developing Countries” in Environment and Trade S.J. Rubin and T.R. Graham, eds. Totowa, N.J.: Allanheld, Osum & Co.

U.S. Department of Labour (1975) Impact of Federal Pollution Control and Abatement Expenditures on Manpower Requirements, Bulletin 1836 Washington D.C.: Government Printing Office.