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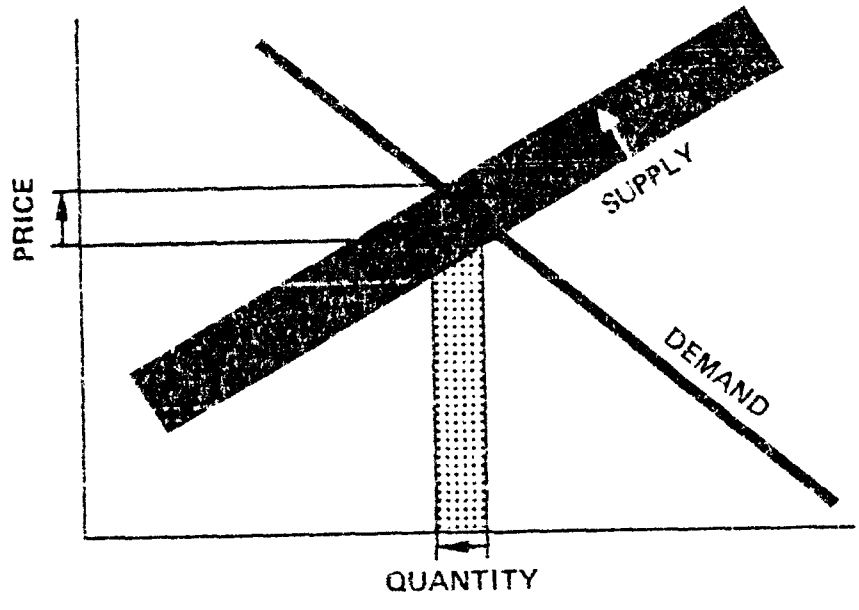
Economic Analysis of Proposed Effluent Standards and Limitations for the Pharmaceutical Industry



Economic Analysis of Proposed Effluent Standards and Limitations for the Pharmaceutical Industry

for

U.S. Environmental Protection Agency
Office of Analysis and Evaluation
Washington, DC 20460

by

Meta Systems Inc
Cambridge, MA

Under Contract No.
68-01-6162

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Preface

The attached document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency ("EPA"). The purpose of the study is to analyze the economic impact which could result from the application of alternative BPT, BCT, BAT, PSES, NSPS and PSNS limitations and standards established under the Federal Water Pollution control Act (the Act), as amended.

The study supplements the technical study ("EPA Development Document") supporting the proposal of regulations under the Act. The Development Document surveys existing and potential waste treament control methods and technology within particular industrial source categories and supports proposed limitations based upon an analysis of the feasibility of these limitations in accordance with the requirements of the Act. Presented in the Development Document are the investment and operating costs associated with various alternative control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the required application of various control methods and technologies. This study investigates the effect of alternative approaches in terms of price increases, effects upon employment and the continued viability of affected plants, and other competitive effects.

The study has been prepared with the supervision and review of the Office of Analysis and Evaluation of the EPA. This report was submitted in fulfillment of Contract No. 68-01-6162, by Meta Systems Inc. This report reflects work completed as of November 1982.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of proposed rule making. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during proposed rule making proceedings necessary to establish final regulations.

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Section 1

Executive Summary

1. Introduction

As required by the Clean Water Act, this study presents the economic effects of the proposed limitations and standards on the pharmaceutical industry. This study was prepared under the supervision of the Office of Analysis and Evaluation, U.S. Environmental Protection Agency. This Executive Summary presents brief descriptions of the other sections of the report. These include:

- o Effluent Limitations and Standards
- o Industry Profile
- o Economic Impact Methodology
- o Economic Impact Results
- o New Source Performance Standards
- o Regulatory Flexibility Analysis
- o Social Costs
- o Limits to the Analysis

The study is based on data from various sources. The Technical Contractor provided estimated treatment costs for each plant under each regulatory option analyzed. Employment for each plant was taken from the 308 Survey. Sales for most plants were provided by Economic Information Systems, Inc. (EIS). For a few of the single-establishment firms, plant sales were provided by Dun and Bradstreet. For the remaining plants, sales were estimated on the basis of employment. Information on products came from a variety of sources, including the 308 Survey, the 1979 Directory of Chemical Producers, state manufacturing guides and studies by other contractors. Company-level financial data were drawn from annual reports and/or 10-K reports. Company product information came from a variety of trade and professional publications, and market studies. Industry-wide information came from academic studies, trade publications, market studies, and the U.S. Census of Manufactures: SIC groups 2831, 2833 and 2834.*

2. Effluent Limitations and Standards

This report analyzes the following proposed regulations:

- o BPT control of cyanide and revision of the TSS limitations for direct discharging plants;
- o BCT control of BOD_5 and TSS for directing discharging plants;
- o BAT control of cyanide and COD for direct discharging plants;

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* See Section 4, Methodology, for a more complete discussion of data sources.

- o PSES control of cyanide for indirect discharging plants;*
- o NSPS control of BOD_5, TSS, COD and cyanide for newly constructed direct discharging plants; and
- o PSNS control of cyanide for newly constructed indirect discharging plants.

3. Industry Profile

The U.S. pharmaceutical industry has been defined by EPA as all establishments producing: biological products classified in Standard Industrial Classification (SIC) 2831; medicinals and botanicals classified in SIC 2833; pharmaceutical preparations classified in SIC 2834; other pharmaceutically active products not covered by SICs 2831, 2833, and 2834; cosmetic preparations in SIC 2844 which function primarily as a skin treatment; and products with multiple end uses at least one of which is as a component of a pharmaceutical preparation. Establishments engaged solely in pharmaceutical research are not included.

U.S. Census of Manufactures data indicate the total value of shipments in 1977 for pharmaceutical establishments classified in SICs 2831, 2833, and 2834 were $14.2 billion with value added equal to $9.9 billion. Value added was one-half of one percent of the $1.9 trillion GNP in that year. Establishments in those SICs employed 80.3 thousand production workers and 156.5 thousand overall.

The industry definition covers the production of both bulk pharmaceuticals (active ingredients) and final pharmaceutical products. The final products of the pharmaceutical industry can be divided into eleven major market areas. Between 1972 and 1977, the average uniform annual growth rate of all eleven groups was 9.3 percent. The group which experienced the most vigorous growth was the vitamins, nutrients, and hematinics category at 17.3 percent annually with shipments of $1.3 billion in 1977. Preparations affecting parasitic and infectious diseases showed the slowest annual growth at 6.3 percent with shipments of $1.3 billion. The 1977 value of shipments of each of the eleven final product groups ranged from $126 million for active and passive immunization agents and therapeutic counterparts to $2.2 billion for preparations affecting the central nervous system and sense organs.

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* A second PSES regulatory option was analyzed, which controlled total toxic organic chemicals as well as cyanide.

The industry cost structure is characterized by large expenditures on R&D and marketing. Approximately 12 percent and 35 percent of sales revenues are directed towards R&D and marketing respectively. Before-tax profits average about 20 percent of pharmaceutical sales; and after-tax profits as a percent of sales are between two and three times greater than the average for other industries.

Pharmaceutical products have two characteristics which effect the price elasticities, level of competition, and market structure. First, for the large number of pharmaceutical products which are patented, competition is greatly reduced and cost increases can be passed on relatively easily in the form of price increases. Second, ethical drugs make up a large percentage of total sales. Since ethical drugs require a prescription, the medical profession influences both total demand and product choice.

The Food and Drug Administration (FDA) has established an approval process in order to insure the safety and effectiveness of drugs entering the market. Additional government involvement is found in the form of: tax incentives, patent and trademark systems, and generic substitution laws.

Foreign involvement in the U.S. pharmaceutical industry and U.S. involvement in world pharmaceutical markets are significant. In 1977, the U.S. was the largest consumer and the second largest net exporter of pharmaceuticals. Foreign involvement in our domestic industry takes the form of imports, partial ownership of U.S. firms, and domestic manufacturing facilities owned by foreign firms.

4. Economic Impact Methodology

Using a demand/supply analysis for each product sector, the economic impacts of the proposed water pollution regulations can be measured in terms of changes in price and production levels. Two barriers preclude such an analysis for the pharmaceutical industry: lack of detailed data and the absence of certain basic market characteristics required for the demand/supply analysis (for example, a competitive market). As an alternative, the methodology assesses the likelihood of establishment closure due to compliance costs. First, all plants are screened to select those plants which are likely to have significant impacts. Those establishments identified by screening are examined in greater detail.

EPA surveyed the industry in the form of a technical 308 Survey. Responses to this survey included 464 manufacturing facilities, of which 60* were direct discharges and 279* were indirect dischargers, with the remaining plants zero dischargers (including such methods as deep-well

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*Including seven (7) plants which are both indirect and direct dischargers.

injection). The Technical Contractor provided estimates of annualized treatment costs for each plant under each proposed regulatory option. See their report for a detailed description of the development of these costs estimates. The economic impact analysis is based on this sample of 464 plants and their estimated costs.

The screening measure compares estimated annualized incremental treatment cost of the proposed regulation to establishment sales. If an establishment incurs costs greater than one percent of sales, further investigation was considered necessary. Because of the high ratio of profits to sales in the industry (over 11 percent), treatment costs less than one percent of sales seemed manageable. Sales data for 202 out of 464 plants were not available. These were estimated based on their reported manufacturing employment after regressing sales against manufacturing employment for similar establishments with data.

After screening, each establishment identified by the cost-to-sales ratio was examined further. Financial positions and lines of business of the parent company along with information on products produced, market positions, and other similar pieces of data on the establishment itself, contributed to a final expectation of the establishment's ability to absorb and/or pass through treatment costs.

5. Economic Impact Analysis

Best Practicable Control Technology Currently Available (BPT)

An estimated six (6) out of the 60 direct dischargers in the 308 sample of 464 establishments may incur costs under the proposed limitations. The total cost of compliance (in first quarter 1982 dollars*) is:

Total capital cost	$2,006,000
Total annualized cost	$ 723,000

No plant closures or significant impacts are expected from this BPT limitation.

Best Conventional Pollutant Control Technology (BCT)

Treatment costs may be incurred by approximately fourteen of the 60 direct dischargers as a result of the proposed BCT regulation for BOD_5

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*Section Five uses 1979 dollars. For comparison purposes, costs are escalated to first quarter 1982 dollars in the Executive Summary, by multiplying 1979 costs by 1.127 to reach 1980 dollars and then by 1.152 to reach first quarter 1982 dollars. The former figure was provided by the Technical Contractor while the latter is based on the ENR Construction Cost Index.

and TSS. The total cost of compliance for these plants (in first quarter 1982 dollars) is:

Total capital cost	$21,837,000
Total annualized cost	$ 8,517,000

There are twelve plants with cost-to-sales ratios greater than one percent, plus a twelfth plant with a ratio exceeding one percent when BPT costs are included. Of these, one small plant might close. The pharmaceutical line at another plant might close while the rest of the plant continues operation. In a third facility the pharmaceutical line might also close or shift to another plant owned by the same firm.

The combined BPT and BCT impacts are nearly the same as those reported for BCT, with no additional closures. If all three facilities/lines shut down, the gross employment loss would be, at most, 143 employees. This is less than one percent of all direct dischargers' employees and less than 0.2 percent of all pharmaceutical manufacturing employees. In general, the price effects would be small, as would any balance of trade impacts.

Best Available Technology Economically Achievable (BAT)

No economic impacts are expected from the proposed BAT limitations because the technology basis for BAT is the same as that for the combined BPT/BCT technologies.

Pretreatment Standards for Existing Sources (PSES)

Two options were considered for PSES: one to control cyanide and one to control both cyanide and volatile organics. The proposed standard requiring cyanide control may affect three plants out of 279 indirect dischargers. The total cost of compliance for cyanide control (in first quarter 1982 dollars) is:

Total capital cost	$1,014,000
Total annualized cost	$ 379,000

There are no expected closures due to the cyanide standard.

The second option was also analyzed but is not being proposed at this time. The second option might affect approximately 47 plants. The total cost of compliance (in first quarter 1982 dollars) is:

Total capital cost	$4,517,000
Total annualized cost	$5,828,000

Six plants have cost-to-sales ratios greater than one percent; however, no plants are expected to close as a result of this second option. There is

a small probability that the pharmaceutical production line at one facility may close while the rest of the plant remains open.

If the threatened production lines do close, up to 44 employees could be affected. This represents about 0.05 percent of the total employment of indirect discharging plants, and about 0.04 percent of all pharamceutical manufacturing employment. In general, price increases and balance of trade impacts are expected to be very small.

New Source Performance Standards (NSPS)

The effluent limitations under NSPS are more stringent than those for existing sources and consequently costs are somewhat higher. However, incremental capital costs associated with NSPS are projected to increase the cost of constructing a new plant by less than two percent. Therefore, this increment is not expected to act as a deterrent either to entry or to making a major modification to an existing plant.

Pretreatment Standards for New Sources (PSNS)

Since the PSNS limitations on cyanide are the same as those for existing sources, there are no incremental costs.

Resource Conservation and Recovery Act (RCRA)

RCRA costs were not analyzed because the sludge generated under the existing BPT limitations, as well as that to be generated as a result of the proposed regulations, is not hazardous and therefore not subject to RCRA regulations.

Regulatory Flexibility Analysis

The differential impact on small businesses was analyzed for each of the regulatory options separately and for the proposed regulations combined. The proposed BPT and PSES regulations have no impacts on small businesses. The proposed BCT regulation has a potential impact on one small business. The combined regulations also have a potential impact on one small business.

Social Costs

Lacking the data necessary to perform a complete social cost calculation, annual social costs are approximated on the basis of the capital and annual O&M costs of compliance. The annual social cost (in

first quarter 1982 dollars) for the proposed regulations are:

BPT:		$ 480,000
BCT:		$6,303,000
BAT:		Zero Cost
PSES:	Cyanide Control	$ 260,000

Limits of the Analysis

The limits of the analysis fall into two broad categories: quality of the data, both technical and economic, and methodological shortcomings and assumptions.

Section 2

Effluent Limitations and Standards

The 1972 Federal Water Pollution Control Act (FWPCA) Amendments (Public Law 92-500) were primarily directed at the control of industrial and municipal wastewater discharges. The legislation and subsequent amendments (Clean Water Act of 1977, Public Law 95-217) require that EPA revise and promulgate effluent limitations and standards for all point sources of pollution. Under FWPCA amendments, EPA must develop technology-based effluent limitations for conventional pollutants (Section 301). Under another part of the legislation (Section 307), EPA must develop effluent standards for individual toxic chemicals and pretreatment standards for indirect industrial discharges to publicly owned treatment works. These permissible levels of pollutant discharge correspond to best practicable control technology currently available (BPT) and best available technology economically achievable (BAT).

The law set specific timetables for achievement of discharge levels corresponding to these levels of treatment (July 1977 for BPT and July 1983 for BAT). These timetables were subsequently revised via the 1977 amendments and distinctions were made among pollutants. The original BPT and BAT regulations were modified by a new regulatory concept, Best Conventional Pollutant Control Technology (BCT), and the universe of pollutants was subdivided into conventional, nonconventional, and toxics.

The law has also provided for toxic effluent standards for new sources and/or discharges to municipal wastewater treatment facilities. These discharge categories are addressed by NSPS (New Source Performance Standards), PSES (Pretreatment Standards for Existing Sources) and PSNS (Pretreatment Standards for New Sources).

On November 17, 1976, the EPA promulgated the interim Final BPT regulations for the Pharmaceutical Industry (40 CFR 439). Under this regulation, each direct discharger of pharmaceutical manufacturing effluent was required to achieve: 90% removal of BOD_5 (long-term average); 74% removal of COD (long-term average); and a monthly maximum TSS of 52 mg/l. The technical basis of this regulation has been provided in EPA 440/1-75/060, published in December, 1976 and known as the 1976 Development Document for the Pharmaceutical Industry.

Option Descriptions*

Best Practicable Control Technology Currently Available (BPT) Effluent Limitations--Revised

EPA is proposing to revise the existing TSS monthly average limits with TSS limits consistent with the 90 percent reduction in BOD_5 loadings and 74

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*Estimates of treatment costs were provided by the Technical Contractor. A complete description of the development of these cost estimates is provided in the Development Document.

percent reduction in COD loadings. The revised monthly average TSS limit is 217 mg/l. EPA is also proposing a limitation on cyanide discharge. The proposed maximum 30 day average is 371 micrograms per liter (ug/l).

EPA is also proposing alternative concentration-based limitations for BOD_5 and COD which are equal to the 30-day average maximum BCT and BAT limitations. This is the result of the fact that in some instances, plants with raw waste loads may be required to achieve lower levels of BOD_5 and COD than required by BCT and BAT if the existing percent reduction limitations are applicable. In any case, the least stringent of the two alternative limitations (percent reduction or concentration-based)) will apply. There are no costs associated with these alternative limitations since, if applied, they would be less stringent than the existing percent reduction-based limitation.

Best Conventional Pollutant Control Technology (BCT) Effluent Limitations

The proposed BCT regulation sets BOD_5 and TSS effluent concentration limitations for all direct dischargers at:

- BOD_5 - 113 mg/l monthly average
- TSS - 104 mg/l monthly average

Best Available Technology Economically Achievable (BAT) Effluent Limitations

BAT proposes a monthly average limit of 570 mg/l for COD and 375 micrograms per liter (ug/l) for cyanide. EPA believes the technology controls that are the basis for the combined BPT/BCT limitations can also serve as the basis for the BAT limitations. Therefore, no incremental costs or impacts are expected.

Pretreatment Standards for Existing Sources (PSES)

Two options are considered: one controlling cyanide and a second controlling both cyanide and total toxic volatile organic compounds. The cyanide limitation is a monthly average of 375 micrograms per liter (for both options). Treatment system costs were estimated for oxidative destruction of cyanide with hypochlorite and for treatment of volative organics using steam stripping. The proposed option is the first option controlling cyanide only.

New Source Performance Standards (NSPS)

The change in effluent limitations over existing sources include the following:

- BOD_5 - 31 mg/l monthly average
- TSS - 72 mg/l monthly average
- COD - 449 mg/l monthly average

Pretreatment Standards for New Sources (PSNS)

This regulation is identical to the limitations proposed for PSES.

Section 3

Industry Profile

The pharmaceutical industry can be distinguished from most other U.S. industries by its intensive research and development efforts, aggressive marketing, higher than average profit margins, and multinational character. A high degree of involvement with regulatory agencies, notably the Food and Drug Administration (FDA), also contributes to its uniqueness. This section discusses these and other aspects of the pharmaceutical industry in order to provide the background necessary for an economic analysis of the effects of the proposed regulations on the industry. The major sections included are: I. Definition of the Industry; II. Industry Size and Cost Structure; III. Pharmaceutical Companies, including lines of business, sales volume, employment, and degree of integration; IV. Establishment Characteristics; V. Final Product Groups, including product sales and growth rates; VI. Government Involvement; and VII. Foreign Trade. A conclusion section, VIII, summarizes important features and trends in the industry.

I. Definition of the Pharmaceutical Industry

The EPA defined the "Pharmaceutical Manufacturing Point Source Category" as those manufacturing establishments having any involvement in the following seven activities:

(1) Production of biological products covered by Standard Industrial Classification (SIC) Code 2831. This primarily includes blood and blood derivatives, vaccines, antitoxins, diagnostics, and other biologicals for human or veterinary use.

(2) Production of medicinals and botanicals covered by SIC Code 2833. Products classified here are synthetic organic and inorganic medicinal chemicals, as well as botanicals produced and shipped in bulk.

(3) Production of pharmaceutical preparations covered by SIC Code 2834. Most of these preparations are ready for consumption in the form of ampuls, tablets, capsules, vials, ointments, medicinal powders, solutions, and suspensions. They include those for human or veterinary use.

(4) Production of products by fermentation, biological and natural extraction, chemical synthesis, and/or formulation which are considered as pharmaceutically active ingredients by the Food and Drug Administration, but which are not covered by SIC codes 2831, 2833, and 2834.

(5) Production of cosmetic preparations included in SIC Code 2844 which function primarily as skin treatments.

(6) Production of products with multiple end uses at least one of which is as a component of a pharmaceutical preparation (SIC 2834). Examples include binders, fillers, and capsules.

(7) Pharmaceutical research which includes biological, microbiological, and chemical research, product development, clinical and pilot plant activities.

Establishments conducting only pharmaceutical research are not covered by the proposed regulations and therefore are not included in the analysis.

There are two large data bases containing information related to this industry. The Bureau of the Census, U.S. Census of Manufactures, defines the pharmaceutical industry in terms of three SIC groups. These are producers of biologicals (SIC 2831), medicinals and botanicals (SIC 2933), and pharmaceuticial preparations (SIC 2834). These data cover 1,243 establishments.

Industry data are also available from EPA's, Technical Study, acquired by an industry survey program (referred to as the 308 Survey).* The need for rapid response required EPA to request information from plants belonging to Pharmaceutical Manufacturers Association (PMA) member firms and non-member firms included in previous EPA guidelines work. This data base included 244 pharmaceutical manufacturing plants with other sites being eliminated because they did not manufacture pharmaceuticals as defined above, were research oriented facilities, or did not respond. Subsequently, EPA produced a revised list containing 540 plant sites of approximately 400 companies and distributed a supplemental 308 portfolio to these additional sites. From these, 220 plants were identified as pharmaceutical manufacturers and added to the original data base.** This data base was also used in the economic impact analysis.

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* A detailed description of these data gathering efforts can be found in Section II of the Development Document.

** Summary of two 308 Surveys:

	Number	Percent of Total Sent	Percent of Total Returned
Questionnaires Sent	982		
Questionnaires Returned	786	80%	
Non-pharmaceutical/ Non-manufacturing	233		30%
Duplicates	54		7%
R&D Only	35		4%
Manufacturing	464		59%

Both the Census and the 308 Survey have shortcomings as data bases for analyzing these proposed regulations. The Census does not provide separate data on facilities covered by the regulations but not included in the three SIC groups considered. In addition, the Census may overestimate the number of production facilities by including separate product lines as separate facilities, while the 308 Survey treats them as a single facility. The 308 Survey does not include all manufacturing sites, but does include the major ones, including some not assigned to the three major SIC groups, and the Survey covers most of the pharmaceutical production. The Census is used as the basis for most of the discussion of this chapter. Since the Census does not include much of the information on the companies owning pharma- ceutical plants desirable for the description of the industry, the company descriptions are based on the 308 Survey.

II. Industry Size and Cost Structure

In the following subsection discussions of industry size and cost structure are presented based on data provided by the U.S. Bureau of the Census.

Size

Table 3-1 presents data available from the 1977 U.S. Census of Manufactures for the industry. It breaks domestic pharmaceutical establishments into categories according to their primary product classifications (not necessarily pharmaceuticals) and then presents various measures of size--number of establishments, number of employees, value added, and value of product shipments.

Number of Establishments. The table shows that 310 pharmaceuticals establishments produce biologicals, 177 produce medicinals and botanicals, and 756 produce pharmaceutical preparations as their primary product. These 1,243 establishments produce 96 percent of the three types of products. The number of facilities producing the remaining four percent is unknown.

Number of Employees. As shown in Table 3-1, these 1,243 pharmaceutical establishments employed 156.5 thousand persons, with a little more than half, or 80.3 thousand, directly involved in production. The majority of these were employed in establishments classified in pharmaceutical preparations (SIC Code 2834). However, because some of the production at these establishments is not pharmaceutically related and no estimate has been made of pharmaceutical employment at establishments in non-pharmaceutical SICs, these employment figures may overestimate pharmaceutical employment.

Value Added and Value of Shipments. Value added and value of shipments are measures of the size of an industry. Value added is derived

Table 3-1

Summary of Selected Measures of Size for the Pharmaceutical Industry

	Pharmaceutical Establishments Classified in:				
	SIC 2831 Biological Products	SIC 2833 Medicinals/ Botanicals	SIC 2834 Pharmaceutical Preparations	All Other SICs	Total for All Pharmaceutical Establishments
Number of establishments	310	177	756	na	na
All employees (1000's)	15.7	14.4	126.4	na	na
Production employees (1000's)	8.8	8.4	63.1	na	na
Value added (mm$)	563	1,162	8,214	na	na
Value of Product Shipments for (mm$):					
1) Biologicals (SIC 2831)	781	244	—[2]	—[2]	1,068
2) Medicinals and botanicals (SIC 2833)	10	1,500	384	312	2,206
3) Pharmaceutical Preparations (SIC 2834)	20	64	9,363	193	9,640
4-7) Other products and activities in the Industry Definition[1]	na	na	na	na	na
Production and miscellaneous receipts not in the Industry Definition	na	na	na	na	na
All products	898	1,890	11,460	na	na

[1] See the Industry Definition.

[2] Withheld by the Census of Manufactures to avoid disclosure of individual operations.

na = not available

Source: Census of Manufactures (1977)

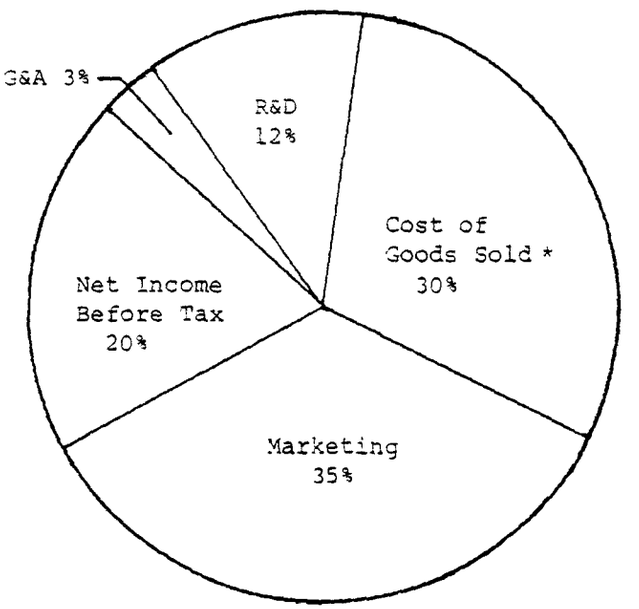
by subtracting the cost of inputs including contract work from the value of shipments (products manufactured plus receipts for services rendered). In 1977, value added for establishments in the three SICs totaled $9.9 billion with the majority ($8.2 billion) in pharmaceutical preparations (See Table 3-1). Value of shipments corresponded, with $0.9, $1.9, and $11.5 billion for establishments in SICs 2831, 2833, and 2834, respectively. Compared to the 1977 gross national product of $1.9 trillion, the pharmaceutical industry contributed at least one half of one percent to national output.

Cost Structure

Breakdown of the Pharmaceutical Sales Dollar. Revenues from pharmaceutical product sales are used to cover six categories of expenditures: research and development (R&D), capital expenditures and production labor, materials cost, marketing, general and administrative expenses (G&A), and before tax net income (see Figure 3-1).

Figure 3-1

Breakdown of the 1976 Pharmaceutical Sales Dollar



* According to Meta Systems' calculations, based on U.S. Bureau of the Census data, Material Costs comprise one-third and Capital Expenditues and Production Labor are two-thirds of the cost of goods sold.

Source: Delphi Marketing Services, Inc.

Perhaps, the most striking feature of the breakdown is the large percentage (20 percent) which goes to net income before taxes. The U.S. Federal Trade Commission reports* that in 1980 pharmaceutical profits were 1.9 times those in the Chemical and Allied Trades Industries (of which the Pharmaceutical industry is a part) and 2.75 times U.S. industry profits as a whole.

Excluding before tax net income, the three largest remaining components are marketing (35 percent), capital expenditures and production labor (20 percent), and R&D (12 percent). Of the remaining sales revenue, the cost of purchasing materials consumed ten percent of the pharmaceutical sales dollar. This includes the purchase of energy and chemicals, plant and animal matter, binders, fillers, and other raw materials required for manufacturing. The last and smallest category, G&A, claims the remaining three percent.

Research and Development R&D is more important to the pharmaceutical industry than it is to most industries. Its role in improving existing products and creating new ones has enabled pharmaceutical companies to continue to earn above average profits. This seems to be especially true for competitors in etnical** drug markets.

R&D expenditures fall into two categories: 1) research for the advancement of scientific knowledge and development of new products and related services; and 2) research oriented to improvement and/or modification of existing products. In 1977, members of the Pharmaceutical Manufactures Association (PMA) spent 80 percent of worldwide R&D on new products, and 20 percent on improvements in existing products.*** In 1979 (the latest available), PMA member firms spent $1,330 million on domestic R&D for ethical drugs, with an additional $300 million of company financed R&D performed outside of the United States. For these PMA member firms, this represented 8.3 percent of their 1979 worldwide human and veterinary ethical drug sales.

These R&D expenditures are spread unevenly among product classes, ranging from 0.4 percent for veterinary biologicals to 16.8 percent for pharmaceutical preparations acting on the central nervous system and sense organs. (See Table 3.2.****) The ratio of ethical R&D expenditure to the

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* Quarterly Financial Report for Manufacturing Mining and Trade Corporations, 1980 q4, U.S. Federal Trade Commission.

** Ethical drugs are those which require prescriptions.

*** According to the 1980 edition of The Kline Guide to the Chemical Industry, PMA member firms account for 95 percent of all domestic sales of prescription drugs.

**** Data for 1977 is the latest year for U.S Census of Manufactures data on which the product breakdown is based. Since the U.S Census of Manufactures covers shipments of domestic establishments only, the U.S. R&D figures are presented rather than global. A global comparison is preferred because R&D benefits and sales cross national boundaries.

Table 3-2

Absolute and Relative Distribution of the
U.S. R&D Dollar for Ethical Pharmaceuticals in 1977

SIC Code[2]	Product Class	Millions of Dollars: Value of Ethical Drug Product Shipments	Millions of Dollars: Domestic R&D	Product R&D as a Percent of Total R&D	R&D as a Percent of Ethical Drug Shipments[3]
28311	Biological Products for	na			na
28312	human use	na	33	3.1	na
28313		na			na
28314	Biological Diagnostics (in vivo) for human use	na	12	1.1	na
28315	Biological Products for veterinary use	na	4	0.4	na
28316	Biological Products for industrial use	na	--1	--1	na
28310	Biological Products not	na	--1	--1	na
28341	(p.p.h.u.) affecting neoplasms, the endocrine system and metabolic diseases	879.5	165	15.7	18.8
28342	(p.p.h.u.) acting on the central nervous system and the sense organs	1675.3	177	16.8	10.6
28343	(p.p.h.u.) acting on the cardiovascular system	745.1	160	15.2	21.5
28344	(p.p.h.u.) acting on the respiratory system	486.8	44	4.2	9.0
28345	(p.p.h.u.) acting on the digestive or genito-urinary systems	725.5	65	6.2	9.0
28346	(p.p.h.u.) acting on the skin	229.8	35	3.3	15.2
28347	Vitamins, nutrient and hematinic preparations for human use	782.9	24	2.3	3.1
28348	(p.p.h.u.) affecting parasite and infective disease	1092.9	196	18.6	17.9
28349	pharmaceutical preparation for veterinary use	248.2	65	6.2	26.2
28340	Pharmaceutical preparations not specified by kind	na	--1	--1	na

(p.p.h.u.) = pharmaceutical prepartions for human use.

na = not available

[1]R&D for SIC Codes 28316, 28310, and 28340 totals $73 million and represents 6.9 percent of total R&D.

[2]SIC 2833 is not included because it includes only bulk medicinals and botanicals.

[3]Value added may be a more relevant parameter for comparison than value of shipments.

Source: Census of Manufactures; 1977-78 PMA Annual Survey; and Meta Systems calculations.

value of ethical product shipments is another measure of the relative emphasis placed on R&D for each product class. These values range from 3.1 percent in vitamins, nutrient and hematinic preparations to 26.2 percent for pharmaceutical preparations for veterinary use, one of the smaller groups. Several explanations may be offered for this variation. A small percentage may indicate a mature product class where continual innovation is difficult or unlikely to enhance a firm's market position. Conversely, a larger percentage might be indicative of intense competition to maintain market shares through innovation or a reasonable potential for breakthroughs into new markets. Biogenetic research is an example of this second case.

Capital Expenditures and Production Labor. Available data indicate that the Pharmaceutical Industry is not capital intensive. In 1977, for establishments classified in SICs 2831, 2833, and 2834, capital expenditures equaled less than six percent of value added (see Table 3-3). In contrast, the Chemical and Allied Products industries is much more capital intensive with capital expenditures of 15 percent of value added. Production labor for the three categories account for ten percent of value added (see Table 3-3) varying from 9.5 percent in pharmaceutical preparations (2834) to 16.1 percent for biologicals (2831).

Table 3-3

Capital Expenditures and Labor Cost for Pharmaceutical Establishments by SIC Groups in 1977

Establishments Classified in:	Expenditures (mm$)	Cost (mm$)	Capital Expenditures	Labor Costs
SIC 2831	35.6	90.5	6.3	16.1
SIC 2833	125.1	127.2	10.8	10.9
SIC 2834	424.1	799.4	5.2	9.5
Total	584.8	997.1	5.9	10.0

Source: 1977 U.S Census of Manufactures.

Marketing. Two distinct advertising and marketing approaches are employed by pharmaceutical companies. The first strategy pertains to sales* of proprietary drugs--drugs which do not require prescriptions and are marketed directly to consumers. Television, radio, newspapers,

* Based on a breakdown of pharmaceutical preparations (SIC 2834) value of shipments, approximately 73 percent are ethical, 25 percent are proprietary, with the remaining two percent being bulk shipments (1977 U.S Census of Manufactures).

magazines, and billboards are the primary means of promoting these products with the general strategy being similar to that for most consumer products.

The second strategy pertains to the sales of ethical products. Since these drugs require prescriptions, the advertising and marketing strategy for ethical products is aimed towards doctors. Advertisements in professional journals and magazines are used to achieve visibility of a product or product line. In addition, a "detail" sales force visits individual doctors as frequently as possible to make a personal sales pitch. Depending on the company and its product line, the detail force can be substantial in size.

The dichotomy in marketing strategies is beginning to blur. Some companies have begun to aim ethical drug ads directly at consumers in the hope that a more aware consumer may influence doctors' prescription habits.*

III. Pharmaceutical Companies

The U.S. Bureau of the Census provides detailed information on individual establishment but only limited information on the individual companies which manufacture pharmaceuticals. Therefore, the following discussion of company characteristics focuses on the sample of companies in the 308 Survey. This data base consists of 464 establishments owned by 243 companies.** Based on a comparison of the 308 Survey data with the Census data, the 308 data contains a larger proportion of big companies and big establishments.

While the majority of the companies associated with the pharmaceutical industry tend to be small, the major portion of pharmaceutical sales are attributable to a relatively small number of large, diversified firms. In the following discussions, companies are characterized in terms of sales and employment, concentration, integration, lines of business and ownership.

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* Newsweek, March 1982.

** The 1977 U.S Census of Manufacturers identifies 249 companies in SIC 2831, 154 in SIC 2833, and 655 in SIC 2834. No information is provided regarding how many companies have establishments in more than one of these SIC groups. Therefore, the total number of firms with establishments in these three SIC groups ranges from 655 to 1058. As discussed earlier, some establishments (and therefore some firms) in these SIC groups may not be covered by these proposed regulations. In addition, the 308 Survey included some establishments covered by the regulation which may not fall in these three SIC groups.

Sales and Employment

The distribution of sales and employment among the 243 companies in the 308 Survey is shown in Table 3-4. As might be expected, these two parameters are highly correlated. Mean employment was 10,500 and mean annual sales was $1.0 billion. Data are frequently unavailable for small privately held companies causing these figures to be overestimates. In addition, some companies own more than one establishment, and these may be non-pharmaceutical establishments, and therefore, the sales and employment figures by company are larger than the same statistics calculated by establishment.

Table 3-4

Company Employment and Sales Distributions for the "308" Survey Companies

Employment		Sales	
Employees	Number of Companies	Sales (MM$)	Number of Companies
0 - 100	98	0 - 100	95
100 - 1,000	42	10 - 100	34
1,000 - 10,000	37	100 - 1,000	33
10,000 - 100,000	43	1,000 - 10,000	43
More than 100,000	4	More than 10,000	5
Missing employment data	19	Missing sales data	33
Total	243	Total	243

Source: 10-K and Annual Reports (Fiscal 1980), Dun and Bradstreet, State Industrial Guides.

Concentration

The degree to which sales are concentrated in a few companies is often measured by the four-firm and eight-firm concentration ratios. A high ratio indicates that a few firms control a large segment of the market, and this may result in less competition. As shown in Table 3-5, this industry is quite concentrated for SIC 2831 and 2833. Pharmaceutical preparations (SIC 2834) is much less concentrated. The U.S Census of Manufactures also publishes concentration ratios for each SIC group. In all cases, the concentration ratios based on the 308 Survey are higher than those provided by the Census. In part this is due to the Census

including a higher proportion of smaller firms than does the 308 Survey. The concentration of firms manufacturing pharmaceutical preparations (SIC 2834) has remained relatively constant since at least 1947 in spite of a trend in the pharmaceutical industry toward fewer and larger companies.*

Table 3-5

Concentration Ratios for Firms Operating
Pharmaceutical Establishments, by SIC Classification

SIC Group	Percent of Total Sales Attributable to Four Largest Firms	Eight Largest Firms
2831	63	83
2833	62	85
2834	28	48

Source: 308 Survey and Meta Systems' calculations.

Concentration ratios are based on total sales rather than pharmaceutical sales alone. However, since the specialization ratios are high in SICs 2831, 2833, and 2834, it is reasonably certain that these concentration ratios apply to pharmaceutical sales as well. (See discussion of specialization under "Pharmaceutical Establishments".)

Integration

Before 1950, few pharmaceutical producing companies were integrated from research and development through to formulation and marketing. With the maturing of research and development, new markets developed and competition between similar patented products became more common. Company level integration increased markedly during the 1960's.** Today, the industry is characterized by large integrated pharmaceutical and cosmetics companies, large chemical companies that are not integrated along pharma- ceutical lines and smaller, less integrated companies. Virtually all of the large pharmaceutical firms are integrated from R&D to marketing, and these large firms dominate R&D in the industry.

* Peter Temin, "Technology, Regulation, and Market Structure in the Modern Pharmaceutical Market," Bell Journal of Economics, Autumn 1979, Vol. 10(2).

** Peter Temin, op. cit..

The 308 Survey provides data on the production processes employed by each firm. Dividing these up into two categories: (1) bulk manufacturing by chemical synthesis, fermentation, or biological extraction, and 2) formulation, a partial measure of integration is possible. See Table 3-6. It is only partial because the R&D segment of the industry has been ignored. By this measure 28.4 percent of the companies are integrated from manufacturing to formulation, while the majority (59.3 percent) only formulate.

Table 3-6

A Measure of Company Integration in the 308 Sample

Activity	Number of Companies*	Percent of Total
Chemical synthesis, fermentation, and/or extraction only	30	12.3
Formulation only	144	59.3
Both	69	28.4
Total	243	100.0

* Two companies lacked production data.

Source: 308 Survey and Meta Systems' calculations.

Lines of Business

Although most companies involved in pharmaceutical activities are principally pharmaceutical companies, some non-pharmaceutical companies are also involved. The latter situation usually occurs when the pharmaceutical production is a by-product of a major line of business. Examples are: chemical companies which also produce medicinal chemicals, such as Tenneco, Inc.'s production of salicylic acid; and a consumer products company, such as General Foods' production of the medicinal caffeine for use in cold remedies.

Of the 243 companies in the 308 sample, 212 are classified by Dun and Bradstreet according to their principal activity. Nearly two-thirds or 141 are principally active in SIC codes 2831, 2833, or 2834. Most of these companies (123) are associated with SIC 2834. SICs 2831 and 2833 were assigned to 4 and 14 companies, respectively. Outside of these three SIC groups, the largest concentration of companies is found in SIC groups 281 (industrial inorganic chemicals), 284 (soap, detergents, perfumes, cosmetics and other toilet preparations), 286 (industrial organic chemicals) and 384 (surgical, medical and dental instruments and supplies).

Ownership

Public companies tend to be larger than private ones in most U.S. industries.* The pharmaceutical industry follows this pattern. Table 3-7 indicates the number of pharmaceutical establishments owned by each firm in the 308 data base. The 93 public companies own 279 pharmaceutical establishments and 152 private firms own only 185 pharmaceutical establishments.

During the past decade, foreign ownership has become an important characteristic of pharmaceutical companies manufacturing in the United States. Table 3-8 shows the ownership status of the 243 companies on the 308 data base, with 24 out of 243 companies having more than ten percent foreign ownership. One third of these represent foreign purchase of stock available in the U.S. The remaining two-thirds are firms which do not file 10Ks and therefore are privately owned, publicly owned with no stock for sale in the United States, or owned by a foreign government.

Table 3-7

Number of Pharmaceutical Establishments
Reported by Private Versus Public Companies

	Number of Pharmaceutical Establishments Owned				
Ownership	One	Two	Three or Four	Five or Greater	All
Public	50	10	10	23	93
Private	138	5	5	2	150
Total	188	15	15	25	243

* The term "public company" is defined as a company required to file 10K reports with the SEC. This definition may exclude foreign public companies with U.S. operations from the public category.

Table 3-8

Extent of Foreign Ownership
in Domestic Pharmaceutical Companies

Percent Foreign Ownership	Publicly Held	Privately Held	All
Greater than 10 percent	8	16	24
Less than or equal to 10 percent	85	134	219
All	93	150	243

Source: 308 Survey, EIS and 10K Reports.

IV. Establishment Characteristics

The following discussion is based on data from the U.S. Census of Manufactures. Establishments are characterized in terms of sales and employment, geographic distribution, specialization, age, and discharge status.

Sales and Employment

The employment distribution across establishments is presented in Table 3-9. Over one-half of the establishments have fewer than twenty employees.

Table 3-9

Establishment Employment Distributions,
for Establishments in SIC Codes
2831, 2833 and 2834

Number of Employees	Number of Establishments	Percent of Total Establishments
1- 4	449	36
5- 19	312	25
20- 99	262	21
100- 499	151	12
500-2499	59	5
More than 2499	10	1
Total	1243	100

Source: U.S. Census of Manufacturers (1977).

Average annual sales and employment have been calculated for each of the three SIC classes (see Table 3-10). SIC 2834 establishments tend to be larger and SIC 2831 establishments tend to be smaller than the average pharmaceutical establishment.

Table 3-10

Average Establishment Sales and Employment

	Sales (MM$)	Employment
SIC 2831	2.9	51
SIC 2833	10.7	81
SIC 2834	15.2	167
Mean for the three SIC groups	11.5	126

Source: U.S. Census of Manufactures (1977).

Geographical Distribution

According to the U.S Census of Manfactures, 41 percent of all pharmaceutical establishments are located in New York, Illinois, and California. Since the Census does not report on plants located in Puerto Rico, the specific number of plants located in Puerto Rico is unknown. However, in 1979, there were 76 drug and pharmaceutical establishments in Puerto Rico.*

Specialization

The specialization ratio is defined here as the ratio of the value of product shipments for products included in the industry definition (i.e., sum of products in SIC 2831, 2833 and 2834) divided by the total value of product shipments at the establishment (See Table 3-11.).**

* The Drug and Pharmaceutical Industry in Puerto Rico, June 1980, Puerto Rico Economic Development Administration, p. 2.

** The U.S. Census of Manufactures defines specialization in a slightly different way. It is the ratio of products in the plant's own SIC group only divided by the total shipments of that plant. The Census specialization ratios are slightly less than the ones calculated by Meta, but also show a highly specialized industry.

Table 3-11

Specialization Ratios of Pharmaceutical Establishments by SIC Classification

Establishments Classified in SIC	Minimum Specialization Ratio (Percent)
2831	96
2833	86
2834	92

Source: 1977 U.S. Census of Manufactures and Meta Systems' calculations.

These ratios demonstrate that pharmaceutical establishments are highly Specialized.

Another measure of specialization provided by the U.S Census of Manufactures shows that of the 310 establishments in 2831, 294 (94.8 percent) have greater than 75 percent of their production within that SIC group. Likewise, 90.4 percent and 90.3 percent of the establishments in SICs 2833 and 2834 have at least 75 percent of their production falling in their primary SIC.

Age

The establishment age distribution is illustrative of industry capital improvement trends. The U.S Census of Manufactures does not provide this information, but data on the start up year was provided for 232 of the 464 establishments in the 308 Survey. According to this data a disproportionately large number of older plants exist in the upper Midwest, while the newer plants are disproportionately concentrated in Puerto Rico, the location of 26 of the 73 establishments which opened between 1970 and 1977.

V. Final Product Groups

For the purposes of the economic analysis, final pharmaceutical products are grouped into eleven major classes following the U.S. Census Bureau classification scheme. The nine major groups from SIC code 2834 (Pharmaceutical Preparations) and two groups from SIC 2831 were selected. SIC code 2833 (medicinals and botanicals) was not included because almost

all products within it are feedstocks to SIC 2834 finished products. The eleven major groups are*:

1. Preparations affecting neoplasms, endocrine system and metabolic diseases.
2. Preparations affecting the central nervous system and sense organs.
3. Preparations acting on the cardiovascular system.
4. Preparations acting on the respiratory system.
5. Preparations acting on the digestive and genito-urinary systems.
6. Preparations acting on the skin.
7. Vitamins, nutrients and hematinic preparations.
8. Preparations affecting parasitic and infective diseases.
9. Preparations for veterinary use.
10. Blood and derivatives for human use.
11. Preparations for active and passive immunization and therapeutic counterparts.

Since the Second World War, the pharmaceutical industry has grown at a rate much greater than the average for all industries. Table 3-12 shows the value of shipments and percent annual change for the major product groups from 1972 to 1977. Value of shipments growth following 1974 had a much larger inflationary component than growth prior to that year. Consequently, it is difficult to determine "real" growth from this table.

Table 3-13 breaks each product class into its ethical and proprietary components. Ethical drugs, those promoted primarily to the medical professions, comprise approximately 73 percent of the total value of shipments of final products (SIC 2834).** Although most pharmaceutical companies produce both ethical and proprietary drugs, the distinction is important for discussing the market characteristics, namely volume growth and price trends, of each product class. Research and patents tend to be more important in the ethical drug markets. In addition, profits in these markets tend to be higher. These factors, combined with marketing differences (targeting the medical professions versus consumers) make the ethical/proprietary distinction a relevant one.

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* A more complete discussion of each of these groups, including important subgroups within each major group and their market characteristics can be found in Appendix B.

** This percentage varies across product classes. Ethical drugs as a percent of total value of shipments ranges from 37 percent for preparations acting on the skin to 99 percent for preparations affecting the cardiovascular system.

Table 3-12

Pharmaceutical Final Product Class Value of Shipments
(current dollars)

Product Class	Value of Shipments Millions of Dollars 1977	1972	Uniform Average Increase (Percent)
Preparations affecting neoplasms, endocrine system and metabolic diseases	900	615	7.9
Preparations affecting central nervous system and sense organs	2231	1636	6.4
Preparations affecting cardiovascular system	751	400	13.4
Preparations affecting respiratory system	896	561	9.8
Preparations affecting digestive and genito-urinary systems	1074	746	7.6
Preparations affecting the skin	621	344	12.5
Vitamins, nutrients and hematinics	1302	587	17.3
Preparations affecting parasitic and infectious diseases	1285	948	6.3
Preparations for veterinary use	354	214	10.6
Blood and blood derivatives for human use	243	126	14.1
Active and passive immunization agents and therapeutic counterparts	126	89	7.2
Total	9783	6266	9.3

Source: 1977 U.S Census of Manufactures Report (Current Industrial Reports figures).

Table 3-13

Breakdown of Final Product Classes Into Ethical and Proprietary Drug Categories (1977).

Product Class	Value of Shipments (mm$)				Value of Ethical Shipments as a Percent of Total
	Ethical	Proprietary	Bulk+	Total@	
Preparation affecting neoplasms, the endocrine system, and metabolic diseases	880	*	20	900	97.8
Preparations affecting the central nervous system and sense organs	1675	538	17	2231	75.1
Preparations affecting the cardiovascular system	745	*	6	751	99.3
Preparations affecting the respiratory system	477	412	7	896	53.2
Preparations affecting digestive and genito-urinary systems	726	336	12	1074	67.5
Preparations affecting the skin	230	378	13	621	37.0
Vitamins, nutrients, and hematinics	783	382	137	1302	60.0
Preparations affecting parasitic and infectious diseases	1093	176	16	1285	85.1
Preparations for veterinary use	248	94	11	354	70.1
Total	6857	2316	239	9414	72.8

+Preparations shipped in bulk, not considered as ethical or proprietary.

*Not applicable.

@Some totals may not equal the sum of the parts due to rounding.

VI. Government Involvement

Regulation to protect the consumer is one of the most important ways the Federal Government influences the pharmaceutical industry. In addition, there are federal regulations governing patent and trademark systems and federal tax incentives which influence industry activities.

Consumer Regulation

The Food and Drug Act of 1906 set up minimum standards of strength, quality, and purity for drugs marketed in interstate commerce.* The first major revision was the Food, Drug, and Cosmetic Act of 1938 which emphasized safety by requiring that any new drug not generally recognized as safe be shown to be so prior to marketing. Today, drugs also have to be demonstrated as effective, as required by 1962 amendments to the Food, Drug, and Cosmetics Act.

The development of a safe and effective drug and the associated regulatory requirements can be characterized in three basic steps. The first is the establishment and investigation of a chemical formulation with a potential for use as a pharmaceutical. This includes testing of the compound's chemical and toxicological properties. Second, if the compound is promising, further tesing is done including the use of animal subjects. If the prognosis is still favorable, an Investigational New Drug (IND) application is filed with the FDA to obtain permission to test the drug on humans. If approved, the third step is clinical testing on human subjects--first on healthy volunteers, then on those suffering from the symptoms or disease to be treated by the drug. After completion of the clinical tests, a New Drug Application (NDA) is filed with the FDA. If approved, the drug can be marketed.

Due to the long process, the tremendous cost involved, and the signficant attrition rate of potential new drugs, R&D has increasingly focused on the potentially lucrative therapeutic markets--problem health areas such as cancer and heart disease--where a successful drug could create a sizable market and earn significant profits.

There is growing concern that these regulations are stifling innovation and thus, reducing the number of important new drugs developed. The relationship is not a simple one. However, steps are being taken to reduce the time involved in the FDA approval process

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* In effect this includes all drugs. The interstate commerce clause of the Constitution is often cited as the authority for Federal regulation.

Another area of federal consumer regulations involves generic drugs. The Court of Appeals for the 8th Circuit recently upheld the FDA's contention that a generic copy of an approved drug with the same active ingredients must be submitted for approval since the inactive ingredients may alter the safety and/or effectiveness of the product.* The generic drug companies do not want to incur the time and expense of this approval process.

Patents and Trademarks

Under the current Patent Act, a patent provides its holder with 17 years of exclusive rights to an innovation. Patents may cover new compositions of matter, as well as new processes or new uses for an old substance (the latter possibility was added with the 1952 Amendment).

Opinion concerning the merits of patents in the pharmaceutical industry vary significantly. On the positive side is the incentive for innovation supplied by the patent. Seventeen years of exclusive rights to a drug formulation can be quite profitable and is often necessary to pay off the resource intensive investment in the development and approval of a new drug, with society benefitting from the proliferation of new products. On the negative side, patents are sometimes viewed as a barrier to entry. New companies are allowed to produce, subject to FDA approval, any of the many drugs not covered by patents; however, these tend to be less profitable. The other major drawback is the tendancy of drug companies to apply for peripheral patents of closely related compounds, thus protecting the main application from imitation by competitors. This barrage of patent applications may dissuade other companies from doing research closely related to a recent discovery.

The Patent Term Restoration Act now pending in Congress is renewing interest in the topic. If passed, it will provide an extension of up to seven years of patents for products (including, but not limited to pharmaceuticals) which have lost part of their patent life in the regulatory approval process. At least part of the motivation behind the proposal springs from the contention that the regulatory process is becoming more and more time consuming and burdensome, thereby reducing the incentive for innovation.

Trademarks are another means of protecting markets. In Inwood v. Ives, 50 U.S.L.W. 4592 (June 1982) the Supreme Court recently recognized the latitude generic manufacturers have in designing their products to look like original brand names.

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* United States v. Undetermined Quantities of Various Articles of the Drug Equidantin, 675 F.2d 994 (8th Cir. 1982).

Tax Incentives

The Federal government also influences the pharmaceutical industry through the enactment of tax incentives. Two incentives are of particular interest: the incentive to attract investment to Puerto Rico and a recent provision to stimulate R&D investment. Many of the larger pharmaceutical companies have established subsidiaries in Puerto Rico to take advantage of Federal and local income tax exemption policies. However, these benefits have been reduced by recent tax legislation. This will result in reduced profitability for plants located in Puerta Rico.

Recent action has also been taken to spur R&D investment. The Economic Recovery Tax Act of 1981 included a provision allowing all companies a 25 percent tax credit on R&D expenditures which represented an increase over average expenditures during a base period.* The credit went into effect July 1, 1981, and will continue through the end of 1985. It is too early to assess its effectiveness in achieving its goal.

Other Involvement

The pharmaceutical industry is affected in a more indirect way by such programs as Medicare and Medicaid and State generic substitution laws. In drugs dispersed under Medicare and Medicaid. Since generics are generally response to the rising cost of national health care programs a Maximum Allowable Cost (MAC) program was initiated in August 1976. The objective was to lower the costs of these programs by setting maximum prices for lower priced this type of action often benefits generic drugs at the expense of brand name drugs.

In a separate effort, state generic drug substitution laws--such as the one in New York--keep the cost of drugs down by requiring pharmacists to substitute generic equivalents in prescriptions except when the physician specifically requires a name brand. This also favors generic drugs.

VII. Foreign Trade

Pharmaceuticals compete in an international marketplace in which the United States is the largest national participant. We are the largest producer, largest consumer (with 16 percent of worldwide sales in 1975), largest developer of ethical drugs (with 24 percent of all new drugs between 1961 and 1973) and second largest exporter of pharamaceuticals.

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* In the first year the base period is the previous year. It is the previous two years in the second and the previous three years for each succeeding year of the credit.

In 1977, the U.S. was second only to West Germany in the sales volume of its pharmaceutical exports and second to Switzerland in net exports (i.e., exports minus imports). In that year, the three industry SIC groups had exports amounting to $1.22 billion, representing nine percent of the total value of shipments for that year of $13.6 billion. Table 3-14 presents the exports by SIC group, over the period of 1977 to 1980. Since many countries have tariffs or other barriers which serve to discourage the import of prepared pharmaceuticals (so as to encourage local manufacturing activity), most U.S. exports are ingredients and intermediate products to be formulated and packaged abroad. Table 3-15 gives the value of imports for the years 1977 through 1980. Exports have exceeded imports by more than 85 percent in each of the four years. The largest class of imported products was bulk antibiotics (part of bulk medicinals and botanicals) constituting 13 percent of all imports in 1980. Another export characteristic is the large number of pharmaceuticals that are not marketed in the United States*. In some instances the market potential for the product may be too limited and in other cases the approval process for sale in the U.S. (such as drugs for tropical diseases) has not been completed.

Most U.S. exports are sent to western Europe, with lesser amounts sent to Japan and Latin America (see Table 3-16). As with exports, most of our imports come from Western Europe (see Table 3-17). Japanese imports have been growing and are expected to increase significantly over the next several years.

Over 40 U.S. companies operate branches or subsidiaries abroad to manufacture and package products for local distribution. Many of these products have no U.S. market. In 1977, the total sales volume of U.S. subsidiaries was $4.9 billion. This volume has been growing rapidly over the past decade (more rapidly than domestic sales) and is expected to continue in the near future. Several foreign corporations have established operations in the U.S. A 1976 Commerce Department survey reported that these subsidiaries tallied U.S. sales exceeding $1.3 billion (about ten percent of U.S. consumption). In addition, many more U.S. companies are owned in part by foreign interests. (As shown in Table 3-8, roughly 10 percent of the companies on the 308 Survey have greater than 10 percent ownership by foreign interests.)

VIII. Summary

The U.S. pharmaceutical industry has been defined, for the purposes of this study, as all establishments producing products classified in SICs 2831, 2833, or 2834 plus all establishments producing other pharmaceutical products classified elsewhere. Since this industry definition extends beyond the scope of conventional sources of information, some sectors of

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* According to a 1976 report by Delphi Marketing Services Inc., three out of every four drugs synthesized in the U.S. are not marketed here.

Table 3-14

Value of Pharmaceutical Exports
(Millions of current dollars)

Year	Total Pharmaceuticals	SIC 2831 Biologicals	SIC 2833 Medicinals/ Botanicals	SIC 2834 Pharmaceutical Preparations
1977	1463.1	138.5	1024.7	299.9
1978	1446.7	187.4	924.1	335.2
1979	1634.1	295.5	999.2	339.4
1980	1966.0	387.5	1157.4	421.1

Source: U.S. Department of Commerce

Table 3-15

Value of Pharmaceutical Imports
(Millions of current dollars)

Year	Total Pharmaceuticals	SIC 2831 Biologicals	SIC 2833 Medicinals/ Botanicals	SIC 2834 Pharmaceutical Preparations
1977	597.2	7.1	556.1	34.0
1978	781.1	9.2	722.2	49.7
1979	810.2	9.0	744.5	56.7
1980	903.4	15.3	826.5	61.6

Source: U.S. Department of Commerce

Table 3-16

World Distribution of U.S. Exports in 1980

SIC Class	Export Value (MM $)						
	Canada	Latin America	Western Europe	Japan	Other Asia	Other World	Total
Biologicals (2831)	23.3	38.7	200.2	99.4	15.2	10.6	387.5
Medicinals and Botanicals (2833)	69.6	173.1	604.5	160.9	71.0	78.3	1157.4
Pharmaceutical Preparation (2834)	49.8	61.1	109.0	80.0	76.9	44.2	421.1
Total	142.7	272.9	913.7	340.3	163.1	133.1	1966.0

Source: U.S. Department of Commerce

Table 3-17

World Distribution of U.S. Imports in 1980

SIC Class	Import Value (MM $)						
	Canada	Latin America	Western Europe	Japan	Other Asia	Other World	Total
Biologicals (2831)	3.8	0.1	10.2	0.7	0.2	0.2	15.3
Medicinals and Botanicals (2833)	15.8	28.9	565.9	118.7	29.2	68.0	826.5
Pharmaceutical Preparation (2834)	0.9	0.4	54.4	3.3	2.4	0.2	61.6
Total	20.5	29.4	630.5	122.7	31.8	68.2	903.4

Source: U.S. Department of Commerce

the industry lack complete data. Based on the U.S Census of Manufactures data for pharmaceutical establishments classified in the three SICs (2831, 2833, and 2834), the total value of shipments in 1977 was $14.2 billion with value added equal to $9.9 billion. Lack of data prevents an estimate of shipments for other establishments covered by the industry definition.

The industry cost structure is characterized by the large proportion of sales revenue directed toward R&D and marketing, along with substantial profit margins. Marketing alone accounts for roughly 35 percent of the sales dollar with much of this aimed at the medical professions. The industry also invests heavily in R&D which is essential for the development of new products and opening of new markets. This innovation, with the protection provided by patents, has contributed to after-tax profits between two and three times greater, as a percentage of sales, than the average for all industries.

The 308 Survey of the pharmaceutical industry consists of 464 establishments owned by 243 companies. The mean 1980 company sales was $1.0 billion.*

All of the 11 major market areas identified experienced growth between 1972 and 1977. The major areas of growth were vitamins, nutrients, and hemantinics. The areas of least growth were active and passive immunization agents and preparations affecting parasitic and infectious diseases.

Other important aspects of the pharmaceutical industry are its relationship with government and its multinational character. In addition to the role of the patent system, the industry is also influenced by the FDA. While this relationship serves to protect consumers, it increases the cost of bringing drugs to market. Foreign involvement in the U.S. pharmaceutical industry and U.S. involvement in world pharmaceutical markets are signficant. In 1977, the U.S. was the largest consumer and the second largest net exporter of pharmaceuticals in that year.

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* As compared to Census data, the 308 Survey has a greater percentage of large establishments.

Section 4

Economic Impact Methodology

This section presents the methodology, including basic assumptions and data sources, used in the analysis of the economic impact of the proposed regulations on the pharmaceutical industry. First, the basic analytic framework is presented, followed by a discussion of the actual impact measures used.

Basic Analytic Framework

The usual measures of the economic impact of a regulation include: changes in price and quantity produced, plant closures or reductions in output and the resulting changes in the employment levels, and changes in the profitability of the firms. Using a demand/supply analysis for each product sector of an industry is a desirable method to produce a base case forecast of price, output, revenues over costs, and capacity utilization for each product sector in the absence of regulations. By adding the treatment costs associated with a specific regulation to the supply curve, the effects of the regulation can be forecast.

This approach was not possible for the pharmaceuticals industry for several reasons. First, price determination in the standard demand/supply analysis assumes a competitive market. Due to patent protection and the need for prescriptions, a large portion of the ethical drugs market is not competitive. Second, neither process economics nor plant- specific production costs are available for pharamaceutical production. An alternative source of information on the cost of production might be the U.S. Census of Manufactures. However, marketing and research and development (R&D) expenditures are extremely large for this industry, making forecasts of future supply functions difficult since they are not simple cases of present supply functions inflated by appropriate indices. Future supply also will be influenced by changes in the Food and Drug Administration (FDA) regulations and procedures, and possible changes in the patent laws extending the life of a pharmaceutical patent.* Third, the future demand for a product group is not a simple extrapolation of past growth rates but also is dependent on the development of new drugs and new uses for existing drugs. Therefore, this assessment of the economic impacts focuses on current conditions, with modifications to reflect expected changes in demand and supply over the next several years.

Assessment of Economic Impacts

In place of a complex model of pharmaceutical production and sales, a two-step analytical procedure was employed. The first step was to screen all plants to identify those which were likely to experience a significant impact

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* See Section 3, Industry Profile, for a more complete discussion.

from the Proposed Regulations. This step consisted of comparing the estimated treatment cost to estimated sales for each plant. Those plants whose costs exceeded one percent of sales moved on to the second step, a detailed analysis to determine their ability to comply with the Proposed Regulations.* The screening and financial analysis was performed separately for each Proposed Regulation, and for the combined costs of regulations.

Sources of Information

Most of the information used in the economic impact analysis was collected from publicly available sources. Additional information was provided by the Technical Contractor and from the technical 308 Survey. The Technical Contractor provided estimated treatment costs for each plant under each regulatory option analyzed.

The economic data can be grouped into three major types: plant-specific data, company data, and industry-wide data.

Plant-Specific Data

Employment for each plant was provided by the 308 Survey. Sales for most plants were provided by Economic Information Systems, Inc. (EIS). For the few plants which belong to single establishment firms and were not covered by EIS, plant sales were provided by Dun and Bradstreet. Sales for the remaining plants were estimated on the basis of employment. To do this, a regression relating sales to employment was estimated for those plants included in the EIS set, and this relationship was used to assign costs to the remaining plants.

Information on the products produced at each plant came from a variety of sources. The 308 Survey provided product information for some plants. Another major source of product information was the 1979 Directory of Chemical Producers, SRI International. In a few cases, this was supplemented by information found in two earlier studies by PEDCo Environmental.** Dun and Bradstreet and state manufacturing guides (including Puerto Rico) provided product information in some cases. For a very few plants, product information was verified by telephone calls to the plants.

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* The choice of one percent is discussed under Treatment Costs-to-Sales Ratio, and the detailed analysis is discussed under Closure Analysis later in this section.

** "The Presence of Priority Pollutant Materials in the Fermentation Manufacture of Pharmaceuticals," and "The Presence of Priority Pollutants in the Synthetic Manufacture of Pharmaceuticals."

Company Data

The major sources of company-level financial data were annual reports and/or 10-K reports. This information was supplemented by data from Dun and Bradstreet and from various state manufacturing and industrial guides. The International Trade Commission provided some information on which firms produced what products. Additional information was collected from the Physician's Desk Reference*, the Merck Index**, and various trade publications+ and market studies.++

Industry-Wide Data

General information concerning the industry, its history and its growth prospects were collected from various academic studies of the industry, and the trade publications and market studies mentioned above. An additional source of industry information was the U.S. Census of Manufactures, SIC groups 2831, 2833 and 2834.

Treatment Costs

The screening measure employs the annualized treatment costs. The Technical Contractor provided estimated incremental treatment costs, both capital and operating and maintenance (O&M), for each plant to meet the requirements of each regulatory option analyzed. These costs were based on model plant costs, scaled to meet the known characteristics of the actual plant. For some plants, flow and concentration levels were not known, and averages for the industry or subcategory had to be used.+++

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* Published by: Medical Economics Co., division of Litton Industries, Oradell, NJ.

** Published by: Merck and Company, Inc., Rahway, NJ.

+ Among which are: Drug and Cosmetics, PMA Newsletter, American Druggist, and Pharmacy Times.

++ Outlook for the Pharmaceutical Industry to 1985, 1977, Delphi Marketing Services, Inc., and The Pharmaceutical Industry, 1979, Morton Research Corporation.

+++ A detailed discussion of the procedures employed in assigning costs to plants can be found in: Development Document for Proposed Effluent Limitations and Standards for the Pharmaceutical Manufacturing Point Source Category.

Annualized treatment costs are derived by converting the capital costs to an annual equivalent and adding this to the annual operating and maintenance cost. Capital costs are converted to an annual equivalent by multiplying by a capital recovery factor which measures the rate of return an investment must achieve each year to cover the cost of the investment and maintain net earnings, including depreciation and taxes. A capital recovery factor of 0.22 was calculated, based on a 10 year life for the treatment equipment, a 13 percent cost of capital, and a five-year depreciation life for tax purposes.

BPT Treatment Costs

The incremental treatment costs associated with the proposed BPT regulation are based on the costs of removing cyanide from the wastestreams of direct dischargers. Treatment costs were provided by the Technical Contractor for the direct dischargers that indicated in the 308 Survey an exposure of wastewater to cyanide during the production process. A small number of plants indicated the actual cyanide effluent concentration on the 308 Survey, while most of the others noted only its presence or absence. For those plants with complete data, the Technical Contractor calculated estimates based on 308 wasteflow and loading data. For the plants indicating exposure but not reporting effluent concentrations, the costs were based on 308 wasteflow data and an average loading. To obtain the total cost of compliance, the Technical Contractor then applied a probability weighting to this second set. In the set of plants which provided cyanide effluent loadings, 24 percent needed treatment. Therefore, it was assumed that the probability of any plant in the second set actually needing treatment was 24 percent and for total cost of compliance, the second set of costs was multiplied by 24 percent.

The incremental capital costs were annualized by use of a capital recovery factor equal to 0.22.* Since the treatment costs were for 1978 and the sales for 1979, treatment costs were increased by a factor of 10.88 percent to reflect the rising cost of pollution control equipment between 1978 and 1979.** Both sales and costs would then be estimated for 1979 in 1979 dollars.

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* See Appendix C for a detailed discussion of the derivation of the capital recovery factor.

** Pollution control costs were separated into their component parts. Each was inflated separately, based on price indices in the Fall 1980, Data Resources, Inc., Chemical Review, and these were aggregated to obtain an overall inflation index. The components, their share of the total cost, and their price indices are:

Component	Share of Total Cost	Price Indices
Power	0.17	19.6
Materials	0.06	8.7
Labor	0.07	8.3
Capital	0.70	9.2
	1.00	

BCT Treatment Costs

The treatment costs assigned to the proposed BCT regulation are based on the costs a plant would incur in order to achieve BCT from their existing level of treatment. These costs were estimated on the basis of existing treatment instead of BPT, since EPA is revising the BPT requirements. These plant-level costs were inflated to 1979 dollars, and a capital recovery factor of 0.22 was used to annualize the capital costs.

PSES Treatment Costs

Two options were considered for the proposed PSES regulations. One option concerned the removal of cyanide and the second option the removal of cyanide and volatile organic compounds. Costs were developed for both options and both options were analyzed. The first option is the proposed regulation.

Cyanide Removal Costs. These were estimated in the same way as the BPT costs. See that discussion.

Steam Stripping. Steam stripping removes volatile organic compounds by passing steam through the wasteflow. Treatment costs were provided by the Technical Contractor for only those indirect dischargers that indicated wastewater exposure to volatiles. Since roughly 90 percent of the plants noting exposure had six or fewer volatiles in their wastestreams, no plant was required to treat concentrations of less than 300 micrograms/liter.

Indirect discharging plants with wastewater exposure to volatiles are divided into four groups. The first set is composed of plants which do not need treatment. Either they reported concentration levels below the 300 micrograms/liter, or they reported no concentration levels but use treatment technologies which would remove volatiles. The second group is comprised of plants which reported flow and concentration levels, and needed treatment. For these, costs are based on flow and concentration. The third set is comprised of plants which reported flow but no concentration. Concentration data is not crucial, since steam stripping efficiency is not very sensitive to loadings. The probability that any one plant in this set will need any treatment is assumed to equal the likelihood found for plants which reported flow and concentration. Twelve plants reported both, and six of these had volatile concentrations which required treatment. Therefore, it is assumed that each plant in this third set has a fifty percent probability of treatment, and the total cost of compliance for this set equals one-half the sum of the costs for all plants in the set. The fourth set is comprised of plants which reported neither flow nor concentration. Costs for these

plants were estimated on the basis of the costs for similar plants* in the third set. Again, the fifty percent probability was applied to these plants. There are six plants in group two which need treatment. There are 63 plants in group three and 19 plants in group four which may need treatment. Applying the fifty percent probability factor to groups three and four, gives an estimate of 47 plants needing treatment for volatile organics.**

Treatment Costs to Sales Ratio

The screening measure compares the annualized cost of treatment to the annual sales of the plant since production costs were not available. If the ratio of costs to sales is less than 1 percent, then the plant is assumed to be able to finance the costs of the regulation and keep operating. In 1980, pharmaceutical companies had an after-tax profit to sales ratio of 11.3 percent. This compares very favorably with profit to sales ratios of other industry groups (see Table 4-1). Therefore, an increase in costs equal to one percent of sales will leave their profit to sales ratios relatively high. By using a relatively conservative screening measure, no plant with significant impacts would be missed.

Table 4-1

Industry Profit Levels

	Ratio of After-Tax Profits to Sales (1980)
All Manufacturing	.048
Chemical and Allied Industries	.063
Industrial Chemicals and Synthetics	.045
Drugs	.113
Food & Kindred	.040

Source: U.S. Trade Commission, Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations, fourth quarter 1980.

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* The subcategories used were: Biological and Natural Extraction, Chemical Synthesis, Formulation, and Biological plus Formulation.

** Calculated as: $6+(.5)(63)+(.5)(19)=47$.

Sales figures in 1979 were obtained from Economic Information Service (EIS) for 237 plants, out of a total 464 plants. In some cases, these sales data may be overestimates. Several plants, particularly large ones, manufacture a variety of products including nonpharmaceuticals. These other product lines tend to be industrial organic and inorganic chemicals, pesticides and dyestuffs. The sales figures for plants such as these will include nonpharmaceutical plus pharmaceutical revenues. Thus the sales would be overestimated and the economic impacts on the pharmaceuticals product group underestimated, assuming the treatment costs involve only the pharmaceutical production and not the entire plant.

EIS sales data on the remaining 227 plants were not available to us. Either EIS had assigned these plants to nonpharmaceutical SIC groups because the majority of their sales are in a nonpharmaceutical area, or the plant has fewer than 20 employees and thus is not included in the EIS data base. Of the 227 plants, 27 belonged to single-establishment firms. For these plants, since the plants and the firm are identical, sales data for the firm as reported by Dun and Bradstreet were used. For the remaining 200 plants sales were estimated based on regressions of sales on employment. Both indirect and direct discharging plants were separated into four groups based on production subcategory. Regression equations associating annual sales and manufacturing employment were then calculated for each of these four groups. Using the appropriate equation, sales as well as a lower 90% confidence interval about the mean production were estimated for each plant. Appendix A contains a detailed discussion of the procedure and the regression results.

Closure Analysis

Additional information was collected about each plant identified by the screening measure. This information was grouped into three sets. First were characteristics of the parent firm, including its financial position, its major lines of business, and the relative importance of pharmaceuticals, both currently and in the future. The second set included information about the specific products produced by that plant and their relative competitive position, such as patent protection and size and share of market. The third set included information about what non-pharmaceutical products were produced at that plant and whether the pharmaceutical products were produced by that firm at other locations.

Based on these plant profiles, a judgment was made as to the likely reaction of the firm to effluent limitations. If the firm was in a position to pass the costs on to the consumer, due to patent protection, then it was assumed that the price would be increased and the plant would remain in operation. If these costs could not be passed on; then a judgment was made based on the above information, as to the ability of the firm to absorb the

costs. This would be done to protect income levels or because the plant was necessary for company-wide production needs. The company's ability to absorb the costs is also a function of the growth rate in sales of its products.* In some cases, a production line might close while the rest of the plant remains open. For some firms, moving production from one location to another also might be an option.

*See Section 3 for a discussion of product group growth rates.

Section 5

Economic Impact Analysis

Introduction

This section presents the results of the economic impact analysis, discussed in Section 4, for the proposed regulations.* Total costs of compliance are presented for each proposed regulation followed by a detailed description of those plants with potentially severe impacts. Probable responses by the potentially affected plants are also discussed.

The pharmaceutical industry data base contains 464 plants, all of which were included in the Technical 308 Survey. The BCT and BPT analyses examined 60 direct dischargers while the PSES analyses considered 279 indirect dischargers.

The plants included in the BPT, BCT and PSES studies were, in part, determined by the presence and quality of the wasteflow and pollutant concentration data found in the 308 Survey reports. Many plants did not provide flow and/or concentration information, and because both of these data were necessary for estimating the treatment costs, the Technical Contractor adopted an alternate costing strategy. Costs were estimated on an "if needed" basis for those plants without complete flow and concentration data. The sum of those treatment costs was then weighted by a probability of needing treatment. This probability was calculated by taking the ratio of plants definitely requiring costs (based on 308 data) to the total number of plants for which complete flow and effluent data were available. For example, 25 plants (out of the 34 reporting cyanide in their wastestreams) reported complete data for flow and cyanide concentrations. Of these, six required treatment. Assuming these plants to be representative, a probability of 0.24 (6/25) was estimated and applied to the sum of the treatment costs for the 9 plants without complete data. Similarly, a weighting factor was estimated for the volatile organics costs. It is important to note that the probability weight is used only in computing total cost of compliance for those plants without complete flow and concentration data, but not for the individual plant analyses. For the individual plant analyses, the worst case assumption was made that each plant would incur its total estimated cost.

Another point of clarification concerns discharge status. BPT and BCT regulations apply to direct dischargers while PSES regulations apply to indirect dischargers. Zero dischargers, which include deep-well injection, are not covered by any of these regulations. Of the 464 plants in the data base, seven plants had both direct and indirect waste flows.

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*See Section 2 for a more detailed description of the regulations.

The complete breakdown is as follows (D=Direct, I=Indirect, Z=Zero):

D only = 53	D/I = 7
I only = 272	
Z only = 132	Total = 464

Based on the 308 data it was seldom possible to distinguish the relative magnitude of process flow in each discharger category for plants with multiple discharge or to determine relative pollutant concentrations in each wastestream. In cases of ambiguity, it was assumed that the entire waste flow was discharged directly or indirectly, depending upon the applicable regulation. This puts an upper bound on the cost of that regulation and is, therefore, a conservative approach. (All costs and sales figures are in 1979 dollars.)

Best Practicable Control Technology Currently Available (BPT)

Total Cost of Compliance

The incremental costs associated with the proposed revision in the BPT regulation cover the discharge of cyanide directly into receiving waters. Sixty plants discharge all or part of their wastes directly and are, therefore, subject to this regu- lation. Of these, thirteen indicated exposure to cyanide in their manu- facturing processes.* However, six reported concentrations already meeting the maximum threshold value. Of the remaining seven, five reported concentrations in excess of the threshold for cyanide and two others did not give the concentration. For the five plants with complete data, costs were computed directly. The Technical Contractor also estimated costs for a sixth plant assuming that it required treatment. As mentioned in the introduction, that cost will be incurred with a proba- bility of 0.24. The probability is derived from the ratio of the number of all plants with known cyanide exposure above the allowable threshold to the number of all plants with known cyanide exposure above or below the threshold The seventh plant was excluded because the Technical Contractor determined that the wastewater exposed to cyanide had a concentration below the threshold.

Total costs of compliance are computed as shown in Table 5-1. The expected capital cost is $1.545 million and the expected annual cost is $0.557 million.

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*Four of the thirteen are multiple discharge category plants. In addition to their direct discharges, two discharge indirectly, one has a zero discharge component, and one has both zero and indirect components. For the BPT and BCT analyses, these are all considered direct dischargers.

Table 5-1. Computation of Total Cost of Compliance for BPT (thousands of 1979 dollars)

Number of Plants	Capital Cost	Annualized Cost	Probability of Incurring Cost	Expected Capital Cost	Expected Annualized Cost
5	1,536	553	1.0	1,536	553
1	35.5	18.9	0.24	9	4
			Totals	$1,545	$557

Plant Impacts

For each of the six plants, the annualized treatment cost (or cost of compliance) was compared to annual sales. (For the plant with the 0.24 probability it was assumed treatment would be required.) The impact ratio compares the annualized treatment cost to plant sales. If this ratio is greater than one percent, then the impact is considered large enough to warrant further analysis. These ratios are shown in Table 5-2. The highest ratio is well below 1.0 percent. Therefore, there will be no significant impacts due to the proposed BPT regulation.

Best Conventional Pollutant Control Technology (BCT)

Total Cost of Compliance

The proposed BCT regulation also applies to the same 60 direct dischargers. Of these, 42 reported complete flow and concentration data for conventional pollutants. Ten of this group exhibited concentrations in excess of the proposed standards and would, therefore, incur treatment costs. Eighteen plants reported only flow data. For these plants, costs were estimated on an "if needed basis". That is, if the plant does discharge conventional pollutants in excess of the standard, then the given cost will be faced. (In fact, these costs are based on average loadings so the actual cost may be higher or lower, though in the aggregate should balance. Insufficient data exist to pinpoint which plants require treatment.) The probability of needing treatment is calculated by observing that 24 percent (ten out of 42) of the plants with complete data show excessive concentrations of conventional pollutants. Assuming the same ratio holds for the eighteen plants failing to report concentration data, the 0.24 probability can be applied to the costs computed on an if needed basis when estimating the total cost of compliance as shown in Table 5-3. The expected capital cost is $16.8 million and the annual cost is $6.56 million.

Table 5-2. Impact Ratios for Plants with BPT Costs Greater Than Zero and/or Plants with BPT and BCT Costs Summed Exceeding One Percent of Sales

Plant I.D.	Ratio of Annualized Treatment Cost to Annual Sales (Percent)		
	BPT	BCT	BPT&BCT
A	0.0++	5.78++	5.78
B	0.0++	3.00+	3.00
C	0.0++	2.95++	2.95
D	0.0++	2.93++	2.93
E	0.0++	2.87+	2.87
F	0.22++	2.31+	2.53
G	0.25++	1.77++	2.02
H	0.0++	1.73+	1.73
I	0.0++	1.22+	1.22
J	0.0++	1.12+	1.12
K	0.0++	1.10++	1.10
DD	0.0	1.02+	1.02
L	0.065++	0.98++	1.04
M	0.42++	0.0++	0.42
N	0.14++	0.0++	0.14
O	0.003+	0.01+	0.01

+0.24 probability of cost.

++1.0 probability of cost.

Table 5-3. Computation of the Total Cost of Compliance for the Proposed BCT Regulation (thousands of 1979 dollars)

Number* of Plants	Capital Cost	Annualized Cost	Probability of Incurring Cost	Expected Capital Cost	Expected Annualized Cost	Expected No. of Plants Needing Treatment
10	13,096	5,164	1.0	13,096	5,164	10
18	15,511	5,834	0.24	3,723	1,400	4
			Totals	$16,820	$6,560	14

* Before applying probability factor.

Plant Impacts

Table 5-2 lists the twelve plants whose cost to sales ratios under the proposed BCT regulation are greater than one percent. Plant L is also included because the combined ratio from BPT and BCT costs exceed one percent. Each of these are examined at greater length in the following section.

Closure Analysis

The first plant, Plant A, is owned by a large multi-national organic chemical firm. In addition to manufacturing active ingredients for prescription drugs, this plant produces plastics, resins, and pesticides. Demand for its pharmaceutical products is somewhat inelastic since they are intended for prescription drugs. However, Plant A may close production lines of more vulnerable products in order to reduce costs.

Plant B is owned by a much smaller company; seventy people are employed. The plant produces cat and dog vaccines and is owned by a company which specializes in animal vaccines. Manufacturing also takes place at the company headquarters which was not included in the 308 sample. If this other plant bears lower costs, management may decide to transfer all operations to the main office and close Plant B.

Plant C shows a cost-to-sales ratio of nearly three percent. The plant is owned by a very large (over 30,000 employees) pharmaceutical company. This company also owns another plant with a cost-to-sales ratio above one percent, Plant G. According to one of the firms' recent annual

reports, the company earns a return on investment (profits divided by assets) in excess of fourteen percent. The plants themselves are both large (approximately 200 manufacturing employees each in 1976) and produce a very widely prescribed pharmaceutical for which the firm holds the process patent. Plant C also has special facilities for producing another pharmaceutical which was among the 30 most prescribed drugs in 1980. Because of this, and the company's size and profitability, it is unlikely that these plants will close due to the proposed regulation.

The plant with the fourth highest cost-to-sales ratio, Plant D, is owned by a very large (over 40,000 employees) organic chemical firm. It produces a wide range of products, particularly pesticides and agricultural chemicals. It also produces animal feed additives. Given its size and diversification of products it is unlikely that the establishment will shut down completely. However, some of its production, particularly the more common drugs, might be shifted to other company plants.

The impact on Plant E is uncertain, although closure is unlikely. It is owned by a large chemical company which has been moving into the pharmaceutical field by purchasing existing operations, with plans to continue expanding in this area. Although this plant produces the less profitable over-the-counter drugs, the recent purchase of Plant E oy its current parent company coupled with the company's interest in breaking into pharmaceutical markets will probably keep the plant open. Although potential treatment costs may discourage the company's interest in additional acquisitions, current operations will most likely be supported.

Plants F and L are in a similar position to Plants C and G. They are large facilities, each with over 500 manufacturing employees in 1976, and are owned by a large firm (over 25,000 employees) specializing in pharmaceuticals. The firm has had a rate of return on its assets of over thirteen percent in recent years. Even if the entire cost of treatment comes out of profits, which is unlikely given the market strength of the company and its patent rights to some products, the company will probably keep both plants in operation.

Plant H (G was discussed with C) is also part of a large pharmaceutical firm (over 20,000 employees). Opened in the 1960s, it employed between 50 and 100 manufacturing employees in 1976 according to the 308 survey. Its primary line of business is the manufacture of glass containers (SIC 3221) for packaging pharmaceuticals and cosmetics. Since this plant probably provides containers for other plants in the company, the plant is not expected to close.

Another large pharmaceutical company owns Plant I. Over one hundred manufacturing employees chemically synthesize and formulate the establishment's main products--laxatives, antacids, and milk of magnesia. The market for these products appears steady as does the firm's position in that market. No changes in operations are expected.

Plant J has a cost-to-sales ratio just over the threshold (1.12 percent). Located in Puerto Rico, this plant is one of many owned by a chemical company employing more than 10,000 people. The plant itself is not large, with only 20 manufacturing employees reported in 1976, and for that reason it may experience some difficulty complying with the proposed regulation. However, the favorable tax status available in Puerto Rico, combined with the marginal burden of treatment costs (1.12 percent of sales) should keep the establishment open. (Recent legislation has reduced some of the Puerto Rican tax advantage. As a result, some operations in Puerto Rico may discontinue. Such a closure would be a "base case" closure, not due to the proposed regulation.)

A medium sized firm with over 2,000 employees owns Plant K also located in Puerto Rico. Manufacturing employment was approximately fifty in 1976, one year after opening. Manufacturing at the plant involves formulating toothpaste and other dental products for sale in the Puerto Rican, mainland, and international markets. Closure is unlikely for largely the same reasons as Plant J: low cost-to-sales ratio (1.10), a strong parent firm and tax exempt status.

Plant DD has a cost-to-sales ratio slightly greater than 1.0 percent. This is a very large plant, employing well over 1,000 workers; and it is owned by a large chemical and pharmaceutical company. Given the low ratio and the size and strength of the owner, currect operations will continue.

All but three plants should be able to continue operations unchanged under the proposed regulation. Two plants may choose to close down a particular production line or shift it to another facility (Plants A and D). Only one plant (Plant B) is in danger of closing.

Combined Effect of Proposed BPT and BCT Regulations

Due to the relatively small costs associated with the proposed BPT regulation, adding them to BCT costs does not change the situation discussed above. Table 5-2 presents the cost-to-sales ratios for the combined BPT and BCT costs.

Employment Losses Due to BPT and BCT Regulations

Table 5-4 shows total plant employment and percentages for all 464 plants, for all direct dischargers, and for those plants with the greatest potential for production line or plant closure under the combined regulations. Employment figures are from the 1976 and 1978 308 surveys. As a percentage of all manufacturing employees the maximum loss is 0.13 percent (total industry includes all 464 plants). As a percentage of manufacturing employement in direct discharging establishments, the maximum loss is 0.59 percent.

Table 5-4. Maximum Loss of Employees Due to Proposed BPT and BCT Regulations

	Number of Manufacturing Employees	Percent of All Manufacturing Employees	Percent of all Direct Dischargers
Total: All types of dischargers	112,000	--	--
Total: All direct dischargers (60 plants*)	24,400	--	--
Possible plant closure: Plant B	45	0.04	0.18
Possible production closure: Plant A	73	0.07	0.30
Possible production line shift or closure: Plant D	25	0.02	0.10
Totals	143	0.13	0.59**

*Direct dischargers are defined here as those plants with discharge status of direct, or multiple discharges including direct.

** Does not sum due to rounding.

The industry employment sum does not include employment figures for nine plants due to missing data while the direct discharger sum is missing two figures. As a result, the percentage values represent upper bounds and are, therefore, conservative estimates.

Price Changes

Due to the lack of data and the complexity of the pharmaceutical industry, it was not feasible to estimate price elasticities. Instead, it was assumed that for products with patent protection, the costs would be completely passed through as price increases without loss in sales volume. For some plants, product information was available. However, the actual output levels for these products were not available. Therefore, a specific price increase due to a cost increase could not be estimated. As an extreme position, it was assumed that all firms would transfer the entire cost of the regulation into higher prices. The annual cost of BPT and BCT is about $7.1 million (= 0.557 + 6.56). Given estimated total sales of $3.9 billion for the 60 direct discharging plants, the cost-to-sales ratio for BPT and BCT combined would then be:

$7.1 million/$3,900 million = 0.18 percent

Clearly this is very rough and should be taken as no more than an order of magnitude estimate. Total sales include some non-pharmaceutical sales which may cause this to be an underestimate. Conversely, not all firms will be able to shift their costs into price increases. In addition, this estimate may not accurately reflect the situation in different product groups because some may have effluent streams which are more difficult and expensive to treat than others. Sufficient data are not available with which to determine those specific types of products that may bear disproportionate costs.

Balance of Trade Impacts

As described in Section 3, "Industry Profile", the United States is the second largest exporter of pharmaceuticals. In 1977, U.S. exports represented about 9 percent of the total value of shipments. The impact of these propsed BPT and BCT regulations should be very small given the small impact on prices estimated above.

Best Available Technology Economically Achievable (BAT)

Since the technology controls that are the basis for the combined BPT/ BCT limitations can also serve as the basis for the BAT regulations, there are no incremental costs. Therefore, there are no additional economic impacts beyond those described above.

Pretreatment Standards for Existing Sources (PSES)

Two options were considered for PSES. One was cyanide destruction, the other was cyanide destruction and removal of total toxic volatile organics. Out of the sample of 464 plants provided by the 308 Survey, 279 discharge at least part of their wastes to POTWs (indirect discharge) and are subject to PSES regulations. (This includes plants with multiple discharges which include indirect. See page 5-2 for complete breakdown.)

Total Cost of Compliance: Cyanide Control

Cyanide destruction costs were provided by the Technical Contractor for plants with direct and/or indirect discharge components. In many cases where multiple discharge status was given it was impossible to distinguish the relative volumes of flow and the relative concentrations of cyanide in each wastestream. As such, all plants with a direct discharge component were considered under the BPT cyanide regulation discussed earlier. To avoid underestimating total costs for the PSES cyanide regulation, seven plants with multiple discharge status were also included here. Only one of these seven actually had treatment costs (with 0.24 probability). The drawback of this approach is that the costs for this one plant are counted twice rather than being allocated to each regulation.

Of the 279 plants, twenty indicated exposure to cyanide in their manufacturing processes. Twelve reported actual effluent concentrations, with only one of these exhibiting a concentration greater than the allowable maximum. Costs for the eight plants without concentration data were estimated by assuming each had a concentration of cyanide equal to the average of three direct discharging plants analyzed in great detail by the Technical Contractor. However, based on the ratio of all plants with known cyanide concentrations above the threshold to all plants with known cyanide concentrations, it was assumed that those eight plants would incur costs with a 0.24 probability. Therefore, adding the cost for the single plant known to incur costs to the sum of the estimated costs of the eight plants multiplied by 0.24 yields the figures for cost of compliance shown in Table 5-5. The expected capital cost is $0.781 million and the annual cost is $0.292 million.

Table 5-5. Computation of Total
Cost of Compliance for the PSES Cyanide Regulation
(thousands of 1979 dollars)

Number* of Plants	Capital Cost	Annualized Cost	Probability of Incurring Cost	Expected Capital Cost	Expected Annualized Cost	Expected No. of Plants Needing Treatment
1	582	211	1.0	582	211	1
8	830	336	0.24	199	81	2
			Totals	$781	$292	3

* Before applying probability factor.

Plant Impacts: Cyanide Control

The annualized treatment costs of cyanide removal were compared to annual sales for each plant. Since it was not possible to determine which of the plants with probabilistic costs would actually bear them, the conservative assumption that each plant would bear its estimated cost was used for this part of the analysis. The nine plants which might incur costs for cyanide destruction all have very small cost-to-sales ratios (see Table 5-6). None is above one percent, with the greatest being equal to 0.18 percent.

Table 5-6. Impact Ratios for Indirect Discharging Pharmaceutical Plants

Plant I.D.	Ratio of Annualized Treatment Costs to Annual Sales (Percent)	
	Cyanide Destruction	Cyanide and Total Toxic Volatile Organics
O	0.003*	0.003+++
P	0.18*	0.57++
Q	0.17**	0.59++
R	0.083*	0.083+++
S	0.050*	0.18++
T	0.033*	0.09++
U	0.032*	0.13++
V	0.017*	0.17+
W	0.016*	0.07++
X	0.0**	3.10++
Y	0.0**	2.50++
Z	0.0**	2.34+
AA	0.0**	2.00+
BB	0.0**	1.40+
CC	0.0**	2.34+

*0.24 probability of cost incidence.

**Treatment for cyanide is required.

+no flow or concentration data, 0.5 probability of cost incidence for volatile organics portion.

++no concentration data, 0.5 probability of cost incidence for volatile organics portion.

+++complete data, showing treatment requirement for volatile organics portion.

Since costs for eight of the nine were estimated assuming average concentrations, it is likely that some of these, if treatment is needed, are underestimated. However, since costs would have to increase by a factor of greater than 5.5 for even Plant P to reach a one percent cost-to-sales ratio and, except for Q, there is only a 24 percent chance of expenditure being required anyway, this is not likely to be a problem. Therefore, no significant impacts, including closures, are expected from the proposed PSES cyanide regulation.

Total Cost of Compliance: Cyanide and Total Toxic Volatile Organics Control

The second PSES option would place limitations on the discharging of total toxic volatile organic chemicals, while maintaining the cyanide limitations of the first option. The estimated compliance costs for this option are the sum of the option one costs and the costs of removing total toxic volatile organics. Of the indirect dischargers, 105 have noted the presence of volatile organics in their manufacturing processes. However, twelve (12) report current use of treatment technologies--aeration, steam stripping, etc.--which remove volatile organics to some extent and it was assumed that no further treatment would be required at these plants. Five (5) additional plants showed concentrations of volatile organics below the maximum allowed by the proposed regulation. This left 88 plants which might incur steam stripping costs. As was the case for cyanide, only a few plants--six (6) in this case--reported both flow and concentration data. Nineteen (19) of the remaining plants lacked both flow and concentration data while 63 reported flow data, but no information on concentration.

The Technical Contractor computed costs for the two groups (82 = 19 + 63)without complete data, assuming that treatment would be needed. Steam stripping costs were estimated as a function of wasteflow for all plants with flow data. This approach was reasonable because the cost of removing volatile organics is relatively independent of initial concentrations. For the nineteen plants without any data, costs were taken as the average of costs for plants in the group of 63 utilizing the same types of production processes (based on production subcategory, see Section 4.) The costs for the 82 plants are on an "if needed" basis. The probability of need was estimated at 0.5 after noting that of twelve (12) plants with known flow and concentration data, six (6) required treatment. The expectation is that approximately 47 plants will incur costs (6 plus approximately half of the 82 plants). Total costs of compliance with the total toxic volatile organics control can be calculated as the costs for the six (6) known plants plus half of the costs for the remaining 82 plants (see Table 5-7.)

Table 5-7. Computation of the Total Cost of Compliance for the PSES Removal of Total Toxic Volatile Organics (thousands of 1979 dollars)

Number* of Plants	Capital Cost	Annualized Cost	Probability of Incurring Cost	Expected Capital Cost	Expected Annualized Cost	Expected No. of Plants Needing Treatment
6	460	690	1.0	460	690	6
63	3970	6080	0.5	1985	3040	31.5
19	520	890	0.5	260	445	9.5
			Totals	$2,710	$4,180	47

* Before applying probability factor.

Therefore, the total cost of compliance for this second option (sum of cyanide destruction and steam stripping costs) would be:

Capital Cost	$3.48 million
Annualized Cost	$4.49 million

Plant Impacts: Cyanide and Total Toxic Volatile Organics Control

Six plants have cost-to-sales ratios greater than one percent under this second option (see Table 5-6). The highest is for Plant X, with a cost-to-sales ratio of 3.10 percent. The other five facilities have cost-to-sales ratios ranging from 2.50 percent to 1.40 percent.

Each of these six plants lacked either concentration or flow data, or both. Costs for plants Z, AA, BB, and CC were based on average costs of plants in their subcategories while the costs for Plants X and Y were estimated with the approximate flow-cost relationship described earlier. Because of this, two factors mitigate these potentially high impacts. First of all, there is only a fifty percent chance that these plants will incur costs at all. Secondly, the highest cost-to-sales ratio of a plant with known costs (i.e., complete flow and concentration data) is 0.35 percent. This indicates that the estimated costs may be too high.

Closure Analysis: Cyanide and Total Toxic Volatile Organics Control

The plant with the highest cost-to-sales ratio, plant X, is owned by a large company (over 9000 employees) and is located at the firm's corporate headquarters. The facility had 873 manufacturing employees involved in the production of pharmaceuticals in 1976. Given the large size of the facility and of its parent company, it is unlikely to be closed by the regulation despite its relatively high cost-to-sales ratio. There is a possibility that this plant may respond to regulatory costs by shifting production away from certain processes and into others with lower compliance costs, however, no change in employment is expected.

Plant Y is a medium-sized facility with approximately 400 manufacturing employees. The plant is owned by a chemical corporation and appears to manufacture pharmaceuticals as one of many types of products. This is partially based on the report of just 44 employees involved in pharmaceutical manufacture in the 308 Survey. Though it is unlikely to close, management may choose to avoid regulatory costs by closing down pharmaceutical production lines and expanding production of other goods.

Plant Z is also owned by a small company, but should be able to comply with the regulation. It is primarily a chemical company and is not solely dependent on its pharamceutical products. Its in-house research activities should also help the facility adjust its activities in response to the regulation.

The plant with the next highest cost-to-sales ratio, Plant AA, is a small establishment (six manufacturing employees) producing bulk pharmaceuticals affecting the central nervous system. Subsequent telephone conversations by EPA with the company indicated that no costs would be incurred because process operations would be altered in response to the regulation.

The next plant, plant BB, is also small. It employs only 10 people according to a 1982 State Industrial Guide. This plant is expected to remain open because it produces enzyme and clinical diagnostic products that are sufficiently specialized for distribution to be worldwide. This product specialization should allow for most, if not all, of the treatment costs to be passed through in higher prices. In addition, the plant's cost-to-sales ratio is less than two percent.

The final plant, plant CC, is owned by a small, well-established pharmaceutical company producing liquids, ointments, and tablets. Although the initial economic analysis showed that costs will represent 2.43 percent of sales, subsequent data provided by EPA indicated that the wastewater flow discharged to a POTW was much less than the flow originally used and so the costs would be negligible.

Under this second proposed PSES regulation, six plants may have cost-to-sales ratios of more than one percent. No plants will close and pharmaceutical production may be curtailed at one large, multi-product facility (Plant Y). Since costs will be incurred by this plant with only a 0.5 probability, this is a worst case scenario.

Employment Losses: Both Options

Since there are no expected closures under the first option, there is no expected employment impact. Total employment for all plants and for the plant which might close under option two are shown in Table 5-8. Employment figures are from the 1976 and 1978 308 Surveys. In all cases, employment lost, as a percent for all facilities or for indirect dischargers only, is extremely small. If the line closure were to take place, it would affect 44 employees or 0.05 percent of the total manufacturing employment at indirect discharging plants or 0.04 percent of all pharmaceutical manufacturing employment.

Table 5-8. Plant Employment Impacts--PSES Regulation for Steam Stripping and Cyanide Destruction

	Number of Manufacturing Employees	Percent of All Manufacturing Employees	Percent of All Indirect Discharger's Employees
Total: All types of dischargers	112,000	--	--
Total: All indirect dischargers (280 plants)	93,500	--	--
Possible Line Closure: Plant Y	44	0.04	0.05
Totals	44	0.04	0.05

Price Changes: Both Options

As discussed above in the section on the combined effects of the proposed BPT and BCT regulations, it was not possible to estimate price increases for specific products. As an extreme case, it was assumed that the total cost of the regulation would be passed on by firms in the form of higher prices. Given total estimated sales for the 279 indirect dischargers of $15.7 billion, the total cost-to-sales ratio for PSES option two would be:

$4.5 million/$15,700 million = 0.03 percent

The price impact of option one would be negligible. This is a very rough estimate. Total sales include some non-pharmaceutical sales, while not all firms can shift their costs forward. In addition, the treatment costs may be concentrated in certain product groups. However, it appears that any price increases are likely to be small.

Balance of Trade Impacts

Given the very small price impacts of either of the PSES options, there is likely to be little or no overall impact on the pharmaceutical balance of trade. AS with the BPT and BCT proposed regulations, this conclusion may not hold for specific pharmaceuticals where the price impact and competition may be significantly greater than the overall levels.

Resource Conservation and Recovery Act (RCRA)

RCRA costs were not included in any of these analyses. The sludge generated as a result of the existing BPT limitations, as well as that to be generated as a result of these regulations, is not hazardous and therefore not subject to RCRA regulation disposal. Some sludges from metal precipitation treatment may in some cases be hazardous, but the amount of metal precipitation anticipated from the treatment of pharmaceuticals wastewater is expected to be quite small. These sludges will have very little or no impact on the RCRA disposal requirements of the regulated plants.

Section 6

New Source Performance Standards (NSPS) and Pretreatment Standards for New Sources (PSNS)

NSPS

The New Source Performance Standards for direct dischargers are more stringent than the standards for existing plants. The 30 day average effluent limitations for NSPS are shown below:

	Proposed NSPS
BOD_5	31 mg/l
TSS	72 mg/l
COD	449 mg/l
Total Cyanide	0.375 mg/l

Except for cyanide, these standards are more stringent than the BPT/BCT/BAT limitations; therefore, they may have a greater impact on new sources than on existing sources, placing them at a disadvantage. The incremental NSPS costs, as provided by the Technical Contractor, appear in Table 6-1. Costs are shown for plants that produce in only one of each of the four subcategories (A, B, C, and D) along with the cost for an average sized plant of a combination of subcategories. Costs for an average mixed category plant are large because diversified plants tend to be larger,

Table 6-1. Incremental Costs to Meet New Source Performance Standards+ (1979 dollars)

	Subcategories*				
	A	B	C	D	Average Mixed Categories
Capital Cost	1,656,000	240,000	1,070,000	300,000	3,660,000
Operating Cost	330,000	32,000	161,000	34,000	632,000
Annualized Cost	690,000	85,000	398,000	99,000	1,440,000

+Costs provided by the Technical Contractor. The first four are based on an average plant for each subcategory and the Contractor's Engineering Report, with basic costs as calculated by Catalytic's computational model. For a model plant which represents the average plant for the entire industry, the last column is used.

*Subcategories: A-Fermentation, B-Biological Extraction, C-Chemical Synthesis, D-Formulation.

while the plants used for costs of Subcategories A, B, C, or D alone tend to be smaller specialty plants.

Based on announced new construction, it is estimated that the capital cost of building a new formulating facility (Subcategory D) is approximately $30 million and the capital cost of a new manufacturing facility is approximately $55 million. The capital costs of providing NSPS treatment in a formulating facility is estimated to be $300,000. Therefore, treatment costs increase the cost of building a new formulating plant by about one percent ($.3 \times 10^6/30 \times 10^6$). It was not possible to determine which subcategories should be assigned to the announced manufacturing facilities. However, the average treatment capital cost for the three manufacturing subcategories is $989,000. This would increase the construction costs by about 1.8 percent ($.989 \times 10^6/55 \times 10^6$).*

Expansion in this industry over the next few years is not expected to be large, even if no new water quality regulations are imposed. Capacity utilization in the late 1970's was low due to rapid expansion during a period of low growth in output. Capacity utilization in 1977 was only 72 percent, as compared with 77 percent in 1976 and 80 percent in 1974.**

Expected low levels of expansion are further supported by an analysis of recently announced expansions and new plant construction.*** For purposes of this study, facilities were categorized as follows: research and development, manufacturing, formulating, and unspecified. There were 31 announced expansions and new facilities, with completion dates ranging from 1981 through 1985. However, twelve of these were for research and development facilities, including four which were multipurpose. Research and development facilities produce very little wastewater and were eliminated from the subcategories specifically studied. Of the 23 remaining announcements, the largest group is manufacturing, with 14 new or expanded plants. Two of these also have R&D facilities. In comparison, formulating will be experiencing very little expansion, with only five new or expanded facilities announced. Two of these also include research and development facilities. For the remaining four announcements, the use of the facility was not specified.

Usually it is not possible to determine from these announcements if a facility will qualify as a new source or an expansion of an existing source, according to EPA criteria. Clearly, some of these will be existing sources. Therefore, the amount of new source expansion will not be large.

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*The analysis assumes that the NSPS costs incurred for a major modification to existing sources would not be greater than the NSPS costs for new sources.

**The Pharmaceutical Industry, March 1979, The Morton Research Corporation.

***This Analysis is based on announcements appearing in Drug and Cosmetic Industry, from April 1981 through June 1982.

It is extremely difficult to estimate the total cost of compliance for NSPS based on the available data. Assuming that approximately one-half of the announced new construction (some already on-line) qualifies for NSPS, then the annualized cost of compliance will be approximately $12 million.

PSNS

Since the Pretreatment Standards for New Sources for cyanide are the same as those for existing sources, there are no incremental costs.

Section 7

Regulatory Flexibility Analysis

Under the Regulatory Flexibility Act of 1980, the EPA and other regulatory agenices are required to consider the effects of proposed regulations on small companies. This section reviews the potential small business impacts of the Proposed Regulations on the pharmaceutical industry.

Definition of a Small Firm

The Act relies on the Small Business Administration (SBA) for guidance in defining a small firm. The Small Business Act, section three, defines a small business as:

> "...a small business concern shall be deemed to be one which is independently owned and operated and which is not dominant in its field of operation. In addition to the foregoing criteria, the Administration (of the SBA), in making a detailed definition may use these criteria, among others: Number of employees and dollar volume of business."

In addition, the SBA published specific employee based guidelines for various business activities including manufacturing. For companies classified in SIC 2834, the SBA defined a small firm as one with not more than 750 employees.* Companies classified in SICs 2831 and 2833 with not more than 250 employees are considered small. For the purposes of this analysis, even 250 employees may be large, given that the Regulatory Flexibility Act is concerned with firms with limited resources and avoiding regulatory barriers to entry into an industry.

As described in Section 3, the pharmaceutical industry is characterized by a large number of small firms, most of which own one facility, and a few number of large firms which each own several facilities. The 308 Survey covered 464 plants owned by 243 firms. Arranging the firms by number of employees, from smallest to largest, and then dividing the firms into quartiles shows how dominant these large firms are in terms of number of plants (see Table 7-1).**

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*Code of Federal Regulations, Title 13, Section 122.3-10.

**For 19 firms, employment could be determined only within a range.

Table 7-1. Size Distribution of Pharmaceutical Companies

Firms by Number of Employees, From Smallest+	Firm Employment Range	Number of Plants Owned by These Firms
First Quartile	3-31	61
Second Quartile	32-115	63
Third Quartile	116-4,801	92
Fourth Quartile	4,802-402,000	248

+ Each Quartile is comprised of 60 or 61 firms.

In the first quartile, each firm has only one facility. In the second, each firm has an average 1.05 plants. However, the firms in the fourth quartile have an average 4.13 plants. Therefore, a large percentage of the firms employ only a small percentage of the workers and control only a small percent of the production.*

In place of setting a single definition of small business, the cost data has been arrayed for each regulation and option, by the employment size quartiles given above. As can be seen in Table 7-2, none of the proposed regulations impose a cost on that quarter of firms with the smallest employment. In addition, the number of firms bearing costs increases as the average size of the firms increases.

BPT Regulation

The only firms which may bear treatment costs under this proposed regulation are in the fourth quartile. The smallest of the firms bearing costs has an employment level of around 15,000. Therefore, this regulation has no small business impact.

BCT Regulation

No firm in the first quartile and only one plant in the second quartile have treatment costs under this proposed regulation. This firm

*Sales and employment are highly correlated for this industry, see Section 3.

employs about 70 persons, while the next firm with costs is in the third quartile and has employment in excess of 2000. Based on the analysis presented in Section 5, the small firm may decide to close a plant in response to this proposed regulation. The other firms bearing costs are larger. Two are projected to close a line or shift production to another facility as a result of the proposed regulation. The others are not expected to alter their pharmaceutical operations. Therefore, although small, this proposed regulation has a potential small business impact.

Another measure of the relative impact of the proposed regulation is the average cost-to-sales ratio of firms bearing costs, for each quartile. For the proposed BCT regulation, these cost-to-sales ratios are:

First Quartile	0.00
Second Quartile	0.0300
Third Quartile	0.0010
Fourth Quartile	0.0018

Based on this measure, the smallest firms bear no impact, but there is a sizeable impact on one small firm in the second quartile.

Since there are only three firms with significant impacts and only one of these is a small firm, there is no disproportionate burden due to this proposed regulation.

BAT Regulation

The proposed BAT Regulation has no impacts over those of the proposed revisions to the BPT regulation.

PSES Regulation

The proposed PSES regulation controls cyanide in the wastewater of plants discharging to publicly owned treatment works. It imposes no costs on firms in the lowest two quartiles. The smallest firm bearing costs has an employment level greater than 1270. Therefore, this proposed regulation has no small business impact.

The second option considered, but not proposed, controlled total toxic volatile organics as well as cyanide. This option would have an impact on small businesses. As shown in Table 7-2, five firms in the lowest quartile and nine firms in the second quartile might bear costs under this option. The smallest firm which might bear costs employs only about ten workers. The average cost-to-sales ratios for firms bearing costs under this option are:

First Quartile	0.0087
Second Quartile	0.0027
Third Quartile	0.0016
Fourth Quartile	0.0004

Table 7-2. Distribution of Firms With Treatment Costs,** by Proposed Regulations, for Firms Divided by Employment Size

Firms by Number of Employees, from Smallest	BPT*	BCT*	PSES Cyanide*	PSES Cyanide and Volatile Organics	Sum+ of BPT*, BCT* and PSES Cyanide*
First Quartile	0	0	0	5	0
Second Quartile	0	1	0	9	1
Third Quartile	0	3	3	18	5
Fourth Quartile	3	15	5	28	19
Total Number of Firms with Treatment Costs	3	19	8	60	25

*Proposed Regulation.

**The probability factor is not applied (see Section 5). Therefore, the worst case assumption that all plants who might have to bear costs will have to bear costs is used here.

+Rows do not sum because a single firm may bear costs under more than one proposed regulation. This column presents the total number of firms in each employment quartile which bear costs under any of the three proposed regulations.

Since this option is not being proposed, no further Regulatory Flexibility Analysis was undertaken.

BPT, BCT, and PSES Combined

The combined impact of the proposed regulations are also examined. There are no costs imposed on firms in the lowest quartile, and only one firm in the second quartile bears costs. Eighteen of the twenty-four firms which might bear costs (or 75 percent) are in the highest quartile. The average cost-to-sales ratios for firms bearing costs under the proposed regulations are:

First Quartile	0.0000
Second Quartile	0.0300
Third Quartile	0.0010
Fourth Quartile	0.0015

The combined impacts, in terms of cost-to-sales ratios, are greatest for the second quartile. However, there is only one firm in that quartile which bears costs (see BCT discussion above). Therefore, the small business impacts are not extensive, but are large in one case.

Section 8

Social Costs of Proposed Regulations

Total social costs of the proposed regulations can be defined as the value of goods and services lost to society due to the use of resources in complying with the regulation, the use of resources in implementing the regulations, and the reduction of output in lieu of compliance. Due to the lack of good data on the pharmaceutical industry, a complete study of the social costs could not be conducted. This chapter presents estimates of the social costs based on available data.

The most significant costs can be estimated by use of a static, partial equilibrium framework. Conceptually, this approach is based on an analysis of the supply and demand relationships found in the market directly affected by the regulations. Compliance results in increased unit costs of production, shifting the industry's supply curve upward. The new equilibrium will result in higher prices and reduced production levels, and the amount of change in each depends on the unit cost increase and the relative elasticities of supply and demand. This framework provides a means of estimating production losses and net welfare losses incurred by producers and consumers due to decreased output, as well as compliance costs. It does not include the costs of implementing and enforcing the regulation, nor non-static effects such as changes in productivity and innovation levels or the costs of reallocating unemployed resources.

The principle component of social costs is the private real-resource cost. This is equal to the net present value of the resources used directly in complying with the regulation. In calculating the net present value of compliance costs, a real discount rate of 10 percent was used.* Due to the complexity of the pharmaceutical industry and the lack of data, it was not feasible to estimate demand and supply elasticities, and changes in output and price for all products. Based on the estimates of small price changes and the few plant and line closures presented in Section 5, the dead-weight losses will be small. Exact estimates of their size were not attempted. The same applies to adjustment costs for displaced resources. Government regulatory cost estimates are not available at this time and could not be included. However, they are expected to be small in relation to compliance costs.

The Proposed Regulations may affect innovation if the costs of compliance result in reductions in research and development expenditures. Likewise, there may be some impact on productivity and market structure. However, based on the results presented in Section 5, these impacts are

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*This is in accordance with the recommendations of the Office of Management and Budget.

likely to result in minor costs. Therefore, social costs are estimated to equal the present value of compliance costs.* The annual social costs of the Proposed Regulations (in 1979 dollars) are as follows:

BPT:	$ 370,000
BCT:	$4,855,000
BAT:	zero costs
PSES, Cyanide Destruction:	$200,000

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*Calculation assumes investment in treatment systems to occur this year. Therefore: Annual Social Costs = .1 (Investment Cost) + (Annual Operating and Maintenance Cost).

Section 9

Limits of the Analysis

This chapter examines various problems and shortcomings in the analysis and recommends certain cautions in applying the results. Two basic types of problems were found: problems with the data used in the analysis and methodological problems.

Definition of the Industry and Sample Size

The total cost of compliance for the industry was calculated on the basis of the sample of establishments used for the Technical 308 Survey. This total cost may be subject to upward revision depending on the comprehensiveness of the sample of establishments. Compared with data provided by the U.S. Census of Manufactures, the survey sample of 464 establishments appears small. This sample includes 306 establishments classified in SICs 2831, 2833, and 2834 which accounted for $13.6 billion in 1979 sales. The remaining 158 establishments in the sample totaled $6.0 billion in 1979 sales. In contrast the estimated 1979 Census figures for SICs 2831, 2833, and 2834 report value of shipments of $18.4 billion for 1,243 establishments.* Therefore compared to the Census figures, the survey sample includes a quarter of the establishments and almost three quarters of sales. No comparison can be made for establishments in other SICs.

Some hesitation is prudent in a literal interpretation of these figures. First of all, there is some uncertainty as to which establishments have been included in the U.S. Census of Manufactures figures. Although central administrative offices and auxiliaries are not included, the Census may include some establishments not subject to the proposed regulations. Second, Economic Information Service (EIS), our source for sales data, states that their establishment sales figures are consistent with the Census' definition of value of shipments. This has not been independently verified. A third caveat is that the 1979 Census figures are estimates and are subject to change. Basing the analysis on the 308 sample may result in an underestimate of the total cost of compliance. However, this is offset by the conservative or "worse case" assumptions made throughout the analysis.

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*The 1979 value of shipments was extrapolated based on the average growth between 1975 and 1978. The number of establishments was estimated assuming no change from 1977.

In addition, the 308 sample includes most, if not all, of the large facilities. Therefore, any underestimate of the total cost of compliance is small.

Treatment Cost to Plant Sales Method

This method involved comparing the treatment cost to the plant sales. The primary obstacle was to find sales estimates for the 146 direct and indirect dischargers which were not included in the EIS pharmaceutical data base. Various methods were examined and discarded in favor of a regression analysis relating plant sales to plant manufacturing employment. The method is described in detail in Appendix A of this report. However, manufacturing employment data came from the 308 Surveys and were valid for 1975-1976 or 1977-1978. EIS provided plant sales estimates for 1979. This casts some doubt on the estimates yielded by the regression equations as the dependent and independent variables do not match with regard to year. In addition, many large pharmaceutical plants also had other product lines operating--usually organic chemicals, pesticides, and flavor and fragrance chemicals. The EIS sales estimates for these plants included the nonpharmaceutical sales as well. Therefore, a number of plants had overestimated sales and probably resulted in a shift of the predicted regression line. In addition to this systematic bias, there is error about the predicted sales due to random factors. Most likely this error is small compared to that introduced by the previous two problems. Another relatively minor source of error may be the use of an average inflation factor to inflate plant treatment costs from 1978 to 1979 dollars.

The sensitivity analysis consisted of replacing the regression estimated sales with their lower 90 percent confidence interval end points. BCT treatment cost to sales ratios were again calculated with this lower sales estimate. No new plants were added to the potentially impacted group, because no additional plants had revised cost to sales ratios of greater than 1 percent. Of the plants already identified as potentially impacted, none had an impact ratio greater than 3.18 percent using these more conservative sales estimates. Previously, the greatest impact ratio equaled 2.96 percent. Thus, despite the data problems inherent in the regression approach, the final results do not seem to be very sensitive to differences in sales estimates. This is due to the "tight" confidence intervals about the mean predicted responses, which are due to the large sample size. Table 9-1 shows the changes in impact ratios estimated by the sensitivity analysis; seven of the 12 plants identified by the screening process had estimated sales. Similar results are expected for the BPT and the PSES cost-to-sales ratios.

Individual Plant Assessments

The limitations of the methods used to calculate the cost-to-sales screening ratio have been discussed above. Due to the uncertainties arising from these limitations, the cut-off levels for the screening measure has

Table 9-1

BCT Cost-to-Sales Method: Sensitivity Analysis

	Based on Predicted Plant Sales	Based on Lower 90 Percent Confidence Interval Endpoint
Tier 1:		
Plants with Impact Ratios Greater Than or Equal to 3 Percent		B D
Tier 2:		
Plants with Impact Ratios Greater Than or Equal to 2 Percent But Less Than 3 Percent	A B C	A C
Tier 3:		
Plants With Impact Ratios Greater Than or Equal to 1 Percent But Less Than 2 Percent	D E F G H I J K L	E F G H I J K L

been set fairly low. The cost-to-sales ratio can not be considered a sufficient condition for identifying impacted plants. It is a tool to identify a set of plants which might suffer a significant impact, while not excluding any significantly impacted plants.

If sufficient plant-specific financial information were available to determine the actual operating costs of each plant, the output levels of the specific items produced, the ability of the plant to expand production or alter product mix, and the financial and production relationships among plants owned by a single firm; then this screening procedure would not be necessary. In its place a model of the industry could be constructed and the relative and absolute impact of the regulation on each plant could be estimated. Instead, similar but less specific and detailed information has

been collected for each plant and its parent firm identified by the screening measures. The actual impact on the plant has been estimated based on the data available. However, the quality and quantity of imformation regarding market/product strength and financial success vary significantly among the plants identified. Therefore, the confidence level in certain plant-specific estimates may be low, but the overall assessment that in general these proposed regulations will have only a small affect remains.

Appendix A

Estimation of Pharmaceutical Plant Sales

In order to estimate the economic impacts on individual pharmaceutical plants and the industry in general, it was necessary to estimate sales for 146 of the plants. The data base was examined and regression equations relating sales to employment were determined.

A data base of 235 pharmaceutical direct and indirect dischargers was compiled from the data supplied by the Technical Contractor and from the Economic Information Systems (EIS) data base. The EIS data base provided 1979 sales estimates for each plant. The Technical Contractor assigned a code to every plant indicating which of the four major types of production processes were carried out there. These four groups of production processes, called production subcategories, are fermentation, biological and natural extractions, chemical synthesis, and formulation. Employment (number of manufacturing employees) and direct and indirect waste flow estimates were available for almost all plants from the Technical Contractor.

Fifteen different combinations of production subcategories were formed and for the purposes of this analysis, these combinations were grouped into four large sets. Group 1 consisted of all plants that used fermentation processes (subcategory A). Group 2 consisted of all plants that used biological extraction processes (subcategory B), not including those in Group 1. Plants using chemical synthesis (subcategory C), but not in groups 1 and 2, were classified as Group 3, and plants that were formulators only (subcategory D) were placed in Group 4. Table A-1 provides a summary of the plant characteristics of each group.

This method of grouping plants was chosen because it preserved some distinctions between production technologies and agreed with some important relationships in the data. For example, all but one of the plants using fermentation processes had wasteflows larger than 1 million gallons per day (MGD), while all other production processes had much smaller wasteflows. Typically, plants with fermentation processes produced more wastewater, had more employees and greater revenues than plants that did not use fermentation. Cross-tabulations of production subcategory versus sales, employment, and wasteflow and the summary statistics by production subcategory demonstrated that the three types of synthesis processes were better indicators of sales, employment and wasteflow than the formulation processes. This was the basis for defining Groups 2, 3 and 4.

Various regression models linking sales to employment and wasteflow within each group were investigated. Both log-transformed and untransformed data were used. Correlation analysis by group indicated that log-transform models between sales and exployment were the most promising. Other models associating sales and wasteflow and untransformed

Table A-1

Summary Statistics of Regression Data Base Plant Characteristics

Group*		1979 Sales** 1000 $	Employment Manufac-turing*** Employees	Sales to Employment Ratio 1,000$/ Employee	Direct Flow*** MGD	Indirect Flow*** MGD
1	Mean	123648	1109	185.9	2.145	.519
	Std. Dev.	156984	1516	120.9	2.529	.854
	Median	68700	450	153.0	1.216	.124
	N	21	21	21	6	14
2	Mean	48966	281	470.9	.059	.173
	Std. Dev.	76393	587	631.9	.071	.496
	Median	14600	65	177.3	.027	.007
	N	44	43	43	6	33
3	Mean	54732	210	1000.7	.151	.216
	Std. Dev.	91389	357	1910.7	.265	.341
	Median	18000	60	295.0	.035	.053
	N	38	36	36	9	20
4	Mean	42256	220	628.6	.104	.024
	Std. Dev.	76712	479	1179.6	.145	.064
	Median	11300	52	229.7	.030	.001
	N	132	130	130	11	79

*Group 1: All plants using fermentation processes.
Group 2: All plants using biological extractions but not fermentation.
Group 3: All plants with chemical synthesis but not fermentation nor extraction.
Group 4: All plants which are formulators only.

**Source: Economic Information Systems.

***Source: Technical Contractor; some plants have 1976 employment while others have 1978 employment.

sales and untransformed employment were clearly inferior in terms of R-squares. The model for Group 1 was:

$$\ln(\text{sales}) = a + b*\ln(\text{employment}),$$

while the model for the remaining groups was:

$$\ln(\text{sales}) = a + b*\ln^2(\text{employment}).$$

The regression equations had R-squares ranging from 0.42 to 0.63. However, the differences between the observed sales and the estimated sales (back-transformed from their logarithims) were very large - as much as 600 percent difference. This is further evidence that small residuals between the transformed variables do not necessarily indicate small residuals between the back-transformed variable. Such error was unacceptable.

After examining plots of sales versus employment (and ln (sales) versus ln (employment)), several extreme outliers were discovered. Typically, these outlying plants had a very small or very large sales to employment ratio. When these plants were removed from the regression data base, the R-squares improved dramatically. Justification for these exclusions can be found by considering the sales data source: the EIS data base. EIS generally classifies a plant under one SIC code, even if many products not found under that SIC code are produced there. Consequently the sales estimate for that plant includes revenues from other SIC group products and, since the employment is the number of manufacturing employees, the sales/employment ratio can be deceptively large. Usually, the very large plants fit this description. Also, because the sales estimates are for 1979 and the employment estimates are from the 308 Survey data, which was done in 1976 and 1978, several sales/ employment ratios are not what would be expected due to unknown changes in employment over the three (or one) year period. Several plants surveyed in 1976 were scheduled to start up in 1977 and so agreement between that employment figure and the recent sales estimate should not be expected.

All plants with sales to employment ratio less than $70,000/employee were removed from the regression data base. This was approximately the 10 percent quantile (i.e., 10 percent of the plants had sales/employment ratios less than 70,000) for Groups 1, 2 and 4. This figure was chosen since it contained nearly all the outliers found on the plots. Additional plants with excessively high or inconsistent sales/employment ratios were removed from Groups 3 and 4. Both indirect and direct plants removed are listed in the following table.

Table A-2

Plants Removed from Regression Data Base

Group	# Excluded	# of Plants in Old Regression Data Base
1	2	21
2	4	43
3	4	36
4	14	130
Total	24	230 5 plants out of 235 have no employment estimates.

The results of the regression analysis are shown in Table A-3. Two different models were used:

$sales = a + b*(employment)$ for Groups 1 and 3, and

$\ln(sales) = a + b*\ln^2(employment)$ for Groups 2 and 4.

Initial analysis showed that the equations for Groups 2 and 4 were virtually identical, so the two groups of plants were pooled and another regression equation was calculated.

After calculating the differences between observed sales and estimate sales for Groups 2 and 4, it was evident that the regression equation generally underestimated sales for these groups, thereby yielding a relatively conservative estimate of sales in regard to the forthcoming economic impact analysis. The elasticity of sales with regard to employment for this model ranged from 0.11 to 1.41; this indicates that economies of scale were preserved. The equations for Groups 1 and 3, on the other hand, have constant elasticities.

Table A-3

Regression Results
(sales in 1000 $)

Group	Model	R^2	a (t)+	B (t)	N
1	sales = a + B * employment	.95	8109.94 (.77)	144.61 (18.94)	19
2&4	ln(sales) = a + B * $\ln^2$(employment)	.71	8.12 (82.91)	0.08 (19.56)	155
3	sales = a + B * employment	.83	11166.32 (2.04)	170.50 (12.25)	32

+(t) - is the t-statistic for testing whether the estimated parameter is significantly different from zero. Except for the y-intercept estimates for Groups A and C, all parameters were significantly greater than zero at the 99.9% confidence level. The problems with the intercept estimates are due to clustering of data points near the origin.

Appendix B

Detailed Descriptions of Product Group

The following is an elaboration of the product group discussion in Section 3. The value of shipments for each of these product groups is presented in Table B-1 (duplicate of Table 3-12).

Preparations Affecting Neoplasms, Endocrine System and Metabolic Diseases

This group includes a fairly diverse number of pharmaceutical products. Shipments of $900 million were recorded in 1977; which accounts for 9.2 percent of the final products shown in Table B-1. Value of shipments increased 7.9 percent annually while shipments for all eleven groups grew 9.3 percent annually.

Hormones accounted for more than 75 percent of total group shipments. Secreted by the endocrine glands (thyroid, pituatory, gonads, and others) and present only in minute quantities, natural hormones regulate the body's metabolic activities. Hydrocortisone, androgens, estrogens, and progestogens are examples of steroid hormones. Corticotropin and insulin are nonsteroidal hormones. Hormones shipments increased slowly at 5.3 percent annually from 1972 to 1977. While ten out of the 200 most prescribed drugs in 1980 were oral contraceptives, they grew at annual rate of only 2.9 percent from 1972 to 1977. Topical and systemic corticoids (used as anti-flammatory agents) accounted for 30 percent of group shipments and show an average annual increase of 8.8 percent from 1972 to 1977. Insulin and antidiabetic agents, sex hormones (other than progestogens and thyroid and antithyroid preparations) all had shipment increases well below the industry average. Antineoplastic agents, used to treat cancerous growths, grew 21.2 percent annually from 1972 to 1977. This subgroup includes radio-isotopes for internal use and specific antineoplastic agents.

In summary, this product group has exhibited a lower than average rate of increase in shipments, with only antineoplastic agents showing a growth rate well above the industry average.

Preparations Affecting Central Nervous System and Sense Organs

Value of shipments for this group accounted for 22 percent of shipments for all product groups, the largest of all groups. Shipments increased only 6.4 percent annually from 1972 to reach $2.231 billion in 1977. Important subgroups are internal narcotic and non-narcotic

Table B-1

Pharmaceutical Final Product Class Value of Shipments
(current dollars)

Product Class	Value of Shipments Millions of Dollars 1977	1972	Uniform Average Increase (Percent)
Preparations affecting neoplasms, endocrine system and metabolic diseases	900	615	7.9
Preparations affecting central nervous system and sense organs	2231	1636	6.4
Preparations affecting cardiovascular system	751	400	13.4
Preparations affecting respiratory system	896	561	9.8
Preparations affecting digestive and genito-urinary systems	1074	746	7.6
Preparations affecting the skin	621	344	12.5
Vitamins, nutrients and hematinics	1302	587	17.3
Preparations affecting parasitic and infectious diseases	1285	948	6.3
Preparations for veterinary use	354	214	10.6
Blood and blood derivatives for human use	243	126	14.1
Active and passive immunization agents and therapeutic counterparts	126	89	7.2
Total	9783	6266	9.3

Source: 1977 U.S. Census of Manufactures Report (Current Industrial Reports figures).

analgesics and antipyretics, psychotherapeutic agents, Central Nervous System (CNS) stimulants, sedatives and hypnotics, anesthetics, and eye and ear preparations.

Analgesics reduce awareness of pain without loss of consciousness; antipyretics help lower body temperature. The narcotic analgesics include morphine and its derivatives, synthetic morphine-like drugs and synthetic moieties of morphine molecules. Shipments of narcotic analgesics were valued at $172 million in 1977, showing an annual increase since 1972 of 13.2 percent. Nonnarcotic analgesics, which include aspirin, phenacetin, and acetaminophen, had 1977 shipments of $746 million with an average annual increase since 1972 of only 5.3 percent. Aspirin, aspirin combinations and other salicylates yielded $391 million in shipments. Aspirin alone had a shipments increase of only 1.5 percent increase from 1972 to 1977. While the narcotic analgesics are all ethical drugs, most of the nonnarcotic are proprietary . Also included in this group are the nonhormonal antiarthritics.

Psychotherapeutic agents include antidepressant drugs and tranquilizers. Shipments in 1977 were $754 million, increasing annually at 4.9 percent since 1972.

Amphetamines, a major subgroup of CNS stimulants, typically are used to reduce fatigue or appetite (anti-obesity drugs). Amphetamine shipments decreased 8.4 percent annually from 1972 to 1977. Stimulants as a whole grew at one percent annually during the same period.

Sedatives and hypnotics (sleep inducing agents) had $97 million in 1977 shipments increasing only 2.6 percent annually since 1972. This slow growth rate is in part due to the introduction of a number of new nonbarbiturate drugs in the late 1970s.

General and local anesthetic shipments grew 8.6 percent annually from 1972 to reach $88 million in 1977. All growth in this subgroup has been in local and topical anesthetics.

Eye and ear preparations have seen the highest growth in shipments (11.6 percent) after the narcotic internal analgesics. Total shipments were valued at $103 million in 1977. Miotics, agents that cause the pupil to contract, mydriatics, agents that dilate the pupils, and contact lens solutions are included in this subgroup.

In summary, while the largest product group in terms of value of shipments , it is one of the slowest growing. Only narcotic analgesics have been growing faster than the industry average.

Preparations Affecting the Cardiovascular System

This group of products had the second highest rate of shipments increase of all eleven groups with an annual rate of increase of 13.4 percent. Total 1977 shipments were $751 million, while 1972 sales were $400 million. This drug market appears rather promising because a number of new drugs with far-ranging possibilities, notably calcium and beta blockers, have entered the market in recent years.

Anticoagulants are agents that delay or counteract blood coagulation and are used to reduce or prevent blood clot formation within blood vessels. Shipments in 1977 were valued at $35 million, having grown 15.0 percent annually since 1972. Hypotensives help control hypertension and its effects, particularly high blood pressure. The major hypotensives contain rauwolfia compounds derived from an herb. Total 1977 value of shipments for hypotensives (the largest subgroup within this group) was $335 million, and increased at 13.7 percent annually from 1972 to 1977.

Vasodilators induce smooth and cardiac muscle relaxation and dilate the blood vessels. Shipments in 1977 were estimated at $156 million, having increased only 4.5 percent annually since 1972.

The last major subgroup includes vasopressors, antiarrhythmics and antiheparin agents. Vasopressors constrict blood vessles and thus raise blood pressure. Antiarrhythmics help slow the irregular, rapid heartbeats knows as arrhythmias (a potentially fatal condition for those with weak or diseased hearts). The beta and calcium blockers are perhaps the most important new drugs in this group. Calcium blockers prevent calcium and minerals from entering muscle tissues and thus ease the pain of angina. Calcium blockers have fewer side effects than beta blockers, which try to influence the hormonal system that can speed up the heart and other organs' action in times of stress. Shipments in 1977 for this subgroup were $201 million, with a growth rate of 25.3 percent annually, from 1972 to 1977.

In summary, this product group has been experiencing very rapid growth in shipments, with vasopressors, antriarrhythmics and antiheparin agents increasing the fastest.

Preparations Affecting the Respiratory System

This product group's shipments increased 9.8 percent annually from 1972 to 1977, slightly above the overall pharmaceutical industry average of 9.3 percent. The largest subgroup--cold preparations, both ethical and proprietary, without antitussives--grew only 7.4 percent annually. This subgroup had $518 million in shipments in 1977 and represented 58 percent of respiratory system product sales. The category includes nasal decongestants, nose drops, lozenges, and antihistamines. Cold preparations include combinations of antibiotics, nasal decongestants, antihistamines, analgesics, and bioflavanoids. Bronchial dilators, agents

that open the lungs, bronchi, and bronchial tubes making breathing easier, and cough preparations, both narcotic (those with codeine) and non-narcotic, had shipments increases greater than the pharmaceutical industry average. Antihistamines are complex amines that prevent the buildup of histamines in body tissues and are typically used for treatment of allergenic diseases. They are also used in nasal and ophthalmic decongestants, sleep inducers, and antipruritics (for relief of itching). Shipments growth of antihistamines, except those in cold preparations, was just 4.0 percent annually from 1972 to 1977 and represented only a small portion of the $896 million of respiratory shipments.

Preparations Affecting the Digestive and Genito-Urinary Systems

This product group accounted for just over a billion dollars in value of shipments in 1977 and represented 11 percent of the product mix. Antacids, the largest subgroup in this category with $300 million in 1977 shipments, have experienced growth of 0.6 percent annually since 1972. Antacids reduce excess gastric acidity by several methods: neutralization; buffering; a combination of absorption, buffering and partial neutralization; or ion-exchange. Sodium bicarbonate, sodium citrate, sodium acetate, magnesium oxide, calcium carbonate, and aluminum hydroxide gel are common active ingredients in antacids. While antacids are proprietary drugs, roughly 65 percent of all products in this group are ethical. Laxative shipments increased much less quickly with an annual percentage increase of 4.3 percent. Still, they represent 15 percent of the digestive and genito-urinary shipments. For both antacids and laxatives there is intense competition and the rising costs of advertising will become an important factor in sales growth in the near future. Phenolphthalein, castor oil, magnesium sulfate, milk of magnesia, agar, methylcellulose, mineral oil, dioctyl sodium, and calcium sulfosuccinates are all active ingredients in laxatives. Antispasmodics and anticholinergenics are drugs that relax involuntary (smooth) muscles and help relieve discomfort from peptic ulcers and asthma.

Diuretics, agents that promote urine excretion, are an important growth market. In 1977, $215 million worth of diuretics were shipped, exhibiting a growth of 9.0 percent annually since 1972. Nearly all the major pharmaceutical manufacturers make or market one or more of these compounds. While diuretics increase urine, sodium, and chloride excretion, many also promote potassium excretion. Perhaps the biggest area for sales growth is with "potassium-sparing" diuretics. A number already exist with others slated for release soon.

The subgroup with the largest percent increase in shipments is the contraceptive agents (not including oral contraceptives) subgroup. Shipments increased from $30 million in 1972 to $68 million in 1977--a rate of 17.8 percent a year. These figures include shipments for contraceptive foams, aerosols, and jellies.

Preparations Affecting the Skin

The value of shipments for this group increased 12.5 percent annually between 1972 and 1977 with $621 million in shipments in 1977. This rate is above the pharmaceutical industry average of 9.3 percent for the same period. Dermatological preparations, used for treatment of skin disorders, represented 63 percent of group shipments and increased 15.9 percent annually. Within this subgroup, antiacne and antiseborrehic preparations increased 22.5 percent annually in shipments. Other drugs contained in this group are hemorrhoidal preparations and external analgesics.

Vitamins, Nutrients and Hematinic Preparations

This group had 1977 shipments of $1.3 billion. It had the highest growth rate in the pharmaceutical industry (17.3 percent) and accounted for ten percent of the total product mix. Group shipments have been increasing strongly since the 1960s; the average annual growth in shipments from 1967 to 1977 was 13.4 percent.

Vitamins are necessary in small quantities for normal metabolism and are most often marketed as dietary supplements. They are also used medicinally to prevent or treat disease. Most of the vitamin production is by chemical synthesis. Bulk vitamins are formulated either as pills or capsules and are frequently used by the animal feed and food additive industries. From 1972 to 1977 multivitamin shipments increased annually at 16.9 percent. Nutrients, not including therapeutic dietary foods and formulations, increased in shipments 40.5 percent annually over the same period. General dietary supplements of calcium, protein and potassium and also infant formulas, such as Similac and Enfamil, are the major products of this subgroup.

Hospital solutions supply a patient with fluids, nutrients and electrolytes and shipments of such products have increased 22.6 percent annually from 1972 to 1977. More than $380 million worth of these products were shipped in 1977. Hematinics, agents that aid blood cell and hemoglobin formation, were the only major subgroup of products to experience a very low rate of sales increase--3.3 percent--in this group.

Preparations Affecting Parasitic and Infectious Diseases

Included in this group are amebicides, anthelmintics, antibiotics, tuberculostatic agents, antimalarials, sulfonamides, antifungal preparations, antibacterials, and antiseptics. In total 1977 shipments value this was the third largest, with $1.28 billion. Value of shipments growth has slowed to 6.3 percent annually from 1972 through 1977. Over 70 percent of total shipments value is due to shipments of antibiotics which grew 7.3 percent annually from 1972 to 1977.

Broad and medium spectrum antibiotics (not including penicillin) accounted for more than 66 percent of total antibiotics shipments; this subgroup includes tetracycline and its derivatives, erythrocin, cephalosporins, and chloramphenicol. Cephalosporins have seen a number of new developments in recent years. They are substances chemically related to penicillins but have a broader spectrum of activity and lower acute toxicities than penicillins. Penicillin shipments grew at a slower rate of 6.3 percent annually. Most likely shipments will continue to grow at a slow rate as more and more pathogens become resistant to penicillin. However, a number of popular antibiotics are semi-synthetic penicillins; the precursor to penicillin is produced by fermentation and then chemically altered to increase effectiveness.

Sulfonamides, or sulfa drugs, have been gradually replaced by antibiotics in treating bacterial infections, but shipments growth is above the group average, 7.4 percent annually. They are used in diuretics, hypoglycemics, and hemotherapeutics. Antibacterials and antiseptics have shown virutally no growth from 1972 to 1977, but represent 13 percent of value of shipments for the group in 1977.

Preparations for Veterinary Use

This group includes all health, vitamin and nutrient products formulated for veterinary use. There were over $350 million worth of shipments in 1977 representing approximately three percent of total shipments for all eleven product groups. Average annual growth from 1972 to 1977 was 10.6 percent. Most of the subgroup had little or no growth, but antibiotics shipments grew at 12.0 percent annually and hormone shipments increased 18.6 percent annually. Together they accounted for 46 percent of group shipments.

Blood and Blood Derivatives for Human Use

Included in this group are whole human blood, blood plasma, normal blood serum, and other blood fractions. Total shipments in 1977 were $243 million, having increased 14.1 percent annually since 1972.

Preparations for Active and Passive Immunization and Therapeutic Counterparts

Total 1977 shipments for this group were $126 million, having shown an average annual increase of 7.2 percent since 1972. Toxoids, antigens, and viral vaccines are used in active immunization. An active immunization agent alerts the body's immunological defense system and causes it to form antigens and antibodies to deal with a possible future pathogen. Passive immunization agents, like antitoxins, help the body deal with a pathogen that has breached the body's defenses. Antivenins, antitoxins, immune globulins, and immune serums are agents of passive immunization.

Other Products

Product types in SIC 2831 not included in the eleven groups above are active and passive immunization agents for veterinary use and diagnostic substances (allergenic extracts and other biologicals). Total 1977 shipments for these product groups was $570 million.

Appendix C

Capital Recovery Factor

The capital recovery factor (CRF) measures the rate of return that an investment must achieve each year in order to cover the cost of the investment and maintain net earnings, including depreciation and taxes. Stated another way, the capital recovery factor is the excess of revenues over variable costs, per dollar of invested capital, needed to cover the cost of borrowing, depreciation and net profit-related taxes, while preserving the market value of the firm's stock.

The formula for CRF used in previous analyses was:

$$CRF = \frac{A(N,K_f) - td}{1 - t} \qquad (C\text{-}1)$$

where:

N	=	lifetime of investment
K_f	=	average after-tax cost of capital
$A(N,K_f)$	=	annuity whose present value is 1, given N and K_f $[K_f/(1-(1+K_f)^{-N})]$
d	=	depreciation rate
t	=	corporate income taxes

Changes in the tax code dealing with rapid depreciation and investment tax credits require alterations in the formula for calculating the capital recovery factor. The revised formula is:

$$CRF = \frac{A(N,K_f)(.9-c)}{1 - t} \qquad (C\text{-}2)$$

where: $$c = \sum_{j=1}^{n} \frac{td'}{(1+K_f)^j}$$

where:

n	=	depreciation lifetime under tax code
d'	=	new depreciation rate

Other variables as above.

The assumptions and data used to obtain values for the above variables are described below.

Average Cost of Capital

The cost of capital, K_f, is the average percentage return that suppliers of debt and equity demand. For firms which have more than one type of capital, K_f is calculated as the average of the after-tax costs of debt and the costs of equity, weighted by the share of market value of each relative to the total market value of the firm. In equation form:

$$K_f^* = bi(1-t) + (1-b)r \qquad \text{(C-3)}$$

where:

K_f^* = average cost of capital after taxes
i = average cost of debt
r = average cost of equity
t = corporate income tax rate
b = share of debt financing

The costs of debt and equity are measured by the current market value of outstanding debt and stock, rather than the original costs when the debt and equity were issued. The argument that projects should be evaluated using the weighted average cost of capital as the discount factor has been made elsewhere* and rests on several assumptions. Firms are assumed to have an optimal debt/equity ratio (or at least some preferred debt/equity ratio), to have already obtained that ratio, and to strive to maintain it over time. In addition, it is assumed that new projects do not alter the overall risk position of the firm. (A change in the risk level might result in a change in the debt/equity level.) Therefore, new projects, on average, will be financed with these same desired fractions of debt and equity.

Cost of Debt. Since firms often have more than one debt issue, it is necessary to calculate an average cost within a company as well as across companies. The following information on the debts of 40 chemical companies was obtained from Standard and Poor's Bond Guide (August 1979).**

*See, for example, J. Fred Weston and Eugene F. Brigham, Managerial Finance (6th ed.), Dryden Press, 1978, Chapter 19.

**It is assumed that the cost of capital to pharmaceutical companies is very close to that for chemical companies in general.

1) yield to maturity
2) debt outstanding
3) closing price

First, the total market value of each bond issue is calculated as the bond price multiplied by the amount of debt outstanding. Second, the average cost of debt is calculated as a weighted average of the various values for yield to maturity, where the weights equal the ratio of the market value of each bond issue to the total value of debt. The average before-tax cost of debt for these companies is 9.89 percent.

Cost of Equity. A firm's cost of equity can be expressed in equation form as:

$$r = \frac{e}{P} + g \qquad \text{(C-4)}$$

where e is the annual dividend, P is the stock price, and g the expected growth rate of dividends.* To estimate the firms' cost of equity, the following data were obtained from Standard and Poor's Stock Guide (August 1979):

1) dividend yield;
2) closing price;
3) number of shares outstanding.

Information was collected for common stocks. The existence of preferred stocks complicates the calculations substantially, since a preferred stock is more nearly a stock-bond hybrid. Preferred stocks are ignored except where they represent more than 10 percent of the market value of all stocks. In those cases where preferred stocks represent a signficiant portion of equity, the company was removed from the survey.

An estimate of the expected growth rate was obtained using data from the USITC Organic Chemicals (1977) and the DRI Chemical Review. A weighted average of annual growth rates for plastics, fibers, and elastomers sales was obtained for the entire industry:

$$g = \underset{\text{Plastics}}{.745(.071)} + \underset{\text{Elastomers}}{.125(.016)} + \underset{\text{Fibers}}{.130(.038)} = .06 \qquad \text{(C-5)}$$

Depreciation

Depreciation is normally defined as the fraction of revenues set aside each year to cover the loss in value of the capital stock. Due to recent changes in the federal tax code, the economic life of a capital item is

*See, for example, J. Weston and E. Brigham, op.cit.

now considerably longer than the depreciation life for tax purposes. Based on earlier work the lifetime of capital stock for this industry is assumed to be about 10 years.* The depreciation rate for most personal property now is straight-line over five years (20 percent). These values are used in the revised calculation of the capital recovery factor.

Tax Rate

The current federal corporate income tax rate is 20 percent on the first $25,000 of profits, 22 percent on the next $25,000, and 46 percent on all profits over $50,000. For this analysis, plants are assumed to be paying an even 46 percent federal tax on all profits. A study by Lin and Leone** indicates that state and local income taxes also are a significant factor in pollution control investments. State corporate income tax rates may be as high as 9.5 percent. In their study, a weighted average of 7 steel-producing states yielded an average state corporate income tax rate of 7.55 percent. State income taxes, of course, are deductible expenses in computing corporate income tax. A state corporate income tax rate of 3 percent is assumed here. Deducting this figure before computing the federal income tax rate reduces the net effect of the 8 percent rate to about 4 percent. Thus, the overall effective income tax rate is approximately 50 percent.

Sensitivity Analysis

Table C-1 presents various values for the capital recovery factor, assuming various weighted costs of capital (K_{ℓ}) and different formulations allowing for changes in the federal tax code. Both the rapid depreciation and the investment tax credit serve to lower the capital recovery factor, thus reducing the return necessary to justify a given investment.

The weighted cost of capital is estimated based on the current costs as reflected in the current prices and yields of a sample of corporate stocks and bonds for that industry. In August of 1979, the weighted cost of capital for the organic chemical industry was estimated to be about 10 percent. There are two major assumptions in using this method. First that current prices and yields accurately reflect future costs of capital. However, interest rates have increased significantly since the summer of 1979. Second, that the current portfolio mix will remain

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*Draft Industry Description: Organic Chemical Industry, Vol. I, Meta Systems, December 1979.

**An Loh-Lin and Robert A. Leone, "The Iron and Steel Industry," in Environmental Controls, (Robert A. Leone, ed.), Lexington, MA: Lexington Books (1976), p. 70.

constant over the next several years. Given changes in tax codes, and changes in the availability of certain sources of capital such as industrial revenue bonds, this is unlikely. Therefore the cost of capital is expected to be higher than 10 percent. Given the mix of financing sources available, the weighted cost of capital for the period covered by this study is assumed to be close to 15 percent.

Table C-1

Alternative Derivations of the Capital Recovery Factor

Variable	Values						
Weighted cost of capital (K_f)	.10	.15	.20	.10	.13	.15	.20
Life of asset (N)	10	10	10	10	10	10	10
A(N, K_f)	.163	.199	.239	.163	.185	.199	.239
Depreciation life (n)	10	10	10	5	5	5	5
Depreciation rate (d)	.10	.10	.10	.20	.20	.20	.20
Tax rate (t)	.50	.50	.50	.50	.50	.50	.50
c				.379	.352	.335	.299
CRF(1)	.226	.298	.378				
CRF(2)				.201	.240	.265	.335
CRF(3)				.169	.202	.225	.288

where: CRF(1) is original formula (C-1 in text)
CRF(2) allows for rapid depreciation but not investment tax credit
CRF(3) allows for both rapid depreciation and investment tax credit (C-2 in text)

A single, industry-wide CRF equal to 22 percent has been used in our analysis. For a given investment, a firm's CRF will vary with their cost of capital and mix of financing. However, it was not possible to estimate a separate CRF for each establishment or firm.