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Economic Impact Analysis of Proposed Effluent Limitations Guidelines and Standards for the Pesticide Manufacturing Industry

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EXECUTIVE SUMMARY

Introduction

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (section 101(a)). To implement the Act, the U.S. Environmental Protection Agency (EPA) is to issue effluent limitations guidelines, pretreatment standards, and new source performance standards for industrial dischargers. This Economic Impact Analysis (EIA) documents the assessment of the economic impacts of the guidelines and standards applying specifically to the pesticide manufacturing industry.

The EIA estimates the probable economic effect of compliance costs in terms of facility closures, product line closures, profitability impacts, and ability to incur debt. Firm-level impacts, local community impacts, international trade effects, and the effect on new pesticide manufacturing facilities are also presented. A Regulatory Flexibility Analysis detailing the small business impacts is also included in the EIA for this industry.

A total of 90 pesticide manufacturing facilities, owned and operated by 64 firms that manufacture one or more pesticide active ingredients (PAIs), are potentially subject to regulation. The EPA analyzed the impacts of two possible regulatory options: a Treated Discharge Option (the proposed option) and a Zero Discharge Option based on on-site and off-site injection or incineration. The economic impacts under each regulatory option were calculated separately for facilities discharging wastewater directly to surface water (direct dischargers) and facilities discharging wastewater to a publicly owned treatment works (POTW) (indirect dischargers). Impacts on direct dischargers were calculated for compliance with a *Best Available Technology Economically Achievable* (BAT) regulation; impacts on indirect dischargers were calculated for compliance with *Pretreatment Standards for Existing Sources* (PSES) regulation. Each discharge category was further analyzed by two subcategories: Organic Pesticide Chemicals Manufacturing (Subcategory A) and Metallo-Organic Pesticide Chemicals Manufacturing (Subcategory B).

The proposed regulation applies to Subcategory A and corresponds to the Treated Discharge Option. Total BAT investment costs (capital and land) for the proposed regulation are projected to be $14.9 million, with annualized costs of $14.7 million including depreciation and interest. Total investment costs for PSES for the proposed regulation are projected to be $9.4 million, with annualized costs of $5.9 million including depreciation and interest.

Cost of Implementing BAT and PSES Regulations for Subcategory A (in millions of 1986 dollars)	BAT	PSES
Capital Costs	$14.9	$9.4
Total Annualized Costs	$14.7	$5.9

The costs, presented in 1986 dollars, are based on the assumption that, whenever possible, facilities will improve existing treatment rather than build new treatment. Although 90 facilities are potentially subject to the regulation, EPA analyzed only 88 facilities for economic impacts. Financial data were not obtained for one facility originally classified as a formulator/packager. The other facility for which economic impacts were not calculated was a research and development facility with no revenues associated with in-scope PAIs. One of these facilities is expected to incur no cost under the proposed regulation; the other is expected to incur only monitoring costs.

Methodology

The costs and impacts of implementing the regulatory options are analyzed on an PAI-specific basis for each facility. Building on the PAI-specific data, the EIA uses three primary impact measures: facility closures, product line closures, and other significant impacts short of closure. The analysis of significant impacts short of closure measures the effect of compliance costs on the ability of facilities to incur debt and on facilities' return on assets. The analysis evaluates these impacts in a hierarchical manner that corresponds to the severity of the projected impact: if a facility closes, product line closures and other significant impacts are not evaluated; if a facility sustains a product line closure, other significant impacts are not evaluated. The impacts are estimated for pesticide manufacturing facilities incurring costs using a combination of data from the *Pesticide Manufacturing Facility Census for 1986* (hereinafter referred to as the Census) and secondary sources, such as Standard and Poor's *Compustat* financial data, plus facility-specific compliance cost estimates developed by the EPA. First, pre-compliance (baseline) estimates of each of the three primary impact measures are calculated for each facility, to gauge the economic vitality of each facility prior to the proposed regulation. If a facility fails one of the measures (e.g., a facility closes) in the baseline scenario, the model does not recount this same level of failure in the post-compliance scenario. The model does allow, however, for progressively severe impacts due to compliance (e.g., a baseline product line closure may become a post-compliance facility closure).

The facility-level closure analysis considers the portion of the facility involved in manufacturing, and also formulating/packaging or performing contract work, for both in-scope pesticides (i.e., those 270 PAIs considered for regulation) and out-of-scope pesticides (all others).[1] A facility closure is projected to result from the regulation if the salvage value exceeds the present value of cash flow in the post-compliance, but not the baseline, scenario.

A product line, or cluster, is composed of PAIs that are close substitutes for each other for a specific end-use. For example, insecticides used on corn is one cluster. Fifty-six clusters were identified as part of the impact analysis, forty-five of which contain in-scope PAIs produced in 1986. A baseline product line closure is projected if the unit cost (average variable cost plus average fixed cost per pound of PAI) of the product line exceeds the unit price (average price per pound of PAI). A post-compliance product line closure is projected if the product line remained open in the baseline, but showed unit costs exceeding unit price due to the addition of compliance costs.

Short of closure, other significant impacts of compliance with the effluent limitations are calculated based on the comparison, between each facility and the industry averages, of two key financial ratios: the "interest coverage ratio"[2] (earnings before interest and taxes divided by interest expense) and "return on total assets"[3] (earnings before interest and taxes divided by assets). If either ratio for a facility falls in the lowest quartile for the industry in the post-compliance but not the baseline scenario, it is said to sustain a significant impact short of closure.

Baseline Results

The baseline economic analysis evaluated each facility's financial operating condition prior to incurring compliance costs for this regulation. This analysis included the estimated costs associated with two significant EPA regulations not in place in 1986 (the base year) and whose costs were therefore not reflected in the annual operating expenses provided by the firm in the Census. Baseline cost additions include (1) RCRA costs for relining surface impoundments that treat, store, and dispose of hazardous wastes, and (2) compliance with the effluent guidelines for the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) industry. Of the 90 facilities potentially subject to the proposed effluent guidelines, 15 are projected to close in the baseline analysis after incorporating the costs of RCRA and OCPSF regulations. In fact, three of these facilities have closed and another two have closed one or more product lines since 1986. An additional 20 facilities are projected to close pesticide product lines. Of these, two have closed entirely, five have closed a pesticide product line, and two have changed ownership since 1986.

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[1]Compliance cost estimates were developed for only that portion of the facility engaged in <u>manufacturing</u> one or more of the in-scope PAIs.) The facility closure analysis uses a net present value approach (which compares discounted cash flow to salvage value) to project whether pesticide operations would remain open after regulatory costs are incurred. The first step in the facility closure analysis was to project baseline costs and revenues over the life of the facility. Projected regulatory costs were then added to the baseline costs; these post-compliance costs were used to estimate a post-compliance cash flow.

[2]Also called "times interest earned."

[3]Also called "return on investment."

Effects of Regulatory Compliance on Facilities

The EPA analyzed the impacts of two possible regulatory options for BAT and PSES: a Treated Discharge Option, and a Zero Discharge Option based on on-site or off-site injection or incineration. The economic impacts associated with these two options are discussed below, by both discharge type and subcategory.

Treated Discharge Option

Impacts on Direct Dischargers

Organic Pesticides Chemicals Manufacturing (Subcategory A)

For manufacturers included in this subcategory, the incremental capital and annualized total costs (including capital, operating and maintenance, and monitoring costs) of complying with BAT limitations are expected to be $14.9 million and $14.7 million, respectively. No facilities are projected to close due to compliance with BAT. One facility, equal to three percent of the 32 direct discharge facilities covered under this subcategory, is projected to close a product line as a result of the regulation. (One other facility projected to close a product line, a zero discharger, incurs only monitoring costs.) No facilities are expected to experience other significant financial impacts short of facility or product line closure. Job losses totalling 31 full-time equivalents (FTE) are expected to occur as a result of the product line closures and the decrease in demand resulting from higher prices. This employment loss represents less than one percent of employment in the pesticide-related portions of all pesticide manufacturing facilities. One firm, equal to 1.5 percent of the 64 firms in the industry, is expected to experience significant financial impacts as a result of compliance with BAT. Foreign trade in PAIs is expected to fall by $5.5 million due to compliance with BAT. In 1986, the United States was a net exporter of PAIs, with a trade balance of $897 million; the decrease in PAI trade is projected to be less than one percent. When compared with U.S. net imports of $152 billion in merchandise for 1986, compliance with the BAT regulation is seen to cause an increase in net imports of less than one one-thousandth of one percent.

Metallo-Organic Pesticides Chemicals Manufacturing (Subcategory B)

No new limitations on direct dischargers are proposed by the EPA for Subcategory B. Therefore, there are no associated costs or economic impacts.

Impacts of PSES Regulations on Indirect Dischargers

Subcategory A

For manufacturers included in this subcategory, the total capital and annualized costs of compliance with PSES are projected to be $9.4 million and $5.9 million, respectively. No facilities are projected to close due to compliance with PSES. One facility, or three percent of the 36 facilities in this subcategory, is projected to close a product line as a result of the regulation. No facilities are estimated to experience other significant financial impacts short of facility or product line closure. Job losses totalling 97 FTEs are expected to occur as a result of the product line closures and the decrease in demand resulting from higher prices. This employment loss represents less than one percent of employment in the pesticide-related portions of all pesticide manufacturing facilities. Two firms are expected to sustain significant financial impacts as a result of compliance with PSES. Foreign trade in PAIs is expected to fall by $16.1 million due to compliance with PSES. This decrease in trade represents about two percent of 1986 net exports of PAIs and about one-hundredth of one percent of the 1986 net national trade imports of all goods.

Subcategory B

No new limitations on indirect dischargers are proposed by the EPA for this subcategory. Therefore, there are no associated costs or economic impacts.

Zero Discharge Option

Impacts of BAT Regulations on Direct Dischargers

Subcategory A

Compliance with limitations based on the Zero Discharge Option is expected to cost manufacturers of Subcategory A pesticides $1.13 million in incremental capital costs and $4.81 billion in annualized costs. Total pesticide-related revenue for all 88 pesticide manufacturing facilities equaled $4.84 billion in 1986: only slightly greater than the projected annualized Zero Discharge Option compliance costs for direct dischargers in this subcategory.

Sixteen facilities (50 percent of the 32 direct discharge facilities in this subcategory) are projected to close due to compliance with this option. Three additional facilities, equal to ten percent of the 32 direct discharge facilities covered under this guideline, are projected to close a product line. (One of the facilities expected to close a product line, a zero discharger, would incur only monitoring costs. Because the 32 facilities against which impacts are compared do not include zero dischargers, the percentage of facilities affected is overstated.) No facilities are expected to experience other significant financial impacts short of facility or product line closure. Job losses totalling 7,110 FTEs are expected to occur as a result of the facility closures, product line closures, and the decrease in demand resulting from higher prices. This employment loss represents 72 percent of employment in the pesticide-related portions of all pesticide manufacturing facilities. Seven firms, equal to about eleven percent of the 64 firms in the industry, are expected to experience significant financial impacts as a result of compliance with this option. Foreign trade in PAIs is expected to fall by $2.4 billion, shifting the U.S. PAI balance of trade from $897 million in exports in 1986 to $1.5 billion in imports. The U.S. national net imports of merchandise would increase by about two percent.

Subcategory B

No new limitations on direct dischargers are proposed for this subcategory. Therefore, there are no associated costs or economic impacts.

Impacts of PSES Regulations on Indirect Dischargers

Subcategory A

For manufacturers of organic pesticides, the total capital and annualized costs of compliance with the Zero Discharge Option are estimated to be $1.1 million and $518.8 million, respectively. Eleven facilities (31 percent of the 36 facilities with indirect discharges in this subcategory) are projected to close if forced to comply with this option. Three facilities (8 percent of the 36 facilities with indirect discharges in this subcategory) are projected to close a product line. No facilities are expected to experience other significant financial impacts short of facility or product line closure. Job losses totalling 802 FTEs are expected to occur as a result of the facility closures, product line closures, and the decrease in demand resulting from higher prices. This employment loss represents 8 percent of employment in the pesticide-related portions of all pesticide manufacturing facilities. Seven firms, equal to about eleven percent of the firms in the industry, are expected to sustain significant financial impacts as a result of compliance with this option. Foreign trade in PAIs is expected to fall by $179.6 million due to compliance with the Zero Discharge Option. This decrease in trade represents 20 percent of 1986 U.S. net PAI exports and 0.12 percent of 1986 net national imports of all goods.

Subcategory B

No new limitations on indirect dischargers are being proposed for this subcategory. Therefore, there are no associated costs or economic impacts.

Effects of Regulatory Compliance on New Sources of Pesticide Manufacture

The EPA is also proposing to establish New Source Performance Standards (NSPS) and Pretreatment Standards for New Sources (PSNS) for the organic pesticide chemicals manufacturing subcategory. These regulations are proposed to be equal to BAT/PSES limitations for PAIs, modified to reflect a wastewater flow reduction of 28 percent in some cases. The NSPS for priority pollutants is being set equal to the BAT limitations. The projected impact of the proposed regulations on new sources is expected to be less burdensome than the impact of the BAT/PSES regulations on existing sources; designing a new technology prior to facility construction is typically less expensive than retro-fitting a facility for a new technology. Because compliance with the Treated Discharge Option has been found to be economically achievable for existing facilities, it is expected that compliance with this option will also be achievable for new sources. NSPS/PSNS for metallo-organic pesticide chemicals are not being proposed at this time. Therefore, there are no associated impacts on new sources.

Regulatory Flexibility Analysis

The Regulatory Flexibility Act (5 U.S.C. 601 et seq., Pub. L. 96-354) calls for the EPA to prepare a Regulatory Flexibility Analysis (RFA) for proposed regulations having a significant impact on a substantial number of small entities. The purpose of the Act is to ensure that, while achieving EPA's statutory goals, the EPA's regulations do not impose disproportionate impacts on small entities.

Both the Treated Discharge Option and the Zero Discharge Option were evaluated to determine their impacts on small entities. The analysis concludes that a substantial number of small entities will not be impacted significantly under the Treated Discharge Option. Although a substantial number of small entities would be expected to be impacted significantly under the Zero Discharge Option, that impact would not be expected to fall disproportionately on small entities. Therefore, no alternative regulations for small entities were considered.

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Chapter 1: INTRODUCTION AND OVERVIEW

1.0 Background and Definitions

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Section 101(a)). To implement these amendments, the U.S. Environmental Protection Agency (EPA) issues effluent limitations guidelines, pretreatment standards, and new source performance standards for categories of industrial dischargers. Specifically, the regulations that the EPA establishes are:

- *Best Practicable Control Technology Currently Available* (BPT). These rules apply to existing industrial direct dischargers, and generally cover control of conventional pollutant discharge.[1]
- *Best Available Technology Economically Achievable* (BAT). These rules apply to existing industrial direct dischargers and the control of priority and non-conventional pollutant discharges.
- *New Source Performance Standards* (NSPS). These rules apply to new industrial direct dischargers and cover all pollutant categories.
- *Pretreatment Standards for Existing Sources* (PSES). These rules apply to existing indirect dischargers (whose discharges enter Publicly Owned Treatment Works, or POTWs). They generally cover the control of toxic and non-conventional pollutant discharges that pass through the POTW or interfere with its operation. They are analagous to the BAT controls.
- *Pretreatment Standards for New Sources* (PSNS). These rules apply to new indirect dischargers and generally cover the control of toxic and non-conventional pollutant discharges that pass through the POTW or interfere with its operation.

This Economic Impact Analysis (EIA) documents the assessment of the economic impacts of the proposed BAT, NSPS, PSES, and PSNS applying specifically to the pesticide manufacturing industry.

1.1 Structure of the Report

Two regulatory options are evaluated: one that would require treatment of process wastewater pollutants (Treated Discharge Option), and another that would require no discharge of process wastewater pollutants to POTWs or surface water (Zero Discharge Option).[2] The economic impacts are calculated

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[1]Conventional pollutants are defined as biochemical oxygen demand (BOD), total suspected solids (TSS), oil and grease, and pH. Other pollutants may also be regulated at the BPT level.

[2]The Zero Discharge Option would limit discharges from the facility site to POTWs or to surface water only; discharges to other media may remain constant or increase as a result of changes in discharge to surface water. For example, pesticide manufacturing facilities could, theoretically, achieve compliance with a zero

separately for the two options and, within each option, for direct and indirect dischargers. Direct dischargers would be required to comply with a BAT regulation; indirect dischargers would be required to comply with a PSES regulation.

This EIA describes both the methodology employed to assess impacts of the proposed options and the results of the analysis. The overall structure of the analysis is summarized in Figure 1.1. There are two main inputs to the analysis: (1) data on industry baseline financial and operating conditions, and (2) projected costs of complying with the proposed regulation.

The industry baseline financial and operating data are based principally on the *Pesticide Manufacturing Facility Census for 1986* conducted under Section 308 of the Clean Water Act.[3] The Census, which reported facility-level data, was divided into two parts. Part A contained technical data, and Part B contained economic and financial data. The projected costs of compliance with the proposed regulation (the second major input to the analysis) were developed by the EPA. Details on the compliance cost estimates can be found in the Technical Development Document for the proposed rule.[4] Additional information on all data sources is presented in Chapter 2.

To fully evaluate the expected impacts of the proposed options, six measures of impact are examined in the EIA:

- Impacts on facilities that manufacture PAIs covered by the regulation;
- Employment losses and associated community effects;
- Impacts on U.S. balance of trade;
- Impacts on firms that own facilities affected by the regulation;
- Impacts on pesticide facilities defined as small businesses; and
- Effects on the construction of new facilities and expansion of existing facilities.

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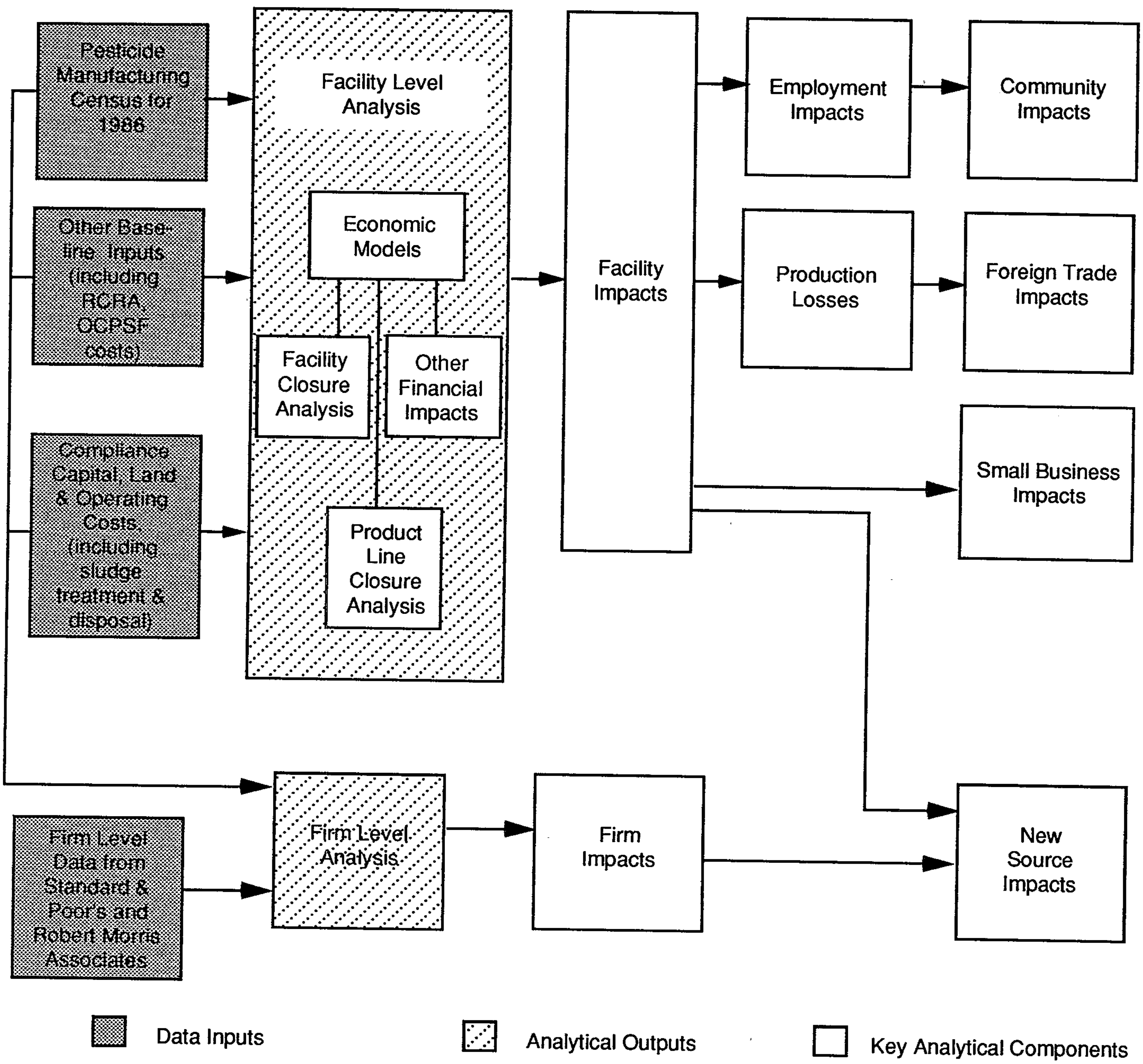
discharge effluent guideline by transferring the waste streams previously discharged to surface water to landfills, incinerators, or deep well injection sites.

[3]Baseline conditions also include certain costs deemed necessary to comply with particular regulations imposed under the Resource Conservation and Recovery Act (RCRA), and the effluent guidelines for the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) Industry. Portions of these regulations took effect after the base year of the Census, and imposed costs on certain pesticide manufacturers. These costs are also included in the analysis.

[4]Full title: *Technical Development Document for Proposed Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Pesticide Chemicals Point Source Category.*

Figure 1.1

Economic Impact Analysis of Pesticides Manufacturing Industry Effluent Limitations Guidelines: Analytic Components



The EIA methodology is based upon a facility-level impact analysis. This analysis drives the other components of the EIA (See Figure 1.1.) The facility-level economic model estimates post-compliance revenues, costs, and profits. The post-compliance financial data are then used to analyze three potential effects of the increased costs on facilities: facility closure, product line closure, and other financial impacts short of closure. The analysis of facility closure is based on comparing the post-compliance facility discounted cash flow to the facility liquidation value. The product line closure analysis compares prices and costs of products to predict whether product lines remain in production post-compliance. The analysis of other significant financial impacts considers changes in financial indicators of facilities' operating conditions between the baseline (i.e., pre-compliance) and post-compliance scenarios.

The impacts of the regulatory options on facilities drive other, secondary impacts, including those on local communities and foreign trade. The effects on communities are measured by the level of employment loss expected to correspond to the decreased production of PAIs potentially subject to this regulation. The significance of the employment loss is evaluated by its impact on the community employment rate. Foreign trade impacts may result from changes in the domestic production of pesticides, because pesticides are traded in an international market. Changes in the balance of trade are calculated based on both the estimated decreases in exported production and the increases in pesticide imports that result from meeting regulatory requirements. The expected changes in exports and imports are compared with baseline (1986) exports and imports for the entire pesticide industry, and with total U.S. merchandise trade (1986), to measure the significance of the change.

The effects of compliance costs are also evaluated at the firm level by considering changes in financial indicators at the level of the parent company. The firm analysis projects whether a firm is capable of financing the investment required to comply with the proposed regulation. The analysis is conducted by examining changes in the financial indicators of a firm's operations conditions between the baseline and post-compliance scenarios.

Two additional potential impacts of the proposed regulation, using the results of both the facility and the firm analyses, are impacts on (1) small businesses and (2) new sources of pesticide production. The evaluation of impacts on small businesses is conducted in three steps. First, it is determined whether the proposed regulation is expected to impact a substantial number of small businesses significantly. Impacts are defined as either a facility closure, a product line closure, or another significant financial facility impact short of closure. If a substantial number of small businesses are projected to sustain significant impacts, the second stage of the analysis evaluates whether these impacts are expected to fall disproportionately on those businesses. Third, if the regulatory burden on small businesses is disproportionate relative to that on larger businesses, alternative regulatory methods that mitigate or eliminate the economic impacts on small businesses would be examined.

Impacts on the construction of new facilities and the expansion of existing facilities are examined in the final section of the EIA.

The following chapter presents a description of the data sources consulted for this EIA. Chapter 3 profiles the pesticide industry, examining both the industry segments involved in PAI production and prevailing market conditions for pesticide products.

Having set the stage for the analysis, each of the remaining chapters describes the data and methodology used to estimate one type of potential impact and the resulting impact estimates themselves. Chapter 4 details the methodology used to estimate the facility impacts. As stated above, facility impacts provide the methodological foundation for this EIA. First, the markets to be analyzed and the basic model of market structure are defined. Then, baseline and post-compliance costs, prices, and production quantities are estimated. This chapter also describes the tests used to predict facility closure, product line closure, and other significant impacts.

Chapter 5 describes the methodology for and results of the community impact analysis, based on the results of the facility analysis. Methods for estimating international trade effects, and the expected effects themselves, are described in Chapter 6. A discussion of the expected impacts of the proposed regulation on firms owning pesticide manufacturing facilities is presented in Chapter 7. Procedures for assessing the impacts on small businesses are presented in Chapter 8, along with the projected impacts themselves. Finally, Chapter 9 describes the expected effects of the regulation on new sources of PAI manufacture.

Chapter 2: DATA SOURCES

This EIA employs data from many sources at differing levels of aggregation. The various sources used are described below.

The *Pesticide Manufacturing Facility Census for 1986*, a census of pesticide manufacturing facilities conducted under Section 308 of the Clean Water Act,[1] is the principal source of facility-level data. The Census includes the 90 facilities that, in 1986, manufactured one or more of the 270 individual or classes of pesticide active ingredients (PAIs) that are within the scope of the proposed regulation. Part A of the Census questionnaire requested the data necessary to perform the technical and treatment cost estimation analysis, including PAI-specific production for 1986. Part B of the Census questionnaire requested detailed economic and financial data, including balance sheet and income statement information for 1985, 1986, and 1987. Three years of data were collected so that the EPA could construct a "typical" year upon which to base the impact analysis. Part B was also designed to obtain information on facility liquidation values and the cost of capital. A copy of Part B of the Census is included as Appendix A. A copy of Part A of the Census can be found in the Administrative Record. Throughout the remainder of this document, the term "Census", if not further specified, will refer to Part B of the *Pesticide Manufacturing Facility Census*.

Part A of the Census questionnaire was sent in July 1988; Part B was mailed in January 1989. Based on an initial review of Part A responses, Part B was sent only to those facilities known to manufacture one or more of the PAIs within the scope of the regulation. Because Part B was sent to a reduced number of facilities, two facilities that were later determined to be manufacturing one or more of the PAIs subject to regulation were omitted. One was thought to be exclusively a formulator/packager; the other performs only research and development.

In the proposed Census questionnaire sent to the Office of Management and Budget (OMB), the EPA proposed to request PAI-specific unit cost and price data. These data would permit the EPA to incorporate the different unit costs, prices, and profit margins of PAIs in the impact analysis. The National Agricultural Chemicals Association (NACA), the trade association representing numerous chemical manufacturing firms and individuals in the industry, was reluctant to have the industry provide these detailed data and voiced objections to the OMB. OMB subsequently rejected the proposed questionnaire. As a compromise, the EPA allowed pesticide manufacturers a choice in the final questionnaire. Manufacturers could provide the PAI-specific data, or could elect to have their facility's impact analysis done using averages. In this latter method, the EPA would

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[1]Federal Water Pollution Control Act, 33 U.S.C. 1318.

assume that all PAIs produced by a single facility have the same unit cost, price, and profitability.[2] Twenty of the 88 facilities responding to Part B chose to provide the PAI-specific cost and price data.

The other major data input to the EIA was the estimated compliance costs of the regulation.[3] The EPA considered compliance costs for the 90 facilities under two potential regulatory options: a Treated Discharge Option and a Zero Discharge Option. The Treated Discharge Option limitations are based on hydrolysis, activated carbon, chemical oxidation, resin adsorption, solvent extraction, incineration, and/or recycle/reuse to control the discharge of PAIs in wastewater.[4] Zero Discharge Option limitations would require no discharge of pesticide manufacturing process wastewater pollutants to surface water by using on-site or off-site incineration and/or recycle/reuse.

Three categories of compliance costs associated with pesticide manufacturing were evaluated for both the Treated and Zero Discharge Options: capital costs, land costs, and operating and maintenance costs. Operating and maintenance costs include monitoring costs, required by permit writers to demonstrate compliance, as well as the costs of sludge disposal. All of the compliance cost estimates are presented in 1986 dollars and are based on the assumption that, whenever possible, facilities will build on existing treatment. For facilities that both manufacture and formulate/package PAIs, the compliance costs apply only to the manufacturing operations of the facility.

The Census data base and the compliance cost estimates were required for all components of this EIA: the industry profile, and the impact analyses for facilities, communities, foreign trade, firms, small businesses, and new sources. The EPA also used data from secondary sources in each of the chapters. The profile of the pesticide industry relied on the *Annual Survey of Manufactures* published by the U.S. Department of Commerce, Kline and Company's *Kline Guide to the U.S. Chemical Industry*, and the International Trade Commission's (ITC) *Synthetic Organic Chemicals*, which together provided production and aggregate industry data. The profile also used import and export data from the United Nations' *International Trade Statistics Yearbook.*

The facility impact analysis used secondary price data from the *Annual Market Survey* published by Doane Marketing Research and from *Agchemprice* published by DPRA, Inc. The facility impact analysis also employed data from The EPA's Office of Pesticides Programs (OPP). The OPP maintains data on PAI-specific sales, prices, and usage from a number of proprietary sources. The OPP data were among those used to

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[2]See Part B of the Census, page 26, text preceding question 2-H.

[3]Full details of the compliance cost estimates can be found in the Technical Development Document.

[4]For some PAIs the Treated Discharge Option limits discharge to zero.

estimate prices, and were also used to calculate the percentage of pesticide production that will not be covered by this regulation at this time.

Data from the OPP also served as the basis for determining the substitutability among PAIs. In 1980, the OPP defined pesticide markets to ensure that the EPA reviewed competing products on roughly the same schedule, so that one pesticide does not have an unfair advantage over another. The pesticide markets were defined as clusters of PAIs that are substitutes for a specific end-use. This classification was adapted and used as the basis for defining pesticide markets in this EIA (see Appendix B). In addition, the facility-level analysis used the estimates of price elasticity of demand developed in the document entitled *Estimates of the Price Elasticity of Demand for Pesticide Clusters* (EPA, 1991; see Appendix C).

The community impact analysis required the use of regional employment multipliers developed by the Bureau of Economic Analysis, population data from the *Current Population Reports* in *Statistical Abstract of the United States* (Bureau of the Census), and employment rates from the Bureau of Labor Statistics. The foreign trade analysis used import data from the OPP and data on the U.S. trade balance from the *International Trade Statistics Yearbook* (United Nations) and the *Statistical Abstract of the United States*. The firm-level analysis was developed using financial statistics from Standard and Poor's *Compustat* and from Robert Morris Associates' *Annual Statement Studies*, in addition to Parts A and B of Bh of the Census. The *Compustat* data provided financial information on domestic firms subject to public reporting requirements, while the information available through Robert Morris Associates was used for the remaining firms. Finally, the analysis of small businesses required data from Dun and Bradstreet's *Million Dollar Directory* to calculate the number of employees at the firm level.

Chapter 3: PESTICIDE MANUFACTURERS PROFILE

3.0 Introduction

The following profile of the chemical pesticide industry describes the products, facilities, and firms associated with pesticide active ingredient (PAI) manufacturing and sales. It is intended to provide a backdrop for the EIA by identifying and discussing key variables defining the market structure of the pesticide manufacturing industry. The prevailing market conditions for pesticide products provide insight into firms' reactions to increased costs due to regulatory compliance.

The pesticide industry is organized vertically into two major segments: pesticide manufacturing and pesticide formulating/packaging/repackaging. Pesticide manufacturing involves the production of PAIs. PAIs are not used directly for pest control, but are instead combined with solid, liquid and/or gaseous diluents before use. PAIs are marketed in many formulations that may be either liquid or dry, and include a wide variety of solutions, emulsions, powders, dusts, granules, pellets, and aerosols. Formulating and packaging therefore involves the combination of active with inert ingredients, such as diluents, inorganic carriers, stabilizers, emulsifiers, aerosol propellants or wetting agents; and packaging the product in plastic, glass, paperboard, or metal containers for distribution and sale. The concentration of a PAI in a formulation may be high or low. Some formulations are ready to use; others must be further diluted before use. Repackaging involves transferring a single PAI or single formulation from any marketable container to another marketable container without intentionally mixing any inerts, diluents, solvents, other PAIs, or other materials of any sort. Data from the Census show that in 1986, 50 of the 90 pesticide manufacturing facilities (56 percent) also engaged in formulating and packaging, indicating that the majority of pesticide manufacturers are vertically integrated.[1]

The seven sections in this chapter focus on pesticide manufacturers, but some of the information presented pertains to both manufacturers of PAIs, and formulators/packagers/repackagers. Section 3.1 categorizes the data used to develop the profile. Section 3.2 describes sources of demand for chemical pesticides in the United States. Characteristics of pesticide manufacturing facilities, including physical characteristics, production costs, revenue, profits, employment, labor productivity, and capital expenditures are described in Section 3.3. Section 3.4 examines the organization of firms in the industry, including firm ownership and vertical industrial integration. Section 3.5 portrays the market structure of the pesticide industry, and includes discussions of barriers to market entry, demand elasticity and product substitution, and firm concentration in the industry. Section 3.6 provides an overview of international trade in pesticides, including a

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[1]Data from the *1988 Survey of the Pesticide Formulating, Packaging, and Repackaging Industry* indicate that in 1988, 51 of the pesticide manufacturers were engaged in formulating and packaging. Since that time, however, 4 of these manufacturers have discontinued production.

discussion of the balance of trade for chemical pesticides and the nature of foreign competition. Section 3.7 summarizes the information presented in the profile.

3.1 Categorization of Data

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) defines a pesticide as "(1) any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant." Section 2(t) of FIFRA defines a pest as "(1) any insect, rodent, nematode, fungus, weed, or (2) any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other microorganism (except viruses, bacteria, or other microorganisms on or in living man or other living animals) which the administrator declares to be a pest under Section 25(c)(1)."

Other data sources used in this profile categorized pesticides in a variety of manners. The *Census of Manufactures* (Bureau of the Census, 1986) classifies the pesticide industry primarily into two standard industrial classifications (SICs). Establishments engaged primarily in the manufacture or formulation of agricultural chemicals not elsewhere classified, and the formulation and preparation of pesticides, are classified as SIC 2879. Establishments involved in the manufacture of pesticides, and other organic agricultural chemicals that are PAIs used to formulate pesticides, are classified as SIC 28694. The *Kline Guide to the U.S. Chemical Industry* classifies pesticides by three major types: herbicides, insecticides, and fungicides. The International Trade Commission's *Synthetic Organic Chemicals* classifies pesticides into cyclic and acyclic fungicides, herbicides and plant growth regulators; and insecticides, rodenticides, and related products such as seed disinfectants, soil conditioners, soil fumigants, and synergists. The *U.N. International Trade Statistics Yearbook* classifies pesticides into disinfectants, insecticides, fungicides, and herbicides for retail sale as preparations or as PAIs. The tables and graphs that present data from these sources refer to all pesticide production, both in-scope (including 270 individual or classes of PAIs) and out-of-scope (all non in-scope PAIs). As an aid in understanding these categorizations, brief descriptions of the primary functions of pesticides are listed in Table 3.1.

The market analysis for this profile relies on another classification of PAIs, based on the cluster groups established by the EPA's Office of Pesticide Programs (OPP). In 1980, the OPP defined PAI markets to ensure that the EPA regulated competing PAIs on roughly the same schedule, so that one PAI did not have an unfair advantage over another. Six hundred PAIs were classified into 48 clusters according to the major use of the chemicals. For instance, all herbicides used on corn production were classified into the same cluster. Each cluster therefore contains PAIs that may be roughly substituted for one another on major use sites.

Table 3.1 Representative Classes of Pesticides and the Pests They Control	
Class	**Target Pest**
Acaricide	Mites, ticks
Algicide	Algae
Attractant	Insects, birds, other animals
Avicide	Birds
Bactericide	Bacteria
Defoliant	Unwanted plant leaves
Dessicant	Unwanted plant tops
Fungicide	Fungi
Growth regulator	Insect and plant growth
Herbicide	Weeds
Industrial Microbiocide	Microorganisms
Insecticide	Insects
Miticide	Mites
Molluscicide	Snails, slugs
Nematicide	Nematodes
Piscicide	Fish
Predacide	Carnivorous animals
Repellents	Insects, birds, other animals
Rodenticide	Rodents
Silvicide	Trees and woody vegetation
Slimicide	Slime molds
Sterliants	Insects, other animals

Source: Minnesota Department of Agriculture, *Rinse and Win Brochure*, 1989.

The EPA's Office of Water used the OPP's cluster segmentation to define individual markets for groups of pesticides, because economic variables, such as demand elasticity, would not be meaningful for a market defined as all pesticides. The Office of Water expanded upon the OPP's cluster segmentation in two ways. First, PAIs registered after 1980 were assigned to one of the 48 clusters. Second, the 48 clusters were expanded to 56 clusters, based upon differences in the sensitivity of product demand to changes in price (see Table 3.2).[2] In addition, although the OPP's cluster segmentation assigned each PAI to only one cluster, this analysis allowed for a PAI to be assigned to more than one cluster if it had more than one important use. The allocation of PAIs to clusters can be found in Appendix B.

Although the economic impact analysis of the proposed effluent guidelines is built on the individual facility's production of PAIs that can be classified as belonging to one or more of these clusters, in the remainder of this profile chapter EPA has aggregated the Census data to prevent disclosure of confidential business information. Information is generally presented in five categories: fungicides, herbicides, insecticides, multiple types of pesticides, and other pesticides.

3.2 Sources of Demand for Chemical Pesticides

The major markets for pesticides are agriculture, industrial/institutional/commercial, and home/lawn/garden.[3] Agricultural sales account for approximately 70 percent of domestic pesticide sales. Industrial/institutional/commercial and home/lawn/garden each constitute about 15 percent of U.S. sales (see Figure 3.1).

Much of the pesticide application for the three markets is performed by commercial applicators. Commercial applicators are trained professionals skilled in applying pesticides in an efficient and environmentally safe manner. The National Pest Control Association estimated that in 1990 the commercial applicator industry would contain 14,250 firms and have annual billings of $3.5 billion (National Pest Control Association, 1991). Commercial applicators are contracted by the agricultural industry to apply pesticides to agricultural crops, as well as to food products during storage and transit. The industrial/institutional/commercial sectors use the services of commercial applicators to control pests in many settings, including schools, health care facilities, prisons, food processing establishments, hotels, restaurants, factories, and

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[2]Clusters were split when (1) there was a wide variety of price elasticities of demand among PAIs within a cluster, and (2) the PAIs among which demand elasticity varied had distinctive uses. For example, the cluster that encompasses herbicides used on fruit trees was split into three clusters: herbicides used on grapes, herbicides used on oranges, and herbicides used on fruit trees (excluding grapes and oranges).

[3]Additional markets, such as stored grain products (elevators), seed treatment, pest control operations (termiticides), cattle, golf courses, utility right of ways, etc., also exist. That level of detail, however, is not necessary in this discussion.

Table 3.2
Pesticide Clusters
Page 1

Cluster	Primary Application
Herbicides used on:	
H-1	Broad spectrum of uses
H-2	Corn
H-3	Soybeans, cotton, peanuts, alfalfa
H-4	Sorghum, rice, and small grains
H-5a	Oranges
H-5b	Grapes
H-5c	Fruit trees
H-6	Sugarbeets, beans and peas
H-7	Drainage ditches, rights of way, forestry and ponds
H-8	Turf
H-9a	Vegetables
H-9b	Tobacco
H-10	Unclassified uses
Insecticides used on/for/as:	
I-1a	Cotton
I-1b	Soybeans, peanuts, wheat and tobacco
I-2a	Corn and alfalfa
I-2b	Sorghum
I-3	Fruit, and nut trees, excluding oranges and grapes
I-4a	Oranges
I-4b	Grapes
I-5	Vegetables
I-6	Livestock and domestic animals
I-7	Non-agricultural sites (as repellent)
I-8	Domestic bug control and for food processing plants
I-9	As fumigants and nematicides
I-10	Termite control
I-11	Lawns, ornamentals, and forest trees
I-12	Mosquito larva
I-13	Unclassified uses

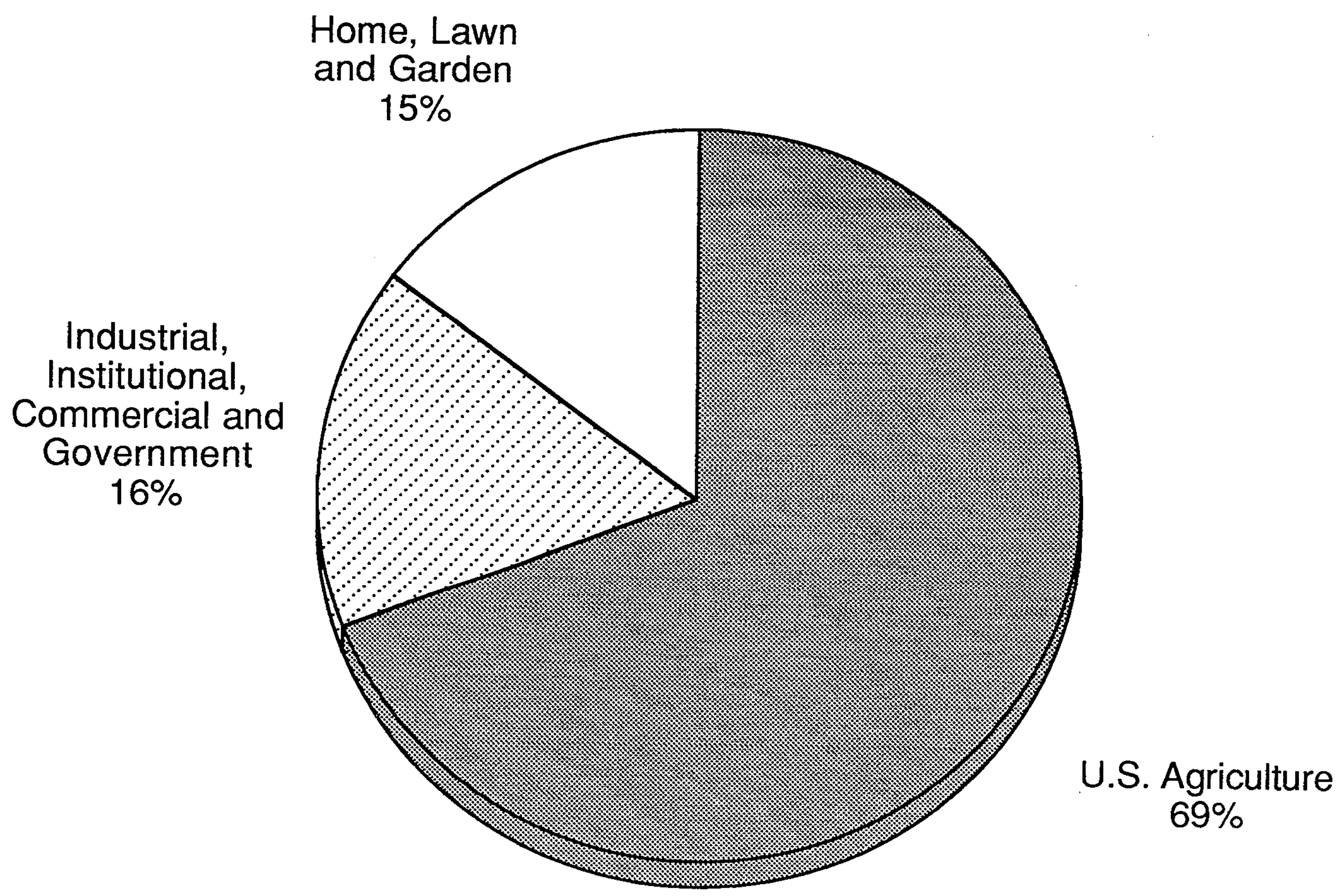
Table 3.2
Pesticide Clusters
Page 2

Cluster	Primary Application
Fungicides used on:	
F-1	Broad spectrum of uses
F-2a	Fruits and nuts
F-2b	Grapes
F-3	Vegetables
F-4	Oranges
F-5	Seed treatments
F-6	Post-harvest fruit and vegetables
F-7	Grain storage
F-8	Ornamentals
F-9	Turf
F-10	Unclassified uses
Other Pesticides:	
R-1	Industrial preservatives
R-2	Slimicides used in pulp and paper, cooling towers, and
R-3	Industrial microbiocides
R-4	Sanitizers used in dairies, food processing, restaurants,
R-5	Synergists used as insecticide synergists, sufacants, cheleating agents and carriers
R-6	Food preservatives
R-7	Wood preservatives, used for industrial, commercial
R-8	Disinfectants
R-9	Water disinfectants
R-10	Plant regulators, defoliants, and desiccants
R-11	Preservatives, disinfectants, slimicides
R-12	Molluscides and misc. vertebrate control agents
R-13	Bird chemosterilants, toxicants, and repellants
R-14	Dog and/or cat repellants
R-15	Rodent toxicants, anticoagulants, predator control
U-1	Unclassified uses

Figure 3.1

U.S. Market Demand for All Pesticides[1], 1988

(Dollar Percentages)



[1]Includes both in-scope and out-of-scope PAIs.

Source: *Pesticide Industry Sales and Usage: 1988 Market Estimates*, U.S. EPA, Office of Pesticides and Toxic Substances, February, 1988.

Note: Census data were not used for this figure, because the question in the Census that refers to markets refers to total facility production, not pesticide production.

warehouses. Household consumers use commercial applicators to manage pests that typically inhabit dwellings, such as termites, cockroaches, and mice, and to rid their lawn and garden of pests. Government entities use the services of commercial applicators to control mosquitos, and to maintain vegetation around roads, and public recreational areas. In 1985, residential services comprised about 60 percent of the non-agricultural commercial applicator industry, commercial services constituted 25 percent, and services to institutions, industries and the government represented 7, 6, and 2 percent respectively (Kline & Company, 1986).

3.2.A Agriculture Market

Agriculture forms the largest market for chemical pesticides. The agricultural market is diverse in terms of the types and amounts of pesticides used and in pesticide management practices, which vary significantly among regions of the country, states, and sometimes even counties. This diversity is an important distinction that separates agriculture from the other pesticide markets, which tend to be more homogeneous nationwide.

Approximately 62 percent of all planted agricultural acres are treated with at least one type of pesticide product (Pimental et al., 1986). Herbicides are the most commonly used type of pesticide in terms of quantity of pesticide product applied. In 1987, the herbicides that were most widely used were Alachlor, Atrazine and 2,4-D (U.S. EPA, 1990). These pesticides were used primarily on peanuts, corn, soybeans, cotton, and rice. Insecticides were the second most commonly used pesticide type. In 1987, the most widely used insecticides were Carbaryl, Malathion, and Chlorpyrifos (U.S. EPA, 1990). These pesticides were used primarily on cotton, fruits, vegetables, nuts, and ornamentals. Fungicides are applied to fewer acres than herbicides or insecticides, but are generally applied to high-value fruit and vegetables. In 1987, Maneb and Captan were the most widely used fungicides (U.S. EPA, 1990).

Table 3.3 provides a brief description of the steps taken to move a PAI through process and distribution channels and then to the end user. As indicated in Table 3.3, end users include farmers, government, and commercial applicators. Farmers either purchase and apply pesticide products themselves or pay commercial applicators to apply pesticides to their crops. The government uses agricultural chemicals to control vegetation around highways, roads, railroads, waterways, pipelines, power lines, government buildings, military complexes, and parking lots.

3.2.B Industrial/Institutional/Commercial Market (I/I/C)

The I/I/C market includes many products, such as disinfectants, cleaning supplies, and air conditioning biocides, that are generally not perceived as pesticides by the public. In addition, products such as paint and wood preservatives may contain substantial amounts of pesticides. The I/I/C market is estimated to exceed $200 million annually, with about 45 percent involving health care institutions (U.S. EPA, 1991).

Table 3.3
Pesticide Agricultural Production and Distribution[1]

Agent	Purpose
Registrant	Registers the pesticide formulation with EPA. Registration involves a long, expensive R&D process to develop the pesticide, produce the data required for registration, and proceed through the registration process.
Manufacturer	Synthesizes the active ingredient from raw materials.
Formulator/Packager	Produces the pesticide formulation by combining the active ingredient(s) with other substances, including surfactants, clays, powders and solvents; involves mixing or blending operations. Formulation may be done in-house, by independent formulators, or by tollers who formulate the product under contract to the manufacturer.
Distributor	Acts as the "middle man;" buys pesticide from the registrant/manufacturer/formulator and sells to the dealer.
Dealer/Co-op/Repackager	Sells the pesticide to the user.[2]

[1] In many cases several steps are performed by one entity. Large companies might register, manufacture, and formulate their pesticides. Some distributors also formulate several pesticides. Additionally, a single facility might function as a distributor, dealer, and commercial applicator.

[2] A user is defined as a farmer, government, commercial ground applicator, commercial aerial applicator, etc.

Source: Based on a table in: *Pesticide Container Report to Congress*, U.S. EPA, Office of Pesticides and Toxic Substances, Draft, March 8, 1991.

The I/I/C market differs significantly from the agricultural market in several ways. First, the use of I/I/C products is generally more uniform across the country. The need for disinfectants in various parts of the United States is approximately the same. However, the use of pesticides for wood preservation and in cooling towers varies somewhat according to the climate (U.S. EPA, 1991). Second, I/I/C pesticides are generally used in smaller quantities than agricultural chemicals. Third, I/I/C products in general are usually less expensive per unit volume of product than agricultural pesticides, because they are less concentrated.

Another major difference between I/I/C and agricultural markets is that fewer manufacturers of pesticides used in the I/I/C market both register and formulate their pesticides; independent formulators/packagers are more predominant in the I/I/C market. In addition, a greater variety of paths exist between the formulators and end users. This is evident in Figure 3.2, which illustrates distribution channels within the I/I/C and home/lawn/garden markets.

The distinction among industrial, institutional, and commercial pesticides is based on the setting in which the pesticide is used. In some cases, the same formulation is used in different types of facilities. Typical industrial end-users include personnel in food processing facilities and breweries. Industrial pesticides, such as preservatives, slimicides or biocides, are used in cooling towers, paper and textile mills, oil wells, metalworking coolants, etc. (U.S. EPA, 1991). Typical institutional end-users include personnel in hospitals, nursing homes, schools, restaurants, hotels, and contract cleaning businesses that serve stores, apartment houses, office buildings, and garages (U.S. EPA et al., 1989). Commercial establishments use pesticides to protect landscaping and to maintain cleanliness and health standards. The federal, state and local governments use I/I/C chemicals on military bases, and in hospitals and other government buildings.

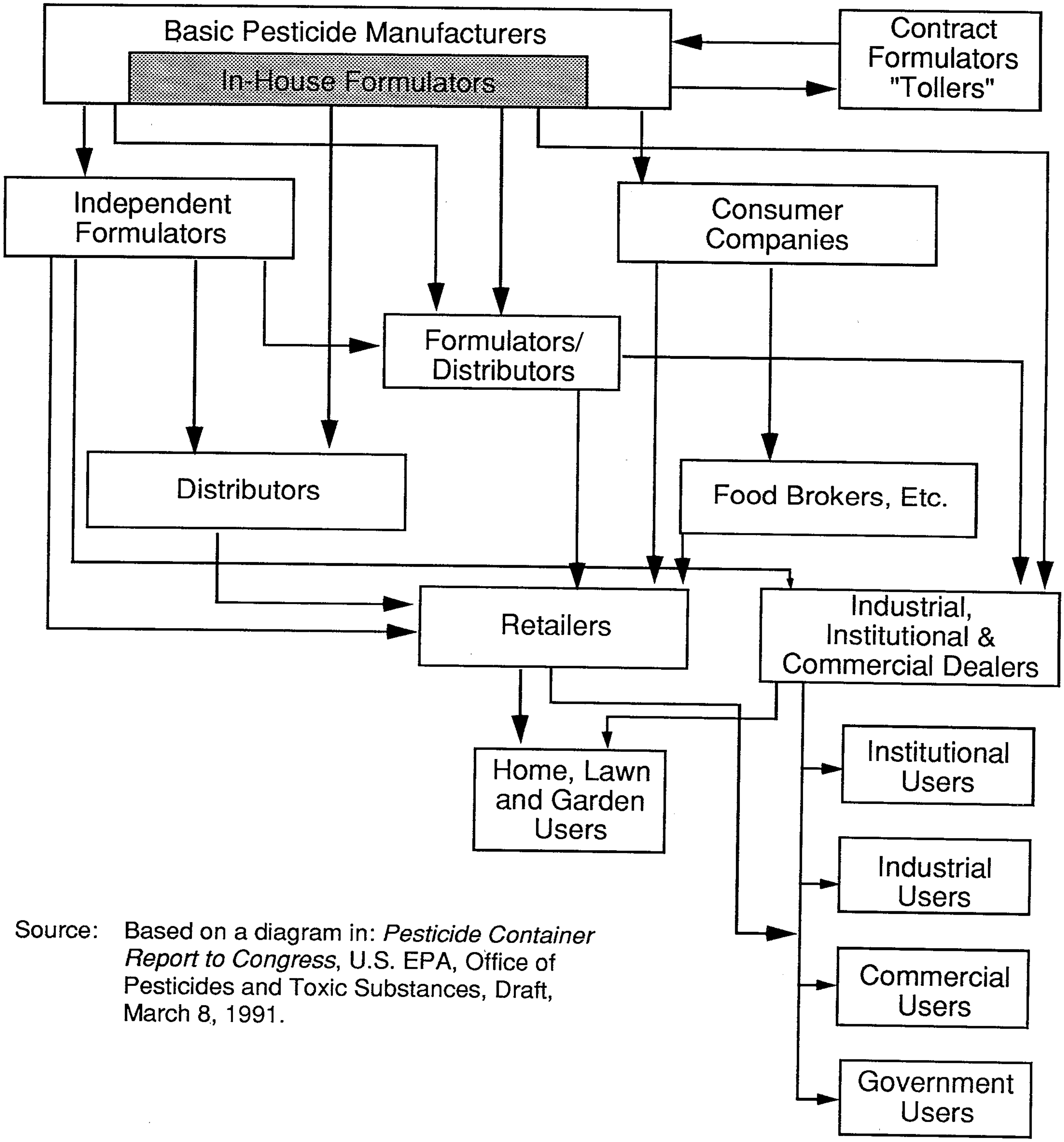
Producers of pesticide products used in institutional settings may sell directly to large users (e.g., hospitals), or they may use distributors at janitorial supply houses to sell indirectly to smaller users. Institutional distributors usually sell general maintenance products (e.g., cleaning supplies and non-pesticide cleaners, as well as sanitizers and disinfectants). Similarly, producers of industrial and commercial pesticides may sell directly to the end-user or indirectly through a warehouse (U.S. EPA et al., 1983).

3.2.C Home/Lawn/Garden Market

The home/lawn/garden pesticide market includes pesticide products that are commonly used in and around the home. These products include rodenticides, insect repellents, lawn and garden pesticides, disinfectants and other pesticidal cleaners, insecticides to protect pets and eliminate household pests, herbicides, fertilizers with herbicides/insecticides, and insect baits and traps. In general, household pesticides are packaged in containers that are smaller than those used in the other markets and may also be less concentrated. Some household pesticides are seasonal (e.g., lawn and garden products), while others meet a demand that remains fairly constant throughout the year.

Figure 3.2

Production and Distribution Channels for the Industrial/Institutional/Commercial and Home/Lawn/Garden Markets



Source: Based on a diagram in: *Pesticide Container Report to Congress*, U.S. EPA, Office of Pesticides and Toxic Substances, Draft, March 8, 1991.

The home/lawn/garden pesticide production and distribution chain, similar to the I/I/C chain, is included in Figure 3.2. The main difference between the household market and the other markets is that the end user, the household consumer, purchases household pesticides from a wide variety of common retail establishments. These include grocery, drug, and discount stores, as well as home and garden shops and pet supply companies. The producer of household pesticide products can sell directly to the retail stores or indirectly through a distributor warehouse. Consumer companies, another distribution channel from manufacturers to retail stores, make consumer products, applying their label to the finished good. Like formulators, consumer companies can sell directly to retail establishments or indirectly through food brokers who distribute products to retail stores.

3.3 Facility Characteristics

3.3.A Physical Characteristics

Figure 3.3, drawn from Census data, shows the geographic distribution of the PAI manufacturing facilities and provides the percentage of in-scope PAI production in each region. Although pesticide facilities are located in all regions of the country, the southeast/south central region of the country has the heaviest facility concentration (35 percent).[4] The northwest/southwest region has the second heaviest concentration (33 percent).[5] Although the southeast/south central region accounts for a larger percentage of facilities, the northwest/southwest region has the largest share of in-scope pesticide production (52 percent).

The Census also provides information on the age of pesticide facilities. The data indicate that most of the facilities are relatively old (i.e., constructed prior to 1970). The 1960s was the most active decade for facility construction, with almost a quarter of the facilities constructed prior to 1970. After 1980 only about 7 percent of existing facilities were constructed. Table 3.4 presents the distribution of facilities by the number of years in which they have produced pesticides. This distribution is shown for the five categories of pesticide type.[6]

3.3.B Industry Output

Several factors have affected the demand for chemical pesticides. These include the decline in agricultural acreage; the production of new, more highly concentrated pesticide products; more efficient

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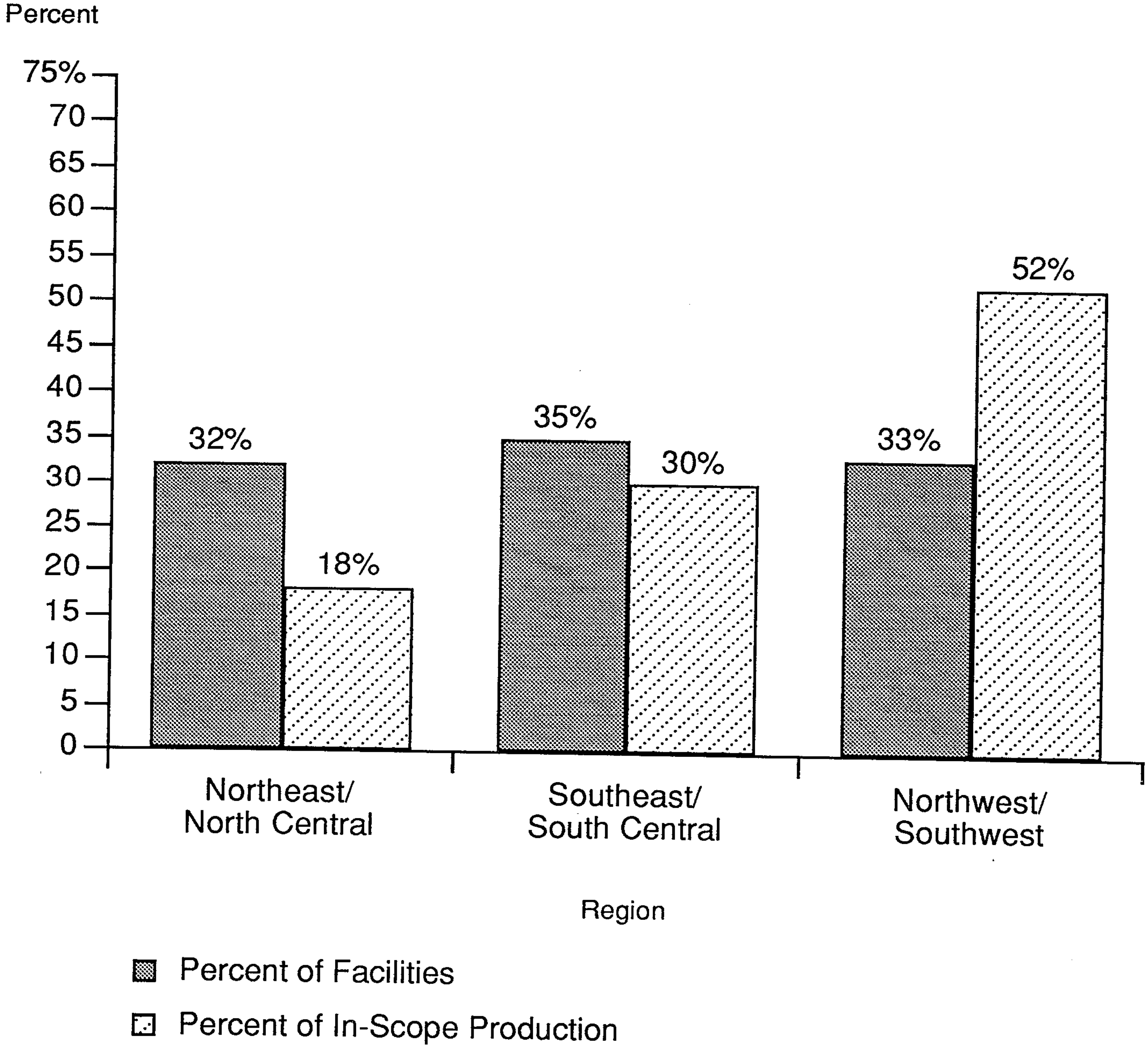
[4]The southeast/south central region includes Alabama, Delaware, Florida, Georgia, Kentucky, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia,

[5]The northwest/southwest region includes all states west of the Mississippi River.

[6]Many of the facilities in the Census did not begin pesticide production until many years after construction. Approximately 38 percent of the facilities have produced pesticides for more than 30 years, while less than 13 percent of the facilities have produced pesticides for fewer than 10 years.

Figure 3.3

Facilities and In-Scope Pesticide Production by Region, 1986



Source: Census.

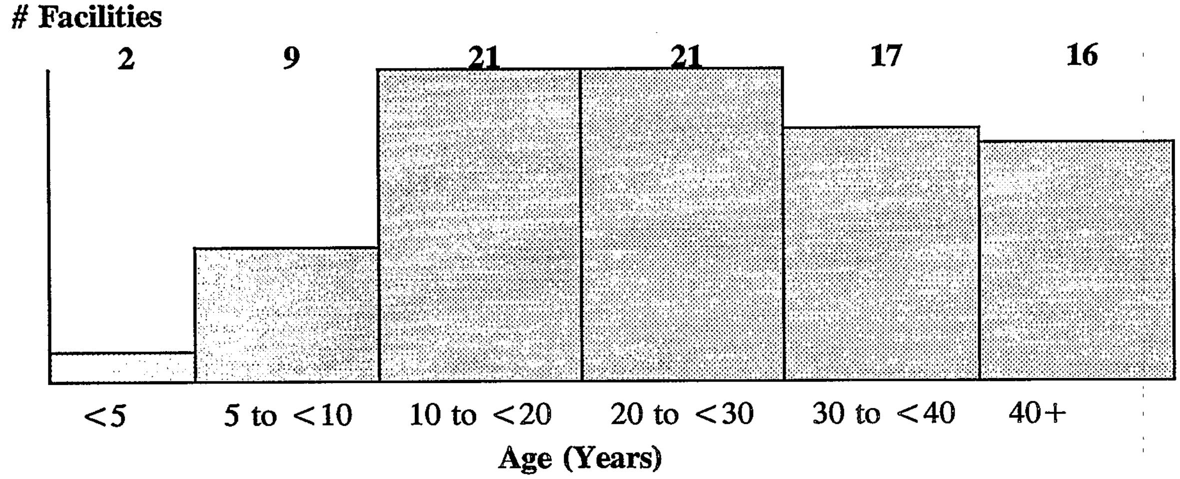
Table 3.4
Pesticide Manufacturing Facilities by Facility Age, 1986[1]

Pesticide Type	Number of Years: <5	5 to < 10	10 to < 20	20 to < 30	30 to < 40	40+	All*
	(Number of Facilities)						
Fungicides	0	2	5	3	1	0	11
Herbicides	1	4	5	5	1	4	20
Insecticides	1	3	3	4	3	3	17
Other Pesticides*	0	0	1	2	4	1	8
Multiple Types of Pesticides**	0	0	7	7	8	8	30
All in-scope Facilities	2	9	21	21	17	16	86***

* Refer to Table 3.2 for a description of other pesticides.
** Multiple types of pesticides include manufacturers that produce pesticides in more than one of the groups outlined above.
*** Excluded from the 88 facilities that provided financial data are two facilities that did not report facility age.
[1] Facility age is the number of years the facility has been producing pesticides.

Source: Census

Number of Facilities by Facility Age, 1986



application of pesticides; the increase in pesticide resistance; the increase in environmental regulations; and greater awareness of environmental issues on the part of both the seller and the buyer. Although these factors have led to a contraction in pesticide production and sales, profitability from pesticide sales in the industry appears to have been largely unaffected by the decline in output (Kline & Company, 1990). Production characteristics of the pesticide manufacturing industry are outlined below.

In 1988, total pesticide production was about 1.2 billion pounds. Production declined by an average of two percent per year from 1980 to 1988 (U.S. Department of Commerce, 1987). The volume of pesticides sold declined by four percent per year (see Table 3.5) (U.S. Department of Commerce, 1987). Figure 3.4 illustrates the decline in pesticide production for fungicides, herbicides, and insecticides from 1980 to 1988. The graph shows that herbicide production reached a trough in 1983, recovered somewhat, and then fell to a new low in 1987. Insecticide production declined to its lowest point in 1983 and recovered somewhat thereafter. Fungicide production was at its lowest point in 1987.

The most significant factor has been a decline in agricultural acreage. Figure 3.5, which plots total pesticide production and total U.S. planted crop acres using 1986 as a base year, shows how pesticide production mirrors planted acres.[7] Pesticide production was lowest in 1983, when the United States Department of Agriculture (USDA) implemented the Payment-In-Kind (PIK) program, taking 48 million acres out of production. Although the number of planted acres increased after 1983, other USDA programs, such as the Conservation Reserve Program, continued to reduce agricultural acreage (Ribaudo, 1989).[8]

Also contributing to the decline in pesticide production was the introduction of new, low-volume pesticides such as postemergence herbicides. Because these new pesticides are effective in significantly smaller doses; the overall volume of pesticide production was reduced (Kline & Company, 1990).

3.3.C Production Characteristics

Table 3.6 details the distribution of 1986 in-scope facility production and sales by facility size. The Census data indicate that, in terms of in-scope PAI production, most facilities (about 68 percent) are small- and medium-sized, producing fewer than 6 million pounds of in-scope PAIs annually. These facilities, however, account for only ten percent of total in-scope pesticide production.

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[7]All production and crop acres were divided by 1986 production and acres respectively, in order to display production and acres on the same scale.

[8]The Conservation Reserve Program was a land retirement program aimed at retiring 40 to 45 million acres of highly erodible crop land by 1990.

Table 3.5
Production and Sales of Pesticides, 1980-1988

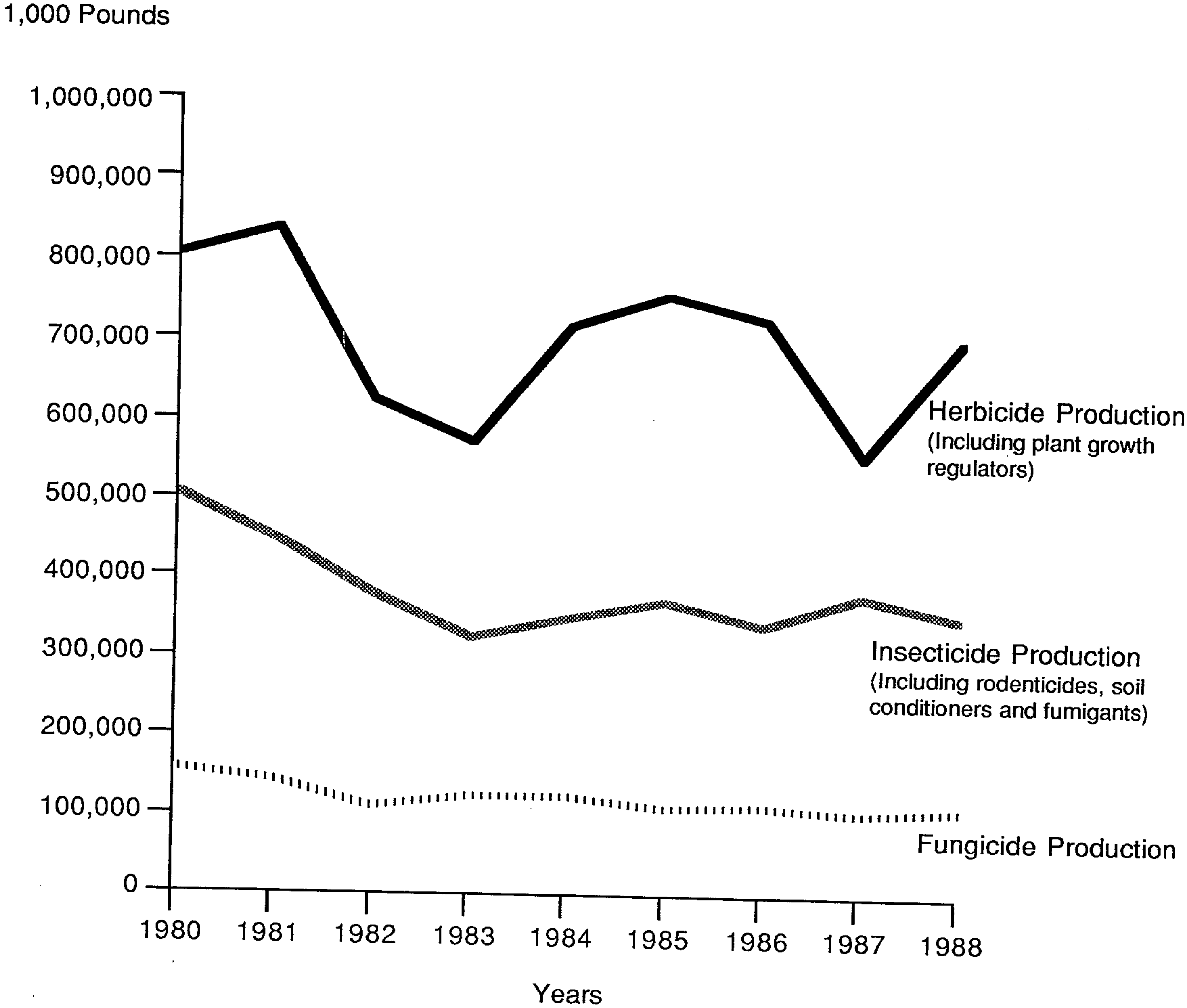
Pesticides		1980	1981	1982	1983	1984	1985	1986	1987	1988	Average Annual Percentage Change
		(1,000 pounds)									
All Pesticides	Produced	1,468,202	1,430,075	1,112,798	1,016,544	1,189,169	1,234,914	1,180,042	1,039,537	1,163,833	-2%
	Sold	1,406,321	1,290,641	1,146,751	1,016,961	1,107,906	1,021,715	940,338	910,595	935,174	-4%
	% in Inventory	4%	10%	-3%	0%	7%	17%	20%	12%	20%	
Fungicides	Produced	156,213	142,675	110,506	122,505	123,111	109,038	113,271	104,610	109,564	-3%
	Sold	146,339	144,149	110,032	106,069	111,793	94,102	89,254	93,365	89,354	-4%
	% in Inventory	6%	-1%	0%	13%	9%	14%	21%	11%	18%	
Herbicides, and plant growth regulators	Produced	805,663	839,080	623,351	570,400	716,432	755,844	724,740	556,056	701,779	-1%
	Sold	767,745	724,015	662,837	604,432	684,193	635,577	578,959	519,353	529,392	-3%
	% in Inventory	5%	14%	-6%	-6%	4%	16%	20%	7%	25%	
Insecticides & rodenticides, soil conditioners & fumigants	Produced	506,326	448,320	378,941	323,639	349,626	370,032	342,031	378,871	352,490	-3%
	Sold	492,237	422,477	373,882	306,460	311,920	292,036	272,125	297,877	316,428	-4%
	% in Inventory	3%	6%	1%	5%	11%	21%	20%	21%	10%	

Source: International Trade Commission, Synthetic Organic Chemicals, 1980-1988.

Figure 3.4

Fungicide, Herbicide, and Insecticide Production[1], 1980-1988

(in 1,000 pounds)



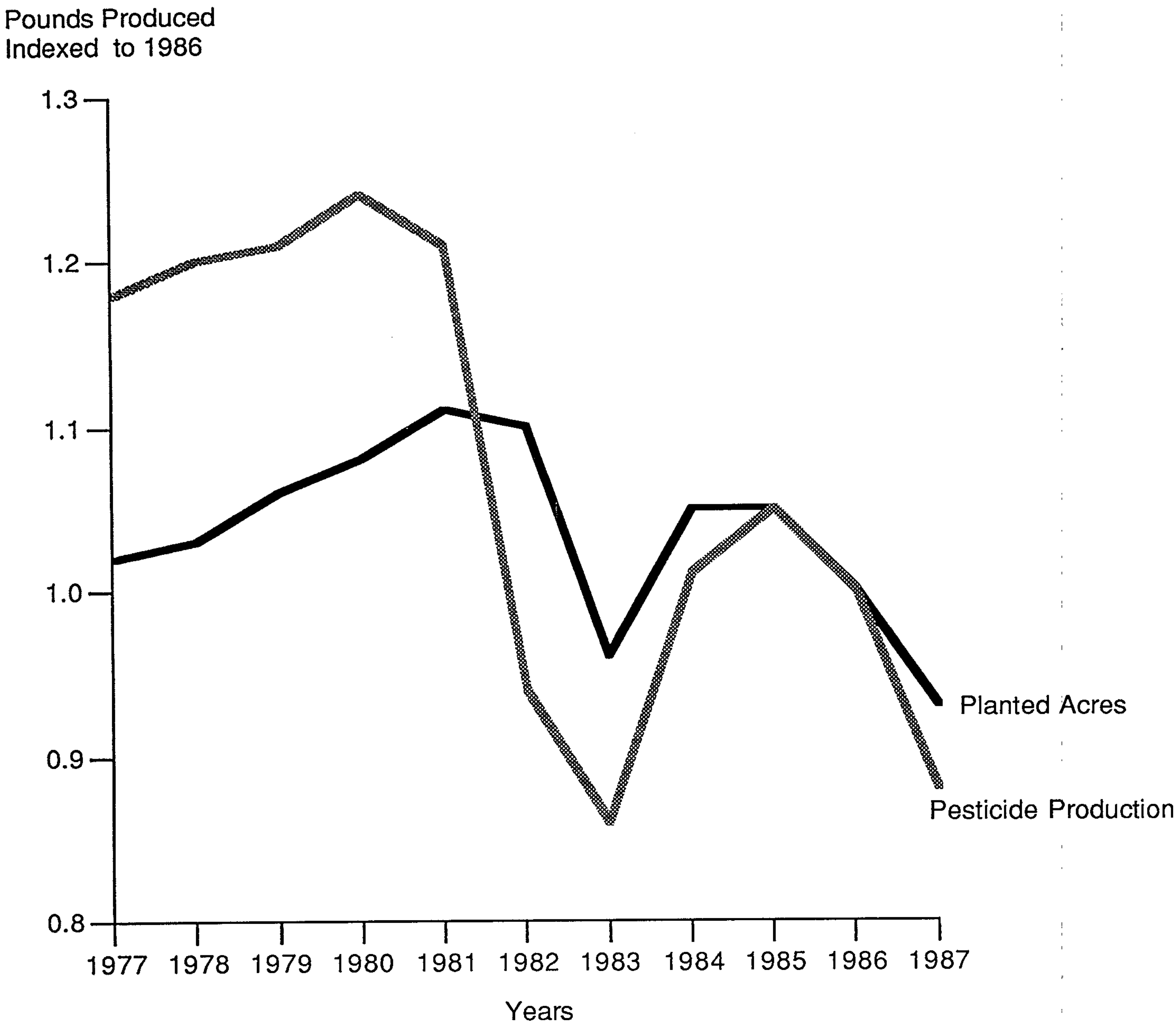
[1]Production data are reported in terms of manufactured PAIs.

Source: International Trade Commission, Synthetic Organic Chemicals, 1980-1988.

Figure 3.5

Pesticide Production and Total Planted Acres, 1977-1987

(1986 Base Year)



Source: International Trade Commission, Synthetic Organic Chemicals, 1977-1987 and United States Department of Agriculture, Agricultural Statistics 1984 and 1989.

Table 3.6
Distribution of In-Scope Pesticide Facility Production and Sales, 1986

	Production Quantity (million lbs.)						Sales (million $)			
	<0.1	0.1 to <1	1 to <6	6 to <25	≥25	All	<$10	$10 to <$50	≥$50	All
Number of Facilities	8	18	35	14	15	90	43	23	19	85[2]
Percent of Total	9%	20%	39%	16%	17%	100%	51%	27%	22%	100%
Cumulative Percent	9%	29%	68%	84%	101%[1]		51%	78%	100%	

[1] Total does not equal 100% due to rounding.
[2] Excluded from the 88 facilities that provided financial data are: one R&D facility and two facilities that obtained pesticide revenues only from contract work or tolling and, therefore, did not delineate in-scope vs. out-of-scope revenues.

Source: Census.

In terms of in-scope facility sales, the Census data indicate that the majority of facilities (51 percent) are relatively small, with in-scope sales of less than $10 million (see Table 3.6). Only 22 percent of all facilities have annual in-scope pesticide sales greater than or equal to $50 million.

For most facilities, large and small, in-scope pesticide production makes up only a part of the facility's production activity. Figure 3.6, which presents the 1986 composition of production activity for facilities in the Census, indicates that, on average, about 41 percent of facility production activity is devoted to the manufacturing and/or formulating and packaging of in-scope pesticides. The manufacture and/or formulating and packaging of chemicals other than EPA-registered pesticides account for another 41 percent of activity. The remaining activities include: other (i.e., non-chemical) production activity (12 percent); manufacturing and/or formulating and packaging out-of-scope EPA-registered pesticides (5 percent); and manufacturing intermediates (1 percent). All pesticide-related activities (in-scope and out-of-scope), on average, account for 47 percent of production activity.

The extent to which a facility is involved in pesticide-related activities vs. non-pesticide-related activities varies slightly, depending upon the size of the facility (see Figure 3.7). Smaller facilities (with total revenues of less that $20 million) devote approximately 31 percent of their production to non-pesticide related activities. Large and medium-sized facilities (with revenues greater than or equal to $20 million) are more diversified, with between 58 and 62 percent of production devoted to non-pesticide related activities. The composition of facility production activity varies more dramatically among facilities when comparing chemical-related (including pesticides) production activities to non-chemical-related production activities. Large facilities (with total revenues greater than or equal to $250 million) are more diversified, with 36 percent of production devoted to non-chemical-related activities. In contrast, small and medium-size facilities (with total revenues of less than $250 million) devote between 5 and 10 percent of production to non-chemical-related activities.

3.3.D Production Costs

Production costs can be classified into two categories: fixed and variable. Fixed costs are independent of the level of production and include depreciation on capital, fixed overhead, costs for product research and development (R&D), and interest on capital. Figure 3.8 shows the composition of pesticide-related facility fixed costs by facility size.[9] In most cases, fixed overhead is the largest component of fixed costs. Depreciation is the second largest component of fixed costs for facilities with revenues greater than or equal to $1 million. While R&D costs constitute the largest component of facility fixed costs for facilities with pesticide

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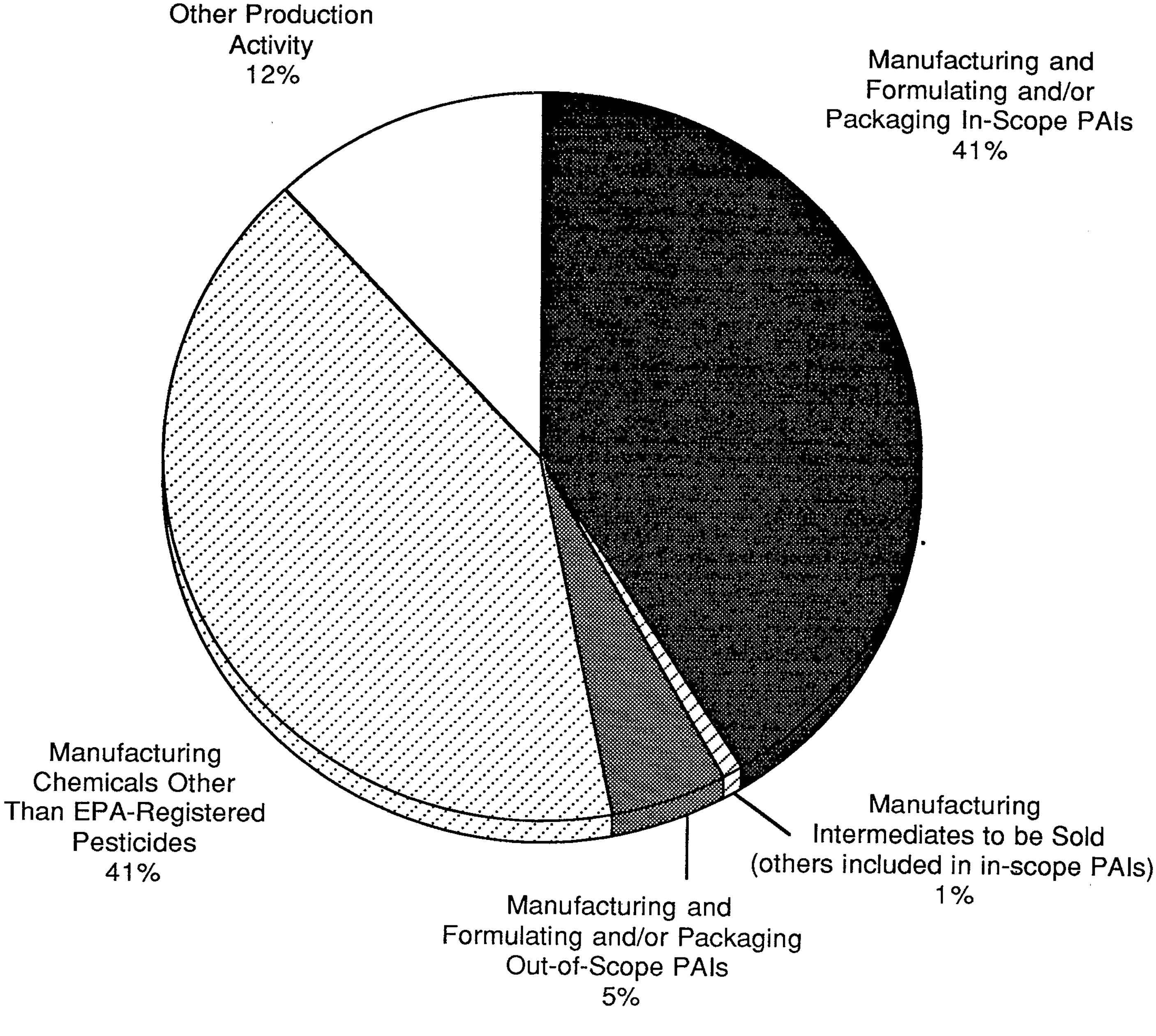
[9]Facility fixed costs were not broken down by pesticide-related vs. non-pesticide-related fixed costs in the Census. This is because facilities maintained records of their fixed costs at the facility level. During the pretest, it was determined that the respondent burden that would have been imposed by requiring facilities to break down costs were too great. Consequently, the ratio of pesticide-related revenues to total facility revenues was applied to each of the categories of fixed costs to obtain estimates of pesticide-related fixed costs.

Figure 3.6

Composition of Facility Production Activity, 1986

(Averaged Across All Facilities)

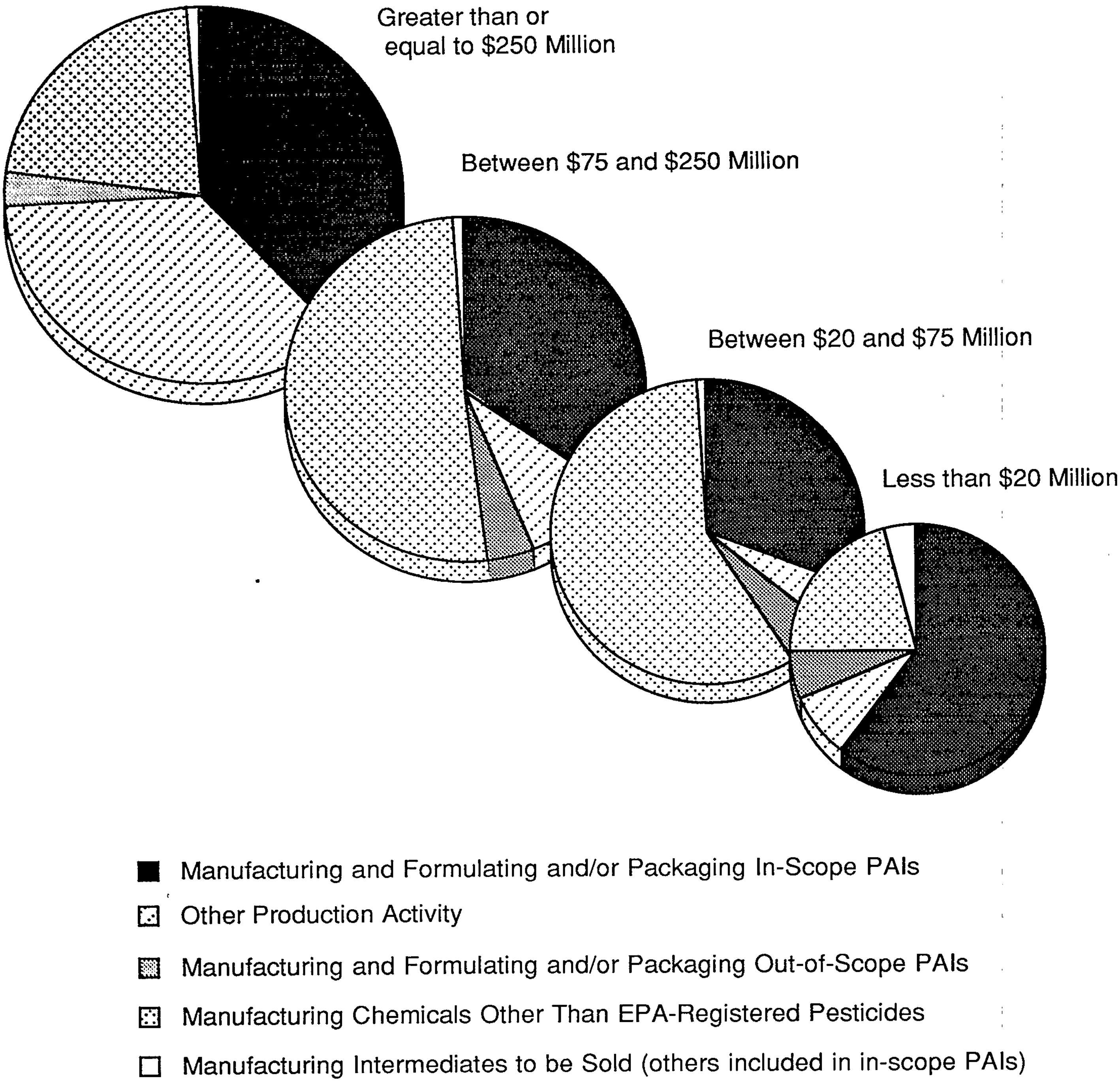


Source: Census.

Figure 3.7

Composition of Facility Production Activity by Facility Size[1], 1986

(Averaged Across Size Categories)

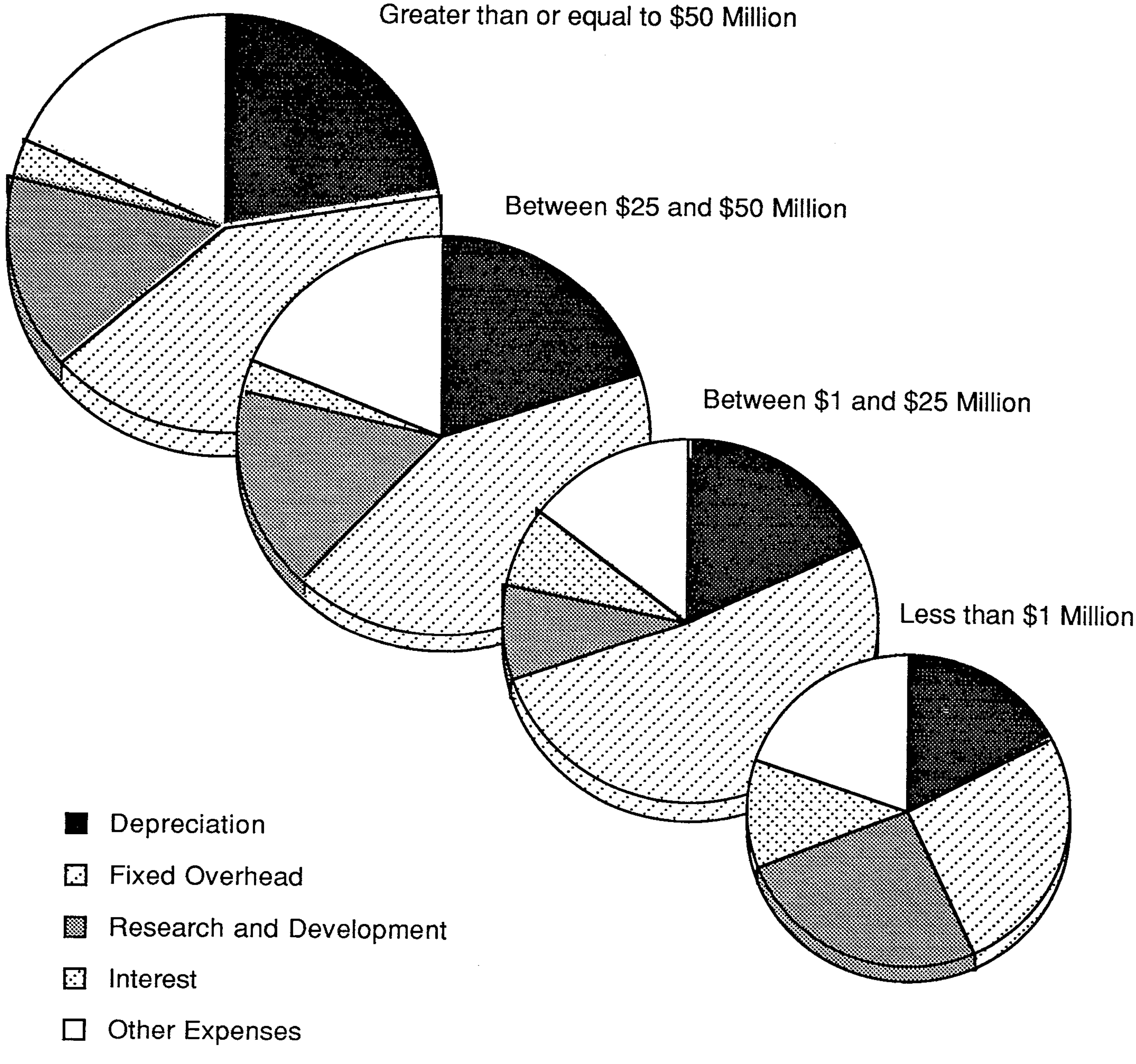


[1] Facility size is measured by total facility revenues.

Source: Census.

Figure 3.8

Composition of Pesticide-Related Facility Fixed Costs by Facility Size[1], 1986



[1] Facility size is measured by revenues from all pesticide-related activities.

Source: Census.

revenues of less than $1 million, R&D expenditures as a percent of total fixed costs (26.1 percent) are only slightly greater than the percentage of fixed costs attributable to fixed overhead (25.7 percent).

Variable costs depend upon the level of production. These costs include pesticide material and product costs, labor costs, contract or tolling costs, taxes, and other pesticide manufacturing costs (i.e., all other pesticide-related operating costs not included in the aforementioned categories).[10] Figure 3.9 shows the composition of pesticide variable costs by facility size. The figure shows that pesticide material and product costs are the largest component of variable costs across all facility sizes. Labor costs, contract work, and other pesticide costs are small in comparison.

Figure 3.10 compares fixed and variable costs by facility size, to show the proportion of fixed costs to total costs by facility size. If fixed costs are a large proportion of total costs, smaller firms may find it difficult to enter the market. The Census data suggest only minor differences in the ratio of fixed costs to total costs across facility size, indicating that fixed costs are not likely to be a barrier to entry.[11] For the category of smallest facilities (with pesticide revenues of less than $1 million), fixed costs comprise 27 percent of total costs. For the category of largest facilities (with pesticide revenues greater than or equal to $50 million), fixed costs comprise 41 percent of total costs. Very large facilities, which often produce a greater variety of pesticide types (e.g., insecticides, fungicides, and herbicides) and PAIs may be more capital intensive, thereby facing a different set of cost constraints than medium and small facilities.

3.3.E Employment Characteristics

According to the Census data, the pesticide manufacturing industry supported a total of 3,432 production workers in 1986 (see Table 3.7). The thirteen largest facilities (all with revenues of greater than or equal to $250 million) employed 58 percent of the total number of pesticide manufacturing production workers in the industry. In contrast, the twenty smallest facilities (all with revenues of less than $20 million) employed 5 percent of the total number of pesticide manufacturing production workers in the industry.

The data presented in Table 3.7 lend further evidence that larger facilities tend to be more diversified than smaller facilities. As facilities increase in size, the percent of the labor dedicated to non-pesticide-related production increases from 23 to 44 percent of total facility employment.

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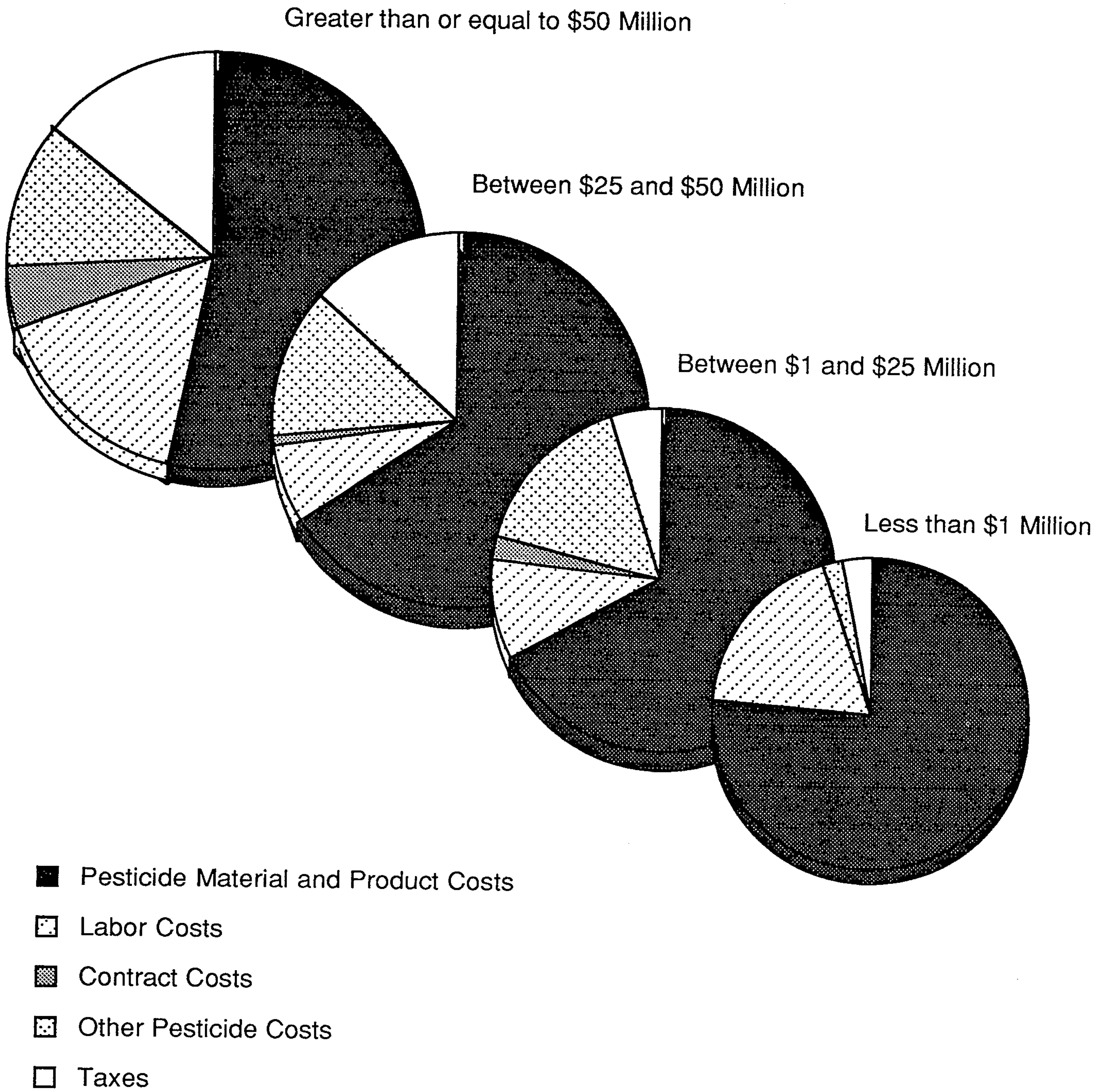
[10]Facility taxes were not broken down by pesticide-related vs. non-pesticide-related in the Census. Consequently, the ratio of pesticide-related revenues to total facility revenues was applied to total facility taxes to obtain estimates of pesticide-related taxes.

[11]Facilities can recover costs incurred by introducing a new product to the market by adjusting the price once they have obtained patent protection. The fact that facilities may be willing to operate at a loss in the short run, knowing that they will ultimately recover their costs, mitigates the barrier to entry that is associated with large fixed costs such as R&D.

Figure 3.9

Composition of Pesticide-Related Facility Variable Costs by Facility Size[1], 1986

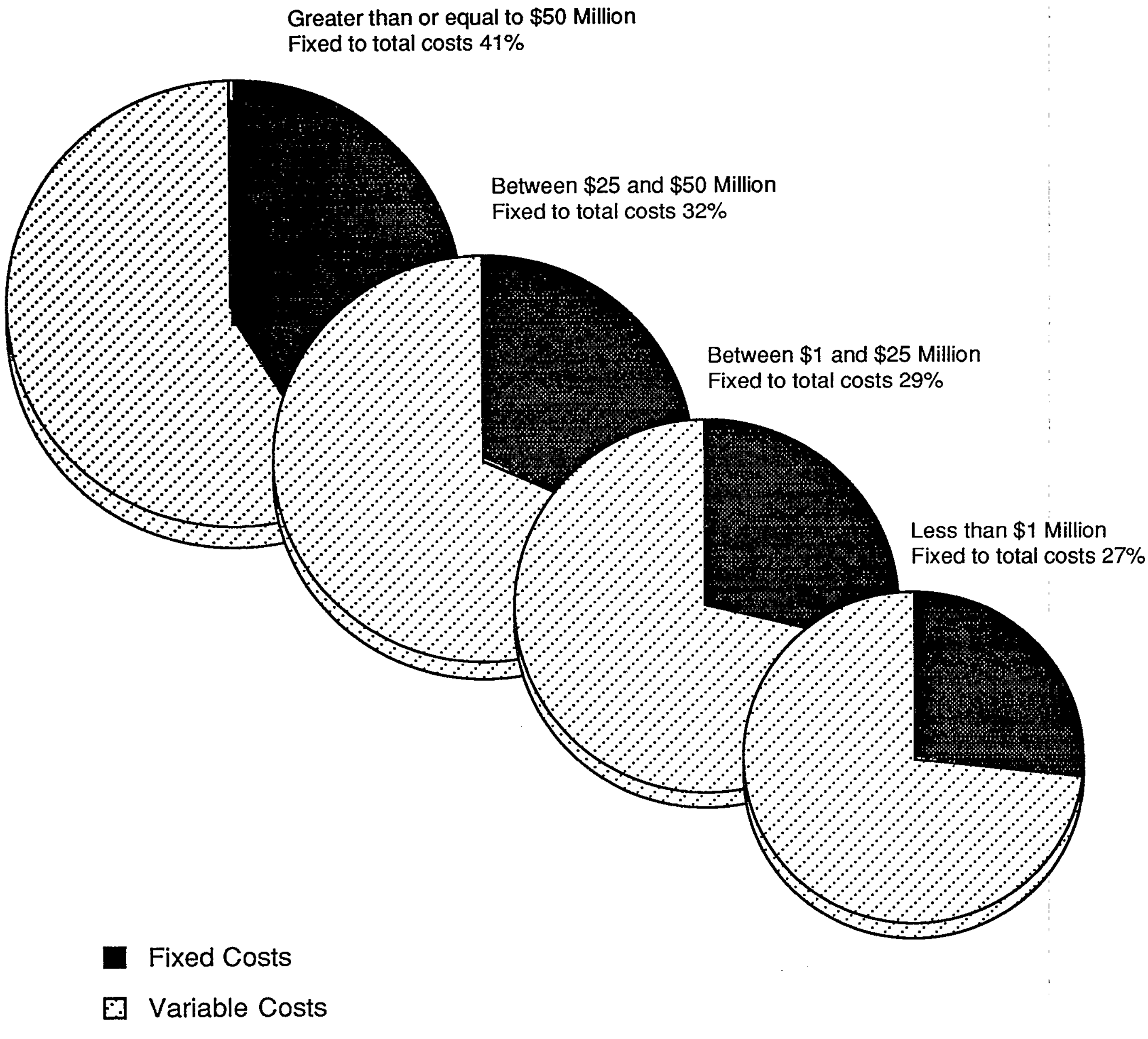


[1] Facility size is measured by revenues from all pesticide-related activities.

Source: Census.

Figure 3.10

Ratio of Pesticide-Related Fixed Costs to Pesticide-Related Total Costs by Facility Size[1], 1986



[1] Facility size is measured by revenues from all pesticide related activities.

Source: Census.

Table 3.7
Total Facility Employment Characteristics, 1986 by Facility Size Full-Time Equivalents (FTEs)[1]

Size of Facility	Number of Facilities	Total Employment	% of Total	Total Pesticide Manufacturing Production Employment	% of Total	Total Formulating and Packaging Production Employment	% of Total	Total Employment for Other Production	% of Total	Total Non-Production Employment	% of Total
Less than $20M	20	971	2%	176	5%	51	3%	226	1%	518	2%
$20M to $74.9M	33	3,246	7%	341	10%	279	17%	976	5%	1,650	8%
$75M to $249.9M	20	8,201	18%	922	27%	235	14%	3,343	18%	3,701	17%
$250M and greater	13	32,943	73%	1,993	58%	1,060	65%	14,540	76%	15,350	72%
Total	86/2	45,361	100%/3	3,432	100%	1,625	100%	19,085	100%	21,219	100%

[1] FTEs are calculated by dividing total annual facility hours by 2,000.
[2] Excluded from the 88 facilities that provided financial data are: an R&D facility; and a facility that did not provide employment data.
[3] Totals may not equal 100% due to rounding.

Source: Census.

Figure 3.9 shows that labor costs make up a relatively small portion of total pesticide variable costs, suggesting that pesticide production is not a labor-intensive industry. On average, pesticide manufacturing facilities employed 527 employees (full-time equivalents, or FTEs), with 40 employees devoted to pesticide manufacturing, 19 to formulating and packaging, 225 to other production, and 250 to non-production (see Table 3.8). On average, production workers (for both pesticide and non-pesticide production) represented 54 percent of total employment, with similar percentages for individual facility sizes. This ratio is in reasonable agreement with data from the *Census of Manufactures*, which reports 1986 production employment to be 59 percent of total employment for both SIC 2879 and SIC 2869.

Figure 3.11 plots employment trends from 1975 to 1987 for all manufactured goods against employment in SIC 2879 (agricultural chemicals, not elsewhere classified [n.e.c.], in pesticide preparations and formulations), SICs 2865 and 2869 (organic chemicals, except gum and wood)[12], and SIC 28 (chemicals and allied products). The figure shows a close correlation between employment trends in all manufacturing industries, and in both the agricultural chemical and organic chemical industries, as well as the chemical industry as a whole. Between 1980 and 1981, however, employment in the agricultural chemical industry increased, while the employment in the organic chemical industry, chemical industry, and all manufacturing decreased.

3.3.F Revenues and Profit

Consistent with the review of production data, examination of facility revenues reveals that facilities derive a large percentage of their revenues from sources other than in-scope pesticide sales (see Figure 3.12). Facilities with revenues greater than or equal to $250 million derive more than half their revenues (approximately 58 percent) from sources other than in-scope pesticide sales, while facilities with revenues of less than $20 million obtain about 42 percent of their revenues from other sources.[13] Although the proportion of revenues derived from sources other than in-scope pesticide sales varies across facility size, the figure illustrates diversity at the facility level for all facility sizes.

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[12]Industrial organic chemicals include SIC 2865 (cyclic crudes and intermediates), SIC 2869 (industrial organic chemicals, n.e.c.), and SIC 2861 (gum and wood chemicals). The *U.S. Industrial Outlook* presents data for organic chemicals as industrial organic chemicals except gum and wood, i.e., SICs 2865 and 2869. Consequently, for consistency in presenting data from secondary sources, organic chemicals are classified as SICs 2865 and 2869 throughout this profile. (Note: In 1986, SIC 2861 constituted only 5 percent of the value of shipments for SICs 2861, 2865 and 2869 combined.)

[13]In-scope revenues are defined as the revenues derived from the sale of in-scope pesticide chemicals. This definition excludes revenues from contract work or tolling, which may be entirely or partially attributable to in-scope pesticides. The figures presented may therefore be larger if a facility also obtains revenues from contract work or tolling.

Table 3.8
Average Facility Employment Characteristics by Facility Size, 1986
Full-Time Equivalents (FTEs)[1]

Size of Facility	Number of Facilities	Average Total Employment	Average Pesticide Manufacturing Employment	Average Formulating and Packaging Employment	Average Employment for Other Production	Average Non-Production Employment	Average Production Employment/2 as % of Average Total Employment
Less than $20M	20	49	9	3	12	27	49%
$20M to $74.9M	33	98	10	8	30	50	49%
$75M to $249.9M	20	410	46	12	167	185	55%
$250M and greater	13	2,534	153	82	1,118	1,181	53%
Average for All Size Facilities	86/3	527	40	19	225	250	54%

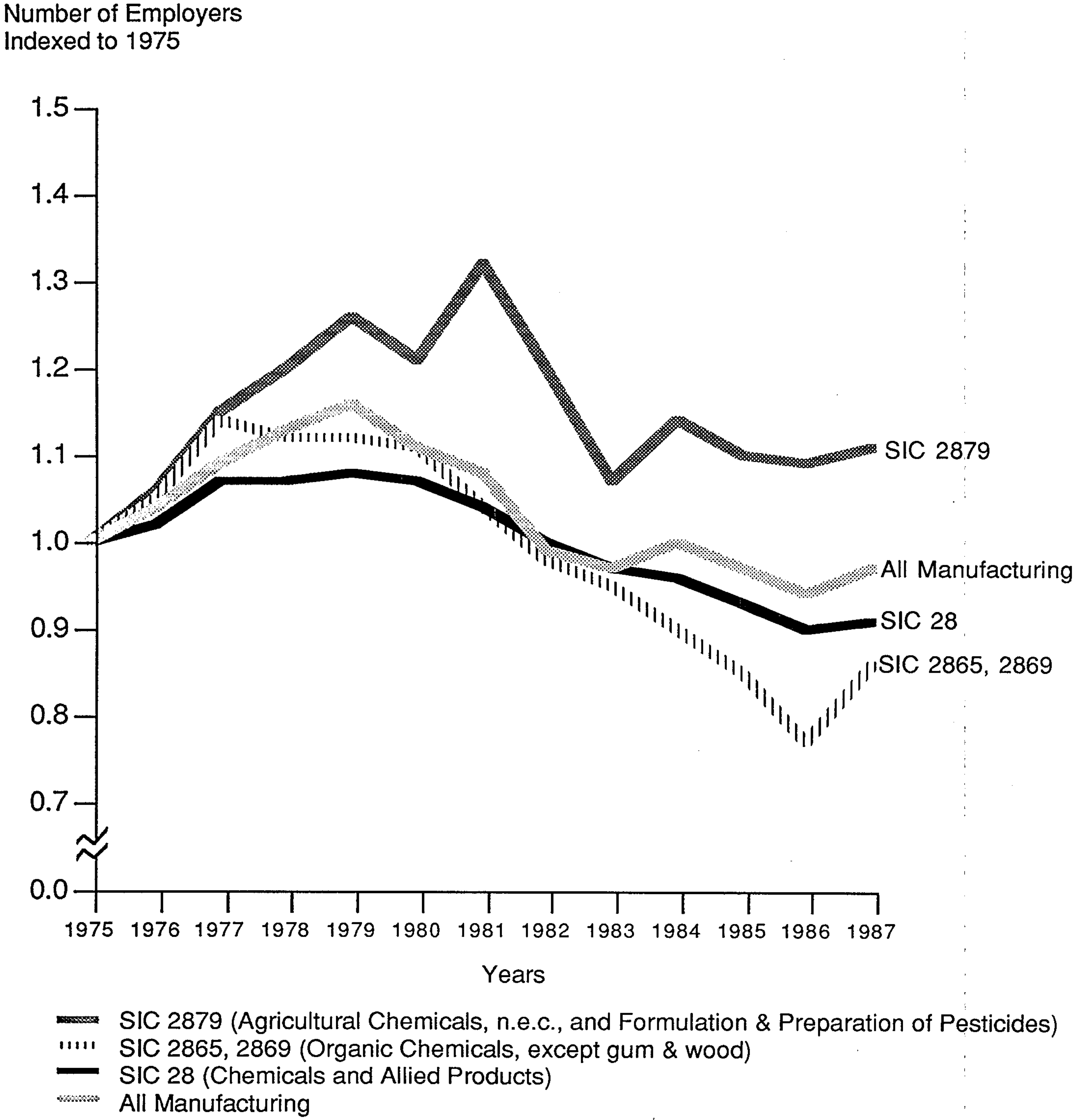
[1] FTEs are calculated by dividing total facility annual hours by 2,000. The average employment figures are the arithmetic mean of FTEs across facility size.
[2] Production employment figures include pesticide manufacturing, formulating and packaging, and other production employment.
[3] Excluded from the 88 facilities that provided financial data are an R&D facility and a facility that did not provide employment data.

Source: Census

Figure 3.11

Employment Trends, 1975-1987

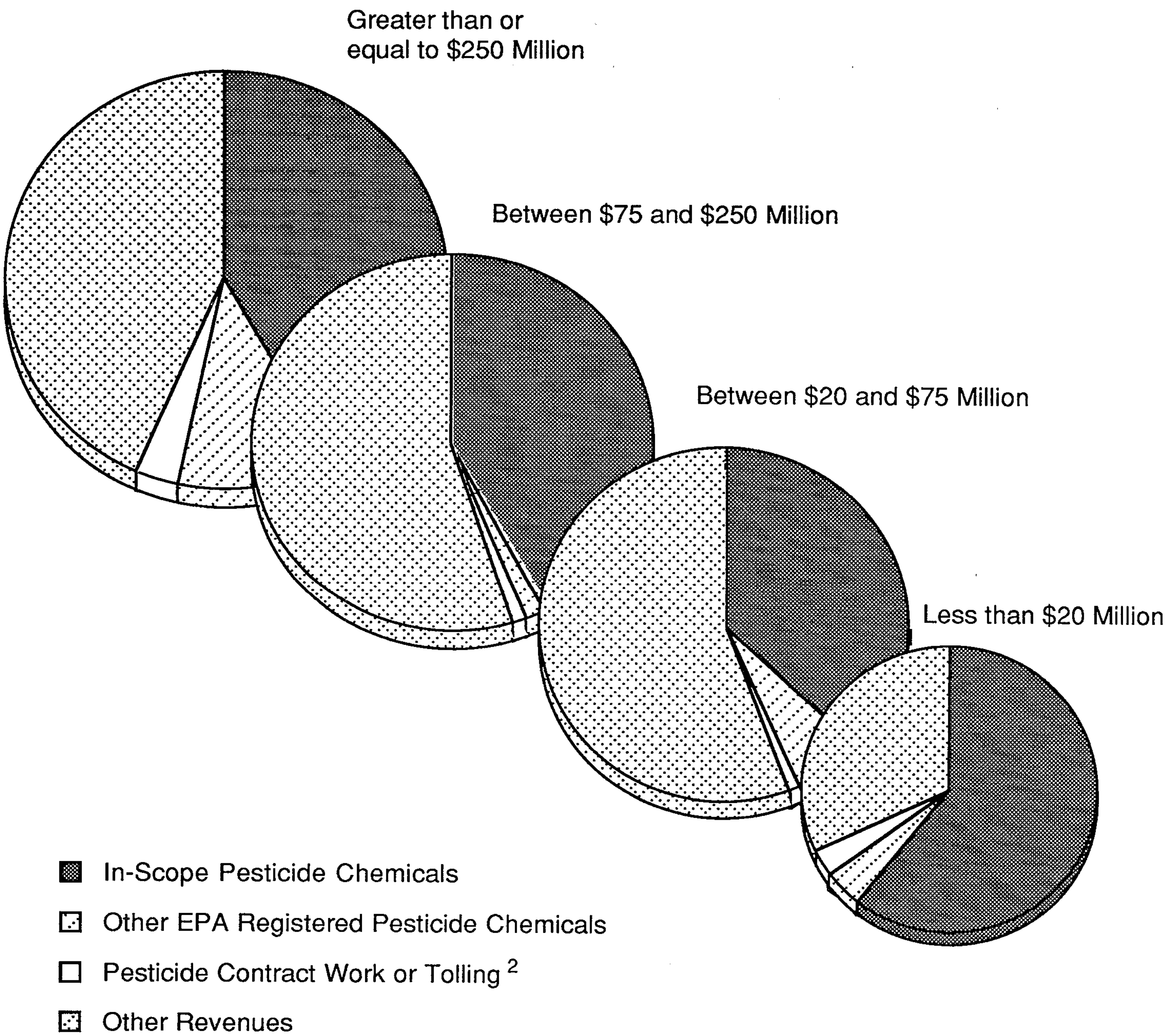
(1975 Base Year)



Source: Census of Manufacturers, 1987.

Figure 3.12

Composition of Facility Revenue by Facility Size[1], 1986



[1] Facility size is measured by total facility revenues.
[2] Tolling work maybe either in-scope or out-of-scope.

Source: Census.

On average, 1986 pre-tax in-scope pesticide facility profits equalled 13 percent of in-scope pesticide facility sales. Figure 3.13 presents 1986 pre-tax in-scope pesticide facility profits as a percent of in-scope pesticide sales categorized by pesticide type, revenues of in-scope pesticides, and total facility revenues.[14] When profits were broken down by pesticide type, facilities that produced only fungicides averaged the highest profit to sales ratio: nearly 0.32. This profit level contrasts with the profit to sales ratio of -0.03 for facilities that produced only insecticides. Facilities that produce multiple types of pesticides (these also tend to be larger facilities) have pre-tax profit to sales ratios of about 0.16. When profits are broken down based on facilities' in-scope pesticide revenues, the data indicate that larger facilities (with revenues greater than or equal to $25 million) were more profitable than smaller facilities (with revenues of less than $25 million) in 1986. This information may indicate that larger facilities, many of which produce several different types of pesticides, are more efficient.

Industry experts, however, attribute the high profits in portions of the pesticide industry to the ability of manufacturers to produce patent-protected pesticides with specific uses.[15] Many of the pesticides included in these profit figures represent patent-protected chemicals produced by only one manufacturer. Although patented products face competition from pesticides with the same end use, many manufacturers appear to have been successful at differentiating their products. Future profits, experts say, will most likely depend on producers' ability to develop new patented products (Kline & Company, 1991). Most competition in the industry is among producers whose products have similar biological activity.

3.3.G Capital Expenditures

Capital expenditures represent funding for additional capacity and/or automating or streamlining existing facilities. Table 3.9 shows that capital expenditures by the pesticide manufacturing industry varied significantly from year to year between 1975 and 1987. On average, capital expenditures decreased by 3 percent per year from 1975 to 1987. Most of the decline took place in the late 1970s and early 1980s. Annual (and, in some cases, biennial) change appears to be cyclical, with downturns followed by upswings. The contraction in the demand for pesticides may be partially responsible for the decline in capital expenditures in the industry.

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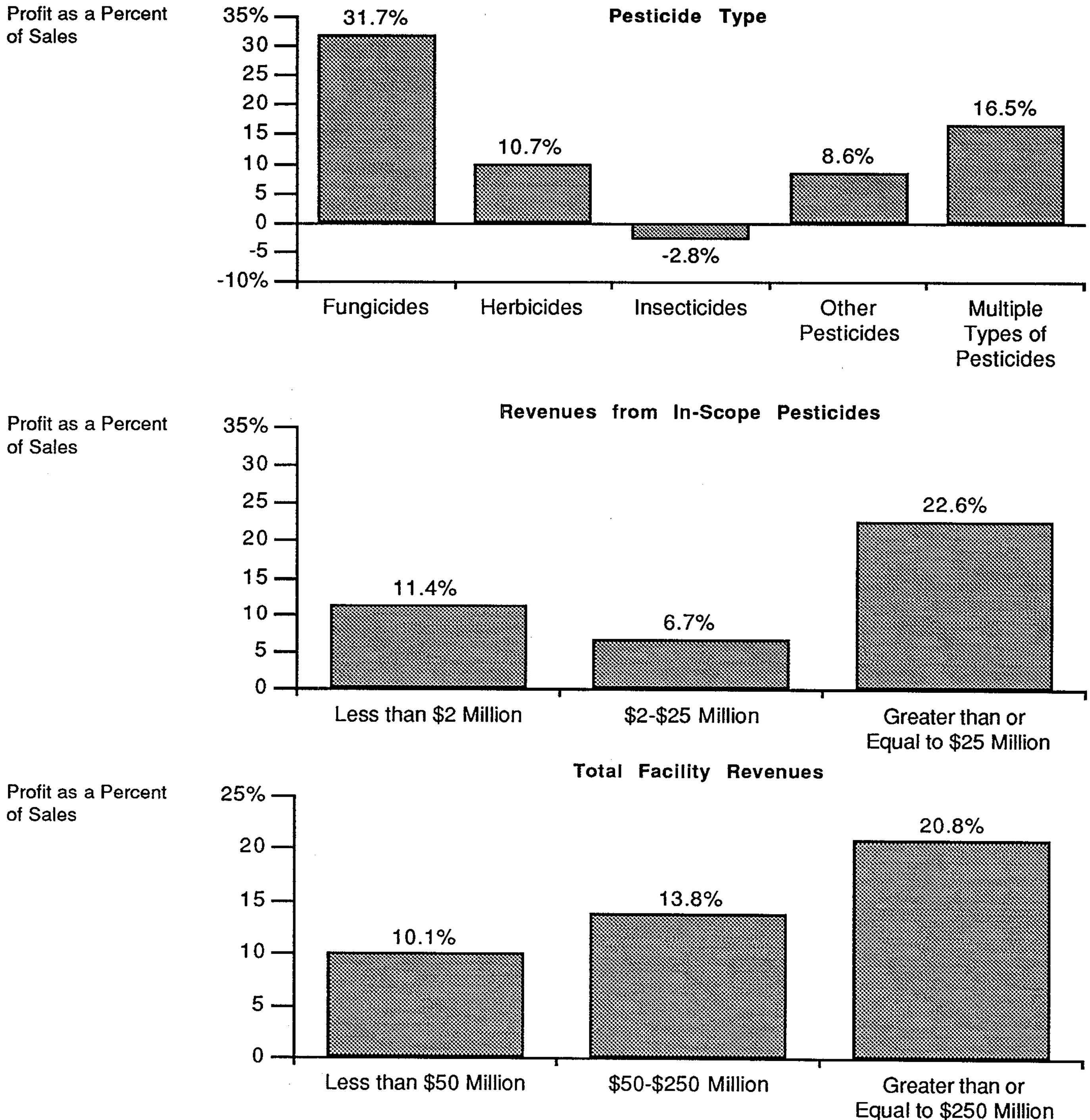
[14]Although revenue information in the Census was broken down by in-scope vs. out-of-scope, facility costs were not. In-scope-related facility costs were therefore calculated by applying the total cost figure to either the ratio of in-scope pesticide revenues to total revenues or, where applicable, the ratio of in-scope pesticide revenues to total pesticide-related revenues.

[15]Production data collected in Part A of the Census indicate that most clusters include production from multiple facilities. In addition, data presented in Section 3.3.F of the profile shows that facilities experience a wide range of profitability, suggesting that the pesticide market is competitive. Conversely, few facilities produce the same PAI within clusters, indicating that product differentiation exists within markets. These characteristics indicate that the pesticide market is competitive with differentiated products.

Figure 3.13

Pre-Tax In-Scope Pesticide Facility Profit as a Percent of In-Scope Pesticide Sales, 1986



Source: Census.

Note: Revenue categorizations for in-scope revenues and facility revenues are broader than those that appear elsewhere in the profile, to prevent disclosure of confidential business information. In addition, the two facilities that changed ownership in 1986 are not included in the information presented in this figure.

Table 3.9
Pesticide Capital Expenditures, 1975-1987
SIC 2879[1]
(in 1986 dollars)

Year	Capital Expenditures (million $)	Annual Percent Change
1975	342.6	73%
1976	301.7	-12%
1977	340.9	13%
1978	381.4	12%
1979	280.8	-26%
1980	246.4	-12%
1981	263.3	7%
1982	295.9	12%
1983	145.0	-51%
1984	199.7	38%
1985	192.6	-4%
1986	200.6	4%
1987	224.1	12%
Average Annual Change		-3%

[1] SIC 2879 includes establishments involved in manufacturing or formulating agricultural chemicals, n.e.c., and formulating and preparing pest control chemicals.

Source: Census of Manufactures, Preliminary Report, Industry Series, 1987

In general, capital expenditures tend to follow the business cycle. Figure 3.14 compares capital expenditures for all manufacturing, as an indicator of the business cycle, to capital expenditures in SIC 2879 (agricultural chemicals, n.e.c., and pesticide formulations and preparations), SICs 2865 and 2869 (organic chemicals, except gum and wood), and SIC 28 (chemicals and allied products). Agricultural chemicals and organic chemicals both exhibit a cyclical trend, with an overall decrease in expenditures of approximately 35 percent from 1975 to 1987. While exhibiting similar swings in capital expenditures to those of agricultural and organic chemicals, the chemicals and allied products industry declined by only 20 percent between 1975 and 1987. Capital expenditures in the manufacturing industry as a whole, like the agricultural chemical industry, appear to be cyclical. From 1978 to 1981, however, "all manufacturing" maintained a fairly constant level of capital expenditures, while capital outlays in the agricultural chemical industry declined. In addition, overall capital expenditures from 1975 to 1987 for "all manufacturing" increased by approximately 20 percent.

In the Census, facilities provided the year of the most recent major expansion of facility or equipment with respect to pesticide production. Almost 90 percent of the facilities indicated that they had made some sort of expansion of facility or equipment related to pesticide production since 1960. More than 80 percent of the facilities invested in an expansion or improvement after 1970, while almost 40 percent of the facilities reported an expansion or improvement after 1985.

3.3.H Production Capacity Utilization

Table 3.10 shows pesticide production capacity utilization rates from 1980 to 1989. The data indicate that production capacity utilization for all pesticides varied significantly during the decade, averaging approximately 68 percent for all pesticides. At times, however, some types of pesticides had much lower production capacity utilization. During 1983 and 1984, for example, capacity utilization for insecticide production was particularly low, declining to 29 percent in 1984. Figure 3.15 compares the capacity utilization rate for pesticide production to that for all manufacturing. The figure shows that the manufacturing capacity utilization trend runs counter to that for pesticides. Capacity utilization for all manufacturing hit a low in 1982 and rose thereafter. Capacity utilization for pesticide production, on the other hand, peaked in 1982 and hit its lowest point in 1984.[16]

The post-1982 decline in pesticide manufacturing capacity utilization may be attributable in part to the Payment-in-Kind (PIK) program.[17] In addition, pesticide production capacity utilization rates may fluctuate over time because some pesticides are not produced on an annual basis. Rather, PAIs may be produced for a limited time period (every second or third year) on what the industry commonly refers to as a campaign basis.

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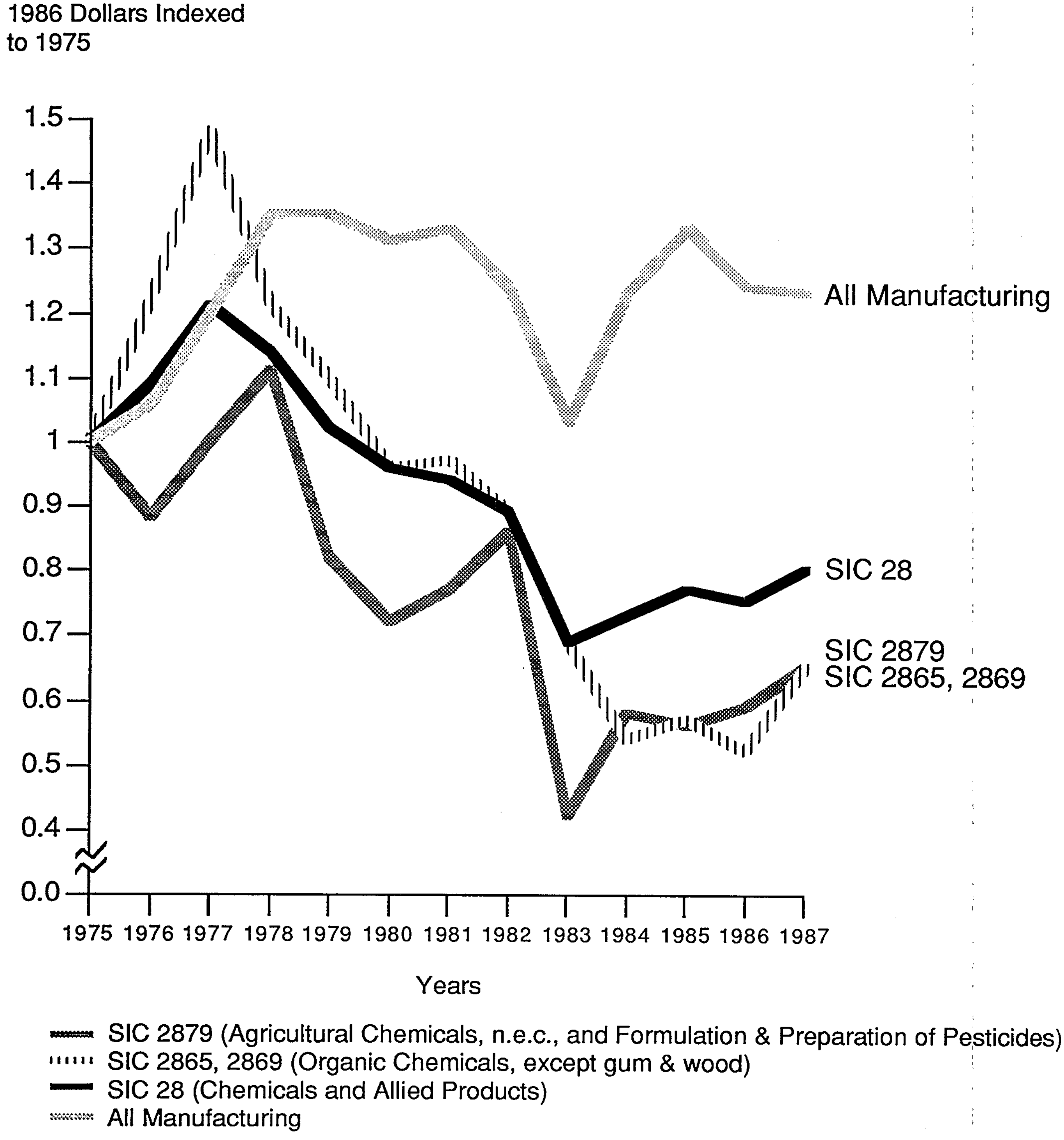
[16]This is reasonable, since pesticide production is more closely related to agricultural production than to measures of industrial activity.

[17]Recall that PIK took 48 million acres out of production in 1983.

Figure 3.14

Capital Expenditures in 1986 Dollars

(1975 Base Year)



Source: Census of Manufacturers, 1987.

Table 3.10
U.S. Pesticide Production Capacity Utilization Rates, 1980-1989
(Percent)

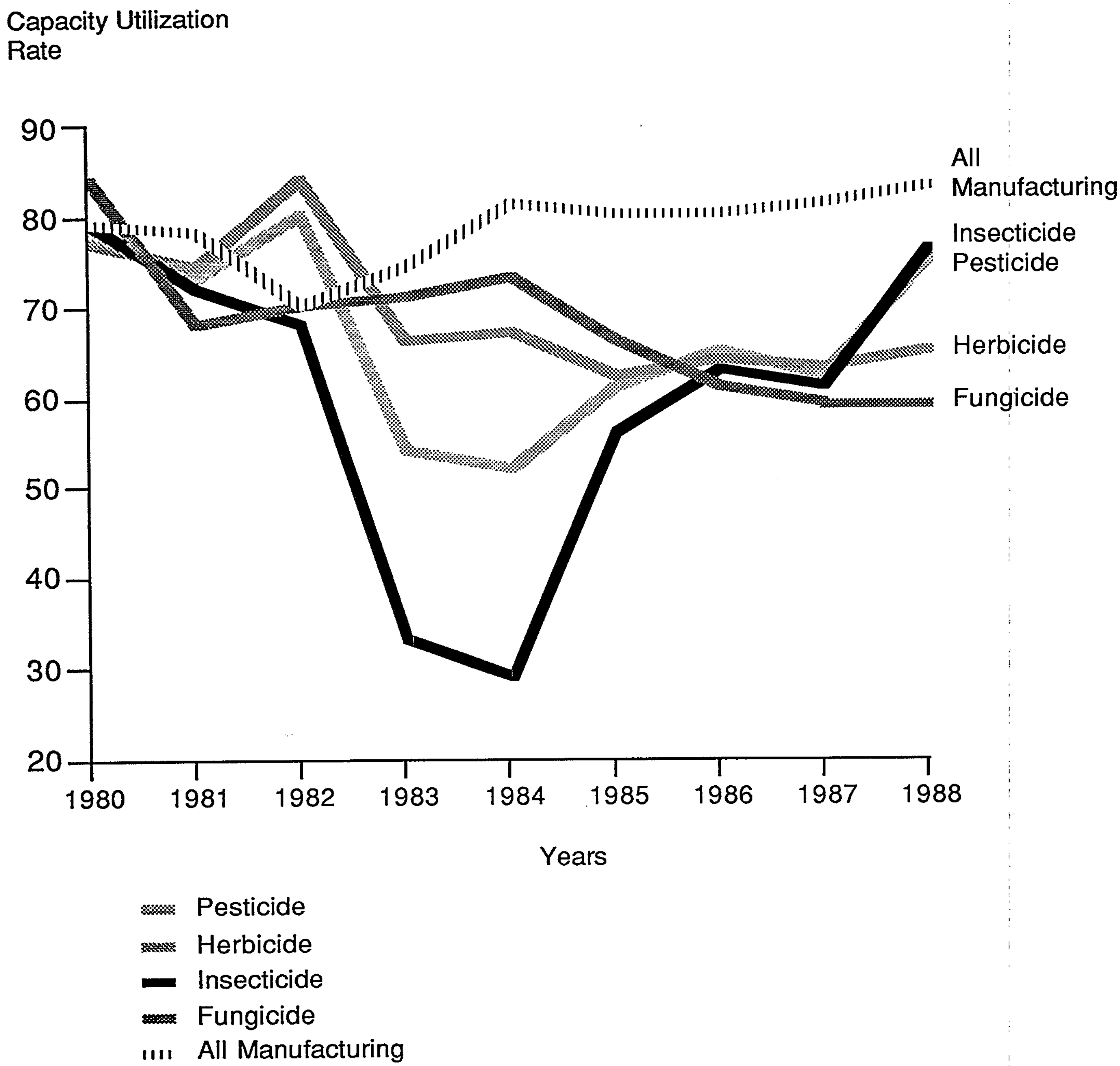
Year	Herbicides	Insecticides	Fungicides	All Pesticides	Annual Percent Change All Pesticides[1]
1980	77	79	84	78	n/a[2]
1981	74	72	68	73	-6%
1982	84	68	70	80	10%
1983	66	33	71	54	-33%
1984	67	29	73	52	-4%
1985	62	56	66	61	17%
1986	64	63	61	65	7%
1987	63	61	59	62	-5%
1988	75	76	59	75	21%
1989[3]	72	76	63	81	8%
Average Capacity Utilization	70.4	61.3	67.4	68.1	Average Annual Change 4%

[1] The rate for all pesticides may be higher than those for herbicides, insecticides, or fungicides. This difference is due to the inclusion of detailed information on capacity rates associated with pesticides either classified as rodenticides or unclassified.
[2] Not available.
[3] Projected.

Source: USDA Agricultural Resources: *Situation and Outlook Report*, AR-13, February 1989.

Figure 3.15

Comparison of All Manufacturing Capacity Utilization and Pesticide Production Capacity Utilization Rates



Source: USDA Agricultural Resources: *Situation and Outlook Report* AR-13 February, 1989.
Statistical Abstract of the United States , 1989.

Although many PAIs are produced annually, it is common industry practice to produce a specific PAI less frequently. This typically occurs when the pesticide is used on a low-volume specialty crop, or for those pesticides with high concentrations that allow for reduced volume. During production, materials are fed into a reactor in order to produce a desired chemical reaction; labor and equipment are used to monitor the process to make sure that all necessary conditions of production are met.

Although the frequency of production is generally determined by product demand, the quantity produced is typically a function of the volume required to make the run cost-efficient. Due to start-up costs such as energy and labor, costs per unit produced increase as quantities are reduced. Total costs associated with the minimum volume a facility is willing to produce may be only slightly greater than total costs for production of much smaller amounts of the pesticide.[18]

3.4 Firm Characteristics

This profile has thus far focused primarily on characteristics of the facility. This section describes the ownership structure of the industry and the way in which firms are organized.

The Census indicates that most in-scope pesticide facilities are owned or controlled by a parent firm (85 percent). Although a number of smaller, single-facility firms control small portions of total production, overall production is becoming increasingly concentrated among large producers as a result of mergers and acquisitions. Only 15 percent of the facilities are single entities not owned or controlled by another firm as of December 31, 1986. Approximately 35 percent of all parent firms are controlled in turn by another company. Large R&D costs, including registration fees, may be a reason why the majority of pesticide producers tend to be part of a larger, multi-facility firm.

In 1986, 64 firms produced in-scope pesticides in the United States. These firms owned 90 facilities, which produced 136 individual or classes of in-scope PAIs. The number of PAIs manufactured by each firm varies (see Figure 3.16). Approximately 45 percent of the firms owning in-scope facilities in 1986 produced only one PAI, although one firm manufactured 11 PAIs.

According to the Census data, approximately three-quarters of the firms owned only one in-scope pesticide manufacturing facility. The remaining firms tended to own two or three in-scope pesticide producing facilities. Of these firms, 44 percent produced the same pesticide at more than one of their in-scope facilities. Figure 3.17 presents the number of in-scope facilities owned by firms.

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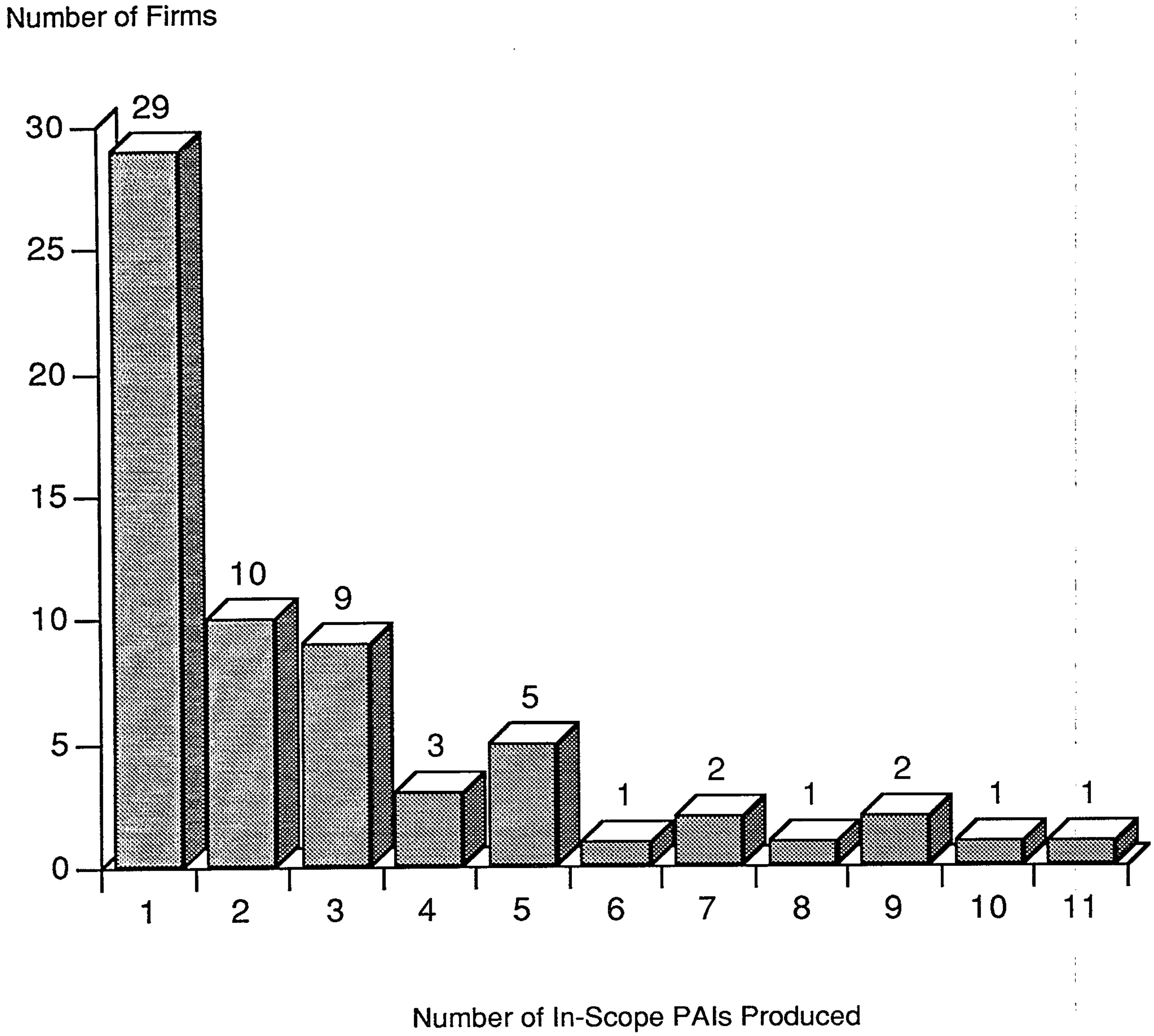
[18]Per unit costs increase as quantities produced decrease. Producing larger quantities may therefore cost less on a per unit basis.

Figure 3.16

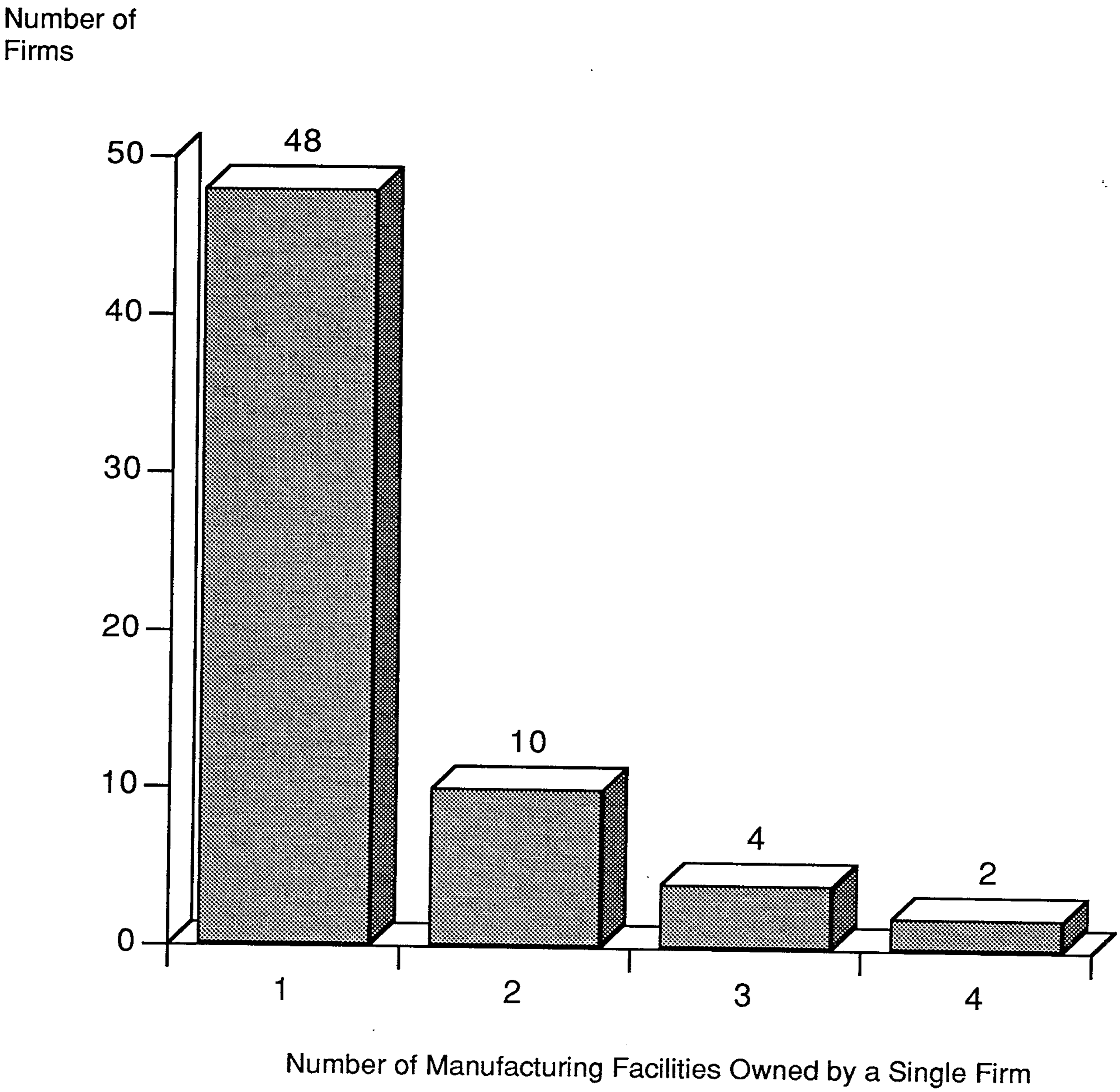
Number of Individual or Classes of In-Scope PAIs Produced by Firms, 1986



Source: Census.

Figure 3.17

Number of U.S. In-Scope Pesticide Manufacturing Facilities Owned by Firms, 1986



Source: Census.

Figure 3.18 shows the composition of 1986 firm sales activity. At the firm level, pesticides constitute a small portion of sales. On average, pesticide manufacturing and pesticide formulating/packaging combined represent five percent of firms' sales.

3.5 Industry Market Structure

Several factors play an important role in determining market structure, including (1) the barriers firms face in entering and exiting the market, (2) vertical integration, (3) the concentration of production, and (4) the degree to which products are substitutable in consumption. This section describes how these factors affect the competitiveness of the industry.

3.5.A Barriers to Entry

Firms' abilities to enter and exit the market determine, in part, the competitiveness of the industry. If significant barriers to entry exist, potential entrants may be dissuaded and existing firms may enjoy market power. If few barriers to entry exist, existing firms are more likely to face competition for market share.

There are several types of entry barriers. The most relevant to the pesticide industry are (1) capital requirements, (2) economies of scale, and (3) R&D requirements, including registration costs. Although data about barriers to entry are limited, the available data reveal that market power exists for many firms in the industry.

A significant number of the PAIs in the Census are produced by only one firm. Given that patent protection exists for pesticide products, it is possible that there is room for only one producer of each PAI, and that each producer maintains market power for that PAI. Figure 3.19 exhibits data to support this assumption, revealing that 106 of the 136 individual or classes of in-scope PAIs manufactured in 1986 were produced by only one firm. The concentration of individual PAI production among single firms may be countered, however, by the fact that some pesticide products are substitutable. Consequently, individual firms that do not produce the same PAIs may produce products that compete in the market place.

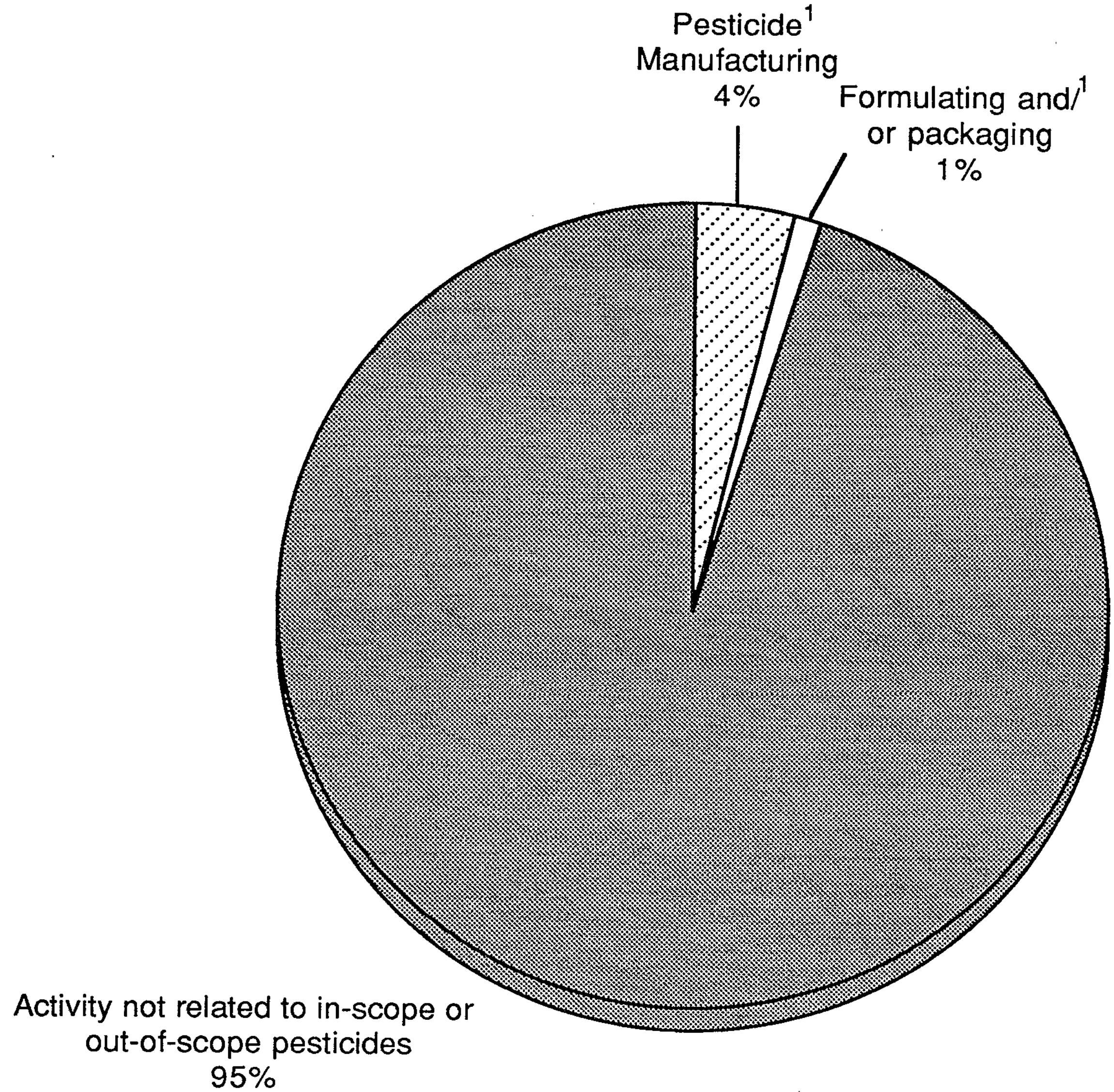
Capital Costs

Firms require capital in order to begin, improve, or expand production. The capital required to enter an industry may be sufficient to impede market entry. There are no readily available data on the amount of capital required for new construction or expansion of a pesticide chemical facility. There are measures, however, that provide an indication of capital intensity in the industry.

Figure 3.18

Composition of Firm Sales, 1986

(Averaged Across All Firms)

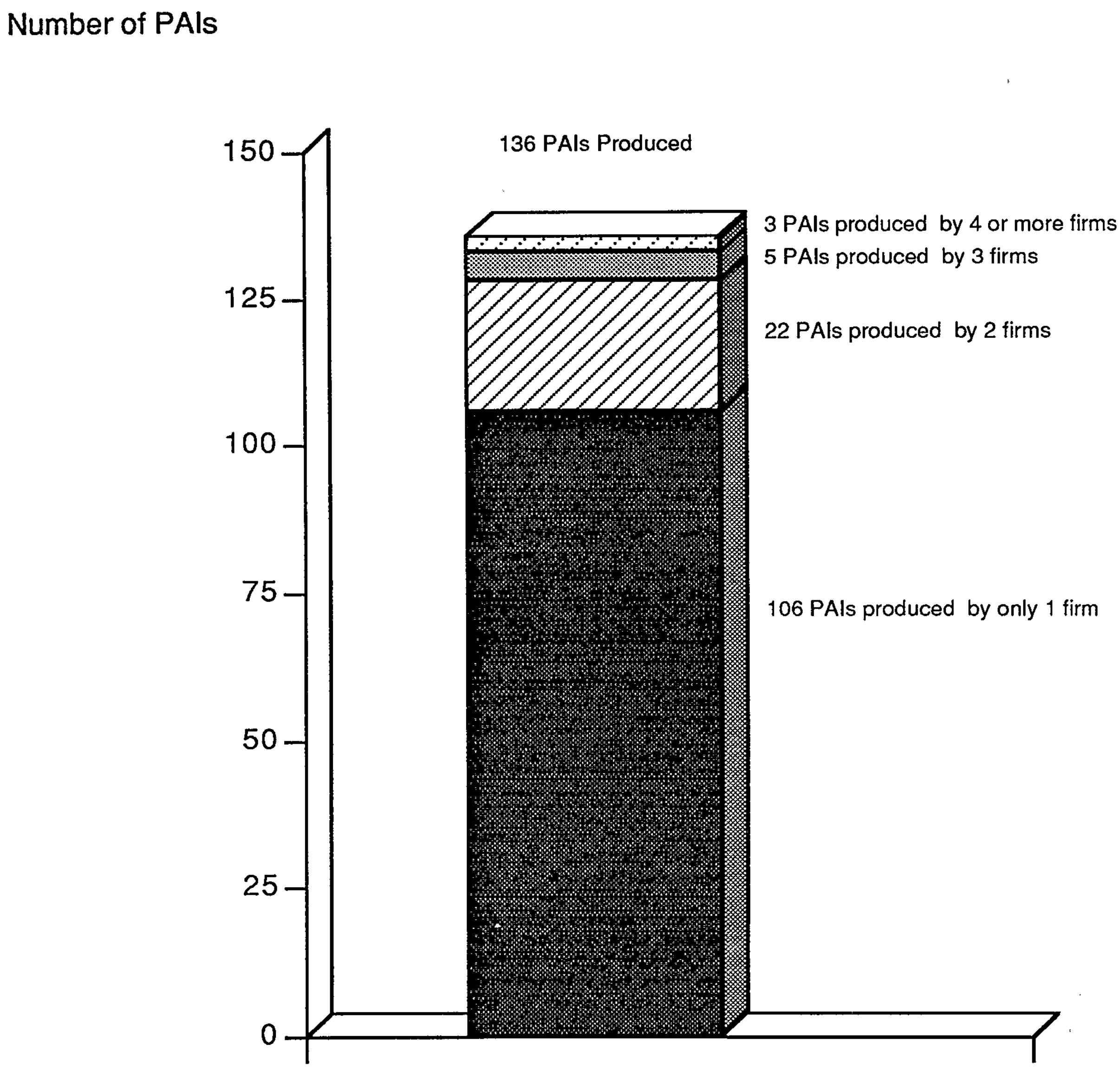


[1] Includes in-scope and out-of-scope production activity.

Source: Census.

Figure 3.19

Number of Firms that Produce an Individual PAI or Class of PAI, 1986



Source: Census.

The ratio of the value added by manufacturing to gross book value of depreciable assets provides a measure of the capital intensity of the industry. The data indicate that pesticide manufacturing is capital intensive, especially when compared to formulating/packaging and to all manufacturing. SIC 2869, which includes the manufacture of basic pesticides and many other organic chemicals, had a value added:depreciable assets ratio of 0.51 in 1987; i.e., the value added represents 51 percent of the value of depreciable assets (U.S. Department of Commerce, 1989a). SIC 2879, industrial organic chemicals, which includes primarily pesticide formulation, had a much higher ratio of 1.13, indicating less capital intensity (U.S. Department of Commerce, 1989a).[19] SICs 20-39, which include all manufacturing, had a ratio of 1.34, demonstrating the relative capital intensity of pesticide production to manufacturing in general (U.S. Department of Commerce, 1989a).

Existence of Economies of Scale

The relative capital intensity of the pesticide industry is one indication of the extent to which economies of scale exist. Although technology determines the minimum efficient size of a facility, efficient scales of production appear to vary widely across PAIs. Comparing facilities that produce the same PAIs suggests that there is a large difference in the quantities produced. Facilities can range in annual output from a few thousand pounds to more than 10 million pounds of the same PAI. The fact that there are vast differences in the size of facilities producing the same product indicates that economies of scale probably are not a major factor within the pesticide manufacturing industry.[20]

Research and Development

Large capital outlays for R&D represent another barrier to entry. Research used to develop new, patented products is considered to be key to chemical producers' success. Patents are important to the pesticide industry because they give producers a monopoly in the production of that pesticide and allow the producer to price a product above cost. Pesticide products carry a 17-year patent; firms need this patent protection to price above costs to recover their R&D expenditures.[21] Since different patented products may compete for the same use, however, pure monopolies do not exist.

Although patented products play an extremely important role in the industry, there are unpatented products on the market that are profitable. The existence of unpatented products signifies that patents alone do

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[19]A higher ratio of value added by manufacturing to gross book value of depreciable assets may also result from the use of older equipment.

[20]The analysis of economies of scale within the pesticide manufacturing industry is complex. Because multiple PAIs may be produced on the same line, using the same equipment, comparing production across individual PAIs may not provide definitive evidence on whether economies of scale exist.

[21]After a pesticide product is patented, the manufacturer must register the product for use. Therefore, manufacturers often have fewer than 17 years to recoup their R&D costs.

not protect profits. Nevertheless, patents for most pesticides are instrumental in recovering R&D costs, and are also a factor in restricting market entry.

Research and development costs are one of the fastest growing components of fixed costs that firms face. In 1976, the average R&D costs of a single new pesticide were estimated at $10 million (1986 dollars), while in 1987 the estimated costs to develop a single new pesticide were $40 million (1986 dollars) (U.S. Department of Commerce, 1987). The increase in costs is partly due to more stringent toxicity tests performed in compliance with environmental regulations. Specifically, use restriction based on the amount of residue toxicity left on food products places new pesticide products under greater scrutiny than existing pesticide products. According to industry experts, it can take 10 years to bring a chemical pesticide from the R&D stage to registration with the EPA (Rich, 1988). To register a pesticide for a major food use, there is a flat fee of $150,000[22]. In order to support R&D and the registration of new products, firms must be able to generate sufficient pesticide sales. The need for a large sales volume may be one explanation for the number of mergers and acquisitions in the 1980s.

The Census data indicate that total average R&D costs for all firms represent about 4 percent of total facility sales.[23] Different levels of R&D are sustained, depending upon the size of firms. Table 3.11 breaks down R&D costs as a percent of total facility sales for three firm sizes.[24] According to the Census, firms with total revenues of between $1 billion and $6 billion have the highest R&D expenses as a percent of sales. High R&D costs and the uncertainty of product success may make it difficult for new firms to put up the capital and to absorb the risk from R&D ventures. These costs may bar entry, with the result that the industry becomes less competitive.

3.5.B Vertical Integration

Vertical integration is the extent to which the different stages of production are organized in a single firm. According to the Census, both small and large firms tend to be vertically integrated, engaging in the R&D, manufacturing, and formulating/packaging of pesticides.

Compared to developing and manufacturing PAIs, formulating/packaging is less expensive but often adds considerable value to the end product. As mentioned previously, data from the Census indicate that 50 of

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[22]The annual maintenance fee is $425 for each registration up to 50 registrations; and $100 for each additional registration, with the exception that no fee is charged for more than 200 registered products held by any registrant (FIFRA, Section 4).

[23]The Census collected total facility, not pesticide-specific, R&D costs.

[24]R&D costs were estimated based on firm size rather than facility size, because firm size is generally more important than facility size in determining the level of R&D.

Table 3.11
Research and Development Costs as a Percent of Total Facility Sales, 1986 by Firm Size[1]

Firm Size (Annual Revenues)	No. of Facilities	Percent of R&D Costs to Total Facility Sales
Revenues less than $1 Billion	46	3.3%
Revenues between $1 Billion and $6 Billion	26	5.5%
Revenues greater than $6 Billion	12	3.7%
All Facilities	84[2]	4.0%

[1] Average R&D to sales ratio across all facilities, by firm size.
[2] Excluded from the 88 facilities that provided financial data are four facilities that did not report firm revenues.

Source: Census.

the 90 in-scope PAI manufacturing facilities also engaged in formulating/packaging. When evaluated at the firm level, these data reveal that 39 of the 64 firms represented in the Census have PAI formulating/packaging capabilities at one or more of their in-scope PAI manufacturing facilities. In addition, five of the firms that do not formulate/package PAIs at their in-scope PAI manufacturing facilities reported that they own other facilities at which PAIs are formulated/packaged. Of the 64 firms represented in the Census, therefore, 44 (69 percent) have both PAI manufacturing and formulating/packaging capabilities.

In addition to in-house formulating/packaging capabilities, many firms, both large and small, contract out some aspects of the production process (tolling), typically the formulating/packaging process. It is estimated that approximately 80 percent of the formulated pesticide business is controlled by PAI manufacturers, either directly with in-house capacity or indirectly through contracting (Kline & Company, 1990).

3.5.C Concentration

Like many industries, the pesticide industry underwent significant restructuring in the 1980s. According to the International Trade Commission's *Synthetic Organic Chemicals*, the number of facilities producing pesticides declined by 23 percent from 1979 to 1988. The Census indicates that between 1980 and 1986, 20 in-scope pesticide facilities had parent firms that were purchased by or merged with other firms. Although the majority of the facilities did not change ownership status, the number of mergers and acquisitions is significant in terms of overall production and sales. Some of the industry's largest firms were restructured during this period, concentrating production further. The number of mergers and acquisitions involving in-scope facilities is shown in Figure 3.20. Further concentration of the industry has occurred since 1986.

Two main types of restructuring occurred in the United States in the 1980s. First, foreign firms acquired U.S. firms either in total or in part;[25] second, U.S. firms acquired or merged with other domestic firms. Some industry experts attribute the foreign component of restructuring to the volatility of the U.S. dollar from 1980 to 1990. The strong U.S. dollar prior to 1985 strengthened foreign firms' positions in the world market, because U.S. products were more expensive relative to foreign counterparts. The increase in environmental controls implemented in the United States during the 1980s also contributed to the price increase of U.S. products. As the dollar weakened after 1985, foreign firms began purchasing production capacity in the United States. As stated above, mergers and acquisitions among U.S. firms may have resulted primarily from the firms' need to generate large amounts of sales to support the rising costs of both R&D and environmental compliance (U.S. Department of Commerce, 1989d and Sine, 1990).

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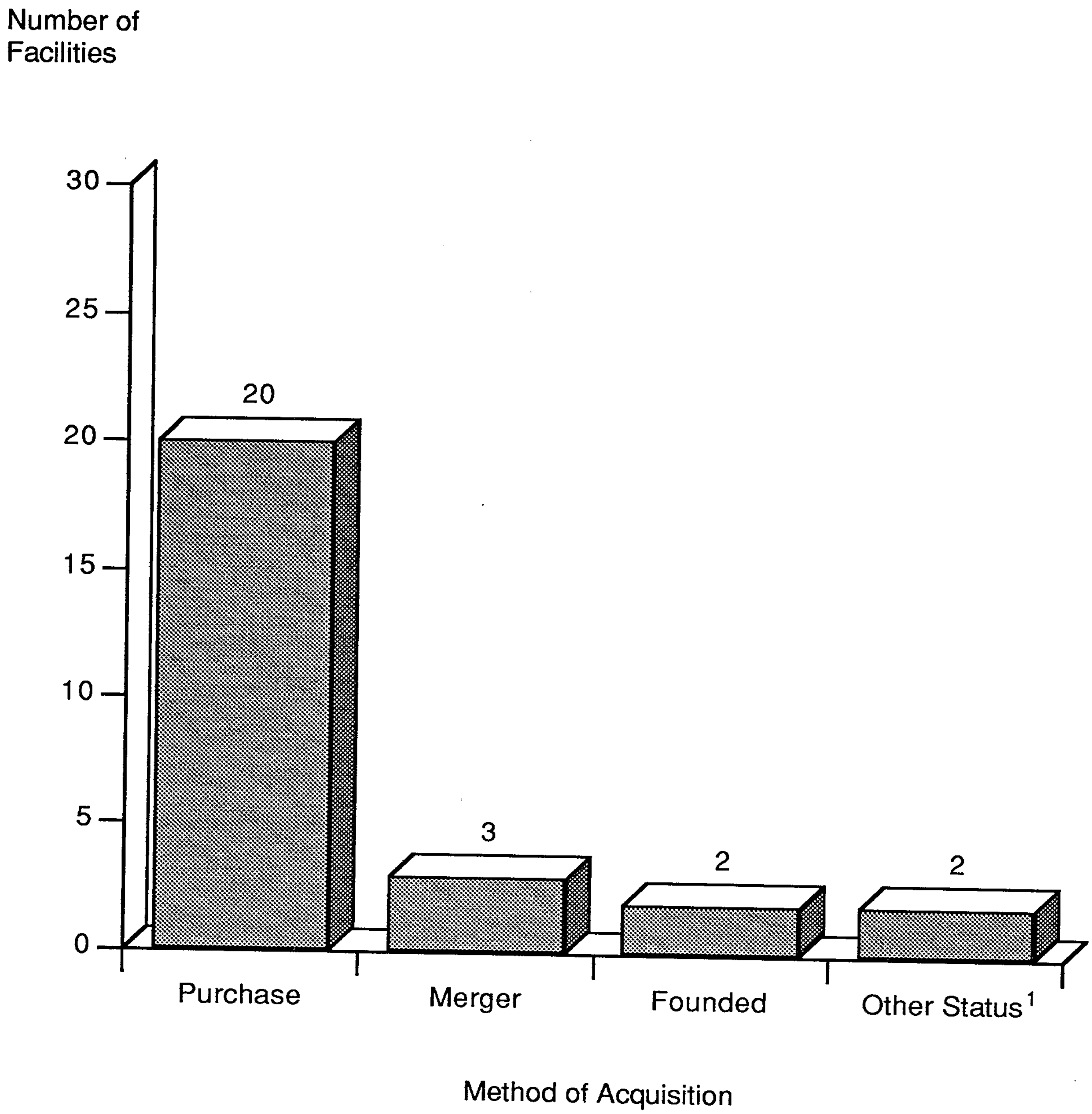
[25]Based on parent firm information reported in the Census, 9 of the 90 facilities (10 percent) were owned by foreign companies in 1986. Note: Foreign ownership was not explicitly requested in the Census, and was determined based on the parent firm address reported in the Census in conjunction with information presented in Dun and Bradstreet's *Million Dollar Directory*.

Figure 3.20

Number of Facilities Acquired by Firms

(From Jan. 81 to Dec. 86,
by Method of Acquisition)



[1] Of the two facilities that reported other, one indicated that the facility was acquired through the contribution of capital by the parent company; the other indicated that the facility was newly constructed.

Source: Census.

In a concentrated industry, the dominant firm or firms are better able to influence market outcomes to their advantage. Industry concentration is frequently measured by concentration ratios, which are the percentage of total sales accounted for by a given number of firms. The Bureau of the Census calculates concentration ratios for the top 4, 8, 20, and 50 producers of basic pesticides. These concentration ratios are displayed in Table 3.12. In SIC 28694 (pesticides and other synthetic organic agricultural chemicals except preparations), the top four firms accounted for 54 percent of the value of shipments in 1982. In SIC 2879 (agricultural chemicals, n.e.c., and pesticide preparations and formulations), the top four firms accounted for 39 percent of the value of shipments. Examining concentration ratios by pesticide type in Table 3.12 shows the fungicide preparations market to be the most concentrated and insecticide preparations to be the least concentrated.

Concentration ratios based on sales of in-scope pesticides were calculated using the Census data. These ratios, shown in Table 3.13, indicate that the four largest firms account for 42 percent of the value of all in-scope pesticide shipments. Like the Bureau of Census data, examination of concentration ratios by pesticide type based on the data presented in Table 3.13 shows that the fungicide market is the most heavily concentrated, while the insecticide market is the least concentrated. The concentration ratios indicate that there may be no dominant firm in the industry as a whole. The pesticide industry is highly differentiated, however, meaning that there may be dominant firms in individual pesticide markets.

3.5.D Demand Elasticity and Product Substitution

Single firms dominate the production of specific pesticides. For these firms to enjoy market power, however, consumers must be unable to find substitutions for their products easily. A common indicator of substitutability in consumption is the price elasticity of demand, which shows the percentage change in demand given a percentage change in the price of a pesticide. Price elasticity of demand is calculated by dividing the percentage change in demand by the percentage change in price. Numeric values associated with price elasticities of demand are generally expressed relative to a one percent change in price. For example, an elasticity of -0.5 suggests that a 1 percent increase in price would result in a 0.5 percent decrease in the quantity demanded.

Price elasticities of demand were estimated for each pesticide cluster in the analysis.[26] In order to develop the elasticity estimates, the EPA developed a comprehensive approach, including:

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[26]This section is based on detailed analyses of pesticide demand elasticities. See Appendix C for further details.

Table 3.12
Share of Value of Pesticide Shipments Accounted for by the 4, 8, 20, and 50 Largest Companies, 1972-1982

Year	Total (Mill. 1986$)	4 largest companies (%)	8 largest companies (%)	20 largest companies (%)	50 largest companies (%)
Synthetic Organic Pesticides, Not Formulated, SIC 28694					
1982	1832	54	76	93	100
1977	2285	65	80	93	99
1972	1424	57	79	97	100
Agricultural Chemicals, n.e.c., and formulations and preparations, SIC 2879					
1982	4919	39	58	81	91
1977	4191	37	57	76	87
1972	3438	34	51	73	85
Insecticide Preparations, SIC 28795					
1982	991	46	71	90	99
1977	1284	45	67	87	98
1972	1039	48	67	87	98
Herbicide Preparations, SIC 28796					
1982	2710	62	77	95	99+
1977	1825	65	84	96	99+
1972	1243	77	89	98	99+
Fungicide Preparations, SIC 28797					
1982	358	69	84	98	100
1977	305	70	85	97	99+
Other Pesticide Preparations, SIC 28798					
1982	198	49	65	87	99+
1977	186	47	66	91	99+
Household Pesticidal Preparations, SIC 28799					
1982	480	53	70	89	99
1977	353	56	71	89	99

Concentration Ratios from the 1987 Census expected to be available April 1992.

Source: Census of Manufactures, Concentration Ratios in Manufacturing, 1982.

Table 3.13
Share of Value of In-Scope Pesticide Shipments Accounted for by the 4, 8, and 20 Largest Firms, 1986

	4 largest firms	8 largest firms	20 largest firms	Total
Number of Facilities				
All Pesticides	11	18	39	90
Fungicides	4	9	24	30
Herbicides	7	14	31	39
Insecticides	9	13	27	36
Concentration Ratio (Percent of Sales)				
All Pesticides	42	68	94	100
Fungicides	67	90	100[1]	100
Herbicides	61	83	99	100
Insecticides	57	81	99	100
Total Sales (Million $)				
All Pesticides	1,640	2,654	3,634	3,884
Fungicides	278	375	416	416
Herbicides	1,510	2,049	2,448	2,463
Insecticides	531	749	918	928

[1] Remaining six firms constitute less than 1% of total fungicide sales.

Source: Census.

(1) Review of empirical studies of pesticide production and use;

(2) U.S. Department of Agriculture's analysis of the price elasticity of demand for food commodities (USDA, 1985, 1989);[27]

(3) Feasibility of employing non-chemical, non-biological pest control methods (Pimental, D., et al., 1991).[28] (The greater the feasibility of substitution, the higher the expected price elasticity of demand.);

(4) An analysis of pesticides' contribution to the cost of production of a commodity, based on estimates of the cost of production in the farm sector (USDA, 1989a).[29] (The greater the contribution of pesticides to the cost of production, the higher the expected price elasticity of demand.);

(5) Analysis of the marginal productivity of pesticides (USDA, 1989, USDA, 1989a);[30] and

(6) Expert opinions within the OPP.

The estimated price elasticities of demand vary significantly among the clusters, since each cluster faces different market forces. Table 3.14 shows that the estimates of elasticity of demand for pesticide clusters with in-scope products in 1986. Elasticity of demand varies among these clusters from -0.12 to -1.38. Despite the wide range of demand elasticities among pesticide clusters, 38 of the 45 have inelastic demand, i.e., the absolute values of the demand elasticities are less than 1. This indicates that demand at a cluster level (although not necessarily at the PAI level) will not vary significantly with moderate price increases.

3.6 International Trade

The U.S. pesticide industry holds a sizable share of the world export market for pesticides: approximately 23 percent of the total value of shipments in 1987 (United Nations, 1987, and Department of Commerce, 1989d). During the last decade, however, the margin between exports and imports has been declining, although the United States remains a net exporter of pesticides. Both the strong U.S. dollar from 1980 to 1985 and increasing foreign competition contributed to the change in U.S. position. U.S. imports, although increasing, do not appear to threaten the market power of domestic firms.

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[27]USDA (1985). *U.S. Demand for Food: A Complete System of Price and Income Effects.*, and U.S.D.A. (1989). *Retail to Farm Linkage for a Complete Demand System of Food Commodities.*

[28]Pimentel, D., et al. (1991). Environmental and Economic Impacts of Reducing U.S. Agricultural Pesticide Use. *Pest Management in Agriculture.* CRC press.

[29]USDA (1989a). *Economic Indicators of the Farm Sector: Cost of Production, 1987.* February.

[30]USDA (1989). *Retail to Farm Linkage for a Complete Demand System of Food Commodities.*, USDA (1989a). *Economic Indicators of the Farm Sector: Costs of Production, 1987.* February.

Table 3.14
Summary of Estimates of Elasticity of Demand for Clusters with Production, 1986
Page 1

Cluster	Elasticity Estimate
Herbicides on sugar beets, beans, peas	-0.12
Herbicides on tree fruits (except oranges), sugar cane, nuts	-0.20
Herbicides on tobacco	-0.20
Fungicides on fruit and nuts trees (except oranges)	-0.23
Fungicides for seed treatment	-0.27
Herbides on vegetables	-0.27
Fungicides on grain in storage	-0.31
Insecticides on vegetables	-0.33
Slimicides	-0.33
Fumigants and nematicides	-0.33
Insecticides on termites	-0.33
Wood preservatives	-0.33
Insect repellents at non-agricultural sites	-0.33
Domestic bug control and food processing plants	-0.33
Mosquito larvacides	-0.33
Fungicides on turf	-0.33
Industrial preservatives	-0.33
Insecticide synergists and surfactants	-0.33
Plant regulators, defoliants, desiccants	-0.33
Sanitizers - dairies, food processing, restaurants, air treatment	-0.33
Insecticides on livestock and domestic animals	-0.33
Industrial microbicides, cutting oils, oil well additives	-0.33
Preservatives, disinfectants, and slimicides	-0.33
Fungicides - ornamentals	-0.33
Insecticides on lawns, ornamentals and forest trees	-0.33
Unclassified uses	-0.33

Table 3.14
Summary of Estimates of Elasticity of Demand for Clusters with Production, 1986
Page 2

Cluster	Elasticity Estimate
Fungicides on vegetables	-0.38
Fungicides - broad spectrum	-0.40
Herbicides - broad spectrum	-0.48
Insecticides on soybeans, peanuts, wheat, tobacco	-0.56
Fungicides - post harvest	-0.65
Herbicides on rights of way, drainage ditches	-0.66
Herbicides on turf	-0.66
Herbicides on soybeans, cotton, peanuts, alfalfa	-0.67
Herbicides on corn	-0.69
Insecticides on corn and alfalfa	-0.69
Insecticides on sorghum	-0.69
Herbicides on sorghum, rice, small grains	-0.69
Herbicides on oranges	-1.00
Insecticides on fruit and nut trees, except oranges and grapes	-1.00
Insecticides on oranges	-1.00
Herbicides - other agricultural uses	-1.00
Insecticides on cotton	-1.06
Fungicides on grapes	-1.38
Herbicides on grapes	-1.38

Source: *Estimates of the Price Elasticity of Demand for Pesticide Clusters*, U.S. EPA and Abt Associates Inc., May 1991.

3.6.A U.S. Pesticide Imports and Exports

Table 3.15 shows U.S. import and export values for pesticides from 1978 through 1987. The table shows that pesticide imports increased more than exports over this period. On average, the value of pesticide imports increased by 7 percent, while the value of pesticide exports increased by only 1 percent. Although imports increased substantially during the period, the United States maintained a positive trade balance.

Similarly, Tables 3.16 and 3.17 show import and export values for herbicides and insecticides, respectively.[31] Exports of herbicides, which comprise the largest U.S. pesticide export, witnessed a dramatic decline in the 1980s. In particular, the value of herbicide exports fell by 64 percent in real terms between 1984 and 1985. In the same year, herbicide imports increased by 41 percent to fill the vacuum left by a facility that closed.[32] In 1985, the United States was a net importer of herbicides. Over the ten year period from 1978 to 1987, exports of herbicides decreased by 5 percent per year, while imports increased by 12 percent per year. Although herbicides have been given the most research funding of all pesticide types, thereby exhibiting the most technological progress, they have also been the most susceptible to violations of intellectual property rights due to the lack of patent protection outside the United States. Of the three major groups of pesticides, herbicides had the least favorable ratio of exports to imports in the 1980s (U.S. Department of Commerce, 1989d).

Insecticides comprise the second largest component of U.S. pesticide exports. From 1978 to 1987, insecticide exports decreased by 4 percent as imports increased by 9 percent. In spite of these trends, insecticides showed a positive trade balance throughout the period. Part of the decline in insecticide exports may be attributed to the decline in chlorinated hydrocarbon insecticide production.

Table 3.18 presents U.S. pesticide exports as a percent of the value of total U.S. pesticide shipments, and U.S. pesticide imports as a percent of new supply for 1978 to 1987. The table shows that pesticide exports as a percent of the value of shipments have decreased over the period, from 25 percent in 1978 to 21 percent in 1987, while the value of overall shipments increased over the same period. These data, coupled with data from Table 3.5 showing a decrease in the quantity of pesticides produced and sold, indicate that U.S. producers have increased sales to domestic markets. Table 3.18 also shows that imports have maintained approximately the same share of new supply: 5 percent in 1978 and 6 percent in 1987.

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[31]Similar data is unavailable for fungicides.

[32]Much of the decline in exports and increase in imports was due to the closing of one facility.

Table 3.15
U.S. Import and Export Values for All Pesticides
(in thousand 1986 $)

Year	Value of Imports	% Change	Value of Exports	% Change	Trade Balance	% Change
1978	260,098	65%	1,238,508	99%	978,410	111%
1979	268,846	3%	1,320,896	7%	1,052,050	8%
1980	317,718	18%	1,241,047	-6%	923,329	-12%
1981	307,553	-3%	1,132,425	-9%	824,872	-11%
1982	284,196	-8%	1,157,006	2%	872,810	6%
1983	271,512	-4%	1,173,584	1%	902,071	3%
1984	322,874	19%	1,357,235	16%	1,034,361	15%
1985	413,772	28%	1,231,455	-9%	817,683	-21%
1986	402,782	-3%	1,299,974	6%	897,192	10%
1987	414,800	3%	1,305,959	<1%	891,159	1%
Average Annual Change	---	7%	---	1%	---	-1%

Source: *United Nations International Trade Statistics Yearbook*, 1978-1987

Table 3.16
U.S. Import and Export Values for Herbicides
(in thousand 1986 $)

Year	Value of Imports	% Change	Value of Exports	% Change	Trade Balance	% Change
1978	88,467	NA	462,023	NA	373,556	NA
1979	146,755	66%	494,605	7%	347,850	-7%
1980	160,924	10%	495,111	<1%	334,187	-4%
1981	158,292	-2%	460,619	-7%	302,327	-10%
1982	166,396	5%	470,692	2%	304,296	1%
1983	119,767	-28%	526,205	12%	406,438	34%
1984	157,569	32%	586,791	12%	429,222	6%
1985	221,698	41%	212,157	-64%	(9,541)	-102%
1986	192,526	-13%	197,936	-7%	5,410	157%
1987	183,863	-4%	233,650	18%	49,787	820%
Average Annual Change	---	12%	---	-5%	---	-10%

Source: *United Nations International Trade Statistics Yearbook*, 1978-1987

Table 3.17 U.S. Import and Export Values for Insecticides (in thousand 1986 $)						
Year	Value of Imports	% Change	Value of Exports	% Change	Trade Balance	% Change
1978	60,539	NA	304,671	NA	244,132	NA
1979	79,350	31%	358,331	18%	278,981	14%
1980	90,055	13%	301,474	-16%	211,418	-24%
1981	90,854	1%	294,367	-2%	203,513	-4%
1982	73,625	-19%	289,169	-2%	215,544	6%
1983	74,508	1%	268,194	-7%	193,686	-10%
1984	65,906	-12%	345,073	29%	279,167	44%
1985	76,508	16%	239,421	-31%	162,913	-42%
1986	90,964	19%	251,425	5%	160,461	-2%
1987	111,376	22%	204,867	-19%	93,491	-42%
Average Annual Change	---	9%	---	-4%	---	-7%

Source: *United Nations International Trade Statistics Yearbook*, 1978-1987

Table 3.18
U.S. Pesticide Trade Compared to U.S. Pesticide Shipments and New Supply, 1978-1987
(in thousand 1986 $)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Value of Shipment[1]	5,055,000	5,306,000	4,884,000	6,101,000	5,575,583	5,017,404	5,675,000	5,158,000	5,357,000	6,101,000
% Change from Previous Year	14%	23%	-3%	15%	-9%	-10%	13%	-9%	4%	14%
Value of Exports[2]	1,238,508	1,320,896	1,241,047	1,132,425	1,157,006	1,173,584	1,327,325	1,231,455	1,299,974	1,305,959
Value of Imports[2]	260,098	268,846	317,718	307,553	284,196	271,512	322,874	413,772	402,782	414,800
New Supply[3]	5,315,098	5,574,846	5,201,718	6,408,553	5,859,196	5,288,512	5,997,874	5,571,772	5,579,782	6,516,800
Exports as % of a Shipment	25%	25%	25%	19%	21%	23%	23%	24%	24%	21%
Value of Imports as % of New Supply	5%	5%	6%	5%	5%	5%	5%	7%	7%	6%

1 Source: Census of Manufacturing, 1987.
2 Source: *United Nations International Trade Statistics Yearbook*, 1978-1987.
3 New Supply: Value of Imports + Value of Shipments

3.6.B U.S. Pesticide Industry in the World Market

Table 3.19 shows U.S. trade in pesticides as a percentage of the world market economy for pesticides from 1978 to 1987. In 1978, U.S. pesticide exports accounted for 26.2 percent of the world export market. In 1981, the U.S pesticides exports percentage peaked, capturing 30.5 percent of the world export market. In 1987, the U.S share of the world pesticide market was 23.4 percent, the lowest percentage of the preceding ten years.

The shift in the U.S. pesticide export position is due, in part, to the increased strength of the dollar relative to other currencies. As mentioned above, the strong U.S. dollar from 1981 to 1985 caused U.S. products to be more expensive than foreign products, thereby contributing to the decline. Because exports and imports do not respond immediately to changes in currency exchange rates, it may take months, even years, for changes in exchange rates to have an impact. The steady reduction in exports, resulting from the price increase of U.S. products, may not be evident in the trade statistics until after 1984 due to the length of contracts for pesticide sales.

Foreign competition in the pesticides industry has increased substantially in the last decade, causing a deterioration in the competitive position of U.S. firms in recent years. Table 3.20 lists the leading pesticide exporting countries in the world economy from 1979 to 1987. Although the United States remains the largest world exporter of pesticides, its export lead has decreased as other countries' pesticide export markets have matured.[33] In particular, the United Kingdom, Switzerland, Italy, and Brazil have increased their share of world pesticide exports.

As indicated in Table 3.19, the U.S. share of world imports for pesticides increased during the 1980s. Between 1982 and 1984, the most dramatic expansion in manufacturing facilities took place outside western Europe and the United States. This expansion took place in major markets such as Brazil, India and eastern Europe. Together with the development of pesticides manufactured in Taiwan and South Korea, this expansion further increased the competition for products manufactured in western Europe and the United States (Shenton, 1989).

Table 3.21 shows the value of pesticide imports from leading importers to the United States as a percentage of total U.S. pesticide imports. As seen in this table, although imports from western Europe still

[33]As stated previously, some of the U.S. companies included in the Census are owned by foreign entities.

Table 3.19
U.S. Trade as a Percentage of the World Market Economy for Pesticides, 1978-1987

Year	U.S. Share of World Imports	% Change in Share of Imports	U.S. Share of World Exports	% Change in Share of Exports
1978	6.8	32.3%	26.2	40.5%
1979	6.9	.7%	26.3	.5%
1980	8.7	26.6%	24.7	-5.9%
1981	11.7	34.7%	30.5	23.4%
1982	7.6	-34.9%	27.1	-11.3%
1983	7.5	-1.5%	27.4	1.0%
1984	8.5	12.5%	29.3	7.0%
1985	10.4	23.5%	26.8	-8.5%
1986	8.6	-17.4%	24.9	-7.0%
1987	8.1	-6.4%	23.4	-6.4%

Source: *United Nations International Trade Statistics Yearbook*, 1977-1987

Table 3.20
Value of Pesticide Exports for Leading Export Nations as a Percent of the Total World Pesticide Exports, 1979-1987

Country	1979	1980	1981	1982	1983	1984	1985	1986	1987	Average Annual Change
United States	26.3	24.7	25.9	27.1	27.4	29.3	26.8	24.9	23.4	-0.37%
Germany Fed. Rep.	20.0	18.2	18.2	17.8	18.8	18.1	18.5	20.8	18.5	-0.18%
United Kingdom	11.4	11.3	12.1	11.5	12.1	12.2	13.9	12.3	14.1	0.34%
France	10.6	9.6	9.6	8.8	10.0	9.9	10.1	10.5	10.6	0.00%
Switzerland	7.4	7.3	7.3	7.5	8.3	8.3	8.2	8.0	9.2	0.23%
Netherlands	3.8	4.7	3.6	4.0	4.8	5.0	5.5	5.9	5.8	0.25%
Japan	3.2	3.2	3.6	4.5	5.8	4.7	3.7	3.0	3.4	0.02%
Italy	2.4	2.7	2.6	2.7	3.2	2.8	2.8	3.7	3.7	0.16%
Belgium	6.3	8.8	6.3	5.8	0.9	0.9	1.3	1.8	1.9	-0.56%
Brazil	0.6	0.6	0.8	1.0	1.1	1.3	1.0	1.3	1.5	0.12%
TOTALS	92.0	91.1	90.0	90.7	92.4	92.5	91.8	92.2	92.1	0.01

Source: *United Nations International Trade Statistics Yearbook*, 1979-1987

Table 3.21
Value of Pesticide Imports for Leading Importers to the United States as a Percent of Total U.S. Imports, 1980-1987

Country	1980	1981	1982	1983	1984	1985	1986	1987	Average Annual Change
Canada	2.5	3.8	2.8	3.9	5.8	4.1	3.6	4.7	0.31%
West Germany	32.3	22.1	23.3	21.1	25.6	24.7	18.3	17.7	-2.09%
United Kingdom	12.5	NA	8.4	10.9	13.7	11.0	15.8	16.0	0.50%
France	2.7	3.4	3.0	3.7	4.4	4.1	5.1	6.4	0.53%
Switzerland	24.2	27.4	34.1	26.2	20.8	29.9	19.1	11.5	-1.82%
Netherlands	3.8	5.0	4.2	4.1	4.7	5.5	3.8	3.1	-0.11%
Japan	12.1	16.0	9.1	9.4	4.7	3.5	4.5	4.4	-1.09%
Italy	2.1	2.5	2.7	2.6	2.2	2.2	4.5	3.4	0.18%
Brazil	0.4	1.2	2.8	6.3	5.5	4.8	11.0	12.1	1.68%
TOTALS	92.6	81.4	90.4	88.2	87.4	89.8	85.7	79.3	

Source: *United Nations International Trade Statistics Yearbook*, 1982-1987

comprise the largest share of the U.S. import market, imports from other countries (such as Brazil) realized substantial increases in exports to the United States.

3.7 Summary

During the 1980s the demand for U.S. pesticide products declined. This decline resulted from various influences, including a decline in agricultural acreage, the introduction of highly concentrated products, more effective application techniques, and various environmental influences. Although these factors resulted in a contraction of pesticide production and sales, the industry as a whole has remained profitable. Continued profitability within the pesticide manufacturing industry is most likely due to patent protection and producers' ability to introduce new products with unique uses.

Data collected in Part A of the Census indicate that the majority of PAIs are produced by only one firm. Although the production data indicate that firms have monopoly power for specific PAIs, this situation lends itself to market power only if no substitutable products exist. Further analysis of production by cluster reveals that while most clusters include production from multiple facilities, few facilities produce the same PAI within clusters. This information indicates that substitutable products exist in the pesticide manufacturing industry, and suggests that the pesticide market is competitive with differentiated products.

The information presented in the profile provides evidence that although barriers to entry exist in the pesticide manufacturing industry (e.g., the high R&D costs required to introduce new products), they are somewhat offset by patent protection. Firms may be willing to incur short-term losses stemming from the introduction of a new product, knowing that with patent protection they will be able to recover their losses in the long run. Because firms require patent protection to recover large outlays in R&D, it is likely that competition within the industry will come in the form of new products, where profits are somewhat protected, rather than from new producers of existing products.

Although the United States remains a net exporter of pesticides, the value of pesticide exports decreased while imports increased during the 1980s. Factors such as the strong dollar and the implementation of more stringent environmental regulations in the United States, which made U.S. products more expensive relative to foreign products, contributed to the deterioration of the United States's trade position in the mid-1980s. Although competition from western European countries is still the most predominant influence on the United States's competitive position in the world pesticide market, there is increasing competition outside western Europe in countries such as Brazil, Korea, and those in eastern Europe.

Chapter 3 References

Kline & Company, Inc. (1986). PCO Industry Thrives; Hits $2.5 Billion Mark. *Pest Control Technology*, December.

Kline & Company, Inc. (1990). *Kline Guide to the U.S. Chemical Industry, Fifth Edition.* New Jersey.

Minnesota Department of Agriculture (1989). *Rinse and Win Brochure.*

National Pest Control Association, Inc. (1991). Fact Sheet.

Pimentel, D., et al. (1991). Environmental and Economic Impacts of Reducing U.S. Agricultural Pesticide Use. *Pest Management in Agriculture*. CRC press.

Pimental, P. and L. Levitan (1986). Pesticide Amount Applied and Amount Reaching Pests. *Bioscience, 36, 86.*

Ribaudo, Marc O. (1989). Water Quality Benefits from the Conservation Reserve Program. *Agricultural Economic Report No. 606*, February.

Rich, Laurie, A. (1988). Environmental Concerns Force Global Changes in the Market. *Chemical Week*, May.

Shenton, Tom (1989). Crop Protection: An Agrochemical Company Perspective. *Chemistry and Industry*, March.

Sine, Charlotte (1990). A Stronger Ag Chem Industry Emerges From the '80s. *Farm Chemicals*, January.

United Nations, Statistical Office (1978-1987). *International Trade Statistics Yearbook.* New York. Annual.

U.S. Department of Agriculture (1984). *Agricultural Statistics 1984.* Washington, D.C.

U.S. Department of Agriculture (1989). *Agricultural Statistics 1989.* Washington, D.C.

U.S. Department of Agriculture (1989a). *Agricultural Resources Situation and Outlook Report, AR-13.* Washington, D.C., February.

U.S. Department of Commerce, Bureau of the Census (1986). *1982 Census of Manufactures, Concentration Ratios in Manufacturing.* Washington, D.C.

U.S. Department of Commerce, International Trade Administration (1987). *1987 U.S. Industrial Outlook.* Washington, D.C., January.

U.S. Department of Commerce, Bureau of the Census (1989). *1987 Census of Manufactures, Preliminary Report Industry Series: Agricultural Chemicals.* Washington, D.C., July.

U.S. Department of Commerce, Bureau of the Census (1989a). *1987 Census of Manufactures, Preliminary Report Industry Series: Industrial Organic Chemicals.* Washington, D.C., July.

U.S. Department of Commerce, Bureau of the Census (1989b). *1987 Census of Manufactures.* Washington, D.C., January.

U.S. Department of Commerce, Bureau of the Census (1989c). *Statistical Abstract of the United States, 1989.* Washington, D.C., January.

U.S. Department of Commerce, International Trade Administration (1989d). *1989 U.S. Industrial Outlook.* Washington, D.C., January.

U.S. EPA, and ICF, Inc. (1980). *Economic Profile of the Pesticide Industry.* Office of Pesticide Programs, August.

U.S. EPA, and Mitre Corporation (1983). *The Supply and Use Patterns of Disinfectants and Sanitizers at Selected Sites.* January.

U.S. EPA, International Sanitary Supply Association, Research Triangle Institute (1989). Meeting Summary. Research Triangle Institute, July.

U.S. EPA (1990). *Pesticide Industry Sales and Usage: 1988 Market Estimates.* Office of Pesticides and Toxic Substances, February.

U.S. EPA (1991). Pesticide Container Report to Congress, Draft. Office of Pesticides and Toxic Substances, March.

U.S. EPA, and Abt Associates, Inc. (1991a). *Estimates of the Price Elasticity of Demand for Pesticide Clusters.* May.

U.S. International Trade Commission (1977-1988). *Synthetic Organic Chemicals, U.S. Production and Sales.* Washington, D.C., Annual.

Chapter 4: FACILITY IMPACT ANALYSIS

4.0 Introduction

This chapter presents the methodology for projecting impacts of the proposed effluent limitations guidelines and standards at the facility level and describes the results of the analysis. As discussed in Chapter 1, the facility analysis is the principal building block of the entire economic impact assessment. The facility impact analysis is characterized by the following:

(1) use of economic models to estimate pre- and post-compliance costs, prices, and quantities for groups of pesticide active ingredients (PAIs) produced by individual facilities;

(2) application of a discounted cash flow analysis to project facility closures;

(3) comparison of unit prices to unit fixed costs plus unit variable costs to project product line closures; and

(4) use of financial ratios to identify facilities that are expected to sustain significant financial impacts, short of closure.

The cost, price, and quantity outputs from the first step provide input to the facility closure, product line closure, and significant financial impact analyses of steps 2, 3, and 4. The analysis evaluates these three impacts in a hierarchical manner: if a facility closes, product line closures and other significant impacts are not evaluated; if a facility closes a product line, other significant impacts are not evaluated. This hierarchy corresponds to the severity of the projected impact; i.e., a facility closure is more severe than a product line closure, which is more severe than a significant financial impact.

The impacts are estimated for 88 of the 90 pesticide manufacturing facilities producing one or more of the 270 PAIs or classes of PAIs considered for regulation. As discussed in Chapter 2, 90 pesticide manufacturing facilities completed Part A of the Census and 88 pesticide manufacturing facilities completed Part B of the Census. Only one of the two pesticide manufacturing facilities from which Part B data were not obtained is predicted to incur costs (for monitoring only) due to the proposed regulation.

This chapter describes the economic models, and then discusses the methodologies for the facility closure analysis, product line closure analysis, and significant financial impact analysis. Finally, the facility-level results are discussed.

4.1 Economic Model

Before presenting the specific model used in the analysis to estimate post-compliance costs, prices, and quantities, a brief overview of the conceptual problem is provided.

4.1.A Generalized Model of the Pesticide Manufacturing Industry

The model of the pesticide manufacturing industry focuses on the short run. The focus on the short run, by definition, limits facilities' and firms' options for responding to increased costs for pollution control and is therefore conservative (i.e., it tends to overstate impacts). For example, in the short run, firms cannot register new products or make major modifications to physical plants. They are free, however, to decrease production, increase production (to the extent that capacity is underutilized), or change the production mix when faced with new pollution control requirements.

Each facility must decide the quantity of each pesticide to produce, given certain technological constraints. Some pesticides may have to be produced together if one is a byproduct of the manufacturing process of another. Pesticides may also be produced as by-products of other organic chemical manufacturing. Pesticide manufacturing equipment may be flexible enough so that the facility may choose to use it to produce an alternate product, perhaps with minor modifications. A producer may also elect to use a facility at a higher level of capacity (perhaps by adding an additional shift), thereby increasing the production of one or more pesticides.

In addition to incorporating the short run options, the model must capture the nature of regulatory compliance costs and their effect on production decisions. Ideally, these costs are a function of the production mix. For example, additional controls may be required if a facility decides to produce pesticide i instead of pesticide j. A facility may also find that the same controls are required for two different pesticides, so that the incremental control costs of producing pesticide i may be very small as long as pesticide k is also produced.

Given all these considerations, the profit maximizing problem for facility f can be depicted as:

$$\Pi_f = \sum_{i=1}^{n} P_i(Q_i,\ i=l,m) \times Q_{if} - C_{if}(Q_{if}) - EC_{if}$$

where:

Π_f	=	profit of facility f;
$P_i(Q_i,\ i=1,m)$	=	price of product i, a function of total industry production of product i (Q_i), and industry production of all products competing with product i;
Q_{if}	=	production of product i by facility f (The sum of the Q_{if}'s, f=1,N equals Q_i);
$C_{if}(Q_{if})$	=	total cost to facility f of producing product i; and
EC_{if}	=	total pollution control costs to facility f required under the proposed option to produce product i.

Each facility in the industry attempts to maximize profits simultaneously. The equilibrium solution is represented by the matrix Q (total industry production), whose typical element Q_{if} represents facility f's production of product i, that solves the profit maximizing problem for all facilities simultaneously.

Data limitations, however, require that the model be simplified. In particular, the entire production choice set (of registered products) available to each facility is unknown. Additional engineering studies of each facility's production process, as well as analysis of firm-level pesticide registrations, would be necessary to relax this assumption. Given this limitation, it is assumed that a facility may respond to a new effluent guideline only by decreasing current production of any or all of the pesticides currently manufactured. This assumption does not allow for the production of new chemicals, i.e., those that were not being manufactured before the guidelines were introduced. Neither does it allow one U.S. PAI manufacturer to benefit from the compliance costs and subsequent decrease in PAI production of another manufacturer. Note that this assumption is extremely conservative, since it severely limits the options available to each facility and thus overstates the impact of the regulation.

This major simplification allows each market to be modeled separately, because the production decisions no longer affect one another. If a facility decides to decrease the production of one chemical, it does not "free up" capacity to produce another chemical. As a result, the supply curve for chemical A does not shift when the supply of chemical B changes. It now becomes possible to find a new equilibrium in each market separately and independently. Built on this generalized model, the applied economic model of the pesticide manufacturing industry is described below.

4.1.B Applied Model of the Pesticides Manufacturing Industry

The construction of a model of the pesticides manufacturing industry, and the simulation of the effects of new effluent limitation guidelines and standards, require the following basic steps:

(1) Define the markets to be analyzed;

(2) Determine the basic model of market structure;

(3) Estimate baseline prices for each PAI cluster at each facility;

(4) Estimate baseline costs for each PAI cluster at each facility;

(5) Adjust baseline costs for other government regulations;

(6) Project facility compliance costs;

(7) Estimate post-compliance costs for each PAI cluster at each facility;

(8) Develop a pricing rule to estimate post-compliance prices for each PAI cluster at each facility; and

(9) Estimate a price elasticity of demand to solve for post-compliance quantities for each PAI cluster at each facility.

These steps are explained below.

Markets to be Analyzed

A market is defined by competing products. Not all PAIs, however, compete with each other at the consumer level. For example, PAIs used as herbicides on corn do not compete with PAIs used as fungicides on residential gardens. Neither do all PAIs used as herbicides compete with one another. Because PAIs compete with each other individually or in groups rather than as a whole, separate PAI markets that capture this competitiveness are defined.

The EPA's Office of Pesticides Programs (OPP) has undertaken a similar categorization exercise for its regulatory purposes. In 1980, the OPP defined pesticide markets to ensure that the EPA regulated competing products on roughly the same schedule, so that one pesticide does not have an unfair advantage over another. As described in Chapter 3, the pesticide markets were defined as clusters of PAIs that are substitutes for a specific end-use. For example, insecticides used on corn is one market or cluster. The OPP assigned each of the PAIs registered in 1980 to one of 48 separate clusters[1]. As reported in Section 3.1, the EPA's Office of Water made minor adjustments to these pesticide clusters for this analysis. First, PAIs registered after 1980

[1]In the OPP's classification, each PAI appeared in only a single cluster, since the purpose of the classification was to develop a regulatory schedule for each PAI.

were assigned to clusters. In addition, clusters were split when a wide range of price elasticities of demand were estimated to exist within a single cluster and it was possible to further differentiate corresponding PAI uses within the cluster (see Appendix C). Four clusters were split, increasing their number from 48 to 56.[2] Finally, PAIs were allocated to more than one cluster when the PAI was known to be used in substantial quantities for different end uses. The adjusted PAI clusters were used as the basis for this EIA. The 270 PAIs, or classes of PAIs, considered for regulation are mapped into the 56 separate clusters in Appendix B.

Basic Model of Market Structure

Assumptions made about market structure have important implications for empirical modeling. For example, the standard model of supply and demand (i.e., perfect competition) necessarily predicts at least one facility closing if production costs increase. (When the supply curve shifts up to reflect the cost increase, quantity must decrease and the marginal facility must close.) The production data contained in Part A of the Census indicates that most clusters include production by several different facilities. In addition, Part B of the Census shows that the pesticide manufacturing facilities experience a range of profitability.

This situation suggests that the pesticide manufacturing markets can be characterized as competitive. The market does not appear to be perfectly competitive, however, since few firms produce the same PAI; product differentiation exists within the markets. For example, PAIs within a cluster may be differentially effective on a regional basis due to climate differences. PAIs may also vary in their effectiveness on different varieties of pests and on different varieties of crops. The structure of the pesticide markets can therefore generally be described as competitive with differentiated products (i.e., monopolistic components). In an industry with these characteristics, different prices may exist for products within a single market. Firms must compete for customers in terms of both price and the kinds of products they sell. Also, new firms may enter the industry with a new product whose differentiation from its competitors' products may make it profitable.

Baseline Prices for Each Pesticide Cluster at Each Facility

Baseline prices for each PAI cluster at each PAI manufacturing facility served as foundations of the economic model. To estimate prices at the cluster level for each facility, prices were first estimated at the PAI level for each facility in one of five ways, as described below.

[2]Only 45 of these clusters had production of one or more of the 270 PAIs or classes of PAIs in 1986.

- *PAI-specific data provided.* Provision of PAI-specific prices in the Census was optional. If these data were provided, they were used in the analysis. Seventeen of the 88 pesticide manufacturing facilities (19 percent) chose to provide price data on their technical grade products.[3]
- *PAI-specific data not reported in the Census and only one in-scope PAI produced.* In this case, reported in-scope revenues were divided by the production quantity of the PAI to obtain the PAI price.
- *PAI-specific data not reported in the Census, multiple PAIs are produced, and price data for all the PAIs are available from a secondary source.* Secondary data on prices were obtained from *Agchemprice* (DPRA, 1990), the *Annual Market Survey* (Doane Marketing Research, 1987), telephone calls to PAI dealers, and EPA estimates. These secondary prices are reasonable indicators of the *relative* prices of the PAIs. If used directly, however, the secondary prices may overstate the price the manufacturer receives for PAIs, because manufacturers may offer volume discounts or sell to a wholesale distributor. Because most facilities in the Census reported their production of, and revenues from, in-scope PAIs, facility PAI prices were estimated using these Census data and the *relative*, rather than the actual, PAI prices from secondary sources. For example, assume Facility A produces two in-scope PAIs. From secondary sources, the price of PAI_1 is found to be twice the price of PAI_2. If Facility A reported producing 200 pounds of PAI_1 and 500 pounds of PAI_2, with total in-scope revenues of $4,500, the analysis would calculate the price of PAI_2 as:

  $$200(2p)+500(p)=\$4,500$$

  where p = the price of PAI_2.

  The solution for "p" is $5. PAI_1 would therefore be estimated to have a price of $10.

- *PAI-specific data not reported, multiple PAIs are produced, and price data from a secondary source is available for only some of the PAIs produced.* For those PAIs for which secondary price data is not available, prices were estimated by first dividing facility in-scope revenue by facility in-scope production. Using these average prices, the analysis proceeded as described in the above paragraph.

[3]Seventeen facilities provided PAI-specific data for technical products, nine facilities provided data on formulated/packaged products, and two facilities provided data on intermediates. A total of twenty facilities provided PAI-specific data for at least one of these product groups.

- *PAI-specific data not reported, in-scope revenue not reported, secondary price information is available for all PAIs produced.*[4] In this situation, the secondary price information was used directly to estimate price.

Cluster-level prices for each facility were then generated as a weighted average of the PAI prices in each cluster. The weightings were based on the production quantities of each PAI at the facility.

Baseline Costs for Each Pesticide Cluster and Facility

Baseline (i.e., pre-compliance) costs were needed for the EIA. Specifically, unit fixed costs and unit variable costs by cluster were required for each facility. The methods of estimating fixed costs and variable costs differed, as discussed below.

Fixed costs were reported on a facility-level in the Census, not on a PAI-specific or a pesticide-related basis. Fixed costs for all in-scope PAIs at a facility were estimated by multiplying 3-year average (1985, 1986, and 1987) total facility fixed costs by the 3-year average percentage of facility revenues derived from sales of in-scope pesticides.[5] This is represented by the equation:

$$IF = F \times (IR/TR)$$

where:

IF	=	fixed costs associated with in-scope PAIs;
F	=	3-year average fixed costs for the entire facility;
IR	=	3-year average revenues from in-scope PAIs; and
TR	=	3-year average total facility revenues.

Cluster-level fixed costs were then allocated based on the revenues for each cluster. Unit fixed costs at the cluster level were calculated as total cluster fixed costs divided by the in-scope cluster production quantity.

[4]Prices were estimated in this manner for only one facility projected to incur compliance costs. This facility's only pesticide-related revenues were for tolling. Due to the construction of the Census, tolling revenues cannot be separated into sales of in-scope vs. other pesticides. For this reason, the reported revenues could not be used to estimate prices of in-scope PAIs. This facility incurs only monitoring costs under the proposed option.

[5]Three-year averages were used in an effort to modulate the variability of particular years and to create data that represents a typical year.

Variable costs were estimated in one of two ways, depending upon whether the facility provided PAI-specific data in the Census.[6] For those facilities that provided PAI-specific unit variable costs, these costs were multiplied by PAI-specific production to obtain total variable costs for each PAI. These variable costs were then summed within clusters. The cluster variable costs were divided by total in-scope production for that cluster to obtain an average unit variable cost for each cluster.

If no PAI-specific data were provided, estimates of unit variable cost at the cluster level were generated assuming a constant (average) profit margin across all pesticide products. Facility pesticide-related variable costs as a percent of facility pesticide sales were multiplied by the unit price of each PAI cluster at the facility to arrive at that cluster's unit variable costs. Algebraically, unit variable costs for each cluster at each facility were calculated as:

$$UVC_j = P_j \times (V/PR)$$

where:

UVC_j	=	unit variable costs associated with cluster j;
P_j	=	price of cluster j;
V	=	3-year average variable (i.e., manufacturing) costs associated with pesticides; and
PR	=	3-year average revenues from all pesticides.

Unit variable and fixed costs were summed to estimate cluster total unit costs for each facility.

Baseline Cost Adjustments Due to Other Government Regulations

Since 1986, the principal year for which much of the Census data were collected, the EPA has promulgated two regulations whose compliance costs to facilities are not reflected in that data. These regulations are (1) Resource Conservation and Recovery Act (RCRA) land disposal restrictions (40 CFR 268), and (2) effluent guidelines for the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) industry (40 CFR 414).[7] The costs associated with these regulations are not reflected in the cost data reported by facilities in the Census. To accurately represent the costs faced by the pesticide manufacturing industry, the costs associated with these regulations are added to reported facility fixed costs. The procedure for allocating these costs to PAI clusters is identical to the allocation of facility reported fixed costs (discussed above). The regulations and their impacts on pesticide manufacturing costs are discussed below.

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[6]As previously discussed, provision of average unit variable costs by PAI code was optional in the Census. Respondents who chose not to provide these data were informed by the Census that EPA would use financial averages to represent all products at a facility.

[7]Compliance costs for OCPSF include changes to the Economic Impact Analysis through January 21, 1992.

The *1984 Hazardous and Solid Waste Amendments* (HSWA) to RCRA had several new provisions, some of which went into effect after 1986. In particular, the Land Disposal Restrictions included in HSWA are likely to have affected PAI manufacturers. These regulations prohibit land disposal of hazardous waste until it has been treated to the level achieved by the Best Demonstrated Available Technology (BDAT).

Congress directed the EPA to write the rules in three stages. Stage 1 regulated solvents and dioxin and was promulgated in 1986. Stage 2, signed July 8, 1987, regulated a group of wastes known as the "California List." For Stage 3, the remaining hazardous wastes were divided into thirds, and signed into regulation on August 17, 1988; June 23, 1989; and May 8, 1990. Each of these rules became effective immediately upon promulgation.

Many pesticide manufacturers generate RCRA-listed wastes as a result of pesticide production, and will therefore have incurred costs of complying with the land disposal restrictions since 1986. For this reason, the compliance costs estimated for the "California List" and the Stage 3 hazardous wastes were added to the baseline fixed costs for PAI manufacturers[8]. The cost estimates were developed from two sources. The 1986 Survey of Hazardous Waste Generators (GENSUR), conducted by the EPA's Office of Solid Waste, was used to determine the waste streams for pesticide manufacturing facilities. These data were combined with cost data from the Regulatory Impact Analyses (RIAs) for the land disposal rules. Of the 90 facilities potentially covered by the pesticide manufacturers effluent guidelines, 45 facilities were included in the GENSUR data base. The GENSUR data are organized by facility and waste stream. For each facility and waste stream, the following data were available:

- RCRA waste codes (up to 10 codes per waste stream);
- Quantity of waste generated on-site and quantity disposed off-site;
- On-site waste management train (up to 10 waste management procedures); and
- Off-site disposal train

For purposes of estimating costs associated with the land disposal restriction rules, the data were first scanned to select only those components dealing with land disposal, e.g., landfill, surface impoundments, and waste piles. The RIAs for the first and last third of the Stage 3 Land Disposal Restrictions included total gallons of waste to

[8]Because Stage 1 of the rule became effective in 1986, the costs associated with this rule are assumed to be reflected in the Census data.

be treated and total incremental costs by baseline management practice and RCRA waste code. This allows calculation of unit (per gallon) costs for each RCRA waste by management practice.[9]

For each pesticide manufacturing facility and waste stream, management and RCRA waste codes were matched to the corresponding codes in the RIA to obtain unit costs for each facility, waste stream, and management combination. These unit costs were then multiplied by the appropriate quantities (e.g., gallons of each waste at each facility managed, using each relevant method) to estimate a total cost for each RCRA rule.

Because the middle third of the Stage 3 rule was not considered to be a major regulation (costs were less than $100 million), compliance costs were not available in similar detail. The available information included total quantity of regulated waste generated and total incremental costs by baseline management practice (i.e., not broken down by RCRA waste code). It was therefore necessary to assume that the wastes covered by this rule had the same unit costs. Given the small number of wastes in this group, this assumption is not expected to affect the analysis substantially.

Costs of complying with restrictions on land disposal of the California List were available in a third format. The RIA contained a table showing total land-disposed wastes and associated costs by four-digit SIC codes. SIC 2879 (pesticide and agricultural chemicals, not elsewhere classified) was among the industries shown. An average unit cost was estimated by dividing total compliance costs by total regulated wastes that were land disposed. This unit cost was assumed to be constant across all RCRA wastes.

Thirty-four pesticide manufacturing facilities incurred costs due to the RCRA rules described above. Total annualized RCRA costs for these facilities are estimated to be $1.3 million (1986 dollars). Not all of these costs may have been borne by the pesticide manufacturers; however, a portion may have been passed through to customers in the form of higher prices. Because no data on the portion of costs likely to be passed through to customers are readily available, the analysis assumes that the burden of the cost increase is split evenly between the facilities and the customers. In other words, the facilities are assumed to bear 50 percent of the cost increase[10]. These costs were added to the baseline fixed costs of the affected facilities.

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[9]The RIA for the first third examined two alternatives and two scenarios within the first alternative. The costs for Alternative A, Scenario I were used because this option was closest to the final rule.

[10]An alternate assumption, in which all RCRA compliance costs were borne by the manufacturers, would result in the projection of additional baseline closures in the current analysis. As a result, fewer closures resulting from the pesticide effluent guideline limitations and standards would be projected. EPA therefore believes that the assumption of a 50 percent cost pass-through is conservative.

The final *OCPSF Effluent Guidelines*, issued November 1987, established effluent limitations guidelines and standards for OCPSF process wastewater. The regulations for direct dischargers covered about 60 priority pollutants; those for indirect dischargers covered 47 priority pollutants. For purposes of the regulation, OCPSF process wastewater was defined to include establishments, or portions thereof, whose products are classified in any one of five SIC codes: SIC 2821 (plastics and resin materials), SIC 2823 (cellulosic manmade fibers), SIC 2824 (non-cellulosic synthetic fibers), SIC 2865 (tar crudes, cyclic intermediates, dyes and organic pigments) and SIC 2869 (industrial organic chemicals, not elsewhere classified). Most facilities were required to comply with these regulations by November 5, 1990.

Substantial overlap exists between facilities subject to the OCPSF effluent guidelines and those covered by the proposed pesticide manufacturer effluent guidelines. (Manufacture of organic PAIs is included in SIC 2869.) Of 90 facilities in the Census, 55 also manufacture compounds regulated under the OCPSF rule. Thirty of these pesticide manufacturers incur costs to comply with the OCPSF effluent guidelines. The estimated costs to comply with the pesticides effluent guidelines will be incremental to those of meeting the OCPSF rule. For this reason, OCPSF costs for all facilities affected by both rules are added to the economic baseline. Capital and annualized OCPSF costs for these 30 facilities total $105 million and $36 million, respectively (1986 dollars). Again, 50 percent pass-through to the customers is assumed. As a result, additional annualized fixed costs for all pesticide manufacturing facilities due to OCPSF effluent guidelines total $18 million.[11]

Facility Compliance Costs

Full details of the methods by which the costs of complying with the proposed regulation were estimated can be found in the Technical Development Document (Chapter 8, Engineering Costs and Non-Water Quality Aspects). A brief summary of the regulatory options and their associated costs is provided below.

As discussed previously, a total of 90 pesticide manufacturing facilities producing one or more of 270 PAIs, or classes of PAIs, are potentially subject to regulation. The EPA has projected costs for these 90 facilities under two regulatory options: one that would require treatment of process wastewater pollutants (Treated Discharge Option) and another that would require no discharge of process wastewater pollutants to POTWs or surface water (Zero Discharge Option). The Treated Discharge Option limitations would be based on the use of hydrolysis, activated carbon, chemical oxidation, resin adsorption, solvent extraction, incineration and/or recycle/reuse to control the discharge of PAIs in wastewater. The Zero Discharge Option is based on

[11]Estimated costs of compliance may vary substantially from actual costs incurred, since companies frequently meet regulatory requirements by means other than those the EPA used for estimating compliance costs.

on-site or off-site incineration and/or recycle/reuse.[12] For both regulatory options, the economic impacts on facilities were calculated separately for direct and indirect dischargers.[13] Each discharge category was analyzed further for two subcategories: organic pesticide chemicals manufacturing (Subcategory A) and metallo-organic pesticide chemicals manufacturing (Subcategory B).

Three categories of compliance costs associated with pesticide manufacturing were evaluated: capital costs, land costs, and operating and maintenance costs (including compliance self-monitoring and sludge disposal). The capital and land costs were one-time "lump sum" costs; the operating and maintenance costs were evaluated on an annual basis. Capital and land costs, annualized using the conservative assumption that they have a productive life of ten years, were adjusted over the ten-year period using the weighted average cost of capital.[14] These annualized capital and land costs were added to operating and maintenance costs to produce total annualized costs. For facilities that both manufacture and formulate/package pesticides, the compliance costs apply only to the manufacturing operations of the facility. All of the compliance cost estimates are presented in 1986 dollars and are based on the assumption that, whenever possible, facilities will build on existing treatment.

The costs and impacts of implementing the regulations were estimated on a PAI-specific basis for each facility. Table 4.1 presents the capital and land, operation and maintenance, and annualized costs associated with the two regulatory options for Best Available Technology Economically Achievable (BAT) and Pretreatment Standards for Existing Sources (PSES) by subcategory. Under the Treated Discharge Option, it is expected that 61 pesticide manufacturing facilities will incur compliance costs: 32 direct dischargers and 30 indirect dischargers (one facility is a joint discharger). Under the Zero Discharge Option, 67 facilities are projected to incur compliance costs: 35 direct dischargers and 33 indirect dischargers (again, one facility is a joint discharger). Under the Treated Discharge Option, total BAT annualized costs (applying to direct dischargers) are projected to be $14.7 million for Subcategory A. There are no BAT costs associated with Subcategory B chemicals. These chemicals are already limited by Best Practicable Control Technology Currently Available (BPT), which requires no discharge of process wastewater pollutants. Total annualized

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[12]The Zero Discharge Option would limit discharges from the facility site to POTWs or to surface water only; discharges to other media may remain constant or increase as a result of changes in discharge to surface water. For example, pesticide manufacturing facilities could, theoretically, achieve compliance with a zero discharge effluent guideline by transferring the waste streams previously discharged to surface water to landfills, incinerators, or deep well injection sites.

[13]Impacts of zero discharge requirements are reported with impacts on direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

[14]For details on the weighted average cost of capital, see Section 4.2.A.

Table 4.1
Costs of the Regulatory Options****

	Treated Discharge Option		Zero Discharge Option	
	Direct Dischargers**	Indirect Dischargers	Direct Dischargers**	Indirect Dischargers
Number of facilities incurring costs	32	30	35	33
Subcategory A/Subcategory B*	32/0	27/5	35/0	30/5
Capital and Land (MM$)	14.91	9.45	1.13	1.19
Subcategory A/Subcategory B*	14.91/0	9.41/0.04	1.13/0	1.11/0.08
O & M (MM$)	12.36	4.50	4812.	521.4
Subcategory A/Subcategory B*	12.36/0	4.39/0.11	4812/0	518.6/2.77
Annualized Costs (MM$)	14.67	6.00	4813.	521.6
Subcategory A/Subcategory B*	14.67/0	5.88/0.12	4813/0	518.8/2.78

* Totals may not equal the sum of Subcategories A and B because five facilities produce active ingredients in both Subcategories and two facilities incur costs for both Subcategories. There are no costs for Subcategory B direct dischargers because direct discharge of Subcategory B chemicals is already limited to zero under BPT. Although costs are shown for Subcategory B indirect dischargers, regulations on Subcategory B are not proposed.

** Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

*** These figures reflect total projected costs regardless of whether a facility has closed pesticide operations or is projected to close pesticide operations prior to incurring the costs of compliance. The total costs are therefore overstated.

costs for PSES (applying to indirect dischargers) under the Treated Discharge Option are projected to $5.9 million and $120,000 for Subcategories A and B, respectively.[15]

The costs associated with the Zero Discharge Option are substantially higher than those for the Treated Discharge Option. Total Zero Discharge Option BAT annualized costs are projected to be $4.8 *billion* for Subcategory A. Again, there are no costs associated with Subcategory B chemicals under the proposed BAT guideline. Total annualized costs for PSES under the Zero Discharge Option are estimated at $518.8 million and $2.8 million for Subcategories A and B, respectively.

Post-compliance Costs for Each PAI Cluster at Each Facility

As stated above, the compliance costs were estimated on a PAI basis for each facility. To combine compliance costs with other facility costs, cluster-level compliance costs for each facility were calculated by summing annualized PAI compliance costs for all PAIs within each cluster for each facility. Dividing total cluster-level compliance costs for each facility by the cluster production quantity at that facility yielded unit compliance costs for each market and each facility. These costs were added to baseline unit costs to arrive at post-compliance unit costs.

Pricing Rule to Estimate Post-compliance Prices[16]

Changes in PAI prices and product demand are determined interactively in the market place. Typically, a producer will raise prices based on the actions expected of competitors and the extent to which consumers will decrease demand. Consumers will then respond to the increased prices with a drop in demand based on several factors, including the percent of their production cost contributed by the product and the availability of substitute products. Producers then examine the impact of the price increase and demand decrease on profitability and reevaluate their price. Consumers again react. This iterative process continues until producers believe they have maximized profit.

This analysis attempts to model an approximate end point of the supply and demand interaction. The percentages of the compliance costs that are translated to price increases for each cluster depend on (1) the degree of substitutability of alternative products, and (2) the extent of supplier price competition. Substitution among PAIs is included by addressing impacts on a cluster basis. Substitution of PAIs with non-chemical alternatives is discussed in the following section on post-compliance quantities.

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[15]The EPA is not proposing to regulate Subcategory B chemicals at this time.

[16]An analysis of economic impacts based on zero pass-through of compliance costs to consumers is presented in Appendix D.

A pricing rule was developed to take into account the effect of supplier competition on the percentage of compliance costs that are passed to the consumer.[17] This rule is based upon the assumption that if production bearing compliance costs makes up a small percentage of total cluster production, then a price increase due to regulation is unlikely. If all production in a cluster is projected to bear compliance costs, then all regulatory costs are likely to be reflected in higher prices.

To capture this effect, price increases for each market and each facility were calculated as:

$$\Delta P_{f,j} = C_{f,j} \times (PC_j / T_j)$$

where:

$\Delta P_{f,j}$ = change in unit price for facility f, cluster j;

$C_{f,j}$ = unit compliance costs for facility f, cluster j;

PC_j = total U.S. production of cluster j that incurs compliance costs; and

T_j = total U.S. production of cluster j.

The quantity of PAI production in each cluster incurring costs was calculated from the production data provided in the Census (Parts A and B) and the estimated compliance costs. Total production of PAIs for each cluster was calculated from the Census and other proprietary data. Post-compliance unit prices were calculated for each facility and each cluster as the baseline unit price plus the change in unit price due to the installation of pollution control equipment.[18]

Post-compliance Quantities

Having estimated post-compliance costs and prices, the remaining step solved for post-compliance quantities. An estimate of the price elasticity of demand for each cluster was used to predict changes in quantities demanded given changes in price. The price elasticity of demand can be defined as the percentage change in the quantity demanded, divided by the percentage change in price. If consumers cut back their purchases to such a large extent that any price increase reduces total revenues, then demand is said to be elastic, i.e., customers are sensitive to price changes. If consumers cut back their purchases only slightly in response to higher prices, resulting in an increase in revenues, demand is said to be inelastic, i.e., customers are not as

[17] Theoretically, the effects of supplier competition could be evaluated by modeling a supply curve in the pre- and post-compliance scenarios. This model was not used for the EIA because production cost data for pesticides not included in the Census are unavailable. In addition, production cost functions within facilities are also unknown, allowing only marginal costs of production to be estimated.

[18] The pricing rule is not meant to be a perfect theoretical simulation of the price response to regulatory cost increases. Given the uncertainty and limited availability of data on production functions and costs by facility and PAI, use of the measure provides a reasonable basis for simulating the pricing response by producers.

sensitive to price changes. The value of the price elasticity of demand is unbounded and may be positive or negative. It is expected, however, that price and demand are negatively correlated, i.e., an increase in price results in a decrease in the quantity demanded. The price elasticity of demand is therefore usually negative.

The methodology for generating estimates of the elasticity of demand relied on five sources. First, the EPA reviewed empirical studies of the price elasticity of demand for pesticides. Few such studies were located, however, and the existing studies offer conflicting conclusions, most of them controversial. Second, the EPA reviewed the U.S. Department of Agriculture's (USDA, 1985) analysis of the price elasticity of demand for food commodities. The elasticity of demand for farm inputs can be derived from the elasticity of demand for farm commodities because demand for production inputs must ultimately reflect demand for the end product. For this reason, the USDA estimates of the elasticity of demand for food commodities provided the basis for estimating the demand elasticity for PAI clusters. Three additional factors were examined as indicators of how the demand elasticity for PAIs might vary from the demand elasticity for food: (1) the feasibility of employing non-chemical or non-biological pest control methods, (2) the percent of production cost contributed by the PAIs of interest, and (3) the productivity of expenditures for PAIs. The elasticity estimates generated from this process were reviewed by OPP staff, whose comments were incorporated into the methodology. A complete description of the process by which the elasticity estimates were developed can be found in Appendix C.

A list of the elasticity estimates by cluster is shown in Table 4.2, in order of increasing elasticity of demand. As can be seen from the table, the elasticity estimates range from -0.12 (herbicides on sugar beets, beans, and peas) to -1.38 (fungicides on grapes and herbicides on grapes). The elasticity estimates vary substantially within the fungicide, herbicide, and insecticide clusters; the type of pesticide is not seen to affect the elasticity of demand.

The demand for pesticides in all but three of the clusters is expected to have unit elasticity (i.e., -1) or to be inelastic. Demand is expected to be elastic for fungicides and herbicides applied to grapes and for insecticides applied to cotton. The main factor driving the high elasticity for the grape clusters is the high elasticity of demand for grapes at the retail level. Demand for insecticides on cotton is expected to be somewhat elastic, based on both the literature estimates of the elasticity and the low marginal productivity of insecticides applied to cotton.

The methodology employed to estimate the elasticity of demand for the PAI clusters yields reasonable best estimates of elasticities. The estimates are a good indicator of whether demand for a certain cluster of PAIs is extremely or only moderately elastic or inelastic; the specific numeric values should not be viewed as definitive. The estimates of elasticity of demand for clusters of PAIs, developed through this analysis, are the most reliable estimates known at this time.

Table 4.2
Summary of Estimates of Elasticity of Demand for Clusters with Production, 1986
Page 1

Cluster	Elasticity Estimate
Herbicides on sugar beets, beans, peas	-0.12
Herbicides on tree fruits (except oranges), sugar cane, nuts	-0.20
Herbicides on tobacco	-0.20
Fungicides on fruit and nuts trees (except oranges)	-0.23
Fungicides for seed treatment	-0.27
Herbides on vegetables	-0.27
Fungicides on grain in storage	-0.31
Insecticides on vegetables	-0.33
Slimicides	-0.33
Fumigants and nematicides	-0.33
Insecticides on termites	-0.33
Wood preservatives	-0.33
Insect repellents at non-agricultural sites	-0.33
Domestic bug control and food processing plants	-0.33
Mosquito larvacides	-0.33
Fungicides on turf	-0.33
Industrial preservatives	-0.33
Insecticide synergists and surfactants	-0.33
Plant regulators, defoliants, desiccants	-0.33
Sanitizers - dairies, food processing, restaurants, air treatment	-0.33
Insecticides on livestock and domestic animals	-0.33
Industrial microbicides, cutting oils, oil well additives	-0.33
Preservatives, disinfectants, and slimicides	-0.33
Fungicides - ornamentals	-0.33
Insecticides on lawns, ornamentals and forest trees	-0.33
Molluscides and misc. vertebrate control agents	-0.33

Table 4.2
Summary of Estimates of Elasticity of Demand for Clusters with Production, 1986
Page 2

Cluster	**Elasticity Estimate**
Unclassified uses	-0.33
Fungicides on vegetables	-0.38
Fungicides - broad spectrum	-0.40
Herbicides - broad spectrum	-0.48
Insecticides on soybeans, peanuts, wheat, tobacco	-0.56
Fungicides - post harvest	-0.65
Herbicides on rights of way, drainage ditches	-0.66
Herbicides on turf	-0.66
Herbicides on soybeans, cotton, peanuts, alfalfa	-0.67
Herbicides on corn	-0.69
Insecticides on sorghum	-0.69
Herbicides on sorghum rice, small grains	-0.69
Herbicides on oranges	-1.00
Insecticides on fruit and nut trees, except oranges and grapes	-1.00
Insecticides on oranges	-1.00
Herbicides - other agricultural uses	-1.00
Insecticides on cotton	-1.06
Fungicides on grapes	-1.38
Herbicides on grapes	-1.38

Source: *Estimates of the Price Elasticity of Demand for Pesticide Clusters*, U.S. EPA and Abt Associates Inc., May 1991.

4.2 Facility Closure Analysis

As previously discussed, the results of the economic model described above are used to estimate three potential impacts of the proposed effluent limitations guidelines at the facility level. The first, and most severe, potential impact on a facility is facility closure. For purposes of this EIA, a pesticide manufacturing facility is defined as the portion of the facility involved in manufacturing and formulating/packaging, or performing contract work for both in-scope and out-of-scope pesticides. A pesticide manufacturing facility, as defined for this analysis, does not include any non-pesticide related activity occurring at the physical facility. A pesticide manufacturing facility that is predicted to close may continue with non-pesticide-related operations, such as production of other organic chemicals. Facility liquidation value, in the case where other products are produced at the facility, refers to the liquidation value of the pesticide product lines and any related fixed assets, working capital, and real estate.

A decision to close a facility is typically made at the firm level. The firm holds pesticide registrations and can consider transferring both pesticide and other products among facilities. In general, a facility owner (i.e., a firm) faced with pollution control requirements must decide whether to make the additional investment in pollution control, to change the products produced at the facility (both in-scope and out-of-scope), or to liquidate the facility. Because data on other products to which a facility may convert are unavailable or limited, this analysis assumes that either the pollution control investment is made or the facility is liquidated. This simplification ignores the possibility that the pesticide product lines at some facilities may be used for the production of other chemicals. The analysis is conservative in that it assumes that facility owners have very limited options.

The evaluation of whether to close a facility is complex and involves a number of factors including:

- Present and expected profitability of the facility;
- Current market or salvage value of the facility;
- Required capital investment in pollution control technology equipment;
- Expected increase in annual operating costs due to pollution control requirements; and
- Expected product price, production costs, and profitability of the facility after pollution control equipment is installed and operating.

In the majority of cases, a rational owner would decide to continue operations if the discounted cash flows are greater than the current liquidation value of the facility. If the expected cash flows are less than the current liquidation value of the facility, the owner would be better off selling the facility.

The calculation used to estimate whether or not a facility will close is intended to model the decision-making process of the owners of the facility. It compares the value of the facility if it is shut down to its value if the necessary treatment were installed and operations continued. Specifically, this calculation entails a comparison of the present value of the cash flow (i.e., discounted cash flow) generated by the facility to the liquidation value of the facility. That is, it compares the value that the firm would receive from its future stream of profits if it continued to operate the facility to the value that it would receive if it sold the facility for its liquidation value. If the liquidation value of the facility is greater than the discounted cash flow, the facility is considered to be a closure.

The analysis of facility closure was conducted in two stages: baseline and post-compliance with the proposed effluent limitations guidelines. If, in the baseline analysis, a facility was projected to close regardless of the imposition of compliance costs, such a facility was not seen as financially viable. If a facility closed in the baseline analysis, it was not considered in the post-compliance analysis. In other words, no economic impacts of the proposed regulation on baseline facility closures were predicted.

4.2.A Baseline Facility Closure Analysis

The steps in the construction of the baseline facility closure analysis involved the estimation of four variables: facility cash flow, cost of capital, discounted cash flow (DCF), and liquidation value. These variables are discussed below.

Facility Cash Flow

Facility cash flow consists of facility net income plus noncash expenditures. Baseline, or pre-compliance, facility cash flow was estimated based on data from the income statement reported in the Census. Cash flow was adjusted to account for the costs of complying with the RCRA land disposal restrictions and the OCPSF effluent limitations guidelines. As discussed above, these rules (or portions thereof) were effective after 1986, the base year for the analysis. The compliance costs associated with the rules were therefore not reflected in the Census data. Specifically, cash flow for each facility was estimated as:

$$CFO = NI + IT(1-CT) + DEP - OC(1-CT)$$

where:

CFO	=	Cash flow;
NI	=	Net income (i.e., after tax profits calculated from the Census);
IT	=	Interest expenses (taken directly from the Census);

CT = Corporate income tax rate (calculated as taxes divided by before-tax profits calculated from the Census);

DEP = Depreciation expenses (taken directly from the Census); and

OC = cost of compliance with other EPA regulations first effective after 1986 (RCRA land disposal restrictions and OCPSF effluent guidelines).

Cost of Capital

The cost of capital is the rate at which a firm obtains funds for financing capital investments. The cost of capital is required for two purposes: (1) to discount future cash flows for the facility closure analysis so that the *present value* of cash flows can be compared to the facility liquidation value; and (2) to annualize the capital costs associated with the proposed rule so that post-compliance changes in cost and price can be projected.[19]

The cost of capital to a particular firm depends on how the investment is financed. One option, equity financing, is taken when a firm issues stocks or retains earnings. A second option involves acquiring additional debt, through bonds, notes, or short-term commercial paper.[20] Typically, acquiring debt is the less expensive option. As a firm expands its debt holdings, however, the cost of debt increases, forcing the firm to reach an equilibrium between debt and equity financing. It is assumed in this analysis that firms use some combination of debt and equity to finance compliance costs. The measure of a firm's overall cost of a capital investment, based on the percentage values of debt and equity used to finance the investment, is termed the weighted average cost of capital (WACC). Thus, the WACC is the average after-tax cost of all funds used to finance a capital investment.

The WACC can be presented in either nominal terms (i.e., not adjusted for inflation) or real terms (i.e., adjusting the nominal WACC for inflation). This analysis uses the real cost of capital to allow for the use of constant annual cash flows (i.e., cash flows that are not inflated over time). The two inputs to calculating the real WACC - nominal WACC and the inflation rate - are discussed below.

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[19]The cost of capital is determined by firm, rather than facility, characteristics. As a key variable in the facility level analyses, however, it is discussed in this section.

[20]Debt capital is provided as a loan which creates a contractual obligation on the borrower to repay the loan and contractually specified interest charges. Traditional sources of debt financing include commercial banks, non-bank lending institutions, and the public capital markets. Except as provided by a security agreement, debt financing does not provide the creditor any rights of ownership in the assets of the borrower. Equity capital represents a right of ownership in the assets of the firm seeking to finance a treatment system (e.g., a corporation or sole proprietorship). Equity capital may be obtained as *externally* provided funds (through the sale of new equity) or may be generated *internally* (from the cash flow provided by the firm's operations).

Nominal WACC

The nominal WACC was calculated by weighting the cost of equity and the cost of debt by the percentage of the investment expected to be financed by these two methods. The equation used was:

$$WACC = R(E/A) + Y(1-CT)(D/A)$$

where:

WACC	=	nominal weighted average cost of capital;
R	=	after-tax return on equity;
E	=	amount of investment financed by equity;
A	=	total amount of the investment;
Y	=	pre-tax interest rate on debt;
CT	=	marginal corporate tax rate; and
D	=	amount of investment financed by debt.

The estimates of the nominal WACC vary by firm. The sources of each of the variables in the WACC equation are discussed below.

The percentages of the investment that a firm is assumed to finance through equity (e/a) and debt (d/a) are assumed to match the firm's historical mix of equity and debt investment. The values of these variables for each firm are obtained from one of two sources. For each domestic public-reporting firm, the mix of debt and equity is obtained from Standard and Poor's *Compustat* service for that firm in 1986. For all firms not included in the *Compustat* data base, the mixture of debt and equity financing was assumed to match the 1986 median mixture of debt and equity financing for the "industrial chemical industry" as calculated from Robert Morris Associates' *Annual Statement Studies*.[21] The calculated values taken from the *Annual Statement Studies* are 40.5 percent equity financing and 59.5 percent debt financing.

The annual return on equity (R) was calculated as:

$$R = i + (RM - 1)\beta$$

[21] The "industrial chemical industry" includes SICs 2861, 2865, and 2869.

where:

i = the risk-free rate of return = 10.18 percent (calculated from the 1981-1990 average interest rate on 30-year U.S. Treasury Bonds as reported in *Statistical Abstract of the United States*, Bureau of the Census, 1989, 1990);[22]

(Rm-1) = Typical risk premium, or the rate of return on market portfolio minus the rate of return on risk free investments = 8.0 percent, a standard value based on the Standard & Poor's 500.

β = A measure of the risk of an individual firm compared with the market. Beta values are based directly on *Value Line Investment Survey, Part I Summaries & Indexes* (February 14, 1992) for publicly traded companies. For private firms, the median beta value calculated for the public PAI manufacturing firms was used. This value is 1.056, indicating that the average risk of the public PAI manufacturing companies is close to the market average risk.

The pre-tax interest rate on debt (Y) is assumed to be 10.95 percent. This interest rate equals the 1981-1990 average yield on AA 10-year industrial bonds (U.S. Department of Commerce, 1990 and 1991).[23] Finally, the marginal corporate tax rate (CT) is assumed to be 34 percent.[24]

Real WACC

To allow the use of cash flows that are not adjusted for inflation, the real WACC was needed. The real WACC was estimated as:

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[22]The variable i represents the risk-free component of the return on equity. Equity has no maturity date; therefore, i is best calculated as the return on *long-term* Treasury Bonds.

[23]Interest rate information reported by individual facilities in the Census was not used for this analysis due to difficulties of interpreting the reported values. For example, a number of respondents reported that funds for capital outlays were obtained from a parent firm at zero percent. This reporting reflects internal accounting conventions but does not accurately represent the interest cost borne by the firm for debt financing. Other firms indicated that interest costs were tied to the prime rate (e.g., prime rate or "prime rate plus one"). Such interest terms would generally apply to a working capital credit line or other short-term credit instrument. The short-term liabilities are usually replaced, however, by longer-term debt to match the expected life of the capital asset being financed. The interest rate charged on longer-term debt is usually higher than that associated with short-term credit rates, so short-term rates may understate potential interest costs. The resulting WACC used for each facility in the EIA is higher than the cost of debt reported in the Census for that facility, thereby increasing the projected burden of compliance. Use of the WACCs is therefore conservative.

[24]Because the *firm*, not the facility, tax rate is needed, use of the facility-level data from the Census was inappropriate.

$$RWACC=((1+WACC)/(1+G))-1$$

where:

RWACC	=	the real weighted average cost of capital; and
G	=	the rate of inflation = 4.74 percent.

The rate of inflation (G) is calculated as the mean annual inflation rate as reported by the unadjusted *Consumer Price Index* between 1981 and 1990.

Discounted Cash Flow

The discounted cash flow (DCF) is the present value of a stream of annual cash flows. In this analysis, the ten-year DCF was compared to the liquidation value of each facility to predict facility closures. The DCF is calculated as:

$$DCF=\sum_{i=1}^{10}\frac{CF}{(1+RWACC)^{i}}$$

where:

DCF	=	facility present value cash flow over 10 years;
CF	=	facility annual cash flow;
RWACC	=	the real weighted average cost of capital; and
i	=	number of years over which cash flows are discounted.

The time period over which cash flows are discounted, ten years, was chosen as a conservative estimate of the average life of the pollution control equipment.

Liquidation Value

Liquidation values for each facility were estimated based on data from the Census. A facility's liquidation value is defined as the gross value the facility would receive from selling its lines for pesticide production and formulating/packaging. The liquidation value includes the value of fixed assets, working capital, and real estate.[25]

[25]The current analysis used gross rather than net liquidation values, thereby overstating the likelihood of facility closure. The EPA expects that the EIA supporting the final rule will use net liquidation values.

For those facilities that reported the liquidation value of their pesticide production and formulating/packaging lines, this value was used as the facility liquidation value. For facilities that could not provide this information in the Census, liquidation values were estimated using regression analysis based on the liquidation values provided by other pesticide manufacturing facilities. Several different regression models were evaluated and are presented in the Administrative Record.

The model used in the analysis has two independent variables: (1) 1986 local property tax assessment of facility land, buildings, equipment, and machinery, and (2) 1986 facility inventories. The liquidation value of a facility is dependent upon the market value of facility-owned land, buildings, and equipment as well as on the facility's inventories of products. As the valuation of these assets increases, one would expect the liquidation value to increase, producing a positive coefficient for each of the independent variables. Given this model specification, the regression equation yielding the strongest results, as measured by goodness-of-fit tests, was:

$$LV = -12{,}906 + (0.417 \times TA) + (1.159 \times INV)$$

where:

LV	=	facility liquidation value;
TA	=	1986 local property tax assessment of facility land, buildings, equipment and machinery; and
INV	=	1986 facility inventories.

The F value for this equation was 2099 with 46 degrees of freedom.[26] The adjusted R-squared was 0.99.[27] The standard error for the TA coefficient was 0.006 while the standard error for the INV coefficient was 0.391.[28] This equation was used in the analysis to estimate liquidation value for facilities that did not provide this data in the Census.

[26]The F statistic tests the overall significance of the regression. The reported value leads to rejection of the hypothesis that the coefficients of all of the independent variables are equal to zero, indicating that the variables are useful in projecting liquidation values.

[27]Adjusted R^2 indicates the proportion of variation explained by the regression model. Values of R^2 that are close to 1 imply that most of the variability in the dependant variable is explained by the regression model.

[28]The standard error for a regressor indicates the accuracy with which the coefficient of that regressor is measured, given the other regressors in the model. The reported standard errors indicate that the contribution of the regressors is significant.

4.2.B Post-Compliance Facility Closure Analysis

Facilities for which *baseline* DCF was less than the facility liquidation value (i.e., those predicted to have baseline facility closures) were not considered as potential facility closures in the *post-compliance* scenario. For the remaining facilities, however, the *post-compliance* DCF was compared with the facility liquidation value to project facilities that would close due to the regulation.

Although the liquidation values of the facilities do not change as a result of the regulation, post-compliance DCFs must be calculated. Three factors are included when estimating the DCF in the post-compliance scenario:

- the compliance costs, including capital, land, and operating and maintenance;
- the resulting change in revenue associated with the new price and quantity; and
- the decrease in variable costs of production due to the reduction in quantity.

Facility changes in DCF were calculated by summing the present value of compliance costs, the present value of the change in revenue, and the present value of the change in variable costs over all clusters produced at a facility. The post-compliance DCF was then calculated by adding the changes in cash flow to the baseline DCF. The corresponding equation is:

$$PCDCF = DCF + \sum_{i=1}^{n} (CCadj_i + Radj_i + Cadj_i)$$

where:

PCDCF	=	the post-compliance facility discounted cash flow;
DCF	=	facility baseline discounted cash flow;
$CCadj_i$	=	compliance cost adjustment to discounted cash flow for cluster i;
$Radj_i$	=	the adjustment in the discounted cash flow due to the change in revenue for cluster i;
$Cadj_i$	=	the adjustment in the discounted cash flow due to the change in variable costs for cluster i;

The three cluster level adjustments are described below.

Adjustment for compliance costs

The compliance costs have three components: operating and maintenance costs, capital costs, and land costs. Operating and maintenance costs will be somewhat offset by the corresponding decrease in taxes the facility will pay due to reduced profit. A present value of operating and maintenance costs is generated by multiplying this value by a present value factor. The present value factor is based on the WACC, as discussed in the previous section. The capital and land costs need no adjustments because they are already in the form of a present value. The equation for the compliance cost adjustment is:

$$CCadj_i = -((PVF \times (OM_i \times (1-CT))) + CPT_i + LAND_i)$$

where:

$CCadj_i$	=	compliance cost adjustment to DCF for cluster i;
PVF	=	present value factor (sum from i = 1 to 10 of $1/(1+WACC)^i$);
OM_i	=	operating and maintenance costs of compliance for cluster i;
CT	=	corporate tax rate;
CPT_i	=	capital costs of compliance for cluster i; and
$LAND_i$	=	land costs of compliance for cluster i.

Adjustment for change in revenue

The change in revenue contains two components: the increase in revenue resulting from the increase in price and the decrease in revenue resulting from the decrease in quantity. Present values of both changes in streams of revenue are needed to adjust the baseline DCF. The cluster-level adjustment to the baseline DCF for the change in revenue is shown by the equation:

$$Radj_j = PVF((\Delta P_j \times PCQ_j) + (P_j \times \Delta Q_j))$$

where:

$Radj_j$	=	the adjustment to the DCF due to the change in revenue for cluster j;
PVF	=	present value factor (sum from i = 1 to 10 of $1/(1+WACC)^i$);
ΔP_j	=	the change in cluster j price from baseline to post-compliance;
PCQ_j	=	the post-compliance quantity for cluster j;
P_j	=	the baseline price for cluster j; and
ΔQ_j	=	the change in cluster j quantity from baseline to post-compliance.

Adjustment for change in variable cost of production

The final adjustment to the baseline DCF reflects the decrease in variable costs associated with decreased production. Variable costs were assumed to decrease in proportion to the decrease in quantity of pesticides produced. The equation is:

$$Cadj_j = PVF\left(\left(\frac{\Delta Q_j}{Q_j}\right) \times VC_j\right)$$

where:

$Cadj_j$	=	the adjustment to the DCF due to the change in variable costs for cluster j;
PVF	=	present value factor (sum from i = 1 to 10 of $1/(1+WACC)^i$);
ΔQ_j	=	the change in cluster j quantity from baseline to post-compliance;
Q_j	=	the baseline quantity of cluster j; and
VC_j	=	the unit variable cost for cluster j.

As previously discussed, a facility with a post-compliance DCF less than the facility liquidation value was predicted to close as a result of the regulation. The projection of closure refers only to the pesticide-related portion of the facility. Other operations, such as production of OCPSF chemicals or pharmaceuticals, may continue at the location.

4.3 Product Line Closure Analysis

Facilities that did not close in either the baseline or the post-compliance scenario were analyzed for possible product line closures. The impact of a product line closure is less severe than that of a facility closure. A facility that closes a product line may still profit from producing and formulating other pesticide products, and may continue to operate while new products are registered or changes are made to the physical plant. Like the facility closures analyzed above, product line closures are evaluated in the baseline scenario first. If a facility is projected to close a product line in the baseline, that facility is not re-evaluated for a product line closure in the post-compliance scenario.

The evaluation of baseline and post-compliance product line closures is straightforward. A product line closure is predicted when the unit total (i.e., fixed plus variable) cost of the product line (i.e., cluster) exceeds the unit price. Note that the comparison of price to *total* costs is very conservative. A comparison of price to variable costs only is a reasonable alternative (in the short run), and would result in an equal or lesser number of product line closures. The calculation of unit prices and costs in both the baseline and post-compliance scenarios was described previously.

Given the methodologies used to calculate facility and product line closures, it is possible that a facility may be projected to close all pesticide product lines, but the facility itself is not projected to close. In such a case, the product line closure analysis serves as an alternate and complementary analysis of potential facility closures. Such results would not be contradictory, because the product line closure analysis evaluates closures based on price and cost while the facility closure analysis also includes asset valuation.

4.4 Other Significant Financial Impacts

Facilities may sustain other significant financial impacts short of facility or product line closure. These impacts are indicative of other less immediate, but also potentially damaging, effects that may occur as a result of compliance. For example, a firm may decide to keep a facility in operation for several years, but may cease reinvestment in the facility's building and equipment, eventually closing it. The impacts measured in this section are less severe than the closure of a facility or a product line, because the facility remains profitable with time to register new products, find ways to cut costs, or shift to other pesticide or non-pesticide products.

Other financial impacts were assessed based on financial indicators of operating performance. Two financial indicators are examined in this analysis: interest coverage ratio (ICR) and return on assets (ROA).[29] The ICR and ROA gauge a facility's ability to continue doing business long term, and also indicate a facility's ability to qualify for a loan or to attract investors. In this way, the ratios are key indicators of a facility's ability to finance costs associated with the proposed regulation.

The ICR is calculated as earnings before interest and taxes (EBIT) divided by interest expense. This ratio provides a comprehensive measure of a facility's ability to meet its fixed cost obligations (e.g., short- and long-term debt) out of operating earnings. Facilities must manage their fixed cost obligations in order to achieve profitability and raise additional capital. With that in mind, lenders and investors tend to avoid potential debtors/investments that have a high proportion of debt or other fixed obligations relative to operating earnings.

ROA is calculated as EBIT divided by assets. ROA is a measure of a facility's operating profitability and asset management capability. This ratio demonstrates the rate of return on the total investment in the facility.

Other significant financial impacts are reported only for facilities that were not projected to experience one of the more severe impacts (e.g., a facility or product line closure) in either the baseline or post-compliance scenario. Significant financial impacts were evaluated by comparing each facility's post-compliance financial ratios to the lowest quartile ratios established for all in-scope pesticide manufacturing facilities. A significant

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[29]The ICR is also known as "times interest earned;" the ROA is also known as the "return on investment." Additional information on these ratios can be found in Chapter 7.

impact is said to result from the proposed guidelines if a facility shifts into the lowest quartile of either the ICR or the ROA for all pesticide manufacturing facilities due to the regulation. [30]

The analysis of other significant financial impacts was conducted in three steps: (1) estimate the ICR and ROA for all pesticide manufacturing facilities, (2) determine the lowest quartile values for the two ratios, and (3) recalculate the post-compliance ICR and ROA for each facility. These steps are discussed below.

Baseline Ratios

The values marking the lowest quartiles for the ICR and ROA were determined by calculating the ratios for all pesticide manufacturing facilities. The three components used to calculate these two ratios were EBIT, interest, and assets. EBIT was calculated as three-year average revenues from pesticides minus three-year average costs (except interest and taxes) associated with pesticides. Pesticide-related revenues were taken directly from the Census. Pesticide-related costs are composed of pesticide variable costs and pesticide fixed costs. Pesticide variable costs were taken directly from the Census. Fixed costs (e.g., depreciation, fixed overheads, R&D, and other) are not broken down in the Census into those related or unrelated to pesticides, but are reported for the entire facility. As a result, the percentage of fixed costs generated by pesticide-related activity was assumed to match the percentage of facility revenues from pesticide-related activity. The equation for calculating EBIT is therefore:

$$EBIT = PREV - VC - FC(PREV/TREV)$$

where:

EBIT	=	earnings before interest and taxes;
PREV	=	pesticide related revenue for a facility;
VC	=	pesticide related variable cost for a facility;
FC	=	total fixed costs (minus interest and taxes) for a facility; and
TREV	=	total facility revenues.

Interest related to pesticides was calculated as the interest reported in the Census multiplied by the percent of facility revenue from pesticides. Likewise, assets related to pesticides were calculated as assets reported in the Census multiplied by the percent of facility revenue from pesticides. EBIT divided by interest provided the ICR; EBIT divided by assets gave the ROA.

[30] The firm analysis is analogous to the "other significant impact analysis" for the facility level. See Chapter 7 for further details.

Lowest Quartile Values

The lowest quartile value for ROA was determined directly from the calculated baseline ROAs for all pesticide manufacturing facilities. Determination of the lowest quartile value for the interest coverage ratio, however, required a decision on where to place firms reporting a zero interest payment. A value of zero cannot be used in the denominator of a ratio, so an assumption must be made regarding these cases for the ICR. The analysis ranked facilities reporting positive EBIT and zero interest as having interest coverage superior to any firm reporting a positive interest value. If EBIT was negative and the reported interest expense was zero, the facility was assigned an EBIT:interest value of zero. In effect, such a facility was seen as being worse off than a facility with positive EBIT and a positive interest expense, but better off than a facility with negative EBIT and a positive interest expense. The EBIT:interest ratio marking the lowest quartile for pesticide manufacturing facilities is 1.13; the lowest quartile ROA value is 0.04.

Post-compliance Ratios

The post-compliance ratios for each facility with compliance costs that was not predicted to have a facility or product line closure were calculated as follows:

post-compliance EBIT =
baseline EBIT
minus compliance operating and maintenance costs
minus the change in variable production costs
plus the change in revenues

post-compliance interest expense =
baseline interest expense
plus the current interest component of compliance debt[31]

post-compliance total assets =
baseline total assets
plus compliance capital and land costs

[31]Compliance debt is the debt the firm is expected to incur in order to finance projected capital and land expenses associated with the proposed regulation.

4.5 Facility Impacts

As discussed previously, a total of 90 pesticide manufacturing facilities produced one or more of the 270 PAIs, or classes of PAIs, potentially subject to regulation. The EPA is regulating 122 of these chemicals and has projected compliance costs for the pesticide manufacturing facilities under two potential regulatory options: a Treated Discharge Option and a Zero Discharge Option. The economic impacts of both these options on the facilities were calculated separately for direct and indirect dischargers. Each discharge category was further analyzed for two subcategories: organic pesticide chemicals manufacturing (Subcategory A) and metallo-organic pesticide manufacturing (Subcategory B).

4.5.A Baseline

Fifteen of the 90 pesticide manufacturing facilities are expected to close in the baseline (see Table 4.3). Three of these 15 facilities have, in fact, closed since 1986, and another 2 of the 15 facilities have closed one or more product lines since that time. An additional 20 facilities are projected to close particular pesticide product lines in the baseline. Two of these 20 facilities have closed entirely; 5 of the facilities closed a pesticide product line, and 2 of the facilities have changed ownership since 1986.

Table 4.3
Baseline Closures

Plant Closures	15
Subcategory A/Subcategory B*	15/0
Product Line Closures	20
Subcategory A/Subcategory B*	18/3

* Five facilities produce PAIs in both Subcategories A and B. Two of these facilities have costs for both Subcategories. Therefore, total closures may not equal the sum of Subcategory A and Subcategory B closures.

4.5.B Effects of Compliance with the Regulatory Options

The economic impacts of the two regulatory options evaluated by the EPA are discussed below. Having reviewed the costs, impacts, and pollutant removals associated with the two options, the EPA is proposing the Treated Discharge Option. The projected results of the Zero Discharge Option are shown for comparison. Although the EPA is not proposing further regulations for Subcategory B chemicals, the costs and impacts that would result from regulation of Subcategory B chemicals are shown below.[32]

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[32]As discussed previously, the analysis of impacts of the regulatory options incorporates the effects of facilities passing a portion of the compliance costs to their customers. An alternative method of analyzing impacts would be to assume that pesticide manufacturers bear the entire burden of the cost increase in reduced

Treated Discharge Option

Impacts of BAT Regulations on Direct Dischargers

Organic Pesticide Chemicals Manufacturing (Subcategory A)

Thirty-two direct discharging and zero discharging facilities producing Subcategory A chemicals are expected to incur costs under this regulatory option (see Table 4.4).[33] For manufacturers included in this subcategory, the incremental capital and annualized costs of complying with BAT limitations are expected to be $14.9 million and $14.7 million, respectively. No facilities are projected to close due to compliance with BAT. Two facilities are projected to close a product line as a result of the regulation. No facilities are expected to experience other significant financial impacts short of facility or product line closure.

Metallo-Organic Pesticide Chemicals Manufacturing (Subcategory B)

Direct dischargers of Subcategory B chemicals are limited to zero discharge of process wastewater pollutants under BPT. No additional options were considered and no new limitations are proposed for the metallo-organic pesticide chemicals manufacturing subcategory. There are therefore no associated costs or economic impacts.

Impacts of PSES Regulations on Indirect Dischargers

Subcategory A

Twenty-seven indirect discharging facilities producing Subcategory A chemicals are expected to incur costs under the Treated Discharge Option. For manufacturers included in this subcategory, the incremental capital and annualized costs of complying with PSES limitations are expected to be $9.4 million and $5.9 million, respectively. No facilities are projected to close due to compliance with PSES. One facility, or 3 percent of the facilities subject to regulation under this category, is projected to close a product line as a result of the regulation. No facilities are expected to experience other significant financial impacts short of facility or product line closure.

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profits. EPA conducted a sensitivity analysis using this zero cost pass-through assumption. The results are reported in Appendix D. For the main analysis, however, the EPA presents impacts using the assumption of partial cost pass-through, because the EPA believes that, in reality, pesticide manufacturing facilities will not bear the entire costs of the regulation. The analysis of zero pass-through (i.e., manufacturers bear all compliance costs) served as a theoretical construct to limit the upper range of impacts of the regulation on facilities.

[33]Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

Table 4.4
Impacts of the Regulatory Options on Facilities***

	Treated Discharge Option		Zero Discharge Option	
	Direct Dischargers**	Indirect Dischargers	Direct Dischargers**	Indirect Dischargers
Facility Closures	0	0	16	11
Subcategory A/Subcategory B*	0/0	0/0	16/0	11/1
Product Line Closures	2	1	3	3
Subcategory A/Subcategory B*	2/0	1/0	3/0	3/1
Other Financial Impacts	0	0	0	0
Subcategory A/Subcategory B*	0/0	0/0	0/0	0/0

* Totals may not equal the sum of Subcategories A and B because five facilities produce active ingredients in both Subcategories and two facilities incur costs for both Subcategories. There are no impacts for Subcategory B direct dischargers because direct discharge of Subcategory B chemicals is already limited to zero under BPT. Although impacts are shown for Subcategory B indirect dischargers, regulations on Subcategory B are not proposed.

** Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

Subcategory B

Five Subcategory B facilities would be expected to incur costs under PSES if the EPA regulated these chemicals. The total expected capital costs would be $40,000, while the annualized costs would be $120,000. No plant closures, product line closures, or other significant financial impacts would be expected to result from these costs.

Zero Discharge Option

Impacts of BAT Regulations on Direct Dischargers

Subcategory A

Thirty-five direct discharging facilities producing Subcategory A chemicals would be expected to incur costs under this regulatory option (see Table 4.4). For manufacturers included in this subcategory, the incremental capital and annualized costs of complying with BAT limitations is expected to be $1.1 million and $4.8 *billion*, respectively. Sixteen facilities would be projected to close due to compliance with BAT. Three additional facilities would be projected to close a product line as a result of the regulation. No facilities would be expected to experience other significant financial impacts short of facility or product line closure.

Subcategory B

As discussed under the Treated Discharge Option, Subcategory B direct dischargers are already limited to zero discharge of process wastewater pollutants under BPT. No additional options were considered and no new limitations are proposed for the metallo-organic pesticide chemicals manufacturing subcategory. There are therefore no associated costs or economic impacts.

Impacts of PSES Regulations on Indirect Dischargers

Subcategory A

Thirty indirect discharging facilities producing Subcategory A chemicals would be expected to incur costs under the Zero Discharge Option. For manufacturers included in this subcategory, the incremental capital and annualized costs of complying with PSES limitations is expected to be $1.1 million and $518.8 million, respectively. Eleven facilities would be projected to close due to compliance with PSES. Three facilities under this category would be projected to close a product line as a result of the regulation. No facilities would be expected to experience other significant financial impacts short of facility or product line closure.

Subcategory B

Five Subcategory B facilities would be expected to incur costs under PSES. The total capital costs would be projected to be $80,000, while the annualized costs would be $2.8 million. One facility is projected to close as a result of the regulation. An additional facility is expected to close a product line. No facilities would be expected to experience other significant financial impacts.

Chapter 4 References

Doane Marketing Research (1987). Annual Marketing Survey. St. Louis, Missouri.

DPRA, Inc. (1990). Agchemprice; *Current U.S.A. Prices of Non-fertilizer Agricultural Chemicals.* January. Manhattan, KS.

U.S. Department of Agriculture (1985). *U.S. Demand for Food: A Complete System of Price and Income Effects.* By Kuo S. Huang, National Economics Division, Economic Research Service. Technical Bulletin No. 1714.

U.S. Department of Commerce (1989, 1990, 1991). Bureau of the Census. *Statistical Abstract of the United States.* Washington, D.C. January.

Chapter 5: COMMUNITY IMPACT ANALYSIS

5.0 Introduction

This chapter evaluates community impacts resulting from both pesticide facility closures and other significant reductions in pesticide active ingredient (PAI) production. Community impacts are measured by the level of employment loss expected to correspond to decreased production resulting from compliance with the proposed regulation.

The impacts corresponding to both the Treated Discharge Option and the Zero Discharge Option are presented. For each option, impacts are shown separately for direct dischargers (including zero dischargers) and indirect dischargers.[1] For the Treated Discharge Option, only those impacts associated with Subcategory A (Organic Pesticide Chemicals Manufacturing) chemicals are shown; no closures or other significant decreases in production are expected for manufacturers of Subcategory B (Metallo-Organic Pesticides Chemicals Manufacturing).[2] For the Zero Discharge Option, impacts are shown for both Subcategory A and Subcategory B chemicals.

5.1 Methodology

Community impacts are analyzed in two stages. The first stage analyzes the primary impact of facility layoffs due to facility closures and other significant production reductions. If the primary employment losses estimated in the first stage of the analysis are determined to be significant, the analysis is then taken to a second stage that determines secondary impacts on the community employment level. Secondary impacts arise from reduced demand for inputs to the affected facility, and reduced consumption due to losses in earnings. Secondary impacts are assessed through multiplier analysis, which measures the extent to which employment levels in other industries are affected by employment changes in a given industry. Secondary and primary employment losses are summed to obtain the total impact on community employment levels resulting from pesticide facility closures and other decreases in pesticide production.

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[1]Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

[2]Direct discharges of Subcategory B chemicals are already limited to zero under the Best Practicable Control Technology Currently Available (BPT) regulation. Best Available Technlogy Economically Available (BAT) regulations are therefore not considered for Subcategory B chemicals under either the Treated Discharge Option or the Zero Discharge Option.

5.1.A Primary Impacts on Employment

Primary impacts on employment are considered for facilities predicted to experience either a closure or a decrease in in-scope PAI production of at least ten percent due to the regulation. All pesticide-related employment at a facility is assumed to be lost in the case of facility closures. The percentage of employment lost due to other significant reductions in production is assumed to equal the percentage of revenues lost.

Facility Closures

Employment loss resulting from a facility closure is assumed to equal the total annual pesticide-related employment hours calculated from that facility's Census data.[3] Total pesticide-related hours are calculated as the sum of both pesticide-related production and non-production hours. Pesticide-related production hours are obtained directly from the Census by adding pesticide manufacturing hours and pesticide formulating/packaging hours. Pesticide-related non-production hours are estimated by computing the ratio of total non-production hours to total production hours and multiplying the pesticide production hours by this ratio.[4] These calculations are shown below algebraically.

Total pesticide production employee hours (TPH) are computed as:

$$TPH = MH + FH$$

where:

MH	=	Annual employee hours spent in pesticide chemical manufacturing production; and
FH	=	Annual employee hours spent in pesticide formulating/packaging.

Non-production employee hours related to pesticide production (TNH) are estimated as:

$$TNH = TPH \times \frac{N}{P}$$

where:

N	=	Annual non-production employee hours spent at facility; and
P	=	Annual employee hours spent in all production at facility.

Total facility production hours (P), used in the above equation, are computed as:

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[3]Employment in the pesticide manufacturing industry tends to be seasonal. Facilities reported employee hours for the months of January, May and November to account for this seasonality. "Annual hours" are estimated by multiplying the average hours of the three months by 12.

[4]The inclusion of pesticide formulating/packaging hours is conservative, because facilities that discontinue manufacture of certain PAIs could purchase the PAIs and continue to formulate/package them.

$$P = MH + FH + OPH$$

where:

OPH = Annual estimate of employee hours spent in other production.

Total pesticide-related employee hours lost due to a facility closure, i.e., the sum of pesticide-related production hours and pesticide-related non-production hours, are converted to full time equivalents (FTE), assuming that 2000 hours = 1 FTE.[5]

Other Significant Reductions in Production

Reductions in pesticide production that fall short of facility closure may also affect employment levels at a facility. In order to capture these impacts, this analysis calculates employment loss for any facility that is projected to have at least a 10 percent reduction in revenues from in-scope PAIs due to the proposed regulation. The percentage of in-scope employment that is lost is assumed to equal the percentage of in-scope revenue that is lost.

Employee hours dedicated to in-scope pesticide work must be estimated because they are not reported in the Census. The ratio of in-scope pesticide hours to total facility-wide hours is assumed to equal the ratio of in-scope pesticide production volume to total facility-wide production volume. Facility-wide employee hours and the ratio of in-scope pesticide production volume to total facility production volume are reported in the Census.[6] Hours related to production of in-scope pesticides are multiplied by the percentage loss of in-scope revenues to estimate lost hours. Employee hours lost are again converted to full time equivalents (FTE), assuming that 2000 hours = 1 FTE.

5.1.B Measuring Impact Significance

The significance of facility employment loss on the community is measured by its impact on the community's level of employment as a whole. For purposes of this analysis, the community is defined as the Metropolitan Statistical Area (MSA), in which the facility is located[7]. The MSA is assumed to represent the labor market area within which residents could reasonably commute to work. If the facility is located in a Primary Metropolitan Statistical Area (PMSA) within the MSA, then the PMSA population is used. If a facility is not located within an MSA, then the community is defined as a county (or township, for eastern states). A

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[5]Computed: (50 weeks/year)(40 hours/week) = 2000 hours/year.

[6]The ratio of in-scope pesticide production volume to total facility production volume, although not the separate numerator and denominator, is reported in the Census.

[7]MSAs are defined by the U.S. Office of Management and Budget.

decline in the community employment rate equal to or greater than one percent is considered significant. Data necessary to determine the community impact from the employment loss include the community's population and employment rate. The community population information used in this analysis is for 1986, as estimated by the Bureau of the Census (1986). Due to inconsistencies in MSA and county-level employment data, state employment rates are used to represent community employment rates. State employment rates are based on 1986 data from the Bureau of Labor Statistics (1989).

5.1.C Secondary Impacts on Employment

As stated above, if primary employment losses are found to have a significant impact on a community, then secondary effects on employment levels are assessed by multiplier analysis. Secondary effects arise from (1) the reduction in demand for inputs by the affected facility, and (2) induced impacts attributable to reductions in consumption due to both primary and secondary losses in earnings. Multiplier analysis is used to account for these secondary effects, and provides a straightforward framework as long as the direct effects are small and a number of other important limitations (e.g., constant returns to scale, fixed input ratios) hold.

The multiplier used in this analysis is based on input/output tables developed by the Department of Commerce, Bureau of Economic Analysis (BEA, 1986). The BEA multipliers are estimated via the Regional Industrial Multiplier System developed by the Regional Economic Analysis Division of the BEA. The multipliers reflect the total national change in the number of jobs given a change in the number of jobs for a particular industry.[8] In this analysis, the industry directly affected is Chemicals and Selected Chemical Products.[9] The multiplier reported by BEA for this industry is 8.37[10]. The change in total number of jobs is computed by:

$$CTJ = 8.37 \times CDCJ$$

where:

CTJ = Change in total jobs; and

CDCJ = Change in direct chemical industry jobs (FTEs).

[8]"Jobs" include both full- and part-time positions.

[9]Multipliers based on direct employment changes are available at an aggregated industry level only.

[10]The use of this national multiplier may overstate the number of jobs affected within the community because some of the inputs may be from sources outside the community or even outside the country. No multipliers that differentiate among the locations of inputs sources are known to exist.

5.2 Results

5.2.A Treated Discharge Option

Impact of Best Available Control Technology Economically Achievable (BAT) Regulations on Direct Dischargers[11]

Under the Treated Discharge Option, no direct discharging facilities are expected to close, while two facilities are expected to have a decline in in-scope revenues of 10 percent or greater. As shown in Table 5.1, total estimated employment loss is 31 FTEs, less than one percent of the total pesticide-related employment figures reported by all PAI manufacturers (approximately 9,940 FTEs). The employment rates in the two affected communities are expected to decline by less than one percent. Therefore, the projected employment loss for direct dischargers under the Treated Discharge Option is considered insignificant.

Impact of Pretreatment Standards for Existing Sources (PSES) Regulations on Indirect Dischargers

The proposed effluent guidelines under the Treated Discharge Option for direct dischargers are not projected to result in any facility closures, while one facility is expected to experience a reduction in in-scope pesticide revenues of at least ten percent. As indicated in Table 5.1, total expected employment loss is about 97 FTEs, approximately one percent of total pesticide-related employment reported in the industry. The community employment levels are not projected to decline by more than one percent and, consequently, the estimated reduction in employment is not considered significant.

5.2.B Zero Discharge Option

Impact of BAT Regulations on Direct Dischargers

Employment losses were considered for 16 direct discharging facilities subject to closure and 3 additional facilities expected to experience a decline in in-scope revenues of at least 10 percent. Under the Zero Discharge Option (see Table 5.2), employment losses due to the primary effects of facility closures and reduced production equal approximately 55 percent (5,461 FTEs) of total reported pesticide-related employment for PAI manufacturers. Only one community is expected to be significantly impacted by the loss of employment. This community, located in the Southeast, is projected to lose 224 jobs within the pesticide industry and 1,649 jobs in other industries, representing 11 percent of the community's total employment base. Total expected employment loss, from both primary and secondary effects, is predicted to be 7,110 FTEs for direct dischargers under the Zero Discharge Option.

[11]Impacts of zero discharge requirements are discussed with direct discharge requirements.

Table 5.1 Community Impact — Treated Discharge Option Employment Loss (FTEs)	Discharger Type		
	Direct[1]	Indirect	Total
Subcategory A[2]			
FTE's Lost Due to Plant Closures	0.0	0.0	0.0
FTE's Lost Due to Reduced Production	31.0	96.8	127.8
FTE's Lost Due to Secondary Effects	0.0	0.0	0.0
Total Subcategory A FTE's Lost	31.0	96.8	127.8

[1] Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

[2] Subcategory B is not shown, since no closures or other significant decreases in production are projected for this subcategory under the Treated Discharge Option.

Table 5.2
Community Impact — Zero Discharge Option
Employment Loss (FTEs)

	Discharger Type		
	Direct[1]	**Indirect**	**Total**
Subcategory A			
FTE's Lost Due to Plant Closures	5,289.2	738.2	6,027.4
FTE's Lost Due to Reduced Production	171.8	64.0	235.8
FTE's Lost Due to Secondary Effects	1,649.3	0.0	1,649.3
Total Subcategory A FTE's Lost	7110.3	802.2	7,912.5
Subcategory B[2]			
FTE's Lost Due to Plant Closures	0.0	0.0	0.0
FTE's Lost Due to Reduced Production	0.0	3.9	3.9
FTE's Lost Due to Secondary Effects	0.0	0.0	0.0
Total Subcategory B FTE's Lost	0.0	3.9	3.9
Subcategories A and B			
FTE's Lost Due to Plant Closures	5,289.2	738.2	6,027.4
FTE's Lost Due to Reduced Production	171.8	67.9	239.7
FTE's Lost Due to Secondary Effects	1,649.3	0.0	1,649.3
Total Employment Loss	7110.3	806.1	7,916.4

1 Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

2 Subcategory B is already limited to zero direct discharge under BPT.

Impact of PSES Regulations on Indirect Dischargers

Organic Pesticide Chemicals Manufacturing (Subcategory A)

Employment losses were considered for 11 facilities subject to closure and five facilities experiencing a decline in in-scope revenues of at least 10 percent.[12] Total expected employment loss among Subcategory A indirect dischargers under the Zero Discharge Option is projected to be 802 FTEs, approximately eight percent of total reported pesticide-related employment by PAI manufacturers (see Table 5.2). Community employment levels did not show a significant change under the Zero Discharge Option for Subcategory A indirect dischargers.

Metallo-Organic Pesticide Chemicals Manufacturing (Subcategory B)

Employment losses for Subcategory B indirect dischargers under the Zero Discharge Option are expected to total approximately 4 FTEs (less than one percent of the total reported pesticide-related employment) by PAI manufacturers. This change stems from two facilities that are expected to experience a decline in in-scope revenues of at least 10 percent. There are no projected closures under the Zero Discharge Option for Subcategory B indirect dischargers. Given that the decline in the employment rates for both of the communities affected is less than one percent, the impacts are considered insignificant.

In summary, total expected employment loss due to the Treated Discharge Option is only 128 FTEs. Total employment losses expected under the Zero Discharge Option are projected to be nearly 62 times the employment losses under the Treated Discharge Option. Under the Zero Discharge Option, one community is expected to experience a significant decline in the employment rate (11 percent). This job loss may overstate the community impact, however, since the use of a national multiplier cannot differentiate between input sources within and outside this community.

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[12]One impacted facility did not report any employment data. According to the records of a follow-up call, facility personnel indicated that employment information was unavailable in the format requested.

Chapter 5 References

Bureau of the Census (1986), *Current Population Reports: Population and Per Capita Income Estimates for Counties and Incorporated Places*, U.S. Department of Commerce.

Bureau of the Census (1988), *Statistical Abstract of the United States*, U.S. Department of Commerce.

Bureau of Economic Analysis (1986), *Regional Multipliers, A User Handbook for the Regional Input-Output Modelling System (RIMS II)*, U.S. Department of Commerce, May.

Bureau of Labor Statistics (1989), *Handbook of Labor Statistics*.

Chapter 6: FOREIGN TRADE ANALYSIS

6.0 Introduction

Pesticide active ingredients (PAIs) are traded in an international market, with producers and buyers located worldwide. Changes in domestic PAI production due to the regulation of effluent from PAI manufacturing facilities may therefore affect the balance of trade. This chapter estimates the extent to which the two regulatory options for PAI manufacturers would affect the balance of trade. To measure the significance of the expected changes in exports and imports, these changes are compared with current U.S. exports and imports for the pesticide industry, and with total U.S. merchandise trade.

The impacts corresponding to both the Treated Discharge Option and the Zero Discharge Option are presented. For each option, impacts are shown for direct dischargers (including zero dischargers) and indirect dischargers.[1] For the Treated Discharge Option, only those impacts associated with Subcategory A (Organic Pesticide Chemicals Manufacturing) are shown; no closures or other significant decreases in production are expected for Subcategory B (Metallo-Organic Pesticide Chemicals Manufacturing). For the Zero Discharge Option, impacts are shown for both Subcategory A and Subcategory B chemicals.[2] The proposed rule, however corresponds to the Treated Discharge Option and does not include Subcategory B chemicals.

6.1 Methodology

Decreased production resulting from compliance with effluent guideline limitations may result in both decreased U.S. exports and increased U.S. imports of PAIs.[3] Exports may decrease as previously exported products are no longer manufactured; imports may increase as domestic purchasers seek new sources of PAIs no longer offered by a particular manufacturer. Changes in exports and imports are considered for facilities

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[1]Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

[2]Direct discharges of Subcategory B chemicals are already limited to zero under Best Practicable Control Technology Currently Available (BPT) regulation. For this reason, Best Available Technology Economically Achievable (BAT) regulations are not considered for Subcategory B chemicals under either the Treated Discharge Option or the Zero Discharge Option.

[3]Environmental laws in other countries are changing, often reflecting the changes in U.S. environmental laws. This analysis conservatively assumes, however, that current foreign environmental laws will remain in effect. As a result of this assumption, effects of the regulation on foreign trade may be overstated.

predicted to close under a regulatory option and for facilities predicted to have a decrease in in-scope PAI production of at least ten percent due to regulation.

6.1.A Exports

Changes in exports are considered only for those facilities expected to incur compliance costs, and who also indicated in the Census that they exported a portion of their production in 1986. These changes are calculated assuming that the foreign response to increased price matches the domestic response, i.e., foreign demand elasticities equal domestic demand elasticities. The analysis assumes that none of the decreased production of exported PAIs is replaced by alternate U.S. products. This "worst case" assumption is very conservative and is likely to overestimate the reduction in exports. If the impact on foreign trade is not significant in this worst-case scenario, then more realistic scenarios would also indicate no significant impacts. The methods of estimating changes in PAI exports are discussed below for four categories of facilities. Separate methods were required, depending on whether the facility was projected to close and whether the facility chose to provide PAI-specific data in the Census.

Facility Closures with PAI-Specific Information

If a facility is projected to close and PAI-specific export percentages were reported in the Census, the loss in exports is estimated as the product of the revenue from each PAI and the export percentage for that PAI, summed over all PAIs produced.[4] Algebraically, export revenue losses are computed as:

$$AIX = \sum_{i=1}^{n} AIV_i \times AIXP_i$$

where:

AIX	=	Change in export revenues for a facility;
AIV_i	=	Facility revenues from PAI i; and
$AIXP_i$	=	Percentage of PAI i production that is exported by the facility.[5]

[4]The export data reported are expressed in percentage of volume. Because percentages of revenue are unavailable, it is assumed that the percentage of revenues generated from exports is equal to the percentage of volume exported.

[5]For facilities projected to close, a full accounting of changes in exports would include changes in exports of formulated/packaged pesticides as well as PAIs. The single facility that reported PAI-specific data and is projected to close, however, did not formulate/package PAIs in 1986. For this reason, changes in exports of PAIs alone are considered in this section.

Facility Closures without PAI-Specific Information

Although the provision of PAI-specific export data in the Census was optional, all facilities were required to provide the percentage of the facility's total 1986 production that was exported. If PAI-specific information was not provided by the facility, then the percentage of exported PAI sales is assumed to equal the percentage of exported facility-level production. Revenues from pesticides and pesticide contract work are added to obtain total pesticide-related sales. The loss in export revenues is estimated by multiplying total facility pesticide sales by the percentage of total production exported by a facility.[6]

Facilities with Reduced Demand and PAI-Specific Information

Facilities incurring compliance costs and remaining open may experience a decline in exports due to decreased demand resulting from price increases. Changes in exports are considered only for those facilities whose in-scope revenues are expected to decrease by at least ten percent due to the regulation.

The decrease in in-scope revenues for facilities with reduced demand is calculated on a cluster basis. Production-based weighted averages of the PAI-specific export data are calculated for each cluster at each affected facility. The decline in exports for each cluster is determined by multiplying the facility's decline in cluster revenues by the facility's cluster export percentage. If a facility is expected to close a product line, the percentage change in production for that product line is 100 percent. The total decline in a facility's exports equals the sum of the decline in exports for all affected clusters in that facility.

Facilities with Reduced Demand and No PAI-Specific Information

As discussed above, if PAI-specific export data are unavailable, the facility-level export percentage is used. The decline in a facility's exports is estimated by multiplying the decline in the facility's revenues by the percent of the facility's total 1986 production that was exported.

6.1.B Imports

An analysis of changes in imports is performed for facilities projected to either close or lose at least ten percent of in-scope pesticide revenues, and that also produce a PAI that was imported to the United States in 1986. Because changes in revenues are evaluated for each facility at the cluster level, the analysis of imports also focuses on clusters. Production of each cluster of PAIs was classified as replaceable by imports if *any* PAI within the cluster was imported in 1986.[7] As a worst-case scenario, it is assumed that all lost revenue in

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[6]The facility-reported export data may not reflect actual exports for facilities that perform contract work, because facilities may not know the trade status of such products.

[7]Import data from several sources were reviewed for this analysis. Sources include the Office of Pesticides Programs (OPP), the Bureau of the Census, and the International Trade Commission. Data published by the Bureau of the Census and the International Trade Commission were so highly aggregated that they were not useful for this

clusters with imported PAIs (with the exception of revenue lost due to reduced exports) is replaced by imports. This assumption is very conservative and is likely to overestimate the increase in imports. If this worst-case scenario does not result in a significant impact on foreign trade, then neither would a more realistic scenario.

6.2 Results

6.2.A Treated Discharge Option

Impact of Best Available Technology Economically Achievable (BAT) Regulations on Direct Dischargers[8]

Under the Treated Discharge Option, no direct discharging facilities are projected to close, and two facilities are expected to have a decline in in-scope revenues of ten percent or greater. Of the two facilities affected, only one facility reported export data (non-PAI-specific). Using the methods outlined above, it is estimated that exports from this facility could decline by about $114,000 due to the regulation (see Table 6.1).

The two direct discharging facilities expected to experience a decline in in-scope revenues of ten percent or greater under the Treated Discharge Option produce PAIs in five clusters. The PAI production in each of these clusters is replaceable by imports. In the worst-case scenario described above, imports are expected to rise by $5.4 million.

The changes in exports and imports expected to result from the BAT regulation are more meaningful when compared to the trade balance of the pesticide industry and the total U.S. merchandise trade balance. In 1986, U.S. exports of pesticides exceeded imports of pesticides by $897 million (United Nations, 1986). Considering all merchandise trade in 1986, however, the U.S. had a negative net trade balance of $152 billion (U.S. Department of Commerce, 1988). The change in pesticide trade due to the BAT regulation under the Treated Discharge Option is minor (less than one percent) in comparison to both total U.S. pesticide trade and total U.S. merchandise trade.

Impacts of Pretreatment Standard for Existing Sources (PSES) Regulations on Indirect Dischargers

Under the Treated Discharge Option, no indirect discharging facilities are projected to close, and only one facility is expected to have a decline in in-scope revenues of ten percent or greater. This facility reported

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analysis. Details of the data review are contained in the Administrative Record.

[8]Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

Table 6.1
Foreign Trade Impact — Treated Discharge Option
(in $ thousands)

Decline in Pesticide Exports

	Discharger Type		
	Direct[1]	**Indirect**	**Total**
Subcategory A			
Due to Plant Closures	0	0	0
Due to Reduced Production	114	5,477	5,591
Total Subcategory A	114	5,477	5,591

Increase in Pesticide Imports

	Discharger Type		
	Direct	**Indirect**	**Total**
Subcategory A			
Due to Plant Closures	0	0	0
Due to Reduced Production	5,408	10,632	16,040
Total Subcategory A	5,408	10,632	16,040

Net Decline in Pesticide Trade Balance

	Discharger Type		
	Direct	**Indirect**	**Total**
Subcategory A			
Due to Plant Closures	0	0	0
Due to Reduced Production	5,522	16,109	21,631
Total Subcategory A	5,522	16,109	21,631

[1] Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.

[2] Subcategory B is not shown, since no closures or other significant decreases in production are projected for this subcategory under the Treated Discharge Option.

export data (non-PAI-specific). Using the methods outlined above, it is estimated that exports from this facility could decline by about $5.5 million due to the regulation.

The one indirect discharging facility expected to experience a decline in in-scope pesticide revenues of ten percent or greater under the Treated Discharge Option produces PAIs in three clusters. The PAI production in each of these clusters is replaceable by imports. In the worst-case scenario described above, imports are expected to rise by $10.6 million. Even with the conservative assumptions incorporated in the analysis, PSES regulations under the Treated Discharge Option are projected to reduce the U.S. pesticide trade balance from $897 million to $886 million, slightly more than a one percent decline. The PSES regulation would increase the total U.S. merchandise net imports by about one one-hundredth of one percent.

6.2.B Zero Discharge Option

Impact of BAT Regulations on Direct Dischargers

Under the Zero Discharge Option, 16 direct discharging facilities are projected to close, and 3 facilities are expected to have a decline in in-scope revenues of 10 percent or greater. Fourteen of these facilities reported export data (only one facility reported PAI-specific data). Using the methods outlined above, exports from these facilities are estimated to decline by about $529 million due to the regulation (see Table 6.2).

The 19 direct discharging facilities impacted under the Zero Discharge Option produce PAIs in 29 clusters. The PAI production in each of these clusters is replaceable by imports. In the worst-case scenario described above, imports are expected to rise by $1.9 billion.

These dramatic impacts of the BAT regulation under the Zero Discharge Option would shift the U.S. pesticide industry from a net export position to a net import position. The change in pesticide trade would increase the total U.S. net merchandise imports by about two percent.

Impacts of PSES Regulations on Indirect Dischargers

Organic Pesticide Chemicals Manufacturing (Subcategory A)

Under the Zero Discharge Option, 11 Subcategory A indirect discharging facilities are projected to close, and 5 facilities are expected to have a decline in in-scope revenues of 10 percent or greater. Ten of these facilities reported export data (non-PAI-specific). Using the methods outlined above, exports from these facilities are estimated to decline by about $59 million due to the proposed regulation.

The 16 Subcategory A indirect dischargers impacted under the PSES regulations produce PAIs in 23 clusters. The PAI production in each of these clusters is replaceable by imports. In the worst-case scenario described above, imports are expected to rise by $121 million. Based on the conservative assumptions incorporated in the analysis, PSES regulations applied to Subcategory A facilities under the Zero Discharge

Table 6.2
Foreign Trade Impact — Zero Discharge Option
(in $ thousands)

Decline in Pesticide Exports			
	Discharger Type		
	Direct[1]	Indirect	Total
Subcategory A			
Due to Plant Closures	520,258	57,843	578,101
Due to Reduced Production	8,399	871	9,270
Total Subcategory A	528,657	58,714	587,371
Subcategory B[2]			
Due to Plant Closures	0	0	0
Due to Reduced Production	0	59	59
Total Subcategory B	0	59	59
Increase in Pesticide Imports			
	Discharger Type		
	Direct	Indirect	Total
Subcategory A			
Due to Plant Closures	1,705,567	96,963	1,802,53
Due to Reduced Production	197,884	23,943	221,827
Total Subcategory A	1,903,451	120,906	2,024,35
Subcategory B[2]			
Due to Plant Closures	0	0	0
Due to Reduced Production	0	1,147	1,147
Total Subcategory B	0	1,147	1,147
Net Decline in Pesticide Trade Balance			
	Discharger Type		
	Direct	Indirect	Total
Subcategory A			
Due to Plant Closures	2,225,825	154,806	2,380,63
Due to Reduced Production	206,283	24,814	231,097
Total Subcategory A	2,432,108	179,620	2,611,72
Subcategory B[2]			
Due to Plant Closures	0	0	0
Due to Reduced Production	0	1,206	1,206
Total Subcategory B	0	1,206	1,206

[1] Impacts of zero discharge requirements are reported with impacts of direct discharge requirements. Zero dischargers may be subject to monitoring costs if they have any process wastewater. Monitoring costs would be imposed by the permitting authority (no separate monitoring requirements are contained in the proposed effluent guidelines for pesticide manufacturers). These monitoring costs are included in the analysis to capture the full cost to industry of controlling process wastewater pollutants.
[2] Subcategory B is already limited to zero direct discharge under BPT.

Option are projected to reduce the U.S. pesticide trade balance from $897 million to $717 million, a 20 percent decline. The PSES regulation would increase the total U.S. merchandise net imports by about one-tenth of one percent.

Metallo-Organic Pesticide Chemicals Manufacturing (Subcategory B)

Under the Zero Discharge Option, no Subcategory B indirect discharging facilities are projected to close, and two facilities are expected to have a decline in in-scope revenues of ten percent or greater. Only one of these facilities reported export data (non-PAI-specific). Using the methods outlined above, it is estimated that exports from these facilities will decline by about $59,000 due to the proposed regulation.

The two Subcategory B indirect dischargers impacted under the PSES regulations produce PAIs in four clusters. The PAI production in each of these clusters is replaceable by imports. In the worst-case scenario described above, imports are expected to rise by $1.1 million. Based on the conservative assumptions incorporated in the analysis, PSES regulations applied to Subcategory B facilities under the Treated Discharge Option are projected to have minimal impact on both the U.S. pesticide trade balance and total U.S. merchandise net imports.

In summary, neither BAT nor PSES regulations under the Treated Discharge Option have a substantial impact on the U.S. pesticide trade balance or the U.S. total merchandise trade balance. Conversely, the impacts of BAT and PSES regulations under the Zero Discharge Option could result in a $2.6 billion decline in the U.S. pesticide trade balance, leading to a trade deficit of $1.7 billion within the U.S. pesticide manufacturing industry. The impacts under the Zero Discharge Option are less dramatic when compared to the total U.S. merchandise trade balance. The $2.6 billion increase in net imports would increase the U.S. trade deficit by approximately 1.7 percent.

Chapter 6 References

United Nations (1986). Statistical Office. *International Trade Statistics Yearbook.* New York.

U.S. Department of Commerce (1988). Bureau of the Census. *Statistical Abstract of the United States.* Washington, D.C. January.

Chapter 7: FIRM IMPACT ANALYSIS

7.0 Introduction

The firm analysis evaluates the impact of regulatory compliance on firms owning facilities subject to a pesticide active ingredient (PAI) manufacturing effluent guideline. Due to the differences between firms and facilities, the firm analysis may capture impacts not included in the facility analysis. For example, some firms may be in too weak a financial condition to undertake the treatment investment required for regulatory compliance, even though the investment may appear to be financially desirable at the facility level. Such circumstances may occur if a firm owns more than one pesticide manufacturing facility that would be subject to regulation; in that case, analysis at the individual facility level will not address the total impact of the financing requirements on the firm.[1] The regulatory action may therefore result in firms deciding to curtail pesticide manufacturing activities at a facility, or a firm may restructure its finances or sell assets to allow the completion of treatment investments. Analysis of the economic impact of regulatory options at the firm level is therefore an important component of the EIA.

The firm impact analysis is organized into three sections. The first section reviews the concepts used to drive the financial analysis. The second section describes the methodology that employs these concepts. This section also highlights some analytic difficulties encountered due to data limitations, and the steps required to overcome them. The third part of the discussion presents the results of the firm analysis.

7.1 Analytic Approach

A firm's ability to comply with regulatory requirements is assessed in two stages:

(1) The *baseline analysis* identifies firms whose financial condition, independent of regulatory action, is sufficiently weak to contraindicate the implementation of a treatment program required by a regulation. Such firms would be at risk of financial failure even without regulatory costs. For this reason, firms that fail the baseline analysis are excluded from the post-compliance analysis.

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[1]Conversely, a firm may be able to reduce its cost of compliance by consolidating the manufacturing activities and, therefore, the treatment investments required of several facilities. This would mitigate the projected impact predicted by a facility-level analysis. While such cases are plausible, it is beyond the scope of this analysis to identify them.

(2) The *post-compliance analysis* identifies those firms, otherwise financially sound, whose financial viability may be impaired by regulatory compliance. Such firms would be weakened by the financing burden and additional operating expenses of a treatment program. These firms are characterized as likely to be significantly affected by a regulatory option.

The firm financial impact analysis is conducted from the perspective of creditors and equity investors who would be the sources of capital to finance a firm's purchase of treatment systems.[2] To attract the financing for a treatment program, a firm must demonstrate financial strength both before and, on a projected basis, after the treatment program (baseline and post-compliance, respectively). The financial analysis presented in this report simulates that performed by investors and creditors in deciding whether to finance the installation of a pollution prevention or wastewater treatment system. Two considerations that influence this decision are (1) the financial performance of the firm (particularly in relation to its competitors) and (2) the expected ability of the firm to manage its financial commitments without risk of financial failure. These considerations, discussed below, form the basis of this analysis.

7.1.A Firm Financial Performance

If a firm's performance is weaker than that of its competitors, the firm may not be able to provide the expected investment return to its creditors and investors. Unless significant improvement in performance is likely, investors and creditors will generally avoid providing financing to such firms. Alternatively, investors and creditors may seek higher returns (in the form of higher interest rates or higher required returns on equity) to compensate for the additional risk associated with the capital they provide. The higher cost of capital may in turn decrease the likelihood that such firms will invest in the treatment options required for compliance with an effluent guideline.

The measure of financial performance used in the firm analysis is pre-tax return on assets (pre-tax ROA, hereinafter referred to as "ROA"), computed as the ratio of earnings before interest and taxes (EBIT) to assets:[3]

[2]For a further discussion of debt and equity financing, see Section 4.2.A.

[3]ROA is also known as "return on investment."

$$ROA = \frac{EBIT}{Assets}$$

ROA is a measure of the profitability of a firm's capital assets, independent of the effects of taxes and financial structure. It is perhaps the single most comprehensive measure of a firm's financial performance.[4] ROA provides information about the quality of management, the competitive position of a firm within its industry, and the economic condition of the industry in which the firm competes. In addition, ROA incorporates information about a firm's operating margin and asset management capability: the ratio of pre-tax income to sales (operating margin), multiplied by the ratio of sales to assets (asset turnover), equals ROA. If a firm cannot sustain a competitive ROA, on both a baseline and post-compliance basis, it will probably have difficulty financing the pollution control investment. This is true regardless of whether financing is to be obtained as debt or equity.

Illustrating typical ROA values from 1982 to 1990, the median ROA for the U.S. industrial chemical industry (as represented by SIC codes 2861, 2865, and 2869) ranged from 10.1 percent to 18.9 percent (Robert Morris Associates [RMA], 1991).[5] At the 75 percent quartile, ROA ranged from 14.5 percent to 23.6 percent over this same period (i.e., firms at this level were more profitable than 75 percent of those in the industry). At the 25 percent quartile, which is indicative of weak performance, ROA ranged from 7.2 percent to 13.4 percent. The computation of ROA, and the interpretation of the computed values as the basis for determining financial viability, are discussed in Section 7.2.

7.1.B Ability To Manage Financial Commitments

The second general area of concern to creditors and investors is the extent to which the firm can be expected to manage its financial burdens without risk of financial failure. In particular, if a firm's operating cash flow does not comfortably exceed its contractual payment obligations (e.g., interest and lease obligations), the firm is seen as vulnerable to a decline in sales or increase in costs.[6] Either scenario may: (1) sharply reduce or eliminate returns to the equity owners of the firm; and/or (2) prevent the firm from meeting its contractual payment obligations. In the first case, earnings might fall or become negative, with a consequent reduction or elimination of dividends and/or reinvested earnings. The market value of the firm's equity is also

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[4]For credit analysis in particular, *pre-tax* ROA is important because interest payments are made from pre-tax income.

[5]RMA provides financial statistics based on bank credit reports from public-reporting and non-public-reporting firms in a variety of industries. The RMA industry group that corresponds best to the pesticides manufacturing industry is the "industrial chemicals" industry, which includes SIC codes 2861, 2865, and 2869. The ROA values are calculated from RMA's reported "operating profit/sales" ratio and "sales/asset" ratio.

[6]For this discussion, a firm's operating cash flow is considered to be revenues minus costs, with the exception of interest, lease expense and depreciation.

likely to fall, causing a capital loss to investors. In the second case, failure to make contractual credit payments will expose the firm and its equity owners to the risk of bankruptcy, forced liquidation of assets, and probable loss of the entire equity value of the firm.

The ability to manage financial commitments is expressed by the ratio of EBIT to interest obligations, or the interest coverage ratio (ICR):[7]

$$ICR = \frac{EBIT}{Interest}$$

Weakness in these characteristics of firm financial condition and performance, as would be indicated by a low ICR, indicates vulnerability of the firm to financial failure and difficulty in obtaining financing for treatment investments. From 1982 to 1990, the median value of interest coverage for industrial chemicals firms (as defined by RMA, see footnote 5) ranged from 2.3 to 5.6. Over the same period, the 75th percentile value ranged from 7.2 to 16.3, and the 25th percentile value ranged from 1.0 to 2.2 (RMA, 1991).

7.2 Analytic Procedure

As described in the preceding section, the firm analysis is based on two financial measures: ROA and ICR. Firm-level data required to calculate these financial measures were obtained from public sources for domestic firms subject to public reporting requirements. In contrast, data for foreign-owned or closely-held domestic firms were not publicly available.[8] The only firm-specific data available for these firms were gross revenues obtained from the Census. Where firm-level data were not publicly available, industry norms of financial condition and performance were used as the basis for firm analysis. For example, baseline financial measures were developed using median values for the industrial chemicals business sector reported by RMA. As a result of these data limitations, the analysis for foreign-owned and closely-held domestic firms is less precise than for public-reporting domestic firms.

For the Treated Discharge Option, detailed financial data were available for 20 of the 44 firms expected to incur costs; the remaining 24 firms, closely-held or foreign-owned entities, required the use of data obtained from RMA. For the Zero Discharge Option, detailed financial data were available for 22 of the 48 firms expected to incur costs; analysis for the remaining 26 firms is based on the industry norms obtained from RMA.

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[7]The ICR is also known as "times interest earned."

[8]Closely-held firms are owned by only a few individuals. They do not trade securities publicly and are therefore not subject to public-reporting requirements under the rules of the Securities and Exchange Commission (SEC).

As mentioned above, ROA is calculated by dividing EBIT by total assets. Data used to calculate ROA for public-reporting firms were obtained from income statement compilations in *Compustat* for 1986.[9] For non-public-reporting firms, firm-level revenues were obtained from the Census. Firm-level values of assets, and EBIT for non-public-reporting firms, were estimated from firm-specific revenues and RMA data (e.g., median values for assets and EBIT as a percentage of revenues in 1986).

Dividing EBIT by interest expense yields the ICR. For public-reporting firms, data for this calculation were obtained from *Compustat*. For non-public-reporting firms, the data sources and calculation procedures are the same as those outlined for ROA. That is, firm-specific interest and EBIT were calculated from firm-specific revenues from the Census and the RMA-reported median values for both interest, and EBIT as a percentage of revenues.

Baseline EBIT, baseline total assets, and baseline interest expense are the components used to determine ROA and ICR. The data sources and calculations used in this analysis differ depending on whether or not the required data are publicly available. The calculation procedure for public-reporting firms and non-public-reporting firms are therefore presented separately.

Computing Baseline Measures for Public-Reporting Firms

Baseline data for public-reporting firms are taken from *Compustat*. The three components of the two financial ratios are described below:

[9] *Compustat*, a data base, provides financial information from SEC 10-K filings. The 10-K document is the form in which public-reporting firms are required to file detailed financial information annually with the SEC. A 10-K document contains information similar to that contained in an annual report but with additional detail.

Public Reporting Firms	
	Baseline EBIT
equals	Operating Income (operating revenues minus all production and operating costs, selling expenses, and general and administrative expense; but before taxes, interest and depreciation)
minus	Depreciation and Amortization (non-cash cost items recognized as a charge against income and meant to reflect the consumption of wasting assets)
minus	Losses from discontinued operations
plus	Nonoperating Income.
	Baseline Total Assets
equals	Total Current Assets
plus	Net facility, property, and equipment
plus	"Other" assets.
	Baseline Interest Expense
	Taken directly from *Compustat*, which lists interest expense as a single line item.

Computing Baseline Measures for Non-Public-Reporting Firms

Baseline financial measures for non-public-reporting firms required firm-level values to be estimated on the basis of: (1) firm-specific revenue information obtained in the Census; and (2) industry averages obtained from RMA's *1991 Annual Statement Studies* for the industrial chemicals business sector and *Compustat*. All values were for the year 1986. The components of baseline financial ratios for non-public-reporting firms were estimated in the following manner:

NON-PUBLIC-REPORTING FIRMS

Baseline EBIT

$$\textit{Estimated EBIT} = \textit{Firm Revenues} \times \left[\frac{\textit{Operating Profit}}{\textit{Revenue}}\right]_{RMA} \times \left[\frac{\textit{EBIT}}{\textit{Operating Profit}}\right]_{COMPUSTAT}$$

$$\textit{Estimated EBIT} = \textit{Firm Revenues} \times 0.058 \times 1.18 = \textit{Firm Revenues} \times 0.068$$

Firm revenues were taken from the responses of individual firms to the Census. RMA, which did not provide an EBIT/revenue ratio directly, gave an industry median *operating profit*/revenue ratio of 0.058 for 1986. The estimated average EBIT/revenue ratio was determined by increasing the RMA operating profit/revenue ratio by the *percentage amount* by which EBIT exceeded operating profit for the *public-reporting* pesticides manufacturing firms included in the analysis. Based on *Compustat* data for the public-reporting firms in the analysis, EBIT was found to be 18 percent higher on average than operating profit. For the analysis of *non-public-reporting* firms, an EBIT/revenue ratio of 0.068 (i.e., 1.18 x 0.058) was multiplied by firm-level revenue data to calculate firm-level EBIT. To summarize, for each $100 million in revenues, a non-public-reporting firm was assumed to have EBIT of $6.8 million.

Baseline Total Assets

Calculated using the median RMA revenue/assets ratio of 2.0 to 1. A firm with $100 million in revenues was therefore assumed to have $50 million in assets.

Baseline Interest Expense

Calculated from the median RMA value of the EBIT/interest ratio, 3.0 to 1. Assuming that the estimated EBIT/revenue ratio for non-public-reporting pesticides firms is 0.068, an EBIT/interest ratio of 3.0 indicates that interest expense averages 2.3 percent of revenue for RMA firms (i.e., 0.068/3.0 = 0.0227 or approximately 2.3 percent). This value was multiplied by firm-level revenue data taken from the Census to estimate baseline interest expense for all non-public-reporting firms. To summarize, for each $100 million in firm-level revenues, annual interest expense was estimated at $2.3 million.

Because the baseline ratio values for all of the non-public-reporting firms in the analysis were calculated using median RMA values, they are the same.[10] Specifically, the estimated ROA is 13.6 percent and the ICR is 2.96. Although these values are the same in the baseline analysis for all non-public-reporting

[10] If firm-level financial data were available for the non-public-reporting firms, the baseline ratio values could be estimated more accurately.

firms, they differ across firms in the post-compliance analysis. This is due to differences in the cost of compliance for facilities, as well as to differences in the numerators and denominators of the baseline ICR and ROA ratios (although not the ratios themselves) among the firms.

Evaluating Baseline Performance Measures

To evaluate the baseline viability of the firms analyzed, the firm-specific values of baseline financial performance were compared against the lowest quartile (i.e., 25th percentile) value in 1986 for the financial performance measures as reported by RMA for the industrial chemicals business sector. The lowest quartile value for the ICR was 1.1; the lowest quartile for ROA was 8.8. Those firms for which the value of either the ROA or the ICR was less than the first quartile value from RMA were judged to be "vulnerable" to financial failure, independent of the application of a pesticides effluent guideline. Because both measures are judged to be critically important to financial success and the ability to attract capital, failure with regard to either measure alone was deemed adequate for the finding of "vulnerability" (see Table 7.1). Because the ratio values for non-public-reporting firms were based on the RMA median values rather than firm-specific data, none of the non-public-reporting firms could be judged to be vulnerable in the baseline analysis.

Two points addressing the methodology's limitations and interpretation should be considered:

(1) The 25th percentile value is an arbitrary one for defining poor financial performance and condition. This approach assumes that the weakest one-fourth of firms in an industry are automatically in poor financial condition and at risk of financial failure. By definition, such firms are in poorer condition than 75 percent of their competitors. In spite of this, some and possibly all firms in the lowest quartile might still be in good financial condition, particularly during periods of stronger economic performance. Alternatively, during a period of weaker economic performance, more than 25 percent of the firms in an industry might be in poor condition and at risk of failure. Although the 25th percentile values can provide insight into a firm's ability (or lack thereof) to manage the financial requirements of regulatory compliance, such an analytic procedure is imperfect.

(2) Using the 25th percentile values from RMA does not mean that 25 percent of the firms in this EIA will be judged to be in poor financial condition. The firms in the RMA sample on which the percentiles were calculated include those in the industrial chemicals business as a whole. The PAI manufacturing firms analyzed in this study are therefore a subset of the RMA sample.

Table 7.1: Determination of Firm-level Financial Viability				
	Interest Coverage Ratio			
ROA	Lowest Quartile		Median	Highest Quartile
Highest Quartile	Vulnerable			
Third Quartile	Vulnerable			
Second Quartile	Vulnerable			
Lowest Quartile	Vulnerable	Vulnerable	Vulnerable	Vulnerable

Note: Baseline firms in the indicated quadrants are labeled "vulnerable." In the post-compliance analysis, firms that move to these quadrants *become* vulnerable due to compliance costs and are said to sustain a "significant impact."

The post-compliance analysis is undertaken only for those firms that were not found to be "vulnerable" to financial failure in the baseline analysis. In the post-compliance analysis, if either the re-computed ROA or ICR for a firm was found to fall below the RMA first quartile value, then that firm was judged to be "vulnerable" to financial failure as the result of regulatory action, and was said to sustain a "significant impact" (see Table 7.1).

To recalculate ROA and ICR, the three baseline components (i.e., EBIT, total assets, and interest expense) were adjusted to reflect compliance costs estimated at the facility level. In the facility analysis, compliance costs were estimated in three categories: capital costs (facility and equipment), land costs, and annual operating and maintenance costs.[11] In the firm analysis, these values were summed over the facilities owned by each firm and used to adjust the baseline components as shown below (see also Table 7.2 for the mathematical formulation of the analysis):

[11]Discharge costs (e.g., the cost of sludge disposal) and monitoring costs are included within the operating and maintenance cost category.

Table 7.2: Calculation of Firm-Level Financial Measures in Post-Compliance Analysis[12]

Firm Financial Performance (ROA)

$$Baseline\ ROA = \frac{EBIT}{Total\ Assets}$$

$$Post\text{-}Compliance\ ROA = \frac{EBIT - \left[\Delta q * \frac{o_1}{q_1}\right] - o_2 + \left[(\Delta p * q_2) - (p_1 * \Delta q)\right]}{Total\ Assets + c}$$

where:

- EBIT = Baseline earnings before interest and taxes
- o_1 = Baseline operating and maintenance expenses
- o_2 = Compliance operating and maintenance expenses
- Δq = Change in production quantity due to elasticity (q_1 - q_2)
- q_1 = Baseline production quantity
- q_2 = Post-compliance production quantity
- Δp = Change in price due to elasticity (p_1 - p_2)
- p_1 = Baseline unit price
- p_2 = Post-compliance unit price
- c = Cost of compliance capital equipment and associated land requirements

Ability to Manage Financial Commitments (ICR)

$$Baseline\ ICR = \frac{EBIT}{Interest\ Expense}$$

$$Post\text{-}Compliance\ ICR = \frac{EBIT - \left[\Delta q * \frac{o_1}{q_1}\right] - o_2 + \left[(\Delta p * q_2) - (p_1 * \Delta q)\right]}{Interest\ Expense + i}$$

where:

- ICR = Interest Coverage Ratio
- i = Average interest payment on debt for capital and land, assuming 10-year repayment, where:

$$\begin{array}{c}Average\ Annual\\ Interest\ Payment\end{array} = \left[\frac{(d * c) * 0.1095}{1 - (1 + 0.1095)^{-10}}\right] - \left[\frac{(d * c)}{10}\right]$$

- d = Percent of compliance capital equipment and land assumed to be financed by debt
- d * c = Debt financing required for compliance capital equipment and associated land

[12]For firms with multiple plants, compliance costs and production quantities are summed. In addition, the average price (baseline and post-compliance) is weighted according to each plant's production quantity.

Post-Compliance EBIT

equals	Baseline EBIT
minus	**Compliance** operating and maintenance costs (summed over facilities)
minus	the change in variable production costs (assumed to decrease by the same percentage as production decreases for each facility)
plus	Change in revenues (based on price elasticity response and summed over facilities)

Post-Compliance Total Assets

equals	Baseline Total Assets
plus	Compliance capital and land costs (summed over facilities)

Post-Compliance Interest Expense

equals	Baseline interest expense
plus	Annual interest expense for the debt component of compliance capital and land requirements (summed over facilities)

The calculation of these values and the subsequent evaluation of post-compliance firm financial viability were based on several secondary financial assumptions. These assumptions are outlined below:

- The percentages of the investment that a firm is assumed to finance through equity (e/a) and debt (d/a) are assumed to match the firm's historical mix of equity and debt investment. The values of these variables for each firm are obtained from one of two sources. For each domestic public-reporting firm, the mix of debt and equity is obtained from Standard and Poor's *Compustat* service for that firm in 1986. For all firms not included in the *Compustat* data base, the mixture of debt and equity financing was assumed to match the 1986 median mixture of debt and equity financing for the "industrial chemical industry" as calculated from RMA's *Annual Statement Studies*. The calculated values taken from the *Annual Statement Studies* are 40.5 percent equity financing and 59.5 percent debt financing.

- To be consistent with the facility analysis (in which capital equipment is assumed to have a ten-year useful life), a ten-year loan period was assumed for the debt used to finance compliance capital and land outlays. To estimate a "steady state" interest payment burden on the firm, debt is assumed to be repaid on the basis of a constant annual payment amortization schedule over the ten-year period. This average annual interest payment is the value used for additional interest expense, and is used to calculate both post-compliance interest expense and the ICR.

- The interest charged on compliance-related debt is assumed to equal the average interest rate, 10.95 percent, for AA-rated industrial debt with 10 years to maturity, over the period 1981-1990, as reported by Salomon Brothers' *An Analytical Record of Yields and Yield Spreads* (U.S. Department of Commerce, 1990 and 1991).[13] To convert this value to a real (i.e., inflation-free) rate, the rate was discounted on the basis of the average annual growth in the *Consumer Price Index* (CPI-U) for the period 1981-1990 (4.74 percent), resulting in a real interest rate of 5.93 percent (*Survey of Current Business*, 1991).[14]

7.3 Results

Analyses of baseline and post-compliance financial viability were undertaken for those firms projected to incur costs as the result of regulatory action. The findings from this analysis are presented below, first for the baseline and then for the two regulatory options analyzed: the Treated Discharge Option and Zero Discharge Option.

7.3.A Baseline Analysis

Forty-eight firms were projected to incur compliance costs under at least one of the two regulatory options. In the baseline analysis, only one of these firms had an ROA below the first RMA quartile value. This firm was also the only one whose ICR fell in the lowest RMA quartile. Because this firm was found to be "vulnerable" to financial failure independent of regulatory action, it was excluded from the post-compliance analysis.

7.3.B Post-Compliance Analysis: Treated Discharge Option

Under the Treated Discharge Option, compliance costs were projected for 44 pesticides manufacturing firms, one of which was found to be vulnerable to financial failure in the baseline analysis. The post-compliance analysis was therefore performed for only the remaining 43 firms. Three of these firms had both

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[13]Interest rate information reported by individual facilities in the Census was not used for this analysis due to difficulties of interpreting the reported values. For example, a number of respondents reported that funds for capital outlays were obtained from a parent firm at zero percent. This reporting reflects internal accounting conventions but does not accurately represent the interest cost borne by the firm for debt financing. Other firms indicated that interest costs were tied to the prime rate (e.g., prime rate or "prime rate plus one"). Such interest terms would generally apply to a working capital credit line or other short-term credit instrument. However, the short-term liability would usually be replaced by longer-term debt to match the expected life of the capital asset being financed. The interest rates on longer-term debt are usually higher than short-term credit rates, so short-term rates may understate potential interest costs.

[14]The interest on debt, the inflation rate, and the mix of debt and equity assumed in the firm-level analysis all match the assumptions in Chapter 4 (the facility-level analysis). An assumption regarding the cost of equity is not required in the firm-level analysis since it is not an input to the calculation of post-compliance EBIT, interest, or assets.

ROA and ICR in the lowest RMA quartile in the post-compliance analysis, and were therefore said to incur significant financial impacts.

7.3.C Post-Compliance Analysis: Zero Discharge Option

Under the Zero Discharge Option, compliance costs were projected for 48 pesticides manufacturing firms. Again, one firm, found to be vulnerable to financial failure in the baseline analysis, was excluded from the post-compliance analysis. On a post-compliance basis, fourteen of the remaining 47 firms shifted into the lowest RMA quartile for both ROA and ICR. The finding of a substantially greater firm impact under the Zero Discharge Option reflects the much higher level of compliance costs estimated for this option in comparison to those estimated for the Treated Discharge Option.

Chapter 7 References

Robert Morris Associates (1991). *Annual Statement Studies.* Philadelphia, PA.

U.S. Department of Commerce (1990, 1991). Bureau of the Census, Statistical Abstract of the United States, *An Analytical Record of Yields and Yield Spreads.*

U.S. Department of Commerce (1991). Bureau of Economic Analysis, *Survey of Current Business.* Washington, D.C.

Chapter 8: SMALL BUSINESS IMPACTS

8.0 Introduction

This chapter considers the expected effects of the proposed effluent limitations guidelines and standards for the pesticide manufacturing industry on small businesses. The Regulatory Flexibility Act (RFA) (Public Law 96-354) requires the Environmental Protection Agency to determine if a proposed regulation is likely to have a significant impact on a substantial number of small entities. If such an impact is expected to be disproportionately large compared to that on larger entities, then alternative regulatory methods to mitigate or eliminate economic impacts on small businesses are examined.

8.1 Methodology

This analysis proceeded in three stages. The first stage of the analysis considers whether the regulatory options are likely to have a significant impact on a substantial number of small entities. At the outset, the term "small entity" was defined. The first stage of this analysis used the threshold for small businesses established by the Small Business Administration (SBA). The SBA thresholds define small businesses based on revenue and/or employment at *firms* (including all affiliates and divisions) for each SIC group. Pesticide manufacturers are classified in SIC code 28694 (pesticide and other organic agricultural chemicals, composed of active ingredients used to formulate pesticides). The SBA size threshold for SIC 28694, given in terms of employment only, is defined as firms employing fewer than 1,000 people. Because firm employment data were not collected in the Census, these data were taken from Dun and Bradstreet's *Million Dollar Directory*. Firms meeting the SBA definition of small entities were then analyzed for the likelihood of sustaining any significant impacts resulting from regulatory compliance (e.g., facility closure, product line closure, or "other significant impact" as defined in Chapter 4). If such an impact on a substantial number of small entities is indicated by the results of the first analytical stage, then the analysis proceeds to the second stage.

The second stage of the analysis examined whether the impacts on small businesses would be disproportionately large. In contrast to the first stage of the analysis, which defined an entity as equivalent to a firm, two additional definitions of an entity were considered: the facility (including pesticide- and non-pesticide-related activities) and the pesticide-related portion of the facility (including activities related to the manufacturing of both in-scope and out-of-scope pesticide active ingredients [PAIs], pesticide formulating/packaging/repackaging, and pesticide contract work or tolling).[1] The second stage of the analysis therefore considered five measures of entity size:

- firm revenues
- total facility revenues
- total facility employment
- pesticide-related facility revenues
- pesticide-related facility employment

To examine whether the economic impacts of the proposed guidelines were expected to fall disproportionately on small businesses, the relationships between financial impacts, (e.g., facility and product line closures), and the five measures of entity size were examined using two analytical methods.[2] First, impacts vs. measures of entity size were plotted to provide a visual understanding of the relationship between the two variables. Second, a series of logistic regressions was performed to test the hypothesis that an entity is less likely to suffer adverse impacts commensurate with an increase in size.[3] For both the plotting and regression analyses, impacts were translated into binary variables. Entities expected to be impacted as a result of the regulation were assigned a value of 0, while entities without impacts were assigned a value of 1. The relationship between impacts and entity size was examined separately for direct and indirect dischargers.[4] [5]

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[1]The RFA states that the promulgating agency has the discretion to establish a new definition of a small entity that it considers more appropriate for conducting a regulatory flexibility analysis if it is determined that the SBA criteria are not suitable. Although the EPA agrees that the firm level is the appropriate one at which to examine small business impacts in this industry, this analysis also considers other definitions of a small entity for two reasons. First, because earlier chapters evaluated the potential impacts of the regulatory options at the pesticide-related level of the facility, small business impacts were also examined at this level. Second, assessing impacts at the firm level based solely on employment would draw inconclusive results because firm employment data were not publicly available for all firms represented in the Census. The entire facility was also examined in this analysis as a mid-point between the firm and the pesticide-related portion of the facility.

[2]No "other significant impacts" (as defined in Chapter 4) were projected to occur under either the Treated Discharge or Zero Discharge Options. "Other significant impacts" are therefore not included in this analysis.

[3]In a linear regression, the response values are unbounded. In contrast, response values in logistic regression are bounded by 0 and 1. Given that the dependent variables used in the analysis are binary, logistic regression was used in the second stage of this analysis.

[4]Zero dischargers, deep well injectors, and off-site incinerators were included with direct dischargers.

[5]The relationship between impacts and entity size was also analyzed combining the direct and indirect dischargers. The results of this analysis are shown in Appendix E.

For the plotting analysis, each of the five measures of entity size were plotted against the two measures of impacts to determine whether a size (threshold) exists above which impacts are stable, i.e., the facility/product line(s) remain open. If any of the plots resemble a discontinuous step function, as illustrated in Figure 8.1, this would indicate that small entities would be impacted disproportionately if the regulation was applied uniformly.

The regressions examined the probability that a facility/product line would remain open as a function of entity size, using the following specification:

$$P(Yi=1)=\frac{e^{X_i\beta_i}}{1+e^{X_i\beta_i}}$$

where:

$P(Y_i=1)$	=	the probability that an entity's facility/product line(s) will remain open for a given entity size (X_i)
Y_i	=	decision to close facility/product line(s); 1=open, 0=close
e	=	base of natural logarithms (2.71828)
X_i	=	measure of entity size; and
β_i	=	the coefficient estimate for X_i.

Altogether, ten regression analyses were performed, each using one of the five measures of entity size as the independent variable and one of the two potential impacts (facility closure and product line closure) as the dependent variable.[6] [7] Coefficient estimates from the regression models that were positive and statistically different from zero would indicate that as entity size increases, the probability that a facility/product line will remain open also increases. This case would support the argument that a disproportionate number of small facilities would suffer adverse economic impacts if the regulation was applied uniformly.

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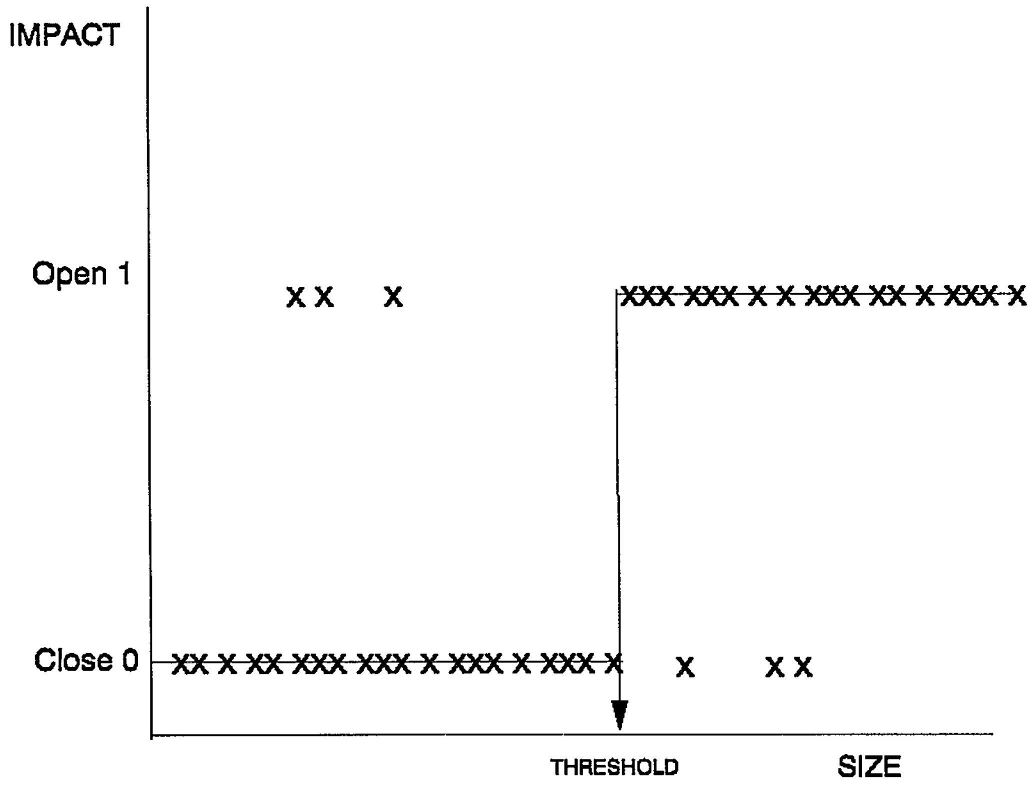
[6]All of the five independent variables incorporated in the ten different regression models are expected to be highly correlated because they all measure the same influence: entity size. For this reason, they were not examined together within the context of one regression model.

[7]A total of 30 plots resulted from the analysis, since the 10 regressions were examined for 3 discharge categories: direct dischargers, indirect dischargers, and all dischargers combined.

Figure 8.1

Discontinuous Step Function



8.2 Results

8.2.A Treated Discharge Option

Impact of Best Available Control Technology Economically Achievable (BAT) Regulations on Direct Dischargers

Under the Treated Discharge Option, no facility closures are projected for direct dischargers and two facilities are expected to close product lines. Employment data were available for both of the firms owning facilities expected to close product lines. Both of these firms are considered small based on the SBA size standard. Because two firms do not constitute a "substantial number of small entities," no further analysis of direct dischargers under the Treated Discharge Option was required.

Impact of Pretreatment Standards for Existing Sources (PSES) Regulations on Indirect Dischargers

Under the Treated Discharge Option, no indirect discharging facilities are expected to close and only one facility is expected to close a product line. The firm owning this facility is not small based on the SBA size standard; therefore, no further analysis of indirect dischargers under the Treated Discharge Option is required.

8.2.B Zero Discharge Option

Impact of BAT Regulations on Direct Dischargers

Under the Zero Discharge Option, 16 direct discharging facilities are expected to close and 3 facilities are expected to close a product line. Firm employment data were available for 13 of the 19 facilities projected to incur significant adverse impacts. Three of the 13 facilities for which firm employment data were available are small based on the SBA size standard. These three facilities are owned by three different firms. Because firm employment data are not available for all firms, the results of the first analytical stage are somewhat inconclusive. To ensure that disproportionate impacts on small entities are fully considered, the impacts on direct dischargers under the Zero Discharge Option are examined in the second analytical stage.

In the second stage of analysis, none of the ten plots (see Figures E.11 - E.20 in Appendix E) showing the relationship between the two impact measures and five measures of entity size for direct dischargers show a disproportionate impact on small entities.[8] In fact, some plots show that larger entities bear a disproportionately large portion of the impacts (see Figures E.16, E.17 and E.19).

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[8]All plots of entity size vs. impact can be found in Appendix E.

Table 8.1 presents the results of the ten regressions performed for direct discharging facilities under the Zero Discharge Option. To evaluate the data presented in Table 8.1, it is necessary to examine the coefficient estimates and their associated p-values.[9] If a coefficient is significantly different than 0 at the 90 percent confidence level ($p < .10$) and the coefficient is positive, then an increase in entity size is expected to increase the probability that a facility/product line remains open. If the coefficient is not significantly different than zero, then entity size is not expected to have an impact on whether a facility/product line remains open.

From the data shown in Table 8.1, it is evident that small entities are not disproportionately subject to facility/product line closures. Although the estimated coefficients for the size of the entity in eight of the ten models are significant at the 90 percent confidence level ($p < .10$), the estimates are all negative. Applying any of these estimates into the logistic regression equation previously presented shows that larger facilities have a higher probability than smaller facilities of closing. For example, if model 4 (Zero Discharge Option) is used to predict a facility closure, a facility with 100 pesticide-related FTEs would have a 0.39 probability of remaining open, while a facility employing 200 FTEs would have a 0.30 probability of remaining open.

Impact of PSES Regulations on Indirect Dischargers

Under the Zero Discharge Option, 11 indirect discharging facilities are expected to close and 3 facilities are projected to close a product line. Firm employment data were available for 13 of the 14 facilities projected to be impacted under the PSES regulation. Seven of the 13 facilities for which employment data were available are small based on the SBA size standard. These seven facilities are owned by seven different firms. Even without complete firm employment data, a substantial number of small entities are expected to be impacted significantly under the Zero Discharge Option. It is therefore necessary to advance to the second stage of the analysis to further evaluate the impacts on small entities for indirect dischargers under the Zero Discharge Option.

In examining the ten plots (see Figures E.21 - E.30 in Appendix E) showing the relationship between impacts and entity size for indirect dischargers, it does not appear that small indirect discharging facilities would be impacted disproportionately under the Zero Discharge Option. None of the figures resemble the discontinuous step function presented in Figure 8.1.

Table 8.2 shows the results of the ten regressions performed to examine the probability that an entity would be adversely impacted as a function of entity size for indirect dischargers under the Zero Discharge Option. The data presented in the table show that none of the coefficients are significant at the 90 percent

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[9] The p-value is the probability of obtaining the value of the coefficient if the true value were equal to zero. Small values of p are interpreted as an indication that the coefficient is not equal to zero.

Table 8.1
Logistic Regression Analysis
Zero Discharge Option: Direct Dischargers

Model #	# of Observations	Impact (y_i)	Measure of Entity Size (x_i)	Coefficient (β_i)	p value
1	45	Facility Closure	Pesticide Revenues	$-9.7E^{-9}$	.0027
2	45	Facility Closure	Facility Revenues	$-6.8E^{-9}$	.0094
3	44	Facility Closure	Firm Revenues	$-7.0E^{-11}$	.1297
4	46	Facility Closure	Pesticide Employment	$-4.3E^{-3}$	.0382
5	46	Facility Closure	Facility Employment	$-1.6E^{-3}$	.0496
6	20	Product Line Closure	Pesticide Revenues	$-2.0E^{-8}$	.0639
7	20	Product Line Closure	Facility Revenues	$-1.1E^{-8}$	.0344
8	20	Product Line Closure	Firm Revenues	$-1.9E^{-10}$	.1528
9	21	Product Line Closure	Pesticide Employment	$-1.5E^{-2}$	.0958
10	21	Product Line Closure	Facility Employment	$-2.6E^{-3}$	.0964

Note: At the 95 percent confidence level $p < .05$ indicates that the coefficient is significant, while $p < .10$ indicates significance at the 90 percent confidence level. Coefficients that are in shaded sections are significant to the 90 percent confidence level.

Table 8.2
Logistic Regression Analysis
Zero Discharge Option: Indirect Dischargers

Model #	# of Observations	Impact (y_i)	Measure of Entity Size (x_i)	Coefficient (β_i)	p value
1	27	Facility Closure	Pesticide Revenues	$-2.6E^{-8}$	.3158
2	27	Facility Closure	Facility Revenues	$-2.7E^{-9}$	.6746
3	26	Facility Closure	Firm Revenues	$-6.2E^{-11}$	.4532
4	27	Facility Closure	Pesticide Employment	$-1.8E^{-2}$	.1304
5	27	Facility Closure	Facility Employment	$-8.3E^{-4}$	.5717
6	12	Product Line Closure	Pesticide Revenues	$3.8E^{-9}$	.9141
7	12	Product Line Closure	Facility Revenues	$2.3E^{-8}$	.4317
8	11	Product Line Closure	Firm Revenues	$5.3E^{-9}$	.4187
9	12	Product Line Closure	Pesticide Employment	$-1.3E^{-2}$	.5867
10	12	Product Line Closure	Facility Employment	$7.4E^{-3}$	.4756

Note: At the 95 percent confidence level $p < .05$ indicates that the coefficient is significant, while $p < .10$ indicates significance at the 90 percent confidence level.

confidence level ($p < .10$). This result indicates that among indirect discharging facilities, entity size does not have a significant impact on whether a facility or product line remains open.

8.3 Conclusions

Under the proposed option, the Treated Discharge Option, it is not necessary to consider an alternative regulation for small businesses, since the regulation is not expected to have a significant impact on a substantial number of small entities. In addition, no alternative regulations for small businesses need to be considered under the Zero Discharge Option. Although a substantial number of small entities are expected to be impacted significantly under this option, the impacts are not expected to be disproportionate in comparison to those on larger businesses.

Chapter 8 Reference

Dun's Marketing Services, Inc. (1991). *Million Dollar Directory*. New Jersey.

Chapter 9: IMPACTS ON NEW SOURCES

9.0 Introduction

In this chapter, two categories of regulation are considered based on the manner in which a new source of pesticide active ingredients (PAIs) discharges wastewater. Direct dischargers are regulated under New Source Performance Standards (NSPS); indirect dischargers are regulated under Pretreatment Standards for New Sources (PSNS). New facilities using either discharge method have the opportunity to incorporate the best available demonstrated technologies, including process changes, in-plant controls, and end-of-pipe treatment technologies, and to use facility site selection to ensure adequate treatment system installation. Both NSPS and PSNS represent the most stringent numerical values attainable through the application of the best available demonstrated treatment technologies for nonconventional, conventional, and priority pollutants. (Zero discharge regulations were not considered for new sources due to the unacceptably large economic impacts projected for existing sources under this option.) The proposed NSPS and PSNS regulations, and the reasonableness of the associated costs, are discussed below by chemical subcategory.

9.1 New Source Performance Standards

Subcategory A (Organic Pesticide Chemicals Manufacturing)

The Environmental Protection Agency (EPA) is proposing NSPS under Subcategory A for the conventional pollutants regulated under Best Practicable Control Technology Currently Available (BPT), 122 organic PAIs, and 28 priority pollutants. The EPA proposes NSPS effluent limitations guidelines that equal Best Available Technology Economically Achievable (BAT) limitations, modified where appropriate to reflect the wastewater flow reduction capability at new facilities. Based on a comparison of wastewater generation and discharge practices at recently constructed vs. older pesticide manufacturing facilities, the EPA concluded that 28 percent wastewater flow reduction had been demonstrated at some of the newer facilities where appropriate. For this reason, the production-based mass limits developed for organic PAIs based on BAT treatment performance data were modified to reflect the 28 percent reduction in wastewater discharge at new facilities. For other non-conventional pollutants and conventional pollutants generated by Subcategory A, the proposed NSPS requires that the BPT limitations for biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) be modified to reflect the 28 percent wastewater flow reduction demonstrated at new facilities.

The projected impact of the NSPS on new sources is expected to be less burdensome than that of the BAT regulations on existing sources. Designing a new technology prior to facility construction is typically less expensive than retrofitting a facility for a new technology. Because the BAT technologies proposed for existing pesticide manufacturers were found to be economically achievable, with some existing facilities already achieving a 28 percent wastewater flow reduction, the proposed NSPS are expected to be economically achievable. Moreover, given the structure of the pesticide manufacturing industry, it is unlikely that expansions in the industry will occur through additional manufacture of currently produced PAIs. Instead, it is more likely that new PAIs will be manufactured at any expanded or new facilities. It is not possible to project NSPS guidelines for treatment of new PAIs, given the difficulty in predicting the nature of the treatability of new PAIs.

Subcategory B (Metallo-Organic Pesticide Chemicals Manufacturing)

The EPA is proposing to reserve NSPS for subcategory B chemicals because BPT already requires zero discharge of process wastewater pollutants.

9.2 Pretreatment Standards for New Sources

Subcategory A Chemicals

Proposed PSNS for the organic pesticide chemicals manufacturing subcategory are based on the proposed Pretreatment Standards for Existing Sources (PSES) technologies, modified where appropriate to reflect the 28 percent flow reduction capability at new facilities. As with Pretreatment Standards for Existing Sources (PSES), the PAI standards are production-based mass limits, while the priority pollutant standards are based on achievable concentrations. The EPA is proposing to establish PSNS for the same conventional pollutants, 122 organic PAIs, and 26 priority pollutants proposed under NSPS.

Similarly to NSPS, PSNS guidelines are expected to be economically achievable because the impact on new sources should be less than that on existing sources, and the proposed PSES guidelines have been found to be economically achievable. In addition, 28 percent reductions in wastewater flow have been demonstrated at some facilities. Also, as discussed above, it is more likely that new PAIs, rather than those currently produced, will be manufactured at any expanded or new facilities. The EPA does not believe it is possible to project PSNS guidelines for treatment of new PAIs, owing to the difficulty in predicting the nature of the treatability of new PAIs.

Subcategory B Chemicals

Under Subcategory B, the EPA is reserving the right to set PSNS at a later date. For this reason, economic impacts have not been calculated.

APPENDIX A

1986 PESTICIDE MANUFACTURER FACILITY CENSUS

Appendix A: 1986 PESTICIDE MANUFACTURER FACILITY CENSUS

This appendix includes Part B of the *Pesticide Manufacturer Facility Census for 1986*, which served as one of the main data sources for the EIA. Part B requested detailed economic and financial data from the facilities, including balance sheet and income statement information for 1985, 1986, and 1987. Part B was also designed to obtain information on facility liquidation values and the cost of capital.

Form Approved
OMB No.: 2040-0111
Expiration Date: 4/30/90

U.S. ENVIRONMENTAL PROTECTION AGENCY

PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986

PART B. FINANCIAL AND ECONOMIC INFORMATION

January 17, 1989

Public reporting burden for this collection of information is estimated to average 65 hours per response. The reporting burden includes time for reviewing instructions, gathering data, and completing and reviewing the questionnaire.

Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to:

Chief, Information Policy Branch (PM-223)
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

and

Office of Management and Budget
Paperwork Reduction Project
(2040-0111)
Washington, DC 20503

Part B: General Instructions

The Pesticide Manufacturing Facility Census has three parts:

Introduction;
Part A: Technical Information; and
Part B: Financial and Economic Information.

The Introduction and Part A were mailed separately and have been completed by your facility. **This package contains the Part B questionnaire and its instructions.** All recipients who completed the Introduction and Part A of the Pesticide Manufacturing Facility Census must complete Part B at this time.

Throughout this questionnaire you will be asked about the Pesticide Active Ingredients listed in Table 1, pages 4 through 12, of this booklet. It may be helpful to review the list and identify active ingredients handled at this facility before completing the questionnaire.

Authority

This mandatory census is conducted under the authority of Section 308 of the Clean Water Act (the Federal Water Pollution Control Act, 33 U.S.C. 1251 et seq., as amended). Late filing or failure otherwise to comply with these instructions may result in criminal fines, civil penalties and other sanctions as provided by law. Provisions concerning confidentiality of the data collected are explained below.

Purpose

The Pesticide Manufacturing Facility Census questionnaire is designed to collect data on pesticide manufacturing activities and waste treatment practices for the calendar year beginning January 1, 1986 and ending December 31, 1986. Part B requests financial and economic information for the calendar years 1985, 1986 and 1987.

Who Must Respond

All recipients who completed the Introduction and Part A of the Census questionnaire must complete Part B at this time. The entire Pesticide Manufacturing Facility Census questionnaire must be completed by all manufacturers of the Pesticide Active Ingredients listed in Table 1, pages 4 through 12, of this booklet.

Completing the Census

Although Part B may be completed by different officials, the individual who signed the certification for Part A should also certify all parts of the questionnaire by completing and signing the Part B Certification Statement located on page 3 of this questionnaire.

If the space allotted for the answer to any question is not adequate for your complete response, please continue the response in the Comments space at the end of each section. Reference the comments to the appropriate question.

GENERAL INSTRUCTIONS - Continued

When and How to Return the Part B Questionnaire

The Pesticide Manufacturing Facility Census Part B questionnaire must be completed and returned within 60 days of receipt to:

Dr. Lynne Tudor WH586
U.S. Environmental Protection Agency
Analysis and Evaluation Division
401 M Street, SW
Washington, D.C. 20460

Questions on the Part B Questionnaire

Questions pertaining to any item in Part B may be directed to:

Dr. Lynne Tudor WH586
U.S. Environmental Protection Agency
Analysis and Evaluation Division
401 M Street, SW
Washington, D.C. 20460
(202) 382 5834

Provisions Regarding Data Confidentiality

Regulations governing the confidentiality of business information are contained in 40 CFR Part 2 Subpart B and 43 Fed. Reg. 40001 (Sept. 8, 1978). Under these regulations, all records, reports, or information supplied to the EPA may be made public by the EPA without further notice if not accompanied by a business confidentiality claim. You may assert a business confidentiality claim covering part or all of the information you submit, other than effluent data, as described in 40 CFR 2.203(b):

> "(b) *Method and time of asserting business confidentiality claim.* A business which is submitting information to EPA may assert a business confidentiality claim covering the information by placing on (or attaching to) the information, at the time it is submitted to EPA, a cover sheet, stamped or typed legend, or other suitable form of notice employing language such as 'trade secret,' 'proprietary,' or 'company confidential.' Allegedly confidential portions of otherwise non-confidential documents should be clearly identified by the business, and may be submitted separately to facilitate identification and handling by EPA. If the business desires confidential treatment only until a certain date or until the occurrence of a certain event, the notice should so state."

Information covered by a claim of confidentiality will be disclosed by EPA only to the extent, and by means of the procedures, set forth in 40 CFR Part 2 Subpart B. In general, submitted records, reports, or information protected by a business confidentiality claim may be disclosed to other employees, officers, or authorized representatives of the United States concerned with carrying out the Clean Water Act, or when relevant to any proceeding under the Act. Effluent data are not eligible for confidential treatment.

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

ID

INTRODUCTION

1. Enter the name of this facility.

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| I1

2. Enter the EPA Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Establishment Number for this facility, as reported to the EPA on Form 3540-16 ("Pesticides Report for Pesticide-Producing Establishments"). Check the box next to "Not Applicable" if this facility does not have an EPA FIFRA Establishment Number:

|__|__|__|__|__| - |__|__| - |__|__|__| I2A ☐ Not Applicable I2B

3. Enter the DUNS Number of this facility. Check the box next to "Not Applicable if this facility does not have a DUNS Number.

|__|__| - |__|__|__| - |__|__|__|__| I3A ☐ Not Applicable I3B

4. Enter the facility mailing address.

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| I4A
Street or P.O. Box

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
City or Town I4B | State | I4C Zip Code I4D

5. Enter the address of the physical location of the facility if different from the mailing address.

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| I5A
Street or Route Number

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
City or Town I5B | State | I5C Zip Code I5D

6. Certification Statement

I certify that I have personally examined and am familiar with the information submitted in all three parts of the Census questionnaire and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Date Survey Completed: |__|__| - |__|__| - |__|__|__|__| I6A
Month Day Year

____
Signature of Certifying Official

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| I6B
Name of Certifying Official (please print or type)

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| I6D
Title

INTRODUCTION - Continued

7. Review the Pesticide Active Ingredients listed in Table 1 below and circle all codes that correspond to active ingredients manufactured, formulated or packaged at this facility.

TABLE 1. PESTICIDE ACTIVE INGREDIENTS

PAI
PAILIST

CODE	ACTIVE INGREDIENT
1	1,1-Bis(chlorophenyl)-2,2,2-trichloroethanol
2	1,2-Dihydro-3,6-pyridazinedione
3	1,2-Ethylene dibromide
4	1,3,5-Triethylhexahydro-s-triazine
5	1,3-Dichloropropene
6	10,10'-Oxybisphenoxarsine
7	1-(3-Chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride
8	1-(4-Chlorophenoxy)-3,3-dimethyl-1-(1H-1,2,4-triazol-1-yl)-2-butanone
9	2,2'-Methylenebis(3,4,6-trichlorophenol)
10	2,2'-Methylenebis(4,6-dichlorophenol
11	2,2'-Methylenebis(4-chlorophenol)
12	2,2-Dichlorovinyl dimethyl phosphate
13	2,3,5-Trimethylphenylmethylcarbamate
14	2,3,6-Trichlorophenylacetic acid or any salt or ester
14a	__________
14b	__________
14c	__________
14d	__________
15	2,4,5-Trichlorophenoxyacetic acid or any salt or ester
15a	__________
15b	__________
15c	__________
15d	__________
16	2,4-Dichlorophenoxyacetic acid or any salt or ester
16a	__________
16b	__________
16c	__________
16d	__________
17	2,4-Dichlorophenoxybutyric acid or any salt or ester
17a	__________
17b	__________
17c	__________
17d	__________
18	2,4-Dichloro-6-(o-chloroanilino)-s-triazine
19	2,4-Dintro-6-octylphenylcrotonate, 2,6-Dinitro-4-octylphenylcrotonate, and Nitrooctylphenols (The octyl's are a mixture of 1-Methylheptyl, 1-Ethylhexyl, and 1-Propylpentyl)
20	2,6-Dichloro-4-nitroaniline
21	2-Bromo-4-hydroxyacetophenone
22	2-Carbomethoxy-1-methylvinyl dimethyl phosphate, and related compounds
23	2-Chloroallyl diethyldithiocarbamate
24	2-Chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
25	2-Chloro-4-((1-cyano-1-methylethyl)amino)-6-ethylamino)-s-triazine
26	2-Chloro-N-isopropylacetanilide

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
27	2-Methyl-4-chlorophenoxyacetic acid or any salt or ester
27a	______
27b	______
27c	______
27d	______
28	2-n-Octyl-4-isothiazolin-3-one
29	2-Pivalyl-1,3-indandione
30	2-(2,4-Dichlorophenoxy)propionic acid or any salt or ester
30a	______
30b	______
30c	______
30d	______
31	2-(2-Methyl-4-chloropnenoxy)propionic acid or any salt or ester
31a	______
31b	______
31c	______
31d	______
32	2-(4-Thiazolyl)benzimidazole
33	2-(Methylthio)-4-(ethylamino)-6-(1,2-dimethylpropyl)amino-s-triazine
34	2-(m-Chlorophenoxy)propionic acid or any salt or ester
34a	______
34b	______
34c	______
34d	______
35	2-(Thiocyanomethylthio)benzothiazole
36	2-((Hydroxymethyl)amino) ethanol
37	2-((p-Chlorophenyl)phenylacetyl)-1,3-indandione
38	3,4,5-Trimethylphenylmethylcarbamate
39	3,5-Dichloro-N-(1,1-dimethyl-2-propynl)benzamide
40	3,5-Dimethyl-4-(methylthio)phenyl dimethylcarbamate
41	3',4'-Dichloropropionanilide
42	3-Iodo-2-propynyl butylcarbamate
43	3-(a-Acetonylfurfuryl)-4-hydroxycoumarin
44	4,6-Dinitro-o-cresol
45	4-Amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one
46	4-Chlorophenoxyacetic acid or any salt or ester
46a	______
46b	______
46c	______
46d	______
47	4-(2-Methyl-4-chlorophenoxy)butyric acid or any salt or ester
47a	______
47b	______
47c	______
47d	______
48	4-(Dimethylamino)-m-tolyl methylcarbamate
49	5-Ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole
50	6-Ethoxy-1,2-dihydro-2,2,4-trimethyl quinoline

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
51	8-Quinolinol sulfate
52	Acephate (O,S-Dimethyl acetylphosphoramidothioate)
53	Acifluoren (5-(2-Chloro-4-(trifluoromethyl)phenoxy)-2-nitrobenzoic acid) or any salt or ester
54	Alachlor (2-Chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide)
55	Aldicarb (2-Methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl)oxime)
56	Alkyl* dimethyl benzyl ammonium chloride *(50% C14, 40% C12, 10% C16)
57	Allethrin (all isomers and allethrin coil)
58	Ametryn (2-(Ethylamino)-4-(isopropylamino)-6-(methylthio)-s-triazine)
59	Amitraz (N'-2,4-Dimethylphenyl)-N-(((2,4-dimethylphenyl)imino)methyl)-N-methylmethanimidamide)
60	Atrazine (2-Chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine)
61	Bendiocarb (2,2-Dimethyl-1,3-benzodioxol-4-yl methylcarbamate)
62	Benomyl (Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate)
63	Benzene hexachloride
64	Benzyl benzoate
65	Beta-Thiocyanoethyl esters of mixed fatty acids containing from 10 - 18 carbon atoms
66	Bifenox (Methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate)
67	Biphenyl
68	Bromacil (5-Bromo-3-sec-Butyl-6-Methyluracil) or any salts or esters
68a	______
68b	______
68c	______
68d	______
69	Bromoxynil (3,5-Dibromo-4-hydroxybenzonitrile) or any salt or ester
69a	______
69b	______
69c	______
69d	______
70	Butachlor (N-(Butoxymethyl)-2-chloro-2',6'-diethylacetanilide)
71	b-Bromo-b-nitrostyrene (Note: b = beta)
72	Cacodylic acid (Dimethylarsenic acid) or any salts or ester
72a	______
72b	______
72c	______
72d	______
73	Captafol (cis-N-((1,1,2,2-Tetrachloroethyl)thio)-4-cyclohexene-1,2-dicarboximide)
74	Captan (N-Trichloromethylthio-4-cyclohexene-1,2-dicarboximide)
75	Carbaryl (1-Naphthylmethylcarbamate)
76	Carbofuran (2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate)
77	Carbosulfan (2,2-Dihydro-2,2-dimethyl-7-benzofuranyl(dibutylamino)thio)methylcarbamate)
78	Chloramben (3-Amino-2,5-dichlorobenzoic acid) or any salt or ester
78a	______
78b	______
78c	______
78d	______
79	Chlordane (Octachloro-4,7-methanotetrahydroindane)
80	Chloroneb (1,4-Dichloro-2,5-dimethoxybenzene)
81	Chloropicrin (Trichloronitromethane)
82	Chlorothalonil (2,4,5,6-Tetrachloro-1,3-dicyanobenzene)

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
83	Chloroxuron (3-(4-(4-Chlorophenoxy)phenyl)-1,1-dimethylurea)
84	Chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate
85	Chlorpyrifos methyl (O,O-Dimethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate)
86	Chlorpyrifos (O,O-Diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorthioate)
87	Coordination product of Manganese 16%, Zinc 2% and Ethylenebisdithiocarbamate 62%
88	Copper 8-quinolinolate
89	Copper ethylenediaminetetraacetate
90	Cyano(3-phenoxyphenyl)methyl 4-chloro-a-(1-methylethyl)benzeneacetate (9CA)
91	Cycloheximide (3-(2-(3,5-Dimethy-2-oxocyclohexyl)-2-hydroxyethyl)glutarimide)
92	Dalapon (2,2-Dichloropropionic acid) or any salt or ester
92a	
92b	
92c	
92d	
93	Decachloro-bis(2,4-cyclopentadiene-1-yl)
94	Demeton (O,O-Diethyl O-(and S-) (2-ethylthio)ethyl)phosphorothioate)
95	Desmedipham (Ethyl m-hydroxycarbanilate carbanilate)
96	Diammonium salt of ethylenebisdithiocarbamate
97	Dibromo-3-chloropropane
98	Dicamba (3,6-Dichloro-o-anisic acid) or any salt or ester
98a	
98b	
98c	
98d	
99	Dichlone (2,3-Dichloro-1,4-naphthoquinone)
100	Diethyl 4,4'-o-phenylenebis(3-thioallophanate)
101	Diethyl diphenyl dichloroethane and related compounds
102	Diethyl dithiobis(thionoformate)
103	Diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate
104	Diflubenzuron (N-(((4-Chlorophenyl)amino)carbonyl)-2,6-difluorobenzamide)
105	Diisobutylphenoxyethoxyethyl dimethyl benzyl ammonium chloride
106	Dimethoate (O,O-Dimethyl S-((methylcarbamoyl)methyl)phosphorothioate)
107	Dimethyl O-p-nitrophenyl phosphorothioate
108	Dimethyl phosphate ester of 3-hydroxy-N,N-dimethyl-cis-crotonamide
109	Dimethyl phosphate ester of a-methylbenzyl 3-hydroxy-cis-crotonate
110	Dimethyl tetrachloroterephthalate
111	Dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate
112	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)
113	Dioxathion (2,3-p-Dioxanedithiol S,S-bis(O,O-diethyl phosphorodithioate))
114	Diphacinone (2-(Diphenylacetyl)-1,3-indandione)
115	Diphenamid (N,N-Dimethyl-2,2-diphenylacetamide)
116	Diphenylamine
117	Dipropyl isocinchomeronate
118	Disodium cyanodithioimidocarbonate
119	Diuron (3-(3,4-Dichlorophenyl)-1,1-dimethylurea)
120	Dodecylguanidine hydrochloride
121	Dodine (Dodecylguanidine acetate)
122	Endosulfan (Hexachlorohexaahydromethano-2,4,3-benzodioxathiepin-3-oxide)

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
123	Endothall (7-Oxabicyclo(2 2 1)heptane-2,3-dicarboxylic acid) or any salt or ester
123a	______________
123b	______________
123c	______________
123d	______________
124	Endrin (Hexachloroepoxyoctahydro-endo,endo-dimethanonaphthalene)
125	Ethalfluralin (N-Ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzeneamine)
126	Ethion (O,O,O',O'-Tetraethyl S,S'-methylene bisphosphorodithioate)
127	Ethoprop (O-Ethyl S,S-dipropyl phosphorodithioate)
128	Ethyl 3-methyl-4-(methylthio)phenyl 1-(methylethyl) phosphoramidate
129	Ethyl 4,4'-dichlorobenzilate
130	Ethyl diisobutylthiocarbamate
131	Famphur (O,O-Dimethyl O-(p-(dimethylsulfamoyl)phenyl)phosphorothioate)
132	Fenarimol (a-(2-Chlorophenyl)-a-(4-chlorophenyl)-5-pyrimidinemethanol)
133	Fenthion (O,O-Dimethyl O-(4-methylthio)-m-tolyl)phosphorothioate)
134	Ferbam (Ferric dimethyldithiocarbamate)
135	Fluometuron (1,1-Dimethyl-3-(a,a,a-trifluoro-m-tolyl)urea)
136	Fluoroacetamide
137	Folpet (N-((Trichloromethyl)thio)phthalimide)
138	Glyphosate (N-(Phosphonomethyl)glycine) or any salt or ester
138a	______________
138b	______________
138c	______________
138d	______________
139	Glyphosine (N,N-bis(Phosphonomethyl)glycine)
140	Heptachlor (Heptachlorotetrahydro-4,7-methanoindene)
141	Hexadecyl cyclopropanecarboxylate
142	Hexazinone (3-Cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione)
143	Isofenphos (1-Methylethyl 2-((ethoxy((1-methylethyl)amino)phosphinothioyl)oxy)benzoate)
144	Isopropalin (2,6-Dinitro-N,N-dipropylcumidine)
145	Isopropyl N-phenyl carbamate
146	Karbutilate (tert-Butylcarbamic acid ester of 3-(m-hydroxyphenyl)-1,1-dimethylurea)
147	Lindane (gamma isomer of benzene hexachloride) 99% pure
148	Linuron (3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea)
149	Malachite green (Ammonium (4-(p-(dimethylamino)-alpha-phenylbenzylidine)-2, 5-cyclohexadien-1-ylidene)-dimethyl chloride
150	Malathion (O,O-Dimethyl dithiophosphate of diethyl mercaptosuccinate)
151	Maneb (Manganese salt of ethylenebisdithiocarbamate)
152	Manganese dimethyldithiocarbamate
153	Mefluidide (N-(2,4-Dimethyl-5-(((trifluoromethyl)sulfonyl)amino)phenyl acetamide) or any salt or ester
153a	______________
153b	______________
153c	______________
153d	______________
154	Methamidophos (O,S-Dimethyl phosphoramidothioate)
155	Methidathion (O,O-Dimethyl phosphorodithioate, S-ester of 4-(mercaptomethyl)-2-methoxy-delta 2-1,3,4-thiadiazolin-5-one)
156	Methomyl (S-Methyl N-((methylcarbamoyl)oxy)thioacetimidate)

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
157	Methoprene (Isopropyl(E,E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate)
158	Methoxychlor (2,2-bis(p-Methoxyphenyl)-1,1,1-trichloroethane)
159	Methyl benzethonium chloride
160	Methyl bromide
161	Methylarsonic acid or any salt or ester
161a	
161b	
161c	
161d	
162	Methyldodecylbenzyl trimethyl ammonium chloride 80% and methyldodecylxylylene bis(trimethylammonium chloride) 20%
163	Methylene bisthiocyanate
164	Methyl-2,3-quinoxalinedithiol cyclic S,S-dithiocarbonate
165	Metolachlor (2-Chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide)
166	Mexacarbate (4-(Dimethylamino)-3,5-xylyl methylcarbamate)
167	Mixture of 83.9% Ethylenebis(dithiocarbamato) zinc and 16.1% Ethylenebisdithiocarbamate, bimolecular and trimolecular cyclic anhydrosulfides and disulfides
168	Monuron TCA = Monuron trichloroacetate
169	Monuron (3-(4-Chlorophenyl)-1,1-dimethylurea)
170	N,N-Diethyl-2-(1-naphathalenyloxy)propionamide
171	N,N-Diethyl-meta-toluamide and other isomers
172	Nabam (Disodium salt of ethylenebisdithiocarbamate)
173	Naled (1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate)
174	Norea (3-Hexahydro-4,7-methanoindan-5-yl-1,1-dimethylurea)
175	Norflurazon (4-Chloro-5-(methylamino)-2-(a,a,a-trifluoro-m-tolyl)-3(2H)-pyridazinone)
176	N-1-Naphthylphthalamic acid or any salt or ester
176a	
176b	
176c	
176d	
177	N-2-Ethylhexyl bicycloheptene dicarboximide
178	N-Butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine
179	O,O,O,O-Tetraethyl dithiopyrophosphate
180	O,O,O,O-Tetrapropyl dithiopyrophosphate
181	O,O-Diethyl O-(3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl) phosphorothioate
182	O,O-Diethyl O-(p-(methylsulfinyl)phenyl) phosphorothioate
183	O,O-Diethyl S-(2-(ethylthio)ethyl) phosphorodithioate
184	O,O-Dimethyl O-(4-nitro-m-tolyl)phosphorothioate
185	O,O-Dimethyl S-(phthalimidomethyl)phosphorodithioate
186	O,O-Dimethyl S-((4-oxo-1,2,3-benzotriazin-3(4H)-yl)methyl)phosphorodithioate
187	O,O-Dimethyl S-((ethylsulfinyl)ethyl phosphorothioate
188	Organo-arsenic pesticides (not otherwise listed)
188a	
188b	
188c	
188d	

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
189	Organo-cadmium pesticides
189a	______________________________
189b	______________________________
189c	______________________________
189d	______________________________
190	Organo-copper pesticides
190a	______________________________
190b	______________________________
190c	______________________________
190d	______________________________
191	Organo-mercury pesticides
191a	______________________________
191b	______________________________
191c	______________________________
191d	______________________________
192	Organo-tin pesticides
192a	______________________________
192b	______________________________
192c	______________________________
192d	______________________________
193	Orthodichlorobenzene
194	Oryzalin (3,5-Dinitro-N4,N4-dipropylsulfanilamide) (Note: N4 = N superscript 4)
195	Oxamyl (Methyl N',N'-dimethyl-N-((methylcarbamoyl)oxy)-1-thiooxamidate)
196	Oxyfluorfen (2-Chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene)
197	O-Ethyl O-(4-(methylthio)phenyl) S-propyl phosphorodithioate
198	O-Ethyl O-(4-(methylthio)phenyl) S-propyl phosphorothioate (9CA)
199	O-Ethyl O-(p-Nitrophenyl)phenylphosphonothioate
200	O-Ethyl S-phenyl ethylphosphonodithioate
201	O-Isopropoxyphenyl methylcarbamate
202	Paradichlorobenzene
203	Parathion (O,O-Diethyl O-(p-nitrophenyl)phosphorothioate)
204	Pendimethalin (N-(1-Ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine)
205	Pentachloronitrobenzene
206	Pentachlorophenol or any salt or ester
206a	______________________________
206b	______________________________
206c	______________________________
206d	______________________________
207	Perfluidone (1,1,1-Trifluoro-N-(2-methyl-4-(phenylsulfonyl)phenyl)methanesulfonamide)
208	Permethrin ((3-Phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate)
209	Phenmedipham (Methyl m-hydroxycarbanilate m-methyl carbanilate)
210	Phenothiazine
211	Phenylphenol
212	Phorate (O,O-Diethyl S-((ethylthio)methyl)phosphorodithioate)
213	Phosalone (O,O-Diethyl S-((6-chloro-2-oxobenzoxazolin-3-yl)methyl) phosphorothioate)
214	Phosphamidon (2-Chloro-N,N-diethyl-3-hydroxycrotonamide ester of dimethyl phosphate)

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
215	Picloram (4-Amino-3,5,6-trichloropicolinic acid) or any salts or esters
215a	______
215b	______
215c	______
215d	______
216	Piperonyl butoxide ((Butylcarbityl)(6-propylpiperonyl)ether)
217	Poly(oxyethylene(dimethyliminio)ethylene(dimethyliminio)ethylene dichloride
218	Potassium dimethyldithiocarbamate
219	Potassium N-hydroxymethyl-N-methyldithiocarbamate
220	Potassium N-methyldithiocarbamate
221	Potassium N-(a-(nitroethyl)benzyl)ethylenediamine
222	Profenofos (O-(4-Bromo-2-chlorophenyl) O-ethyl S-propyl phosphorothioate)
223	Prometon (2,4-bis(Isopropylamino)-6-methoxy-s-triazine)
224	Prometryn (2,4-bis(Isopropylamino)-6-(methylthio)-s-triazine)
225	Propargite (2-(p-tert-Butylphenoxy)cyclohexyl 2-propynyl sulfite)
226	Propazine (2-Chloro-4,6-bis(isopropylamino)-s-triazine)
227	Propionic acid
228	Propyl (3-dimethylamino)propyl carbamate hydrochloride
229	Pyrethrin coils
230	Pyrethrin I
231	Pyrethrin II
232	Pyrethrum (synthetic pyrethrin)
233	Resmethrin ((5-Phenylmethyl)-3-furanyl)methyl 2,2-dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylate)
234	Ronnel (O,O-Dimethyl O-(2,4,5-trichlorophenyl)phosphorothioate)
235	Rotenone
236	S,S,S-Tributyl phosphorotrithioate
237	Siduron (1-(2-Methylcyclohexyl)-3-phenylurea
238	Silvex (2-(2,4,5-Trichlorophenoxypropionic acid)) or any salt or ester
238a	______
238b	______
238c	______
238d	______
239	Simazine (2_Chloro-4,6-bis(ethylamino)-s-triazine)
240	Sodium bentazon (3-Isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide)
241	Sodium dimethyldithiocarbamate
242	Sodium fluoroacetate
243	Sodium methyldithiocarbamate
244	Sulfoxide (1,2-Methylenedioxy-4-(2-(octylsulfidynyl)propyl) benzene
245	S-Ethyl cyclohexylethylthiocarbamate
246	S-Ethyl dipropylthiocarbamate
247	S-Ethyl hexahydro-1H-azepine-1-carbothioate
248	S-Propyl butylethylthiocarbamate
249	S-Propyl dipropylthiocarbamate
250	S-(2-Hydroxypropyl)thiomethanesulfonate
251	S-(O,O-Diisopropyl phosphorodithioate ester of N-(2-mercaptoethyl)benzenesulfonamide
252	Tebuthiuron (N-(5-(1,1-Dimethylethyl)-1,3,4-thiadiazol-2-yl)-N,N'-dimethylurea)
253	Temephos (O,O,O',O'-Tetramethyl-O,O'-thiodi-p-phenylenephosphorothioate)

TABLE 1. PESTICIDE ACTIVE INGREDIENTS - Continued

CODE	ACTIVE INGREDIENT
254	Terbacil (3-tert-Butyl-5-chloro-6-methyluracil)
255	Terbufos (S-(((1,1-Dimethylethyl)thio)methyl) O,O-diethyl phosphorodithioate)
256	Terbuthylazine (2-(tert-Butylamino)-4-chloro-6-(ethylamino)-s-triazine
257	Terbutryn (2-(tert-Butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine)
258	Tetrachlorophenol or any salt or ester
258a	
258b	
258c	
258d	
259	Tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione
260	Thiophanate-methyl (Dimethyl 4,4'-o-phenylenebis(3-thioallophanate))
261	Thiram (Tetramethylthiuram disulfide)
262	Toxaphene (technical chlorinated camphene (67-69% chlorine))
263	Tributyl phosphorotrithioite
264	Trifluralin (a,a,a-Trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine)
265	Warfarin (3-(a-Acetonylbenzyl)-4-hydroxycoumarin) or any salt or ester
265a	
265b	
265c	
265d	
266	Zinc 2-mercaptobenzothiazolate
267	Zineb (Zinc ethylenebisdithiocarbamate)
268	Ziram (Zinc dimethyldithiocarbamate)
269	(2,3,3-Trichloroallyl)diisopropylthiocarbamate
270	(3-Phenoxyphenyl)methyl d-cis and tran* 2,2-dimethyl-3-(2-methylpropenyl)cyclopropanecarboxylate *(Max. d-cis 25% ; Min. trans 75%)
271	(4-Cyclohexene-1,2-dicarboximido)methyl 2,2-dimethyl-3-(2-methylpropenyl)cyclopropanecarboxylate
272	Isopropyl N-(3-chlorophenyl) carbamate

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 1: FIRM FINANCIAL INFORMATION

1-A. Was this facility owned or controlled by a parent firm or firms on December 31, 1986?

S1A

YES .... 1 (GO TO BOX 1-A)
NO .... 2 (SKIP TO SECTION 2, PAGE 18)

BOX 1-A

If there is more than one parent firm, such as in a joint venture, photocopy Section 1, pages 13 through 16, and complete all Section 1 questions for each parent firm.

1-B. Report the name, mailing address and DUNS number of the parent firm.

[1] Name of Parent Firm

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1B1

[2] Mailing Address of Headquarters

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1B2A
Street or P.O.Box

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
City or Town | State | Zip Code

S1B2B S1B2C S1B2D

[3] What is the DUNS Number of the parent firm?

|__|__| - |__|__|__| - |__|__|__|__| ☐ Not Applicable

S1B3A S1B3B

1-C. Report the percentage of the parent firm's total 1986 sales (in dollars) generated by each of the activities listed below. (Enter zero if the activity was not applicable. The sum of all percentages must be 100%).

[1] Percentage of sales generated by manufacturing pesticides listed in Table 1, pages 4 through 12 .... S1C1 |__|__|__|%

[2] Percentage of sales generated by formulating or packaging pesticides listed in Table 1, pages 4 through 12 .... S1C2 |__|__|__|%

[3] Percentage of sales generated by other activities (SPECIFY) .... |__|__|__|%

S1C3A (Variable) S1C3B (Description)

Total .... 1 0 0 %

SECTION 1: FIRM FINANCIAL INFORMATION

1-D. Did the parent firm acquire this facility after December 31, 1980?

S1D

YES .... 1 (CONTINUE)
NO .... 2 (SKIP TO QUESTION 1-E)

[1] In what year was this facility acquired by the parent firm?

|1|9|__|__|
Year S1D1

[2] How was this facility acquired by the parent firm? (CHECK ONE): S1D2

☐ Purchase

☐ Merger: Please list names of the companies that merged

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1D2A

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1D2B

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1D2C

☐ Takeover

☐ Founded

☐ Other (SPECIFY) ____________________________

1-E. On December 31, 1986, did the parent firm own or control any other U.S. facilities at which any of the pesticides listed on Table 1, pages 4 through 12, were manufactured or formulated and/or packaged?

S1E

YES .... 1 (CONTINUE)
NO .... 2 (SKIP TO QUESTION 1-G)

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 1: FIRM FINANCIAL INFORMATION

1-F. Report the names and EPA Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Establishment Numbers (as reported to the EPA on Form 3540-16) for all other facilities owned or controlled by the parent firm at which any of the pesticides listed on Table 1, pages 4 through 12, were manufactured or formulated and/or packaged. Check the box next to "Not Applicable" if the facility does not have an EPA FIFRA Establishment Number. Check whether each facility was a manufacturer or formulator/packager of the pesticides listed on Table 1. If more space is required to give a complete answer to this question, photocopy this page.

[1] |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| S1F1A
Name of Facility

S1F1B |_|_|_|_|_|-|_|_|-|_|_|_| ☐ Not Applicable S1F1C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager
S1F1D S1F1E

[2] |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| S1F2A
Name of Facility

S1F2B |_|_|_|_|_|-|_|_|-|_|_|_| ☐ Not Applicable S1F2C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager
S1F2D S1F2E

[3] |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| S1F3A
Name of Facility

S1F3B |_|_|_|_|_|-|_|_|-|_|_|_| ☐ Not Applicable S1F3C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager
S1F3D S1F3E

[4] |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_| S1F4A
Name of Facility

S1F4B |_|_|_|_|_|-|_|_|-|_|_|_| ☐ Not Applicable S1F4C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager

S1F4D S1F4E

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 1: FIRM FINANCIAL INFORMATION

1-F. Report the names and EPA Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Establishment Numbers (as reported to the EPA on Form 3540-16) for all other facilities owned or controlled by the parent firm at which any of the pesticides listed on Table 1, pages 4 through 12, were manufactured or formulated and/or packaged. Check the box next to "Not Applicable" if the facility does not have an EPA FIFRA Establishment Number. Check whether each facility was a manufacturer or formulator/packager of the pesticides listed on Table 1. If more space is required to give a complete answer to this question, photocopy this page.

[1] |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1F5A
Name of Facility

S1F5B |__|__|__|__|__|-|__|__|-|__|__|__| ☐ Not Applicable S1F5C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager
S1F5D S1F5E

[2] |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1F6A
Name of Facility

S1F6B |__|__|__|__|__|-|__|__|-|__|__|__| ☐ Not Applicable S1F6C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager

S1F6D S1F6E

[3] |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1F7A
Name of Facility

S1F7B |__|__|__|__|__|-|__|__|-|__|__|__| ☐ Not Applicable S1F7C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager

S1F7D S1F7E

[4] |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| S1F8A
Name of Facility

S1F8B |__|__|__|__|__|-|__|__|-|__|__|__| ☐ Not Applicable S1F8C
EPA FIFRA Establishment Number

☐ Manufacturer ☐ Formulator/Packager

S1F8D S1F8E

SECTION 1: FIRM FINANCIAL INFORMATION

1-G. Report the total revenue of the parent firm for 1985, 1986, and 1987 in thousands of dollars.

($000)

[1] 1985 Revenue .... ____________

[2] 1986 Revenue .... ____________

[3] 1987 Revenue .... ____ ______

1-H. Was the parent firm (listed on question 1B) itself owned or controlled by another company?

SIH

YES .... 1 (CONTINUE)
NO .... 2 (SKIP TO SECTION 2)

1-I. Report the name, mailing address and DUNS number of the controlling firm.

[1] Name

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| SII1

[2] Mailing Address of Headquarters

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| SII2A
Street or P.O.Box

|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
City or Town | State | Zip Code
SI

[3] DUNS Number

|__|__| - |__|__|__| - |__|__|__|__| ☐ Not Applicable

SECTION 1: FIRM FINANCIAL INFORMATION

Section 1 Comments. Reference entry by question number.

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 2: FACILITY FINANCIAL INFORMATION

All of the information requested in Section 2 applies to this facility.

2-A. Report the percent by quantity of total 1986 production volume generated by each of the following activities at this facility. (Enter zero if the activity was not applicable. The sum of all percentages must be 100%).

[1] Production generated by manufacturing and/or formulating and packaging pesticide active ingredients listed in Table 1, pages 4 through 12 .... S2A1 ___ ___ ___ %

[2] Production generated by manufacture of intermediates that are sold .... S2A2 ___ ___ ___ %

[3] Production generated by manufacturing and/or formulating and packaging EPA registered pesticides not listed in Table 1, pages 4 through 12 .... S2A3 ___ ___ ___ %

[4] Production generated by manufacturing and/or formulating and packaging chemicals other than EPA registered pesticides .... S2A4 ___ ___ ___ %

[5] Production generated by other activities (SPECIFY) .... ___ ___ ___ %
S2A5A(Variable), S2A5B (Description)

Total .... 1 0 0 %

2-B. Report the calendar year during which:

[1] Operations began at this facility .... S2B1 ___ ___ ___ ___ Year

[2] Manufacturing and/or formulating/packaging of either pesticide active ingredients or pesticide products began at this facility .... S2B2 ___ ___ ___ ___ Year

[3] The most recent major expansion of plant and equipment with respect to pesticides occurred at this facility .... S2B3 ___ ___ ___ ___ Year

SECTION 2: FACILITY FINANCIAL INFORMATION

2-C. Instructions for reporting Balance Sheet information on page 21.

Question 2-C on page 21 requests facility Balance Sheet information. Please read the instructions and definitions below before completing Question 2-C. The number in brackets, for example, "[1] Inventories," correspond to Balance Sheet entries.

Reporting Period

Amounts for items in the Balance Sheets must be reported as of December 31, of calendar years 1985, 1986 and 1987 or the last day of the facility fiscal year. If your facility does not operate on a calendar year, you may substitute fiscal year data.

Reporting Conventions

Report all data for the facility. Report all dollar amounts in thousands.

If, for certain items, you do not have amounts at the facility level, you may use the balance sheets of the firm that owns and controls your facility to estimate the amounts at the facility level. Base the estimate on your facility's share of sales. If you have estimated an amount for a particular item, then place an asterisk (*) to the right of the entry.

Balance Sheet Definitions

Current Assets: Report current assets, including cash and other assets that are reasonably expected to be converted to cash, sold or consumed during the year.

[1] **Inventories:** Report the total value of all inventories owned by this facility regardless of where the inventories are held. Inventories consist of finished products, products in the process of being manufactured, raw materials, supplies, fuels etc. Report inventories at cost or market value, whichever is lower.

[2] **Other Current Assets:** Report all other current assets such as prepaid expenses like rent, operating supplies, and insurance; also include cash and accounts receivable.

[3] **Total Current Assets:** Report the sum of items [1] and [2].

SECTION 2: FACILITY FINANCIAL INFORMATION

2-C. Instructions for reporting Balance Sheet information on page 21 - continued

Noncurrent Assets: Report the total dollar value of all noncurrent assets, including physical items such as property, plant and equipment; long-term investments and intangibles. Include:

Land: Report the original cost of land.
Buildings/Plant: Report the cost of buildings including expansions and renovations net of depreciation.
Equipment and Machinery: Report the cost of all equipment and machinery net of depreciation.
Intangibles: Report intangibles including franchises, patents, trademarks, copyrights net of accumulated amortization.
Other Noncurrent Assets: Report all noncurrent assets, like investments in capital stocks and bonds.

[4] **Total Noncurrent Assets:** Report the total noncurrent assets from each of the items listed above that apply.

[5] **Total Current and Noncurrent Assets:** Report the sum of items [3] and [4].

Current Liabilities: Report the total dollar value of all current liabilities that fall due for payment within the year.

[6] **Total Current Liabilities:** Report all current liabilities like accounts payable, accrued expenses and taxes and the current portion of long-term debt.

Noncurrent Liabilities and Equity: Report all noncurrent liabilities that fall due beyond one year.

[7] **Long Term Debt and Other Noncurrent Liabilities:** Report all long-term debt such as bonds, debentures, and bank debt, and all other noncurrent liabilities like deferred income taxes.

[8] **Owner Equity:** Report the difference between total assets and total liabilities. The amount obtained should include contributed or paid in capital (preferred and common stock) and retained earnings.

[9] **Total Noncurrent Liabilities and Equity:** Report the sum of items [7] and [8].

[10] **Total Liabilities and Equity:** Report the sum of items [6] and [9].

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 2: FACILITY FINANCIAL INFORMATION

2-C. Complete the facility Balance Sheet: Table 2-C below. Enter all information in thousands of dollars as of December 31 for calendar years 1985, 1986, and 1987. If the facility fiscal year does not correspond to the calendar year, please enter the months of the facility fiscal year below.

Facility 1986 fiscal year was from S2CA month to S2CB month.

TABLE 2-C. BALANCE SHEET

ASSETS

Current assets		1985 ($000)	1986 ($000)	1987 ($000)
[1]	Inventories	S2C1A	S2C1B	S2C1C
[2]	Other current assets	S2C2A	S2C2B	S2C2C
[3]	Total current assets	S2C3A	S2C3B	S2C3C
Noncurrent assets				
[4]	Total noncurrent assets	S2C4A	S2C4B	S2C4C
[5]	Total current and noncurrent assets	S2C5A	S2C5B	S2C5C

LIABILITIES AND EQUITY

Current liabilities		1985 ($000)	1986 ($000)	1987 ($000)
[6]	Total current liabilities	S2C6A	S2C6B	S2C6C
Noncurrent liabilities and equity				
[7]	Long term debt and other noncurrent liabilities	S2C7A	S2C7B	S2C7C
[8]	Owner equity	S2C8A	S2C8B	S2C8C
[9]	Total noncurrent liabilities and equity	S2C9A	S2C9B	S2C9C
[10]	Total liabilities and equity	S2C10A	S2C10B	S2C10C

SECTION 2: FACILITY FINANCIAL INFORMATION

2-D. Instructions for reporting facility Income Statement information on page 24.

Question 2-D on page 24 requests facility income and expense information. Please read the instructions and definitions below before completing Question 2-D. The numbers in brackets, for example, "[1] Sales of Pesticide Chemicals," correspond to the entries on Table 2-D.

Reporting Period

Amounts for items in the Income Statements must be reported as of December 31 of calendar years 1985, 1986 and 1987 or the last day of the facility fiscal year. If your facility does not operate on a calendar year basis, you may substitute fiscal year data.

Reporting Conventions

Report all data for the facility. Report all dollar amounts in thousands.

If, for certain items, you do not have amounts at the facility level, you may use the Income Statements of the firm that owns and controls your facility to estimate the amounts at the facility level. If you need to estimate any items, estimate them based on your facility's share of sales. If you have estimated an amount for a particular item, then place an asterisk (*) to the right of the entry.

Income Statement Definitions

Revenues

[1] **Sale of Pesticide Chemicals:** Report the total sales value of all pesticide chemicals. This should include all pesticide active ingredients, intermediates, and finished pesticide products. In cases where the pesticide chemical is not sold (there is no known sales price) but is transferred to another facility owned by the company for further processing and/or formulating/packaging, the facility share of sales generated by the final product should be allocated to the facility. This share should be estimated based on its percent of total production costs. Divide the sale of pesticide chemicals into the following categories:

- [a] **Pesticide chemicals listed in Table 1:** Report revenues from the manufacture and/or formulating/packaging of pesticide active ingredients listed in Table 1, pages 4 through 12 or intermediates produced during the manufacture of active ingredients listed in Table 1.
- [b] **Other Registered Pesticide Chemicals:** Report revenues from pesticide chemicals not reported in [1a].

[2] **Revenue from Pesticide Contract Work or Tolling:** Report the revenue from pesticide contract work done by this facility for other facilities or firms.

[3] **Other Revenue:** Report all other revenues like the sales value of products and services not reported in items [1] and [2].

[4] **Total Facility Revenues:** Report the sum of items [1] through [3].

SECTION 2: FACILITY FINANCIAL INFORMATION

2-D. Instructions for reporting facility Income Statement information on page 24 - continued

Expenses

Manufacturing Costs (Cost of Materials and Services Used): Include all manufacturing and/or formulating/packaging costs like direct materials, direct labor and indirect costs that were either put into production, used as operating supplies, or used in repair and maintenance. Report total delivered cost after discounts and including freight of materials actually consumed or put into production during the year. Include purchases, cost of interplant transfers to the facility, and withdrawal from inventories.

Pesticides

[5] **Material and Product Costs:** Report the total cost of all raw materials including packaging materials that were used in the production and/or formulating/packaging of pesticide chemicals/products. Include cost of products bought and sold.

[6] **Direct Labor Costs:** Report the total cost, including fringe benefits, of all direct labor that can be traced to the production and/or formulating/packaging of pesticide chemicals/products.

[7] **Cost of Pesticide Contract Work or Tolling:** Report the cost of all contract work done for you by others using materials furnished by your facility. Include the total payments made during the year for such work, including freight out and in.

[8] **Other Pesticide Costs:** Include all other pesticide related expenses, such as effluent treatment and disposal, and energy used directly in producing the product, not included in [5] through [7].

Non Pesticides

[9] **Nonpesticide Costs:** Report all other manufacturing costs not included in items [5] through [8]. Include manufacturing costs associated with nonpesticide chemicals or products. Report the types of cost for items [5] through [8] for nonpesticide products and services.

Report the expenses listed below for the whole facility, not just pesticides.

[10] **Depreciation:** Report the depreciation on buildings, plant, equipment, and machinery at your facility.

[11] **Fixed Overheads:** Report the total from all types of overhead. Include rent, nonproduction utilities, selling costs, administration and general expenses for your facility.

[12] **Research and Development:** Report all research and development costs incurred during the year.

[13] **Interest:** Report the total interest expense on all funds during the year.

[14] **Federal, State and Local Taxes:** Report the total federal, state and local taxes payable during the year.

[15] **Other Expenses:** Report all other expenses not reported in items [10] through [14].

[16] **Total Costs and Expenses:** Report the sum of items [5] through [15].

ENVIRONMENTAL PROTECTION AGENCY
PESTICIDE MANUFACTURING FACILITY CENSUS FOR 1986
Part B Financial and Economic Information

SECTION 2: FACILITY FINANCIAL INFORMATION

2-D. Complete the facility Income Statements, Table 2-D below. Enter all information in thousands of dollars as of December 31 for calendar years 1985, 1986, and 1987. If the facility fiscal year does not correspond to the calendar year, please enter the months of the facility fiscal year below.

Facility 1986 fiscal year was from S2DA month to S2DB month.

TABLE 2-D. INCOME STATEMENTS

REVENUES	1985 ($000)	1986 ($000)	1987 ($000)
[1] Sales of pesticide chemicals			
[a] Pesticide chemicals listed in Table 1	S2D1AA	S2D1AB	S2D1AC
[b] Other registered pesticide chemicals	S2D1BA	S2D1BB	S2D1BC
[2] Revenue from pesticide contract work or tolling	S2D2A	S2D2B	S2D2C
[3] Other revenue	S2D3A	S2D3B	S2D3C
[4] Total facility revenues	S2D4A	S2D4B	S2D4C

EXPENSES	1985 ($000)	1986 ($000)	1987 ($000)
Manufacturing costs			
[5] Pesticide material and product costs	S2D5A	S2D5B	S2D5C
[6] Pesticide direct labor costs	S2D6A	S2D6B	S2D6C
[7] Cost of pesticide contract work	S2D7A	S2D7B	S2D7C
[8] Other pesticide costs	S2D8A	S2D8B	S2D8C
[9] Nonpesticide costs	S2D9A	S2D9B	S2D9C
Facility costs			
[10] Depreciation	S2D10A	S2D10B	S2D10C
[11] Fixed overheads	S2D11A	S2D11B	S2D11C
[12] Research and development	S2D12A	S2D12B	S2D12C
[13] Interest	S2D13A	S2D13B	S2D13C
[14] Federal, state and local taxes	S2D14A	S2D14B	S2D14C
[15] Other expenses	S2D15A	S2D15B	S2D15C
[16] Total costs and expenses	S2D16A	S216B	S2D16C

SECTION 2: FACILITY FINANCIAL INFORMATION

2-E. Did this facility borrow funds to finance a capital investment during calendar year 1986?

S2E

YES .... 1 (CONTINUE)
NO .... 2 (SKIP TO QUESTION 2-G)

2-F. What was the 1986 interest rate charged? ......S2F...................................... |__|__|__ %

2-G. Enter the number of years over which a typical capital project is financed.

S2G ________ years

Comments for Section 2: Questions 2-A through 2-G. Reference entry by question number.

SECTION 2: FACILITY FINANCIAL INFORMATION

Does the respondent choose to have the Agency assess economic impacts based on financial averages calculated from information submitted in Part A and Part B (without data requested in Tables 2H, I, and J) of this census for all products within a given facility (manufacturing site)?

Note: The use of financial averages to represent all products at a facility may affect the accuracy of economic impact projections for some products.

_____ YES .... 1 (SKIP TO SECTION 2-K ____ PAGE 38)

NO .... 2 (CONTINUE)

2-H. This section requests information on Table 1 Pesticide Active Ingredients produced at your facility in 1986.

Instructions for completing Table 2-H Pesticide Production: Technical Grade Products, p. 30.

Column [1] **Active Ingredient Code.** Enter the code for every Table 1 active ingredient that your facility produced in 1986 as a technical grade product. If part of the production was transferred to another facility, list that part as a separate entry as described by Product Code B. If you need additional space to report, photocopy the table before making any marks on it.

Column [2] **Product Code.** Enter the code that best describes the product reported in column [1].

Code Definition

A Table 1 Pesticide Active Ingredients produced at this facility in 1986 to be sold as technical grade products by this facility.

B Table 1 Pesticide Active Ingredients produced at this facility in 1986 and transferred to another facility owned by this firm.

C Table 1 Pesticide Active Ingredients produced at this facility in 1986 for another firm (i.e., tolling).

Column [3] **1986 Average Unit Production and Packaging Cost in Dollars.** Provide the average production cost for one unit of the item reported in column [1]. Include such costs as material costs (i.e., the costs of all raw materials, including packaging materials that were used in the production and packaging of pesticide products), direct labor costs, and any other pesticide costs.

Note that the column [3] entry corresponds to items [5] through [8] under question 2-D on page 23.

Express the costs in dollars. Do not include allocations for corporate overhead, administrative expenses, research and development, capital costs or interest expense.

Column [4] **1986 Average Unit Sales Price in Dollars.** Report the average selling price for one unit of the item reported in column [1]. Express the selling price in dollars. If the pesticide chemical is not sold when it leaves the facility, but is transferred to another facility owned by the firm for further processing, the sales price of the final product should be allocated to both facilities based on their share of the costs to produce the product. This is referred to as the "percentage of cost procedure." An example of the percentage of cost procedure can be found on pages 28-30.

SECTION 2: FACILITY FINANCIAL INFORMATION

Instructions for completing Table 2-H Pesticide Production: Technical Grade Products - continued

Column [5] **1986 Production Quantity.** In column [5], report the total quantity of the item reported in column [1] that was manufactured at this facility during 1986.

Column [6] **Unit of Measure.** In column [6], circle the code that corresponds to the unit of measure you used to calculate the information you reported in columns [3], [4], [5] and [7].

P = Pounds
T = Short tons
M = Metric tons
G = Gallons

Column [7] **Sum Annual Production Over Three Years (1985-1987).** Provide the total amount (sum) of the product reported in column [1] that was produced by this facility in 1985, 1986, and 1987 combined.

Column [8] **Percent Exported Over Three Years (1985-1987).** Report the percent of the product in column [1] exported in 1985, 1986, and 1987 combined, i.e., what percentage of column [7] was exported?

SECTION 2: FACILITY FINANCIAL INFORMATION

EXAMPLE OF PERCENT OF COST PROCEDURES

The following is an example of a hypothetical facility that both produces and formulates/packages active ingredients. It demonstrates use of the "Percentage of Cost Procedure."

Assume the facility produces 1,200 lbs of active ingredient 000 in 1986, of which:

400 lbs are sold as technical grade.

200 lbs are formulated and packaged on site as product group P01.

200 lbs are formulated and packaged by another facility owned by this company also as product group P01

200 lbs are formulated and packaged as product group P01 under contract by another facility not owned by this firm. The contract work is paid for by this plant.

200 lbs are combined with 100 lbs of active ingredient 001 to formulate 300 lbs of product group P02. Active ingredient 001 is purchased from another firm.

Unit sales are:

$2.50/lb for technical grade

$4.00/lb for formulated product group P01

$4.25/lb for formulated product group P02

Unit production, formulating and packaging costs are:

Production of active ingredient 000	$1.50/lb
Purchase of active ingredient 001	$2.00/lb
Formulating and packaging on site	$0.50/lb
Formulating and packaging at other facility owned by this company	$0.50/lb
Formulating and packaging at other facility not owned by this company	$0.60 lb

SECTION 2: FACILITY FINANCIAL INFORMATION

EXAMPLE (continued)

Instructions for completing the 1985-1987 Pesticide Production Tables. This facility would complete the Pesticide Production Table for Technical Grade Products and Formulated/Packaged Products as follows:

Technical Grade Products (Table 2-H, p. 30)

Line 1 400 lbs of AI 000 are sold as technical grade. The unit cost of production is $1.50/lb and the unit sales price is $2.50/lb. This corresponds to Product Code A on page 26.

Line 2 200 lbs of AI 000 are transferred to another facility owned by this firm to be formulated and packaged. The unit cost of production to this facility remains $1.50/lb and the selling price of the formulated product is $4.00/lb. Since the production cost represents 3/4 of the total cost to produce the formulated product, the unit sales price for this facility is 3/4 of the total unit sales price of $4.00/lb or $3.00/lb. This corresponds to Product Code B on page 26.

Formulated/Packaged Products (Table 2-J, p. 37)

Line 1 200 lbs of AI 000 are formulated/packaged on site by this facility. The total unit cost of the formulated and packaged product is $2.00/lb ($1.50/lb for production plus $.50 for formulating and packaging. Since all unit costs are incurred by this facility, the total unit sales price of $4.00/lb is allocated to this facility. This corresponds to Product Code A on page 35. (Note: This 200 lbs is in addition to the 400 lbs + 200 lbs listed on Line 1 and Line 2 under Technical Grade Products.)

Line 2 200 lbs of AI 000 are produced by this facility and formulated/packaged by another firm under contract to this facility. This facility pays for the contract work. The total unit cost of the formulated/packaged product is $2.10/lb ($1.50/lb for production plus $.60/lb for formulating/packaging). Since all unit costs are incurred by this facility, the total unit sales price of $4.00/lb is allocated to this facility. This corresponds to Product Code B on page 35.

Line 3 200 lbs of AI 000 are combined with 100 lbs of AI 001 to formulate 300 lbs of products in Product Group P02. AI 001 is purchased from another firm. The total cost of production is $2.16/lb (2/3 of $1.50 + 1/3 of $2.00 for active ingredients plus $.50 for formulating/ packaging). Since this facility incurred the total unit cost, the total unit sales price is allocated to this facility. This corresponds to Produce Code E on page 35. (Note: If the facility purchases active ingredient 001 from another firm and then formulates/packages it, this would be product group P03 and would also be assigned Product Code E.

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2-H. EXAMPLE PESTICIDE PRODUCTION: TECHNICAL GRADE PRODUCTS

[1] Active Ingredient code	[2] Product code	[3] Average unit production and packaging cost in $	[4] Average unit sales in $	[5] 1986 Production quantity	[6] Unit of measure	[7] Sum annual production over 3 yrs. (1985 - 1987)	[8] Percent exported over 3 yrs. (1985 - 1987)
0 0 0	A	1.50	2.50	400	P. T M G	1,000	_ 1 0
0 0 0	B	1.50	3.00	200	P T M G	600	_ _ 5

2-J. EXAMPLE PESTICIDE PRODUCTION: FORMULATED OR PACKAGED PRODUCTS

[1] Product group	[2] Active ingredient code	[3] Product or trade name	[4] Product code	[5] Average unit product and formulating/ packaging cost in $	[6] Average unit sales in $	[7] 1986 Production quantity	[8] Unit of measure	[9] Sum annual production over 3 yrs. (1985 - 1987)	[10] Percent exported over 3 yrs. (1985 - 1987)
P 0 0 1	0 0 0 _ _ _ _ _ _ _ _ _	RDX	A	2.00	4.00	200	P T M G Other (specify)	500	_ 1 5
P 0 0 1	0 0 0 _ _ _ _ _ _ _ _ _	RDX	B	2.10	4.00	200	P T M G Other (specify)	700	_ 1 5
P 0 0 2	0 0 0 _ _ _ _ _ _ _ _ _	BANY	C	2.16	4.25	300	P T M G Other (specify)	600	_ 1 0

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2-H. PESTICIDE PRODUCTION: TECHNICAL GRADE PRODUCTS

[1] Pesticide active ingredient code	[2] Product code	[3] 1986 Average unit production and formulating/packaging cost in $	[4] 1986 Average unit sales in $	[5] 1986 Production quantity	[6] Unit of measure	[7] Sum annual production over 3 yrs. (1985 - 1987)	[8] Percent exported over 3 yrs. (1985 - 1987)
|__|__|__|	|__|	|____.__|	|______|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|
|__|__|__|	|__|	|____.__|	|____.__|	|______|	P T M G ________ Other (specify)	|______|	|__|__|__|

SECTION 2: FACILITY FINANCIAL INFORMATION

2-I. During calendar year 1986, did this facility sell any Intermediates produced during the manufacture of pesticide products containing a pesticide active ingredient listed in Table 1? (CIRCLE YES OR NO)

YES .... > (READ THE INSTRUCTIONS BELOW AND COMPLETE TABLE 2-I ON PAGE 34)

NO .... > (GO TO QUESTION 2-J ON PAGE 35)

<u>Instructions for completing Table 2-I Pesticide Production: Intermediates.</u>

Column [1] **Intermediate Name.** Enter the name of every intermediate produced in 1986 during the manufacture of Table 1 Pesticide Active Ingredients and sold. Please include all chemicals and codes that you listed in Part A of the Pesticide Manufacturing Facility Census questionnaire. If you need additional space to report, photocopy the table before making any marks on it.

Column [2] **Active Ingredient Code.** Enter the code for every Table 1 active ingredient associated with your production of the intermediate listed in column [1].

Column [3] **Average Unit Production Cost in Dollars.** Provide the average production cost for one unit of the item reported in column [1]. Include such costs as material costs (i.e., the costs of all raw materials, including packaging materials that were used in the production and packaging of pesticide products), direct labor costs, the costs of pesticide contract work or tolling done for you by others, and any other pesticide costs.

Note that the column [3] entry corresponds to items [5] through [8] under question 2-D on page 23.

Express the costs in dollars. Do <u>not</u> include allocations for corporate overhead, administrative expenses, research and development, capital costs or interest expense.

Column [4] **1986 Average Unit Sales Price in Dollars.** Report the average selling price for one unit of the item reported in column [1]. Express the selling price in dollars. If the pesticide chemical is not sold when it leaves the facility, but is transferred to another facility owned by the firm for further processing, the sales price of the final product should be allocated to both facilities based on their share of the costs to produce the product. This is referred to as the "percentage of cost procedure."

SECTION 2: FACILITY FINANCIAL INFORMATION

Instructions for completing Table 2-I Pesticide Production: Intermediates - continued

Column [5] **1986 Quantity Sold.** In column [5], report the total quantity of the item reported in column [1] that was produced at this facility during 1986 and sold.

Column [6] **Unit of Measure.** In column [6], circle the code that corresponds to the unit of measure you used to calculate the information you reported in columns [3], [4], [5] and [7].

P = Pounds
T = Short tons
M = Metric tons
G = Gallons

Column [7] **Sum Annual Quantity Sold Over Three Years (1985-1987).** Provide the total amount (sum) of the product reported in column [1] that was produced and sold by this facility in 1985, 1986, and 1987 combined.

Column [8] **Percent Exported Over Three Years (1985-1987).** Report the percent of the product in column [1] exported in 1985, 1986, and 1987 combined, i.e., what percent of column [7] was exported.

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2-I. PESTICIDE PRODUCTION: INTERMEDIATES

[1] Intermediate name	[2] Active ingredient code	[3] 1986 Average unit production cost in $	[4] 1986 Average unit sales price in $	[5] 1986 Quantity sold	[6] Unit of measure	[7] Sum annual production over 3 yrs. (1985 - 1987)	[8] Percent exported over 3 yrs (1985 - 1987)
					P T M G Other (specify)		
					P T M G Other (specify)		
					P T M G Other (specify)		
					P T M G Other (specify)		
					P T M G Other (specify)		
					P T M G		

SECTION 2: FACILITY FINANCIAL INFORMATION

2-J. During calendar year 1986, did this facility produce any formulated or packaged products containing a pesticide active ingredient listed in Table 1? (CIRCLE YES OR NO)

YES .... > (READ THE INSTRUCTIONS BELOW AND COMPLETE TABLE 2-J ON PAGE 37)

NO .... > (GO TO QUESTION 2-K ON PAGE 38)

Instructions for completing Table 2-J Pesticide Production: Formulated or Packaged Products.

Column [1] **Product Group.** Group all formulated/packaged products according to the active ingredient(s) they contain, regardless of relative proportions or concentrations and assign each group a number. For example, if your products contain two active ingredients (say A and B), group all products containing only A into one group (call it #1), group all products containing B into a second group (call it #2) and all products containing both A and B into a third group (call it #3). Report dry and wet formulations separately. If you need additional space to report, photocopy this table before making any marks on it.

Column [2] **Active Ingredient Code.** For each product group formulated/packaged in 1986, enter the code for every Table 1 active ingredient that it contained.

Column [3] **Product or Trade Name.** Enter the trade name or name of the product.

Column [4] **Product Code.** Enter the code that best describes the product reported in column [1].

Code Definition

A Table 1 pesticide products produced and formulated/packaged at this facility in 1986.

B Table 1 pesticide products produced at this facility in 1986 and formulated/packaged for you by another firm on a contract basis.

C Table 1 pesticide products formulated/packaged by this facility in 1986, and produced by another facility owned by the firm that owns this facility.

D Table 1 pesticide products formulated/packaged by this facility on a contract basis in 1986, for a firm other than the firm that owns this facility.

E Table 1 pesticide products formulated/packaged by this facility from active ingredients purchased from another firm.

SECTION 2: FACILITY FINANCIAL INFORMATION

Instructions for completing Table 2-J Pesticide Production: Formulated or Packaged Products - continued

Column [5] **1986 Average Unit Production and Formulating/Packaging Cost in Dollars.** Provide the average production cost for one unit. Include such costs as material costs (i.e., the costs of all raw materials, including packaging materials that were used in the production and/or formulation and packaging of pesticide products), direct labor costs, the costs of pesticide contract work or tolling done for you by others, and any other pesticide costs.

Note that the column [5] entry corresponds to items [5] through [8] under question 2-D on page 23.

Express the costs in dollars. Do not include allocations for corporate overhead, administrative expenses, research and development, capital costs or interest expense.

Column [6] **1986 Average Unit Sales Price in Dollars.** Report the average selling price for one unit of the item reported in column [1]. Express the selling price in dollars. If the pesticide chemical is not purchased by your facility, but is transferred to your facility from another facility owned by the firm for further processing, the sales price of the final product should be allocated to both facilities based on their share of the costs to produce the product. This is referred to as the "percentage of cost procedure." An example of the percentage of cost procedure can be found on pages 28 and 29.

Column [7] **1986 Production Quantity.** In column [5], report the total quantity of the item reported in column [1] that was formulated/packaged by this facility during 1986.

Column [8] **Unit of Measure.** In column [6], circle the code that corresponds to the unit of measure you used to calculate the information you reported in columns [5], [6], [7] and [8].

P = Pounds
T = Short tons
M = Metric tons
G = Gallons

Column [9] **Sum Annual Production Over Three Years (1985-1987).** Provide the total amount (sum) of the product reported in column [1] that was formulated/packaged by this facility in 1985, 1986, and 1987 combined.

Column [10] **Percent Exported Over Three Years (1985-1987).** Report the percent of the product exported in 1985, 1986, and 1987 combined, i.e., what percent of column [9] was exported.

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2-J. PESTICIDE PRODUCTION TABLE: FORMULATED OR PACKAGED PRODUCTS

[1] Product group	[2] Active ingredient code	[3] Product or trade name	[4] Product code	[5] 1986 Average unit production and formulating/packaging cost in $	[6] 1986 Average unit sales price in $	[7] 1986 Production quantity	[8] Unit of measure	[9] Sum annual production over 3 yrs. (1985 - 1987)	[10] Percent exported over 3 yrs. (1985 - 1987)
P				.	.		P T M G Other (specify)		
P				.	.		P T M G Other (specify)		
P				.	.		P T M G Other (specify)		
P				.	.		P T M G Other (specify)		
P				.	.		P T M G Other (specify)		

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2-K. Facility 1986 Markets

Estimate the percentage of this facility's total 1986 production that was delivered to the markets listed below. (Enter zero if the market is not applicable. The percentages should sum to 100%).

[1] Agriculture (U.S.A.) .... S2K1 .... _ _ _ %

~~[2] Industry, commerce, government (U.S.A.)~~ .... S2K2 .... _ _ _ %

[3] Home, garden (U.S.A.) .... S2K3 .... _ _ _ %

[4] Export (Outside U.S.A.) .... S2K4 .... _ _ _ %

[5] Other markets (SPECIFY) .... S2K5A (Variable) .... _ _ _ %

S2K5B (Description)

Total .... 1 0 0 %

2-L. Facility Operations

Report the operational information listed below for calendar year 1986. (Enter zero if the category is not applicable).

[1] The number of days the entire facility was in operation .... S2L1 .... |_|_|_|

[2] The number of days part or all of the facility manufactured pesticide chemicals .... S2L2 .... |_|_|_|

[3] The number of days part or all of the facility formulated/packaged pesticide chemicals .... S2L3 .... |_|_|_|

2-M. Employee Information

In lines [1] through [4], report the total employee hours worked at this facility in the months of January 1986, May 1986 and November 1986 in the categories indicated. In lines [5] and [6], enter the average number of shifts run in the entire facility in a week, and the average number of hours per shift for the months of January 1986, May 1986 and November 1986.

	January 1986	May 1986	November 1986
[1] Total employee hours in pesticide chemicals production	S2M1A	S2M1B	S2M1C
[2] Total employee hours in pesticide formulating and packaging	S2M2A	S2M2B	S2M2C
[3] Total employee hours in other production	S2M3A	S2M3B	S2M3C
[4] Total employee hours in non-production	S2M4A	S2M4B	S2M4C
[5] Average number of shifts run in the entire facility in a week	S2M5A	S2M5B	S2M5C
[6] Average number of hours per shift in the entire facility	S2M6A	S2M6B	S2M6C

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2-N. Estimate the liquidation values less closure and post-closure costs of the pesticide production and pesticide formulating/packaging lines at this facility if you were to close them permanently within the next three years. Include the value of fixed assets, working capital and real estate in your calculation of liquidation values. Report the estimates in thousands of dollars and enter zero dollars if the item is not applicable.

Pesticide production lines	($000)
[1] Liquidation value (less closure and post-closure cost)	S2NA1A
Closure and post-closure cost	S2NA1B
[2] Cost to convert to non-Table 1 pesticide active ingredients or non-pesticide products	S2NA2
Pesticide formulating/packaging lines	
[1] Liquidation value	S2NB1
[2] Cost to convert to non-Table 1 pesticide active ingredients or non-pesticide products	S2NB2

2-O. Did this facility have any property tax assessment for 1986?

S2O

YES .... 1 (CONTINUE)
NO .... 2 (SKIP TO QUESTION 2R)

2-P. What was the 1986 property tax assessment value of the items listed below? Report the values in thousands of dollars and enter zero if the item listed is not applicable.

State tax assessment value	($000)
[1] Land	SP1
[2] Buildings	SP2
[3] Equipment and machinery	SP3
[4] Total property tax assessment value	SP4
Local tax assessment value	
[5] Land	SP5
[6] Buildings	SP6
[7] Equipment and machinery	SP7
[8] Total property tax assessment value	SP8

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2-Q. What was the 1986 assessed value of the property expressed as a percentage of market value (1986 level of assessment)? (Enter zero if the item was not applicable).

[1] State assessment percentage ....S2Q1.............................. ___ ___ . ___ %

~~[2] Local assessment percentage~~ ....S2Q2.............................. ___ ___ . ___ %

2-R. Overall, what is the major source of competition for pesticide products produced at this facility in each of the three markets listed below?

The same products means competing products containing identical or nearly identical pesticide active ingredients or percentages of active ingredients but having different trade or brand names. Substitute products means competing products performing the same pesticidal functions but containing different pesticide active ingredients.

Competition		Market		
		Local Regional	National	International
[1]	Domestic producers of the same products	☐	☐	☐
[2]	Foreign producers of the same products	☐	☐	☐
[3]	Domestic producers of the substitute products	☐	☐	☐
[4]	Foreign producers of the substitute products	☐	☐	☐
[5]	No competition	☐	☐	☐
[6]	No market share	☐	☐	☐
		S2R1	S2R2	S2R3

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Comments for Section 2. Reference entries by question number.

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SECTION 3: FACILITY CONTACT

Enter the name, title, telephone number and address (if different from the facility mailing address) of the facility representative to be contacted with questions regarding your responses to **Part B**:

______________________________ S3A
Name (First and Last)

______________________________ S3B
Title

_______________ S3C
Telephone Number

Address (if different from facility mailing address):

______________________________ S3D
Firm or Facility Name

______________________________ S3E
Street or P.O. Box

____________________ | ____ | ________
City or Town | State | Zip Code
S3F S3G S3H

CERTIFICATION: The information provided in **Part B** of the questionnaire, as well as that provided in all others, must be certified by having the responsible individual for your facility complete and sign the Certification Statement Item 6 on page 3 of this questionnaire.

APPENDIX B

MAPPING OF PESTICIDE ACTIVE INGREDIENTS INTO CLUSTERS

Appendix B: MAPPING OF PESTICIDE ACTIVE INGREDIENTS INTO CLUSTERS

This appendix lists the 56 PAI clusters used to define PAI markets in the EIA. As discussed in Chapters 3 and 4, the clusters were developed by EPA's Office of Water based on previous work by EPA's Office of Pesticide Programs (OPP). Individual PAIs that are included in each cluster are listed in three columns. The first column includes the 270 PAIs that were considered in-scope. (The next column shows the Chemical Abstract Service Number for the in-scope PAIs.) Since the PAIs that will not be covered by the effluent guidelines may compete with those that are covered, non-regulated PAIs have also been assigned to clusters. Thus, the second PAI column ("Other PAIs on OPP List") includes those PAIs not considered for regulation at this time, but included in the original OPP clusters. Many of these chemicals have already been regulated (see the header of the table for notation indicating whether PAIs are covered by other regulations, as well as the production/marketing status of the PAIs). The third PAI column ("new PAIs") lists PAIs that have been registered since 1980 and were, therefore, not included in the original OPP clusters.

PESTICIDE CLUSTERS

< > - Denotes pesticides that are not marketed in the U.S.
[ ] - Denotes pesticides that have been cancelled for use in the U.S.
{ } - Denotes pesticides that have been discontinued by manufacturer
(B) - Denotes biological pesticide
(O) - Denotes pesticide covered by OCPSF
(I) - Denotes pesticide covered by Inorganic Reg
(P) - Denotes pesticide covered by Pharmaceutical
Δ - Denotes pesticides not produced 1984-1988
∇ - Denotes pesticides not produced 1986-1988
◁ - Denotes pesticides not produced 1984-1985
▷ - Denotes pesticides not produced 1984-1986

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
F-1	**Fungicides** **Broad spectrum of uses**			
261	Thiram	137-26-8	Inorganic Copper Compounds *(I)*	Myclobutanil (Systhane, Rally)
260	Thiophanate Methyl	23564-05-8	Metalaxyl (Ridomil)	Vinclozolin (Ronilan)
205	PCNB	82-68-8	Calcium Polysulfide (Lime sulfurs)	Propiconazole (Tilt, CGA-64250)
192	Organo-tin Fungicides		Inorganic Sulfur Compounds	
190	Organo-Copper			
151	Maneb	12427-38-2		
149	Malachite Green	12069-69-1		
96	{Amobam}	3566-107		
87	Mancozeb	8018-01-7		
82	Chlorothalonil	1897-45-6		
62	Benomyl	17804-35-2		
32	Thiabendazole (Mertect)	148-79-8		
F- 2a	**Fungicides** **Fruit and nut trees, except oranges and grapes**			
268	Ziram	137-30-4	Triforine	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
164	Quinomethionate (Morestan)	2439-01-2	Streptomycin *(P)*	
134	Ferbam	14484-64-1	{Ammonium Polysulfide} *(I)*	
121	Dodine	2439-10-3	Sodium Polysulfide *(I)*	
99	{Dichlone}	117-80-6	Iprodione	
74	Captan	133-06-2	Inorganic Coppers	
			Coppers	
			Glyodin ∆	
			<Dithianon>	
			Calcium Polysulfide (Lime sulfurs)	
F- 2b	**Fungicides Grapes**			
134	Ferbam	14484-64-1	Sulfur *(I)*	
8	Triadimefon (Bayleton)	43121-43-3	<Glyodin>	
			<Dithianon>	
			Calcium Polysulfide (Lime sulfurs)	
F- 3	**Fungicides Vegetables**			
228	Propamocarb Hydrochloride (Previcur N)	25606-41-1	Coppers	Fosetyl-Aluminum (Aliette)
167	Metiram	9006-42-2	Fluoride Compounds	
152	{Niacide}	15339363	Inorganic Chromium Compounds	
99	{Dichlone}	117-80-6		
73	[Captafol]	2939-80-2		
20	Dicloran, DCNA - Plant closed; only U.S. producer	99-30-9		
18	Anilazine (Dyrene)	101-05-3		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
9	Hexachlorophene (Nabac)	70-30-4		
F- 4	**Fungicides** **Citrus**			
267	Zineb (Dithane)	12122-67-7	Sec-Butylamine *(O)*	
211	{Phenyl Phenol}	90-43-7	Inorganic Coppers	
F- 5	**Fungicides** **For use as seed treatments**			
250	{HPMTS}		Sodium Hypochlorite *(I)*	Imazalil (Fungaflor, Fungazil)
227	Propionic acid	79-09-4	{Fenaminosulf (Lesan)} *(O)*	Triadimenol (Baytan)
120	Metasol DGH	13590971	{Chloronitropropane (Lanstan)}	
80	Chloroneb	2675-77-6	Carboxin	
49	Etridiazol (Terrazole, Etrazole, Truban)	2593-15-9		
35	TCMTB (Busan 30A)	21564170		
F- 6	**Fungicides** **Post harvest fruit and vegetables**			
67	Biphenyl, Diphenyl	92-52-4	Sodium Dehydroacetate *(I)* {Isothan}	Imazalil (Fungaflor, Fungazil)
F- 7	**Fungicides** **Grain storage**			
227	Propionic acid	79-09-4	Isobutyric acid *(O)* Ammonium Isobutycite	

PESTICIDE CLUSTERS (cont'd)

		PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
F- 8		**Fungicides Ornamentals**			
	189	{Organo-Cadmium}		Piperalin *(O)*	Dodemorph Acetate (Milban)
	167	Metiram	9006-42-2	{Parinol (Parnon)}	Fosetyl-Aluminum (Aliette)
	132	Fenarimol (Rubigan)	60168-88-9	{Dichloroethyl Ether}	
	91	{Cycloheximide (Acti-dione)}	66819		
F- 9		**Fungicides Turf**			
	132	Fenarimol (Rubigan)	60168-88-9	Inorganic Cadmium Compounds *(I)*	Fosetyl-Aluminum (Alliete)
	100	{Thiophanate Ethyl}	23564-06-9	Nickel Sulfate *(I)*	
	91	{Cycloheximide (Acti-dione)}	66819		
F-10		**Fungicides Unclassified**			
				{Ditalimfos}	Pseudomonas Fluoescens (Dagger G) *(B)*
				{Allyl Alcohol} *(O)*	
H- 1		**Herbicides Broad spectrum of uses**			
	138	Glyphosate	38641-90-0	Paraquat Sodium Chlorate *(I)*	Monocarbide Dihydrogen Sulfate (ENQUIK, N-tac)
	16	2,4-D	1702-17-6		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
H- 2	**Herbicides Corn**			
249	Vernolate (Surpass)	1929-77-7	TCBC, Trichlorobenzyl Chloride *(O)* ▿	Primisulfuron
246	EPTC	759-94-4	{Cyprazine (Outfox)}	Nicosulfuron (Thiameturon)
239	Simazine	122-34-9		{Tridiphane (Tandem)}
204	Pendimethalin	40487-42-1		Pyridate
165	Metolachlor	51218-45-2		
161	Methanearsonic acid	124583		
130	Butylate	2008-41-5		
69	Bromoxynil	1689-84-5		
60	Atrazine	1912-24-9		
58	Ametryn	834-12-8		
54	Alachlor	15972-60-8		
32	Cloprop	148798		
26	Propachlor	1918-16-7		
25	Cyanazine (Bladex)	21725-46-2		
H- 3	**Herbicides Soybeans, cotton, peanuts, alfalfa**			
272	{Chlorpropham}	101-21-3	{Dipropetryn}	Chlorimuron Ethyl (Classic)
264	Trifluralin	1582-09-8	Methazole	Clomazone (Command)
254	Terbacil	5902-51-2	Dinitramine ▿	Sethoxydim (Poast)
249	Vernolate (Surpass)	1929-77-7	Dichlofop Methyl	Quizalofop-Ethyl (Assure)
240	Bentazon	25057-89-0	{Fluchloralin}	Mepiquat-Chloride (Pix)
224	Prometryn	7287-19-6	{Perfluidone}	Lactofen (Cobra)
204	Pendimethalin	40487-42-1	{Ethylene Glycol bis Trichloroacetate Glytac} *(O)*	Fluazifop-butyl (Fusilade)
196	Oxyfluorfen	42874-03-03	{Nitralin (Planavin)}	Imazethapyr (Pursuit)
194	Oryzalin	19044-88-3	{Profluralin (Tolban)}	Imazaquin (Scepter)

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
178	Benefin, Benfluralin	1861-40-1		Fomesafen (Reflex)
176	Naptalim (Alanap)	132-66-1		
175	Norflurazon	27314-13-2		
165	Metolachlor	51218-45-2		
148	Linuron	330-55-2		
142	Hexazinone	51235-04-2		
135	Fluometuron	2164-17-2		
125	Ethalfluralin (Sonalan)	55283-68-6		
92	Dalapon	75-99-0		
78	{Chloramben}	1954-81-4		
53	Acifluorfen	62474-59-9		
45	Metribuzin (Sencor)	21087-64-9		
39	Pronamide (Kerb)	23950-58-5		
17	[2,4-DB] - Salts and Esters still produced	94-82-6		
H- 4	**Herbicides Sorghum, rice, small grains**			
269	Triallate (Far Go)	2303-17-5	Difenzoquat Methyl Sulfate (Avenge)	Clopyralid (Lontrel)
257	{Terbutryn}	886-50-0		
247	Molinate	2212-61-1	Butralin	Chlorsulfuron (Glean)
254	Terbacil	5902-51-2	Thiobencarb	Imazamethabenz-Methyl, AC 222, 293 (Assert)
226	{Propazine}	139-40-2	{Barban (Carbyne)}	Isoxaben (EL 107. Prolan)
170	Napropamide	15299-99-7	Bensulfuron Methyl (Londax)	
92	Dalapon	75-99-0	Thifensulfuron-methyl, DPX-M6316 (Harmony, Pi)	
70	<Butachlor>	23184-66-9		
69	Bromoxynil	1689-84-5	Tribenuron methyl (Express)	
68	Bromacil	314-40-9	Metsulfuron Methyl (Ally)	
66	{Bifenox}	42576-02-3		

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
58	Ametryn	834-12-8		
41	Propanil	709-98-8		
27	MCPA	94-74-6		
26	Propachlor	1918-16-7		
H- 5a	**Herbicides** **Oranges**			
			Glufosinate (Devine) *(B)*	
H- 5b	**Herbicides** **Grapes**			
196	Oxyfluorfen	42874-03-03		
194	Oryzalin	19044-88-3		
170	Napropamide	15299-99-7		
H- 5c	**Herbicides** **Fruits (except oranges and grapes), tree nuts and sugarcane**			
194	Oryzalin	19044-88-3	Dichlobenil	
170	Napropamide	15299-99-7	Asulam	
92	Dalapon	75-99-0		
58	Ametryn	834-12-8		
44	DNOC	534-52-1		
H- 6	**Herbicides** **Sugar beets, beans and peas**			
256	Terbuthylazine (Gardoprim)	5915-41-3	Pyrazon	Diclop
245	Cycloate (Ro-Neet)	1134-23-2	{Sodium TCA}	Clopyralid (Lontrel)
209	Phenmedipham	13684-63-4	{Diallate}	Diethatyl-Ethyl (Antor)
112	[Dinoseb]	88-85-7	Ethofumesate	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
95	Desmedipham (Betanex)	13684-56-5	Chloridazon ▿	
47	MCPB	94-81-5		
H- 7	**Herbicides Drainage ditches, rights of way, forestry and ponds**			
259	Dazomet, DMTT (busamid, Mylome, Nefusan)	533-74-4	Diquat	Imazapyr
252	Tebuthiuron	34014-18-1	Dichlobenil	Aquashade (Dyes and Water)
251	Bensulide (Betesan)	741-58-2		Fluridone (Sonar)
239	Simazine	122-34-9	Acrolein *(O)*	Sulfometuron Methyl (Oust)
238	[Silvex]	93-72-1	AMS, Ammonium Sulfamate *(I)*	
223	Prometon	1610-18-0	Amitrole *(O)*	
178	Benefin, Benfluralin	1861-40-1		
169	Monuron	150-68-5		
168	Monuron TCA	150-68-5		
146	Karbutilate	4849-32-5		
142	Hexazinone	51235-04-2		
123	Endothall	129-67-9		
119	Diuron	330-54-1		
110	DCPA	1861-32-1		
68	Bromacil	314-40-9		
31	Mecoprop (MCPP)	7085-19-0		
30	Dichlorprop	120-36-5		
15	Weedone	93765		
14	Chlorfenac	85-34-7		
H- 8	**Herbicides Turf**			
259	Dazomet, DMTT			

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
	(busamid, Mylome, Nefusan)	533-74-4	Potassium Cyanate *(I)*	Flurprimidol (Cutless)
237	Siduron	1982-49-6	Oxadiazon	
			{Terbutol}	
			Ferrous Sulfate *(I)*	
H- 9a	**Herbicides Vegetables**			
272	{Chlorpropham}	101-21-3	{CDAA (N,N-Diallyl-2-Chloroacetamide)}	
251	Bensulide (Betesan)	741-58-2	Metabromuron ∆	
248	Pebulate (Tillam)	1114-71-2	Nitrofen (Tok) ∆	
176	Naptalam (Alanap)	132-66-1		
174	Norea	18530-56-8		
170	Napropamide	15299-99-7		
115	{Diphenamid}	957-51-7		
110	DCPA	1861-32-1		
102	Bisethylxanthogen (Herbisan)	502556		
83	Chloroxuron	1982-47-4		
39	Pronamide (Kerb)	23950-58-5		
23	{CDEC (Vegadex)}	95-06-7		
H- 9b	**Herbicides Tobacco**			
248	Pebulate (Tillam)	1114-71-2	Metabromuron ∆	Prime +
176	Naptalam (Alanap)	132-66-1	Nitrofen ∆	
174	Norea	18530-56-8	{CDAA (N,N-Diallyl-2-Chloroacetamide)}	
170	Napropamide	15299-99-7		
144	Isopropalin	33820-53-0		
115	{Diphenamid}	957-51-7		
110	DCPA	1861-32-1		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
102	Bisethylxanthogen (Herbisan)			
39	Pronamide (Kerb)	23950-58-5		
23	{CDEC (Vegadex)}	95-06-7		
H-10	**Herbicides Unclassified**			
215	Picloram	1918-02-1	Trichlopyr	Fenridazone-Potassium (Hybrex)
98	Dicamba	1918-00-9	{Erbon} <Neburon> Allyl Alcohol}	
I- 1a	**Insecticides/Nematicides Cotton**			
262	[Toxaphene]	8001-35-2	{Bollex}	Bifenthrin (Talstar)
225	Propargite	2312-35-8	Monocrotophos (Azodrin) ▵	Lambda Cyhalothrin (Karate)
222	Profenofos (Curacron)	41198-08-7	[Chlordimeform (Galecron, Fundal)]	Tralomethrin (Scout)
214	Phosphamidon	287-99-4	{Heliothis Polyhedrosis Virus (Elcar)}	Cyfluthrin (Baythroid)
203	Parathion	56-38-2	Grandlure Mixture	Thiodicarb (Larvin)
199	[EPN (Santox)]	2104-64-5	Gossyplure	
197	Sulprofos (Bolstar)	35400-43-2	Chlordimeform Hydrochloride ▿	
195	Oxamyl	2135-22-0		
186	Azinphos-Methyl (Guthion)	86-50-0		
156	Methomyl	16752-77-5		
124	[Endrin]	72-20-8		
108	Dicrotophos (Bidrin)	141-66-2		
107	Parathion Methyl	298-00-0		
104	Diflubenzuron	35367-38-5		
94	{Demeton (Systox)}	8065-48-3		
90	Fenvalerate (Pydrin)	51630-58-1		

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
63	[Benzene Hexachloride, BHC]	608-73-1		
55	Aldicarb	116-06-3		
52	Acephate	30560-19-1		
1	Dicofol (Kelthane, DTMC)	115-32-2		
I- 1b	**Insecticides/Nematicides Soybeans, peanuts, wheat and tobacco**			
262	[Toxaphene]	8001-35-2	Monocrotophos (Azodrin) ▵	Tralomethrin (Scout)
208	Permethrin	52645-53-1	[Chlordimeform (Galecron, Fundal)]	
199	[EPN (Santox)]	2104-64-5	{Bollex}	
183	Disulfoton (Disyston)	298-04-4	Chlordimeform Hydrochloride ▿	
156	Methomyl	16752-77-5	{Heliothis Polyhedrosis Virus (Elcar)} *(B)*	
127	Ethoprop	13194-48-4		
124	[Endrin]	72-20-8		
106	Dimethoate	60-51-5		
86	Chlorpyrifos	2921-88-2		
63	[Benzene Hexachloride, BHC]	608-73-1		
55	Aldicarb	116-06-3		
I- 2a	**Insecticides/Nematicides Corn, alfalfa**			
255	Terbufos	013071-79-9	TEPP (HETP) ▵	{Tefluthrin (Force)}
225	Propargite	2312-35-8	{Carbophenothion (Trithion)}	
212	Phorate	298-02	Formetanate Hydrochloride (Carzol) ◃	
208	Permethrin	52645-53-1	{Bufencarb (Bux)}	
200	Fonofos	944-22-9		
193	{Orthodichlorobenzene}	95-50-1		
182	{Fensulfothion (Dasanit)}	115-90-2		
150	Malathion	121-75-5		
111	Trichlorfon (Dylox)	52-68-6		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
107	Parathion Methyl	298-00-0		
86	Chlorpyrifos	2921-88-2		
76	Carbofuran	1563-66-2		
75	Carbaryl	63-25-2		
13	{Landrin 2}	2686-99-9		
I- 2b	**Insecticides/Nematicides Sorghum**			
203	Parathion	56-38-2	{Carbophenothion (Trithion)}	{Tefluthrin (Force)}
193	{Orthodichlorobenzene}	95-50-1	TEPP (HETP) ▵	
75	Carbaryl	63-25-2	{Bufencarb (Bux)}	
13	{Landrin 2 }	2686-99-9		
I- 3	**Insecticides Fruit (excluding oranges and grapes) and nut trees**			
225	Propargite	2312-35-8	Petroleum Oils	Chitin (Clandoșan 618)
214	Phosphamidon	297-99-4	Ovex (Chlorfensom) ▵	
213	Phosalone	2310-17-0	2-Naphthol, Beta-Naphthol *(O)*	
203	Parathion	56-38-2	{Chloropropylate (Acalarate)}	
195	Oxamyl	2135-22-0	Tetradifon, Tedion ▿	
186	Azinphos-Methyl (Guthion)	86-50-0	Tetrasul (Animert V-101) ▿	
185	Phosmet (Imidan)	732-11-6	Formetanate Hydrochloride (Carzol) ◃	
156	Methomyl	16752-77-5	Dialifor (Torak) ◃	
155	Methidathion	950-37-8		
141	{Cycloprate (Zardex)}	54460-46-7		
129	Chlorobenzilate (Acaraben)	510-15-6		
122	Endosulfan	115-29-7		
107	Parathion Methyl	298-00-0		
103	Diazinon (Diazitol, Basudin, Dipofene, Spectracide)	333-41-5		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
90	Fenvalerate (Pydrin)	51630-58-1		
75	Carbaryl	63-25-2		
59	Amitraz	33089-61-1		
19	Dinocap	39300-45-3		
I- 4	**Insecticides/Nematicides Oranges**			
173	Naled	300-76-5	Petroleum Oils	
155	Methidathion	950-37-8	Tetradifon, Tedion ▽	
126	Ethion	563-12-2	Formetanate Hydrochloride (Carzol) ◁	
113	{Dioxathion}	78-34-2	Cryolite (Kryocide) *(I)*	
75	Carbaryl	63-25-2		
19	Dinocap	39300-45-3		
1	Dicofol (Kelthane, DTMC)	115-32-2		
I- 4b	**Insecticides/Nematicides Grapes**			
			Cryolite	
I- 5	**Insecticides/Nematicides Vegetables**			
235	Rotenone	83-79-4	{Sabadilla} *(B)*	Bacillus Thuringiensis Tenebrionis (Trident) *(B)*
214	Phosphamidon	297-99-4	Ryanodine (Ryania) (B)	Pirimiphos Methyl (Actellic) △
212	Phorate	298-02	Pirimicarb (Pirimor)	Chitin (Clandosan 618)
195	Oxamyl	2135-22-0	Pirimiphos-ethyl (Primicid) △	Cyromazine (Larvadex Premix)
187	Oxydemeton-Methyl (Metasystox-R)	301-12-2	Bacillus Thuringiensis (Cutlass) *(B)*	Flucythrinate (Pay Off)
183	Disulfoton (Disyston)	298-04-4	Cryolite (Kryocide)	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
173	Naled	300-76-5	Nicotine	
158	Methoxychlor	72-43-5	Nicotine Sulfate	
154	Methamidophos	10265-92-6		
150	Malathion	121-75-5		
127	Ethoprop	13194-48-4		
122	Endosulfan	115-29-7		
107	Parathion Methyl	298-00-0		
101	{Ethylan (Perthane)}	72-56-0		
94	{Demeton (Systox)}	8065-48-3		
90	Fenvalerate (Pydrin)	51630-58-1		
55	Aldicarb	116-06-3		
22	Mevinphos (Phosdrin)	7786-34-7		
I- 6	**Insecticides Livestock and domestic animals**			
234	{Ronnel}	299-84-3	{Benzene} *(O)*	
220	KN Methyl	137417	Bomyl ▵	
210	Penothiazine	92842	Muscalure *(O)*	
181	Coumaphos (Co-Ral)	56-72-4	Bone Oil (Dippel's Oil) *(O)*	
147	Lindane	58-89-9	Butoxy Polypropylene Glycol (Stabilene, Crag Fly Repellant) *(O)*	
131	Famphur	52-85-7	Butonate ▿	
116	Diphenylamine	122-39-4	Tabutrex ▿	
109	Crotoxyphos (Ciodrin)	7700-17-6	Piperazine Dihydrochloride *(O)*	
84	Tetrachlorvinphos (Stirofos, Gardona, Rabon)	961-11-5	Diisobutyl Phenoxyethanol *(O)*	
64	Benzyl Benzoate	120-51-4	Crufomate (Ruelene) ▿	
59	Amitraz	33089-61-1	Linseed Oil *(O)*	
24	Chlorfenvinphos (Supona)	470-90-6		
12	DDVP, Dichlorvos (Vapona)	62-73-7		

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
I- 7	**Insecticides**			
	For use as insect repellants at non-agricultural sites			
171	Deet	134-62-3	N-Butylacetanilide *(O)*	Fish Oil (Fruit Builders Oil)
117	MGK 326	136-45-8	{Benzaldehyde} *(O)*	
			Citronella, Oil of	
			{Indalone, Dihydropyrone}	
			Camphor	
			Ethyl Hexanediol (Turgers 612) *(O)*	
I- 8	**Insecticides**			
	Domestic bug control and in food processing plants			
271	Tetramethrin	7696-12-0	{Isobornyl Thiocyanoacetate (Thanite)}	Periplanone-B
270	D-Phenothrin (Sumithrin)	26002802	{Mitin FF}	Sulfluramid/GX-071
233	Resmethrin	10453-86-8	Chloroethyl Ether	Propetamphos
232	Pyrethrum	8003-34-7	Boric Acid *(I)*	Bagworm
231	Pyrethrum II	121-29-9	Zinc Fluosilicate *(I)*	Hydroprene (Altozar)
230	Pyrethrum I	121-21-1	Ammonium Fluosilicate (Dri-Die) *(I)*	N-Ethyl Perfluorooctane
229	Pyrethrin Coils		Sodium Fluosilicate *(I)*	
202	Para-Dichlorobenzene	106-467	Hydramethylnon (Amdro)	
201	Propoxur (Baygon)	114-26-1	MGK Repellant 874 (2-Hydroxyethyl Octyl Sulfide)	
177	MGK Repellant 264	113-48-4	Isothymyl	
173	Naled	300-76-5	Sodium Fluoride (Florocid) *(I)*	
150	Malathion	121-75-5	Silicon Dioxide *(I)*	
103	Diazinon (Diazitol, Basudin, Dipofene)		333-41-5	Ethylene Glycol Ether of Pinene
	(DHS Activator) *(O)*			
85	Chlorpyrifos-Methyl	5598-13-0	Napthalene *(O)*	
65	{Lethane 384}	122-56-1	Silica Gel *(I)*	
65	Lethane 60	301-11-1		
61	Bendiocarb	22781-23-3		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
57	Allethrin	584-79-2		
I- 9	**Insecticides** **Fumigants and nematicides**			
243	Metam-Sodium (Vapam)	13742-8	<Perchloroethylene, Tetrachloroethylene> *(O)*	Aldoxycarb (Standek)
179	{Sulfotep (Bladafum)}	3689-24-5	{Hydrogen Cyanide, Hydrocyanic Acid} *(I)*	Chitin (Clandosan 618)
160	Methyl Bromide	74-83-9	Ethyl Formate *(O)*	{Fosthietan (Nem-a-Tak)}
128	Fenamiphos (Nemacur)	22224-92-6	Ethylene Oxide *(O)*	Isazophos (Triumph, Miral)
97	[DBCP, Dibromochloropropane Nematocide]	96-12-8	Aluminum Phosphide (Phostoxin) *(I)*	
81	Chloropicrin	76-06-2	Calcium Cyanide (Cyanogas) *(I)*	
5	1,3-Dichloropropene	542-75-6	Chloroform *(O)*	
3	[Ethylene dibromide]	106-93-4	{Diamidofos (Nellite)}	
			Propylene Oxide *(O)*	
			{Dichloropropane, Propylene Dichloride}	
			Carbon Tetrathiocarbonate	
			Methylene Chloride *(O)*	
			Epichlorohydrin *(O)*	
			Ethylene Dichloride, EDC *(O)*	
			[Carbon Tetrachloride] *(O)*	

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
I-10	**Insecticides for termite control**			
198	Sulprofos Oxon	38527901	[Dieldrin]	Azadirachtin (Margosan-o-Concentrate) *(B)*
143	Isofenphos	25311-71-1	[Aldrin]	
140	[Heptachlor]	76-44-8	Sulfuryl Fluoride (Vikane) *(I)*	
86	Chlorpyrifos	2921-88-2		
79	[Chlordane]	57-74-9		
I-11	**Insecticides/Nematicides Lawns, ornamental and forest trees**			
184	Fenitrothion	122-14-5	Gypchek *(B)*	Fluvalinate (Mavrik)
180	{Aspon}	3244-90-4	Methyl Eugenol	N-Trap Elm Bark Beetle *(B)*
166	{Mexacarbate}	315-18-4	Dispalure *(O)*	
143	Isofenphos	25311-71-1	Nuclear Polyhedrosis Virus of Douglas Fir Russock Moth *(B)*	
103	Diazinon (Diazitol, Basudin, Dipofene)		333-41-5	Dichlofenthion (Mobilawn) ▵
93	Dienochlor (Pentac, Pentac Aquaflow)	2227-17-0	{Bromophos (Nexion)}	
77	Carbosulfan (Advantage)	55285-14-8	{Kinoprene (Enstar)}	
48	{Aminocarb (Maticil)}	2032-59-9	Bacillus Popillae and B-Lentimorbus *(B)*	
I-12	**Insecticides For use as mosquito larvacides**			
253	Temophos	3383-96-8	Dimethrin ▿	Arosurf MSF
157	Methoprene	40596-69-8	Copper Acetoarsenite (Paris Green) *(I)*	BT, Butrizol ▹, very low production 1987-88
133	Fenthion	55-38-9	Kerosene	Fenoxycarb
38	{Landrin I}	2686-99-9		

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
I-13	**Insecticides Miscellaneous**			
			Lead Arsenate, Basic *(I)*	Clofentizine (Apollo)
			Methyl Trithion	Abamectin (Affirm, Avid)
			[DDT]	Pro-Drone
			Pine Tar	Nosema Locustae Canning (Noloc) *(B)*
			{Mobam}	Hirsutella Thompsonii (Mycarl) *(B)*
			Lead Arsenate, Acid *(I)*	Hesythiazox (Savey)
			Dimetilan (Snip) ▿	Luretape
			Sodium Arsenate *(I)*	
			Potassium Nitrate (Saltpeter) *(I)*	
R- 1	**Industrial preservatives Plastics, paints, textiles, paper and adhesives**			
191	Organo-Mercury		[Onyxide]	
137	Folpet	133-07-3	Visco P-25-F	
88	Copper 8 Quinolinolate	10380-28-6	Dodecyl Dimethyl Benzyl Ammonium Chloride	
42	Polyphase	55406536	Terramycin *(P)*	
11	Dichlorophene	97-23-4	Nvosept 95	
6	Thenarsazine oxide	58366	Mercaptobenzothiazole	
4	Vancide TH	7779274	Fluorosalan ▿	
			Biobor	
			Trans-1,2-bis (Propylsulfonyl) Ethylene	
			Vinyzene *(O)*	
			Biomet 4	
			2-Chlorophenol *(O)*	
			Amical	

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
			Cetyl Pyridinium Bromide	
			2,4,5-Trichlorophenol *(O)*	
R- 2	**Slimicides**			
	For use in pulp and paper, cooling towers and sugar mills			
259	Dazomet, DMTT			
	(busamid, Mylome, Nefusan)	533-74-4	2,4,6 Trichlorophenol	
241	Sodium Dimethyl Dithiocarbamate	128-04-1	Bis (Trichloromethyl) Sulfone	
221	{Metasol J-26}	12002-57-2	2,3-Dibromopropionaldehyde *(O)*	
219	Busan 40	51026289	1,4-Bis (bromoacetoxy)-2-Butene	
217	Busan 77	31512740	4-Bromoacetoxymethyl-M-Dioxolane	
172	Nabam	142-59-6	3,3,4,4-Tetrachlorotetrahydrothiophene 1,2-dioxide	
163	Nalco D-2303	6317186	2,6-Bis [(Dimethylamino Methyl] Cyclohexanone *(O)*	
118	Nabonate	138932	Chlorinated Levulinic Acids	
89	Copper EDTA	14951918	Sodium Chromate *(I)*	
71	Giv-gard	7166190	Sulfonated Cresol	
33	Belclene 310	22936750	XD-1603 (2,2-Dibromo-3-Nitrilopropionamide)	
21	Busan 90	2491385	Methyl-2-3-Dibromopropionate	
			Potassium Chromate *(I)*	
			Slimitrole	
R- 3	**Industrial Microbiocides**			
	Cutting oils and oil well additives			
28	Octhilinone	26530201	Grotan	R-32104
			Bioban 1487	Metronidazole
			Polyethylene Polyamine N-Oleylamine	Busan 1024
				CIS-2-Pinanol

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
R- 4	**Sanitizers**			
	For use in dairies, food processing, restaurants and air treatment			
162	Hyamine 2389	1399800		
159	Methyl Benzethonium Chloride	15716026	Magnesium Silicate *(I)*	
105	Hyamine 1622	121-54-0	Oley Trimethyl Ammonium Chloride (Aliquat 21)	
56	Hyamine 3500	68424-85-1	Phenol *(O)*	
51	Oxine-Sulfate	134316	Potassium Bromide *(I)*	
36	HAE	34375285	Potassium Hydroxide *(I)*	
			Sodium Bisulfate *(I)*	
			Sodium Bisulfite *(I)*	
			Benzalkonium Chloride (BTC)	
			Sodium Hydroxide *(I)*	
			Butanoic Anhydride *(O)*	
			4,5-Dibromosalicylanilide	
			3,5-Dibromosalicylanilide	
			Ammonium Acetate *(I)*	
			HCL *(I)*	
			N-Laurel Diethylenetriamin *(O)*	
			Neomycin *(P)*	
			Carbonates: Mg, K, Am, Na *(I)*	
			Alkyl Bis (2-Hydroxyethyl) Sodium	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
R- 5	**Synergists** **Used as insecticide synergists, surfactants, chelating agents and carriers**			
244	{Sulfoxide}	120-62-7	Arbanol Dee ▿	Bacillus Thuringiensis var Kurstaki
216	Piperonyl Butoxide	51-03-6	Pentasodium Diethylenetriamine Pentaacetate *(I)* N-Propyl Isome, Propyl Isome Heliotropin (Tropital) ▿ Calcium Sulfate *(I)* Turkey Red Oil (Sulfonated Castor Oil) Sesame Oil (Nematrol)	Kurstaki (EG 2348) *(B)* Kurstaki (EG 2371) *(B)*
R- 6	**Food preservatives** **Food**			
			Benzoic Acid *(O)* Sorbic Acid *(O)* Methyl P-Hydroxybenzoate *(O)* Proxel ▿ Acetic Acid *(O)*	
R- 7	**Wood Preservatives** **For industrial commercial and marine use**			
258	(Tetrachlorophenol (Dowicide))	25167-83-3	Sodium Arsenite *(I)*	
206	PCP, Pentachlorphenol	131-52-2	Sodium Pyroarsenate *(I)*	
190	Organo-Copper		Tar	
188	Organo-Arsenic		Potassium Bifluoride *(I)* Calcium Arsenate *(I)* Arsenic Pentoxide *(I)*	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
			Coal Tar Oils	
			Chromic Acid	
			Cobalt Naphthenate	
			Ammonium Arsenite *(I)*	
			Creosote *(I)*	
R- 8	**Disinfectants** **Medical, industrial, institutional, household, veterinary, poultry and livestock**			
			Glutaraldehyde *(O)*	
			Hydrogen Peroxide *(I)*	
			N-Alkyl-N-Ethyl Morpholinium Ethyl Sulfate	
			Gluconic Acid	
			Hexahydro-1,3,5-Tris (2-Hydroxypropyl)-S-Triazine ◁	
			Iodine Compounds	
			Propylene Glycol *(O)*	
			Uniquat CB 50	
			O-Benzyl-p-Chlorophenol	
			Octyl Decyl Dimethyl Ammonium Chloride	
			Alkyl Bis (Hydroxyethyl) Methyl Ammonium Chloride	
			Calcium Hypochlorite *(I)*	
			Chlorhexidine	
			4-Tert-Amylphenol	
			3,4,5-Tribromosalicylanilide	
			Alkyl (5-Hydroxy-4-Oxo-2(4H) Pyranyl Methyl)	
			Dimethyl Ammonium Chloride	
			Chlorine-B	
			Furfural *(O)*	
			Didecyl Dimethyl Ammonium Chloride	
			Formaldehyde *(O)*	

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
			Didecyl Decyl Dimethyl Ammonium Chloride	
R- 9	**Water disinfection** **Swimming pools. sewage effluents and potable water**			
			Silver *(I)* Sodium Persulfate *(I)* Sodium Bromide *(I)* Chlorinated Isocyanurates *(I)* Dialkyl Methyl Benzyl Ammonium Chloride Chlorinated Glycorulil Aluminum Sulfate *(I)* Chlorine Dioxide *(I)* EPIC Liquid Algacide	
R-10	**Plant regulators, defoliants and desiccants** **All uses**			
263	Folex	150-50-5	Fatty Alcohols *(O)*	Nibroxane
236	Tribufos (DEF)	013071-79-9	Ancymidol	Mon 4620
153	Mefluidide	53780-36-2	Cycocel	Marstat PN
145	Propham (IPC)	122-42-9	Gibberellic Acid *(O)*	Acoel
72	Cacodylic Acid	75-60-5	Ethephon	Requat
50	Ethoxyquin	91-53-2	Daminozide	Paclobutrazol (Clipper)
46	CPA (Fruitone)	122883	Arsenic Acid *(I)*	Sherichem DM
2	Maleic Hydrazide	123-33-1	NAA, 1-Naphthalenacetic Acid *(O)*	Baguacil
			Chloroflurenol	Triacantanol (Triacon)
			Methyl Esters of Fatty Acids *(O)*	YEA, Chitosan
			Sulfuric Acid *(I)*	
			Ethylene *(O)*	
			{TIBA} *(O)*	

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
			Thidiazuron	
			Hexachloroacetone *(O)*	
			Fluoridamid	
			Fosamine Ammonium	
			Indole-3-Butyric Acid	
R-11	**Preservatives, disinfectants, slimicides**			
211	{Phenylphenol (Orthoxenol)}	90-43-7	Nitrapyrin	
7	Dowicil 75		Lime *(I)*	
			Omadine-Sodium	
			Potassium Permanganate *(I)*	
			Potassium Iodate *(I)*	
			Hexylene Glycol *(O)*	
			Chlorobenzene *(O)*	
			Abietylamine *(O)*	
			Dowicide 31 and 32 (4 and 6-Chloro-2-Phenylphenol)	
			Chromic Acid *(I)*	
			Dowicil A-40 (2,3,5-Trichloro-4-(Propylsulfonul pyridine)	
R-12	**Molluscides and Misc. Vertebrate control agents All uses**			
192	Organo-tin		Niclosamide (Bayluscide, Bayluscid)	Stirrup M *(O)*
40	Mercaprodimethur, Methiocarb	2032-65-7	Magnesium Sulphate (Epsom Salts) *(I)*	
			Lamprecid	
R-13	**Bird Chemosterilants, toxicants and repellants All uses**			
			Copper Oxalate *(I)*	
			Ornitrol	

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
			1,4-benzoquinone (Quinone) *(O)*	
			4-Aminopyridine (Avitrol) *(O)*	
			Paloja	
			Polyethylene *(O)*	
			Polyisobutylene *(O)*	
			Zinc Oxide *(I)*	
			Polybutene *(O)*	
			Starlicide	
R-14	**Dog/Cat Repellants** **All uses**			
			Allyl Isothiocyanate (Mustard Oil) *(O)*	
			Anethole (anise camphor) Cinhamic Aldehyde *(O)*	
			Benzyl diethyl 2,6-xylylcarbamoylmethyl ammonium benzoate (Bitrex)	
			Blood	
			Capsaicin	
			Citral	
			Citrus Oil	
			Cresylic Acid	
			Pentanethiol *(O)*	
			Geranium Oil	
			Methyl Nonyl Ketone *(O)*	
			Trichloroethylene	
			Pyridine *(O)*	
			Thymol *(P)*	
			Hefty Dog and Cat Repellant	
R-15	**Rodent toxicants, anticoagulants, predator control** **For all uses**			

PESTICIDE CLUSTERS (cont'd)

	PAIs Subject to Regulation	Chemical Abstract Service # for PAIs Subject to Regulation	Other PAIs on OPP List	New PAIs (registered after 1980)
265	Warfarin	81-81-2	Strychnine Sulfate	Bromadiolone (Maki)
242	{Sodium Fluoroacetate, 1080}	62-74-8	Strychnine	Bromethalin Bait
136	[Fluoroacetamide]	144-49-0	Red Squill *(B)*	Epibloc *(P)*
114	Diphacinone	82-66-6	R-55 (tert-butyl dimethyltrithioperoxycarbamate)	Cholecalciferol (Quintox) *(P)*
43	{Fumarin (Bromethalin)}	117-52-2	Phorazetim (Gophacide)	
37	Chlorophacinone	3691-35-8	PMP (Valone)	
29	Pindone (Pival)	83-26-1	Sodium Cynanide *(I)*	
			2-Isovaleryl-1,3-Indandione, Calcium Salt	
			Zinc Phosphide *(I)*	
			Phosphorus *(I)*	
			Brodifacoum (Talon)	
			Alpha-Naphthylthiourea (Antu) *(O)*	
U- 1	**Unclassified**			
266	Zetax (Zine MBT)	155044		
218	Arylane (Busan 85)	128030		
189	Organ-Cadmium (none registered)			
139	{Glyphosine}	2439-99-8		
10	Tetrachlorophene	1940438		

APPENDIX C

METHODOLOGY FOR ESTIMATING THE PRICE ELASTICITY OF DEMAND FOR PESTICIDE CLUSTERS

Appendix C: METHODOLOGY FOR ESTIMATING THE PRICE ELASTICITY OF DEMAND FOR PESTICIDE CLUSTERS

This appendix provides the complete methodology for estimating the price elasticity of demand for pesticide clusters. The price elasticity of demand is used in the EIA to predict the change in demand given an increase in PAI price due to compliance with the effluent guidelines. (See Chapter 4.)

ESTIMATES OF THE PRICE ELASTICITY OF DEMAND FOR PESTICIDE CLUSTERS

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1.0 INTRODUCTION

Purpose of the Analysis

Abt Associates has submitted a draft economic impact assessment (EIA) methodology for assessing the costs of new effluent guidelines for the pesticide industry. The draft EIA methodology relies on the use of price elasticities of demand for pesticide clusters. In this memorandum, demand elasticities for each cluster are estimated based on a review of empirical analyses, the elasticity of demand for food commodities, and a consideration of the factors predicted by microeconomic theory to influence elasticity of demand.

Definition of the Price Elasticity of Demand

In general, the economic concept of elasticity measures the sensitivity of the dependent variable to a change in the value of an independent variable. In particular, the price elasticity of demand measures the sensitivity of consumers to changes in price. (Since this is the elasticity measure of concern for this report we may, for convenience, use the term 'demand elasticity' in place of the term 'price elasticity of demand'.)

The price elasticity of demand estimates the degree to which a change in price results in a change in the quantity demanded. It can be defined as the percentage change in demand divided by the percentage change in price. If consumers cut back their purchases to such a large extent that any price increase reduces total revenue, then demand is said to be elastic, i.e., customers are sensitive to price changes. If consumers cut back their purchases only slightly in response to higher prices, resulting in an increase in revenue, demand is said to be inelastic, i.e., customers are not as sensitive to price changes. The value of the price elasticity of demand is unbounded and may be positive or negative. It is expected, however, that price and demand are negatively correlated, i.e., an increase in price results in a decrease in the quantity demanded. The price elasticity of demand is therefore usually negative.

Four possible values, or ranges of values, of the price elasticity of demand are of particular interest. First, if the absolute value of the elasticity of demand is greater than one, demand is termed elastic. In other words, the percentage change in demand is greater than the percentage change in price. Second, demand is said to be inelastic when the absolute value of the elasticity of demand is less than one but greater than zero. Third, if the value of the elasticity of demand is zero, demand is said to be perfectly inelastic. That is, consumers will continue to purchase a given quantity of a good, despite any changes in price. Finally, if demand and price change by equal percentages, the value of the demand elasticity is exactly one, and demand is said to have unit elasticity. Numeric values are generally expressed relative to a one percent change in price. For example, an elasticity of -1.5 means that a 1 percent increase in price would result in a 1.5 percent decrease in the quantity demanded.

Measurements of the price elasticity of demand are of use in predicting the incidence of a price increase. As the absolute value of the price elasticity rises, the proportion of the cost increase that can be passed on to consumers declines. If demand is perfectly elastic, no cost pass through is possible.

Market Definition

In order to estimate the price elasticity of demand for pesticides, a clear definition of the markets of concern must be developed. In this analysis, the markets are defined to be 44 separate clusters of pesticides. The clusters are groups of pesticide active ingredients which are close substitutes for a given end-use. For example, insecticides used on vegetables is one of the clusters; herbicides used on turf is another.

The elasticity of demand for pesticides may vary significantly between the clusters, since each cluster faces different market forces. In particular, a distinction may be drawn between the agricultural end-uses and the non-agricultural end-uses. Agricultural sales represent approximately 70 percent of the total expenditures for conventional pesticides in the U.S., with the remainder split about equally between commercial and domestic sales (U.S. EPA, 1988). In contrast to the non-agricultural markets, the basic market structure within which fungicides, herbicides, and insecticides are used agriculturally is somewhat consistent across users and some documentation is available by which to estimate the elasticity of demand. The price elasticity of demand for pesticides used agriculturally will be analyzed first, followed by a discussion of the elasticity of demand for pesticides used in the non-agricultural sector.

2.0 PRICE ELASTICITY OF DEMAND FOR AGRICULTURAL PESTICIDES

Within the agricultural pesticide market there exist several industry sectors including manufacturers, formulators and packagers, distributors, and retailers of pesticides. The primary goal of this analysis is to estimate the elasticity of demand faced by the manufacturers of the active ingredients. However, most studies consider the demand elasticity of the end-user rather than that of the formulator/packager (usually the direct customer of manufacturers). This analysis will assume that the demand elasticity of the formulator/packager is equal to the demand elasticity of the end-user since data on formulator/packager demand elasticity were not located. Assuming competitive markets, the long-run elasticities faced by the manufacturing sector should be similar to the elasticities faced by formulators/packagers.

2.1 Methodology

There is no one recognized source of information for the price elasticity of demand for pesticides; in fact, there is an acknowledged lack of information in this area of study. Abt Associates conducted a thorough search for analyses of the price elasticity of demand for pesticides and also sought expert opinion as to the expected elasticities. The sources considered included literature searches using the following databases from Dialog Information Services: Economic Literature Index, Dissertation Abstracts Online, Agribusiness U.S.A., Agricola, Agris International, and NTIS. A search for subject matter containing the following key words was conducted: price elasticity, or demand, or demand elasticity, and agricultural, or chemical, or pesticide, or herbicide, or fungicide, or insecticide. In addition to the literature search, Abt Associates sought information from the U.S. EPA Office of Pesticide Programs, the U.S. EPA Office of Policy, Planning, and Evaluation, several offices of the U.S. Department of Agriculture, the U.S. International Trade Commission, the Chemical Specialty Manufacturers Association, the National Agricultural Chemical Association, the World Bank, Resources for the Future, the editor of the American Journal of Agricultural Economics, a market research firm, Cornell University, North Carolina State University (Dr. Gerald Carlson), Texas A&M University (Dr. Ron Lacewell), Virginia Polytechnic Institute (Professor George Norton), Iowa State University, Stanford University (Dr. Sandra Archibald), the University of Massachusetts (Professor Joe Moffitt), the University of Arkansas (Professor Mark Cochran), and Harvard University.

The literature search and conversations with the listed expert sources indicated that studies of the price elasticity of demand for pesticides are sparse, and that the existing analyses offer conflicting conclusions and are often controversial. Further, an attempt at compiling expert opinions as to expected elasticities failed; the lack of available research on this issue precluded compact, ready answers that could be conveyed by telephone. In order to develop the elasticity estimates, Abt Associates developed a five-pronged approach.

First, as described in Section 2.2, Abt Associates considered the relevant empirical studies. Though these studies do not comprehensively answer the question at hand for reasons that are presented below, they do provide estimates of demand elasticity for selected clusters. The second input, and the main source of data from which pesticide elasticities are derived in this analysis, is U.S. Department of Agriculture's (U.S.D.A.) analysis of the price elasticity of demand for food commodities (U.S.D.A., 1985, 1989). The elasticity of demand for farm inputs can be derived from the elasticity of the demand for farm commodities since demand for production inputs must ultimately reflect demand for the end product. Though the two elasticities may not correspond exactly, the elasticity of demand for the food commodities can serve as a reasonable proxy for the elasticity of demand for pesticides in the absence of more relevant data. U.S.D.A.'s estimates of elasticity and the use of these estimates for purposes of this analysis are discussed in Section 2.3.

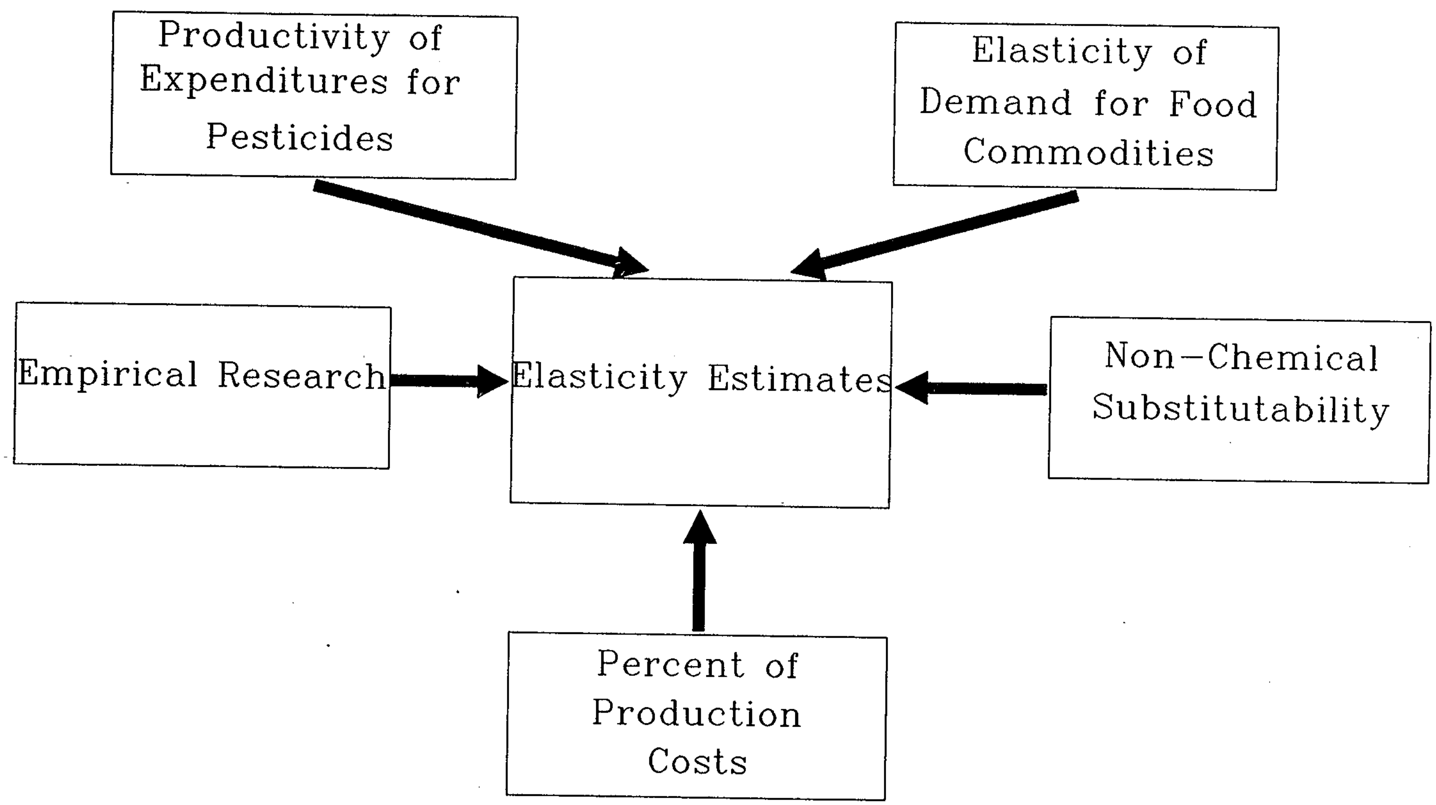
The other three factors used to estimate the elasticity of demand for pesticides are (1) the feasibility of employing non-chemical or non-biological pest control methods, (2) the percent of production cost contributed by the pesticide of interest, and (3) the productivity of expenditures for pesticides. Section 2.4 groups pesticide clusters based on the feasibility of substituting another pest control method for chemical and biological pesticides. The greater the feasibility of substitution, the higher the expected price elasticity of demand. Since the clusters group chemical and biological substitutes, the potential substitutes for a cluster of pesticides are cultural or environmental control technologies, such as crop rotation or the introduction of predatory insects. The rankings of the feasibility of non-chemical substitution for a cluster of pesticides are based on Pimentel et al. (1991).

The analysis of pesticide contribution to the cost of production of a commodity is based on U.S.D.A.'s published estimates of the cost of production in the farm sector (U.S.D.A., 1989a, 1989b, 1988). The greater the contribution to the cost of production, the higher the expected price elasticity of demand. Pesticide contribution to production costs is reported in Section 2.5.

Finally, the productivity of expenditures for pesticides is examined in Section 2.6. In theory, if pesticides are highly productive (i.e., the costs of pest damage without pesticides greatly exceeds the expenses of pesticide application), a prescribed pesticide dosage will be applied regardless of some degree of price variation. In other words, if pesticides are highly productive, the demand for pesticides is likely to be inelastic.

Figure 2.1

Approach to Estimating Price Elasticity of Demand for Pesticides



Section 2.7 combines the information from the empirical studies, the elasticity of demand for food commodities, the substitutability rankings, the data on pesticide contribution to production cost, and the measures of pesticide productivity to estimate the price elasticity of demand for agricultural pesticide clusters. The U.S.D.A. estimates of the elasticity of demand for food commodities are used as the basis for the final elasticity estimates. The other factors are analyzed to determine cases in which the elasticity of demand for food commodities may vary substantially from the elasticity of demand for pesticides applied to the food commodities. In cases where there is a clear indication that the elasticity of demand for the food commodities and the elasticity of demand for the pesticides applied to the food commodities differ, the elasticity estimates are adjusted in the appropriate direction.

Precise quantification of the elasticity of demand, however, is not revealed through the examination of feasibility of substitution, contribution to costs, and productivity of the pesticides. The results only indicate whether demand for the pesticides is likely to be more or less elastic than demand for the relevant food commodities. Therefore, unless there is compelling evidence that the elasticities of demand for food and pesticides applied to food differ substantially, this analysis relies on the estimates of elasticity of demand for food commodities to represent the elasticity of demand for pesticides applied to those food commodities. It should be clear that the resulting elasticity estimates serve as indicators of the approximate magnitude of demand elasticity and not as precise quantifications of these elasticities.

2.2 Review of Empirical Studies of the Price Elasticity of Demand For Pesticides

The empirical analyses of the price elasticity of demand for pesticides can be separated into econometric analyses and other analyses. The econometric analyses of demand elasticity employ several different dependent variables. Variations in the dependent variable influence the resulting demand elasticities. In particular, the dependent variables differ in the level of aggregation of pesticides and in whether pesticides are measured in units of production or units of use.

The level of aggregation of the pesticides may influence demand elasticity by determining the number of close substitutes that are available. According to microeconomic theory, the more narrowly a product is defined, the more substitutes that are likely to be available. For example, more substitutes are available for pork chops than are available for meat.

If a product has many close substitutes, it is likely to be characterized by an elastic demand. Consumers can react to a price increase by switching products without much loss of utility. If a product has a more limited number of substitutes, consumers have little choice but to bear more of the price increase. For chemical pesticides in general, substitutes include only labor and other non-chemical pest control methods. These are also the only substitutes for fungicides, herbicides, or insecticides since pesticides are generally effective against only either pathogens, weeds, or insects. Since the clusters used in this analysis were chosen to include all close chemical and biological substitutes for an end-use, the only pest control alternatives are non-chemical and non-biological. Substitutes for specific active ingredients, however, may include other active ingredients in addition to the non-chemical, non-biological alternatives.

For the purposes of determining the incidence of the cost increase resulting from new effluent regulations, the ideal price elasticity of demand is that corresponding to each pesticide cluster. However, few of the relevant analyses that Abt Associates located estimate elasticity of demand for clusters of pesticides. Some of the analyses reviewed in this report consider pesticides as a group as the dependent variable; other studies analyze herbicides, fungicides, and insecticides separately or study the demand elasticity for pesticides by crop. Another group looks at specific active ingredients.

In determining the elasticity of demand for clusters of active ingredients, it may at first appear reasonable to bound the elasticity of demand for clusters of pesticides by using the elasticity of demand for pesticides as a group as the lower bound and the elasticity of demand for individual active ingredients as an upper bound. Since pesticides as a group will include all clusters of pesticides, it could be argued that a cluster will exhibit an elasticity no lower than the elasticity of pesticides as a group. However, since the elasticity of pesticides as a group represents an average of the elasticities of clusters it can not serve as a boundary for any one cluster. Similarly, since the elasticities of demand for individual active ingredients within a cluster will vary, the elasticity of any one active ingredient can not act as an upper boundary for the elasticity of the cluster. For purposes of comparison, however, this analysis considers the empirical analyses in two groups: those which consider pesticides as a group and those which consider individual active ingredients.

A second major variation between the regression analyses of demand elasticities reviewed in this report is whether the dependent variable was measured in units of production (e.g., pounds produced per year) or in units of use (e.g., pounds applied per acre per year). Due to potentially significant inventories of pesticides and the dissimilar market structures of pesticide manufacturers and packagers/formulators of pesticides, units of production and use may result in different estimates of elasticity. Further, some studies defined the dependent variable in absolute terms while others used the percent of crop treated. Also, the dependent variable was alternately measured in units of expenditure (e.g., dollars) and units of quantity (e.g., pounds).

Finally, the studies differed in the specification of the model (e.g., simultaneous equations vs. single equation models, inclusion of an independent variable for labor), the time period included, and the region of the country considered. All of the factors discussed above contribute to the difficulty of comparing the empirical studies.

The results of the analyses of elasticity of demand, categorized by their definition of the dependent variable, are described below.

<u>Aggregated dependent variable measured in units of use</u>

Five analyses were located which estimated demand elasticity for pesticides as a group and measured the dependent variable in units of pesticide use. The studies are: Pingali and Carlson (1985), Miranowski (1980), U.S. EPA (1974), Huh (1978), and Burrows (1983). The results of these studies are conflicting. Huh reports demand for herbicides and insecticides used on corn as elastic. Contradicting this result, U.S. EPA (1974) indicates that demand for corn and soybean herbicides and corn insecticides is inelastic. Miranowski also concludes that demand for herbicides used on corn is moderately inelastic when labor is not included in the analysis. However, the price coefficient in his equation is not significantly different from negative one. When Miranowski includes labor in his model, price is insignificant, suggesting that labor is a substitute for herbicides used on corn. Miranowski did not find price to be a significant factor in predicting the level of corn insecticides used. Therefore, his model offers little further insight into the elasticity of demand for insecticides. Burrows also found pesticide price to be insignificant in explaining demand for pesticides and mitacides used on cotton. Finally, Pingali and Carlson estimate that the price elasticity of demand for insecticides and fungicides used in orchards to be significantly different from zero, but not significantly different from negative one.

Pingali and Carlson estimated price elasticity of demand as part of a larger, multidisciplinary study over the 1976-1980 period for forty-seven orchards in Henderson County, North Carolina. To analyze the effect of errors in subjective perception on the demand for pest controls, Pingali and Carlson ran a simultaneous model of pest populations and pest controls. Their model involved a five-equation system with two pest population equations (insect and disease infestation levels), two pesticide equations (insecticides and fungicides), and one pruning status or labor equation.

The variables used in the pesticide equations were obtained from input demand functions developed by Pingali and Carlson. The derived demand functions had four groups of variables: biological, input prices, risk aversion, and human capital. The levels of insecticides and fungicides were given in terms of pounds of active ingredients applied per acre of orchard. The cost per unit of insecticides and fungicides were given in dollars per pound of active ingredients. A two-stage least squares estimate of the system resulted in a price elasticity of demand for insecticides of -1.39. The fungicide price elasticity of demand was estimated as -0.92. The elasticities of demand for both insecticides and fungicides were found to be significantly less than zero but not significantly different from negative one. The model can therefore be interpreted to confirm a negative correlation between price and demand; it does not, however, indicate with certainty whether demand is elastic or inelastic.

Miranowski (1980) considered alternative pest management systems for corn production with rising energy prices. He used historical data from U.S.D.A. agricultural regions from 1968, 1971, and 1976 to estimate derived demand equations for insecticide and herbicide treatment. Separate weighted least squares regression models for insecticide and herbicide treatment were developed as follows:

$$\ln ST_{i,h} = a_0 + a_1 \ln P_{i,h} + a_2 \ln P_f + a_3 \ln y + a_4 \ln SCA + a5 \ln RE + \ln P_l + e$$

where

$ST_{i,h}$	=	share of corn treated with insecticides (i) or herbicides (h),
$P_{i,h}$	=	price of insecticides (i) or herbicides (h),
P_f	=	price of fuel,
y	=	value of corn output per acre,
SCA	=	share of corn acres in cropland acres,
RE	=	lagged production-oriented research and extension expenditures, and
P_l	=	farm wage rate.

Miranowski obtained data on insecticide and herbicide treatment, as the share of corn acres treated, from the U.S.D.A. annual pesticide surveys for 1968, 1971, and 1976. The input price indices, $P_{i,h}$ and P_f, were derived from data in U.S.D.A.'s Agricultural Prices - Annual Summary (for 1967, 1972, 1977).

Miranowski estimated price elasticity of demand for insecticides as -0.78. However, the coefficient was not significantly different from zero. He reported results of two herbicide demand models, one with and one without the price of labor. When the price of labor is not included in the analysis, the coefficient on herbicide price, -0.75, is significantly less than zero but not significantly different from negative one. Therefore the elasticity of demand may be either elastic or inelastic, but only moderately so.

When the wage rate is held constant, the herbicide price coefficient is 0.03 and becomes insignificant. Though the results of the model with labor held constant may be consistent with inelastic demand for herbicides, the coefficient on labor is positive and significant, suggesting that labor and herbicides are substitutes. The coefficients of the price of pesticides in the two herbicide models suggest that the price of labor and the price of pesticides are co-linear. Since the coefficient for the price of herbicides becomes insignificant when labor is included in the model, it may be the case that the labor price variable is dominating the herbicide price variable with the result that change in the dependent variable appears to be largely a function of the cost of labor rather than the price of herbicides. However, when labor is absent from the model, the coefficient of the price of pesticides probably includes some of the influence of labor rate changes. The "true" elasticity of demand is therefore likely to fall between the two coefficients of -0.78 and 0.03, still indicating inelastic demand.

Huh (1978) estimated pesticide price elasticity of demand in his doctoral dissertation. Using cross-sectional farm data from Minnesota, Huh modeled pounds of active ingredients of herbicides and insecticides used on corn per farm (Q_T). Exogenous variables included in his final aggregate demand equation were:

x_{2w} = adjusted and weighted price of pesticides (dollars per pound),

x_7 = acres of corn per farm, and

D_5 = a dummy variable for crop rotation plan (0 when farmer did not intend to plant corn again in 1978, 1 when farmer intended to plant some or all of corn in 1978).

The results of the regression analysis were as follows (standard errors are in parentheses):

$$\ln Q_T = 2.212 - \underset{(0.161)}{1.464} \ln X_{2w} + \underset{(0.064)}{1.099} \ln x_7 + \underset{(0.110)}{0.381} D_5 + e$$

The coefficient of the price of pesticides was significantly less than zero and also significantly different from negative one, indicating elastic demand. However, since an independent variable for pesticide substitutes (e.g., labor) was not included, the coefficient on pesticide price may include the effect of changes in labor or other substitute prices and therefore have a bias towards greater elasticity. Huh's model is therefore likely to overstate the elasticity of demand to an unknown degree.

As part of an analysis of farmers' attitude towards alternate crop protection methods, U.S. EPA (1974) described a survey of farmer sensitivity to pesticide price changes. Farmers in Iowa and Illinois responded to the survey as follows:

Percent of Respondents		
Iowa	Illinois	
88	82	(of corn growers) believe all of their corn acres need herbicides each year
62	56	(of corn growers) would not change herbicide use if cost doubled
55	55	(of corn insecticide users) believe all of their corn acres need insecticides
29	39	(of corn growers) believe all of their corn acres need insecticides
77	61	(of corn insecticide users) would not change insecticide use if cost doubled
96	86	(of soybean growers) believe all of their soybean acres need herbicides each year.
72	67	(of soybean growers) would not change herbicide use if cost doubled

The results indicate that the majority of farmers surveyed are insensitive to price changes. Demand for corn and soybean herbicides and corn insecticides appears to be inelastic.

The final study in this category was conducted by Burrows (1983). Burrows tested the hypothesis that integrated pest management (IPM) will significantly reduce pesticide use. He also examined the methodological issue of simultaneity between pesticide use and IPM adoption. Burrows considered only insecticides and mitacides. His data were drawn from a random sample of San Joaquin Valley cotton growers. The observations contain detailed information on output, pesticide and other input use, cost, and revenue for 47 growers spanning a 5 year period from 1970-1974.

Burrows performed a Generalized Least Squares (GLS) procedure for both single and simultaneous equation models. The dependent variable is insecticide and mitacide use measured in sales dollars per acre of cotton grown. Explanatory variables include average pesticide price per pound, an IPM consultant fee per acre, and the expected yield in pounds per acre. Weather and cultural practices are included as proxies for both the size of the pest population and pesticide persistence in the environment. A risk proxy, the ratio of acres planted in cotton to total acres, is used assuming that, for higher ratio values, risk-averse growers will be likely to use more pesticides as insurance against crop loss. Pesticide price is a quantity-weighted price index.

In both the single and simultaneous models, pesticide prices are insignificant. Burrows explained that this may result from limited degrees of freedom (there are only ten price observations). He also offered an alternative explanation that expenditures may not be sensitive to price when conflicting sources of information - personal experience, pesticide salespersons, IPM consultants, and extension representatives - affect the decision to spray. Another potential explanation is that if the expected rate of return from pesticide use is high, price movements over a modest range would not have much explanatory value. The price elasticity determined by the single equation model is approximately unity, -0.90. The elasticity resulting from the simultaneous version of the model is -1.23. Since the coefficients were not significant, these values are inconclusive.

Aggregated dependent variable measured in units of production

An earlier version of an economic impact assessment of pesticide effluent guidelines analyzed aggregated pesticides and measured the dependent variable in units of production (U.S. EPA, 1985). U.S. EPA found that the price elasticity of demand for pesticides as a group, as well as for fungicides, herbicides, and insecticides was significant and inelastic. EPA estimated pesticide elasticity of demand based on the following log-linear function:

$$\ln PROD_t = a + b \ln PROD_{t-1} + c \ln ACRE_t + d \ln RPRICE_t + f (IX_t)$$

where:

$PROD_t$, $PPROD_{t-1}$	=	production of pesticide active ingredients in year t and t-1
$ACRE_t$	=	acreage of principal crops planted in year t
$RPRICE_t$	=	real unit price for pesticide active ingredient in year t
IX_t	=	Industrial production index in year t

Elasticities were calculated for herbicides, insecticides, fungicides, and all pesticides. Pesticide production rates were obtained from U.S. International Trade Commission, Synthetic Chemicals. The units of production were not given. Pesticide prices were average prices for each product group and for all pesticides and were calculated from U.S. International Trade Commission, Synthetic Chemicals and converted to real prices using the GNP Deflator. Based on this model, EPA obtained the following results:

Ln of Production of	Intercept	Ln Acres	Ln Real Price	Ln Production Previous Year	Industrial Production Index
Herbicides $R^2 = 0.98$	-12.93 (-3.51)	3.19 (4.02)	-0.67 (-2.49)	0.299 (1.88)	-0.00651 (-3.24)
Insecticides $R^2 = 0.68$	-3.49 (-1.32)	1.53 (2.90)	-0.32 (-2.51)	0.142 (0.57)	
Fungicides $R^2 = 0.35$	-1.46 (-0.47)	1.04 (2.02)	-0.35 (-2.07)	0.05 (0.18)	
All Pesticides $R^2 = 0.89$	-6.42 (-2.26)	1.88 (3.02)	-0.49 (-2.37)	9.427 (1.84)	

T-statistics are given in parentheses. The analysis indicated that demand is inelastic for each of the three pesticide groups as well as for pesticides in general. All price elasticities were significantly less than zero, and significantly lower than one in absolute value, except for the coefficient for herbicides which is not significantly different from negative one. The model, therefore, indicated that the price elasticity of demand for insecticides, fungicides, and all pesticides is inelastic. According to the model, the price elasticity of demand for herbicides is near unity, meaning that demand may be either elastic or inelastic.

The analysis suggested that the demand for herbicides is more elastic than the demand for insecticides or fungicides. EPA explained that during the 1970's herbicides experienced a large increase in application rates and the proportion of acres treated and that "the coefficient on acres in the herbicide equation reflects this". The authors also noted that "one of the reasons the amount of variation explained by the fungicide equation was so low was that a very large proportion of fungicides were used for non-agricultural purposes". The authors were unable to explain why business cycles are important for herbicides and not for the other two product groups. It should be noted that the study did not include a variable for prices of substitutes or final products. If these prices are correlated with pesticide prices, the coefficients may be biased. Finally, the authors did not identify the type of end-use (e.g., agriculture, commercial, domestic) of the pesticides included in their analysis.

Another factor that may influence the results obtained by EPA is that the dependent variable is measured by weight (pounds). This may not accurately reflect price elasticities since more effective and expensive pesticides may be substituted for pesticides requiring higher doses to be effective. EPA acknowledged this issue, stating that there has been a decrease in the amount of insecticides produced due to the substitution of synthetic pyrethroids for more conventional pesticide ingredients. The synthetic pyrethroids are more powerful than conventional pesticides, thus reducing the weight of pesticides required for pest control. EPA asserted, however, that in terms of total insecticide production, these impacts are small.

Active ingredient as dependent variable: measured in units of use

The following three studies examined demand elasticity for specific pesticides and measured demand in units of use: Lacewell and Masch (1972), Carlson (1977), and Carlson (1977a). Lacewell and Masch found that the demand for the herbicide 2,4-D was inelastic. Carlson's price coefficient for 2,4-D was small and negative, but not significant, which may be consistent with price inelasticity. Carlson's significant price coefficients for insecticide active ingredients indicated that demand is elastic in both the short-run and the long-run.

Lacewell and Masch selected a five county area in the Northern High Plains of Texas as the study area to evaluate the effect of a tax vs. a marketing quota farm program on the level of chemicals used in a specific agricultural region. The primary agricultural crops of the area were grain sorghum and wheat. To control weeds in wheat and grain sorghum, herbicides, especially 2,4-D, were utilized.

Using data on land utilization for 1969, Lacewell and Masch constructed a linear programming model for the five county region. For illustrative purposes, the change in the quantity of 2,4-D used in response to changes in the price of 2,4-D was investigated. Requirements for weed control were assumed to be met by one of three weed control alternatives: (1) use of 2,4-D, (2) use of 2,4-D and dicamba, and (3) use of dicamba, other chemicals and additional tillage operations. The price of 2,4-D was increased by increments, using parametric programming, from 52 cents per pound to $37.00 per pound, at which point the model predicted no 2,4-D would be used. In response to a more marginal price increase of 78 percent (from $0.52 to $0.93 per pound), Lacewell and Masch predicted a decrease in use of 2,4-D of 30 percent. This translates to an inelastic demand of approximately -0.38.

Carlson's two articles (1977 and 1977a) used the same log-linear model to examine demand elasticities of particular herbicides and insecticides. Carlson first considered price elasticity of demand for pesticides as part of a study to determine the importance of pest resistance to insecticides in affecting demand for specific compounds. In his second article, Carlson illustrated some advantages and disadvantages of price incentive systems relative to quantity incentive systems for pollution control.

Carlson used individual farm data on insecticide use from several cotton production regions to test hypotheses of decreasing productivity of insecticides and substitutability between chemical types. His original estimation model is

$$Q_t = c_0 + c_1 R_{1t} + c_2 R_{2t} + c_3 e_t + c_4 C_t + E_t$$

where

Q_t = quantity of a given insecticide purchased in year t (pounds of actual material),
R_{1t} = insecticide price deflated by an index of all agricultural input prices,
R_{2t} = substitute insecticide price,
e_t = resistance index,
C_t = agricultural product price index, and
E_t = error term.

The agricultural product price variable, C_t, was not statistically significant and was deleted from the model. A lagged dependent variable was added to account for the assumed effects of delayed adjustments to price changes. Carlson used this model to analyze several of the largest selling groups of insecticides. The specific dependent variables and their price elasticities were as follows (standard errors appear in parentheses):

Dependent Variable	Price elasticity
(A) Domestic and foreign sales of cyclic organophosphate insecticides (1953-1970)	-1.461 (0.796)
(B) Same as (A) except divided by domestic cotton acreage planted	-1.552 (0.780)
(C) Total sales of parathion and methyl parathion (1953-1970)	-1.06 (0.273)
(D) Domestic sales of DDT (1945-1969)	-0.667 (0.397)
(E) Domestic sales of DDT (1953-1969)	-1.091 (0.625)

Insecticide price has the expected negative effect on insecticide purchases. Carlson concludes that sales of the compounds are quite responsive to price, indicating that there are many substitute pest controls in the long run. None of the coefficients, however, are significantly different from negative one, so the model indicates that elasticity of demand is unlikely to be either highly elastic or highly inelastic.

In Carlson's subsequent article (1977a) he reported a slightly different elasticity for the parathion and methyl parathion group and also includes the herbicide 2,4-D in his analysis. Further he reported long-run elasticities for DDT and 2,4-D. The results were as follows:

Dependent Variable	Price elasticity
(F) Domestic sales of parathion, methyl parathion (1953-1969)	-0.945 (0.339)
(G) Domestic sales of 2,4-D (1950-1970, except 1965-68) divided by cropland index	-0.193 (0.349)
(H) Same as (D) except long-run	-1.53
(I) Same as (G) except long-run	-0.594

The analysis indicates that the elasticity of DDT increases substantially from the short-run to the long-run, as would be expected as more substitutes may be developed with time. The coefficient for 2,4-D shows demand to be inelastic, but is insignificant. Though this result may be consistent with inelastic demand, it is inconclusive.

Active ingredient as dependent variable; measured in units of production

Abt Associates located no studies which fit this category.

Summary

Table 2.1 summarizes the empirical studies discussed above; Figure 2.2 displays the empirically-derived elasticity estimates graphically. As can be seen from Figure 2.2, elasticity estimates ranged from approximately zero to -1.5. While most estimates indicate that the demand for pesticides is relatively inelastic, the results are inconclusive. Since the studies used different models and, in particular, different dependent variables, variation in the estimates is expected. The number of studies which considered clusters of pesticides as the dependent variable was insufficient to draw reliable conclusions as to the price elasticity of demand for clusters of pesticides. However, the results of the analyses which did define the dependent variable as a cluster of pesticides will be considered in the final estimations of demand elasticities.

Table 2.1
SUMMARY OF ECONOMETRIC ANALYSES

Study	Model Type	Data Sources	Time period of study	Dependent Variable	Independent Variables	Price Coefficients (standard errors)	R square	Significantly different fro zero?	Significantly different from negative one?
Pingali and Carlson (1985)	5 equation system;	Study of 47 orchards	1976–1980	Active ingredient applied	canopy rating	insecticides: –1.39		yes	no
	Separate least squares	in Henderson County, NC		per acre of orchard (lbs)	disease density	(0.35)			
	regressions for insecticides				insect populations	fungicides: –0.92		yes	no
	and fungicides;				variety of trees	(0.32)			
	log-linear function				spacing				
					humidity				
					temperature				
					rainfall				
					tree age x tree size				
					fruit yield				
					cost/unit insecticide				
					cost/unit fungicide				
					additional labor				
					potential income				
					variance of insect damage				
					variance of disease damage				
					schooling				
					extension publications				
ınowski (1980)	Separate least squares	Historical data from	1968,1971, and 1976	Share of corn treated with	price of insecticides	insecticides: –0.78	0.36	no	no
	regressions for insecticides	USDA agricultural regions		insecticides or herbicides	or herbicides	(–0.53)			
	and herbicides;				price of fuel	herbicides:			
	log-linear function				value of corn output	(wage rate constant)	0.77		
					per acre	0.03		no	yes
					share of corn acres in	(0.30)			
					cropland acres	(wage rate varies)	0.67		
					lagged production-oriented	–0.75		yes	no
					research and extension	(0.18)			
					expenditures				
					farm wage rate				

Table 2.1 (cont.)
SUMMARY OF ECONOMETRIC ANALYSES

Study	Model Type	Data Sources	Time period of study	Dependent Variable	Independent Variables	Price Coefficients (standard errors)	R square	Significantly different fro zero?	Significantly different from negative one?
U.S. EPA (1985)	time series; log-linear function	acres – various U.S.D.A. publications real price – U.S. International Trade Commission, Synthetic Chemicals; GNP Deflator U.S. Department of Commerce Bureau of Economic Analysis production – U.S. International Trade Commission, Synthetic Chemicals, various issues industrial production index – U.S. Board of Governors of the Federal Reserve System, Federal Reserve Bulletin, various issues.	Herbicides, Fungicides, and all pesticides: 1967–81. Insecticides: 1967–79	Production of pesticide active ingredients in year t	Acreage of principal crops planted in year t Real unit price for pesticide active ingredients in year t Industrial production index in year t Production of pesticide active ingredients in year t-1	herbicides: -0.67 (0.27) insecticides: -0.32 (0.13) fungicides: -0.35 (0.17) pesticides: -0.49 (.21)	herbicide 0.9 insecticid 0.68 fungicide 0.35 pesticide 0.89	yes yes yes yes	no yes yes yes

Table 2.1 (cont.)

SUMMARY OF ECONOMETRIC ANALYSES

Study	Model Type	Data Sources	Time period of study	Dependent Variable	Independent Variables	Price Coefficients (standard errors)	R square	Significantly different fro zero?	Significantly different from negative one?
Huh (1978)	Step-wise regression for herbicides and insecticides; log-linear function	self-designed and conducted survey of of 130 farms growing corn in Minnesota	1977	Active ingredients of herbicides and insecticides used on corn per farm (lbs)	adjusted and weighted price of pesticides (dollars per pound) acres of corn per farm dummy variable on 78 repeat corn	all herbicides and insecticides: -1.464 (.161)	0.79	yes	yes
Burrows (1983)	Simultaneous and single GLS regressions for insecticides and mitacides	Random sample of San Joaquin Valley cotton growers	1970-1974	Sales dollars per acre	Average pesticide price per pound Consultant fee expected yield farm size risk crop price IPM maximum temperature minimum temperature degree days frost days rain irrigation	single equation: -0.90 simultaneous equation: -1.23	single equation: 0.18 simul-tancous equation: -0.18		no no

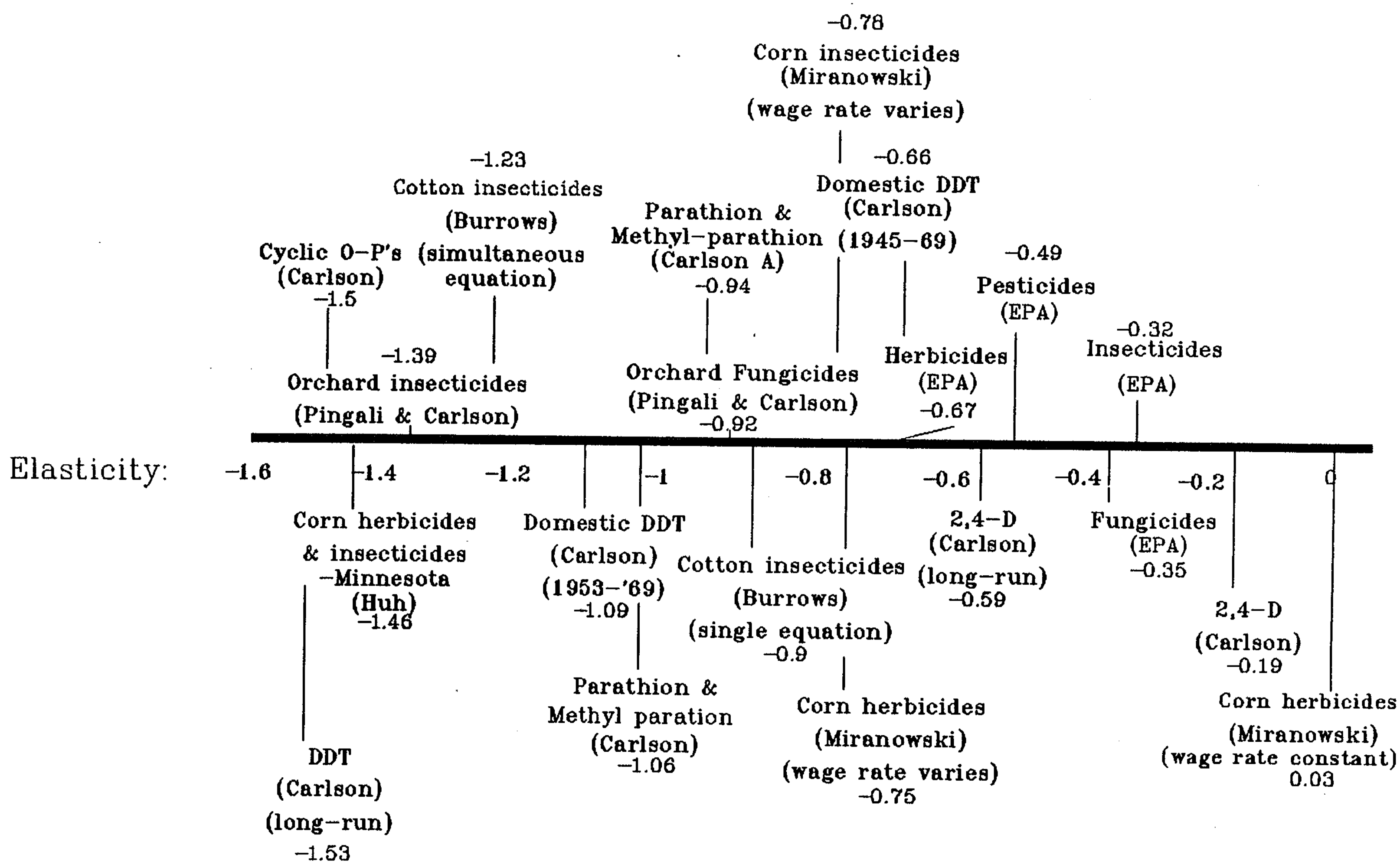
Table 2.1 (cont.)
SUMMARY OF ECONOMETRIC ANALYSES

Study	Model Type	Data Sources	Time period of study	Dependent Variable	Independent Variables	Price Coefficients (standard errors)	R square	Significantly different fro zero?	Significantly different from negative one?
Carlson (1977)	log-linear function for specific active ingredients	USDA annual reports	1945-1970	Quantity of active ingredient purchased in a year (lbs):	insecticide price deflated by an index of all agricultural prices	A. -1.461 (0.796)		yes	no
				A.domestic and foreign cyclic organophosphate insecticides (1953-70)	substitute insecticide price	B. -1.552 (0.780)	0.96	yes	no
				B.same as A. except divided by domestic cotton acreage planted	resistance index	C. -1.06 (0.273)		yes	no
				C.parathion and methyl-parathion (1953-70)	agricultural product price index	D. -0.667 (0.397)		yes	no
				D.Domestic DDT (1945-69)		E. -1.091 (0.625)	0.82	yes	no
				E.Domestic DDT (1953-69)		F. -0.945 (0.339)	0.98	yes	no
				F.parathion and methyl-parathion (1953-70) (alternate estimate)		G. -0.193 (0.349)	0.81	no	yes
				G.2,4-D (1950-70 except 1965-68) divided by cropland index		H. -1.53			
				H.Same as D. except long-run		I. -0.594			
				I.Same as G. except long-run					

Figure 2.2

ELASTICITY OF DEMAND

Summary of Econometric Studies



2.3. Price Elasticity of Demand for Food Commodities

Given that the empirical analyses are insufficient to derive estimates of demand elasticity for clusters of pesticides, an alternative method of estimation of the elasticity was developed. The method used in the remainder of Section 2 of this report relies on a consideration of four factors: (1) the price elasticity of demand for food commodities, (2) the availability and relative costs of non-chemical pest management, (3) the contribution of pesticides to the variable cost of farm production, and (4) the productivity of expenditures on pesticides. Though these sources will not reveal precise quantifications of the price elasticity of demand for pesticides, they can be used to indicate whether demand for the pesticides is expected to be elastic or inelastic and to construct approximate estimates of the elasticity of demand.

Since the demand for particular inputs to a product is in part derived from demand for the end product, the demand for pesticides used in the agricultural sector will be influenced by the demand for food. The demand elasticities of food commodities, developed in this section, are used to provide initial estimates of the elasticity of demand for clusters of pesticides.

Estimates of the direct price elasticity for foods at the retail level are taken from the U.S.D.A. report entitled "U.S. Demand for Food: A Complete System of Price and Income Effects" (1985), authored by Kuo S. Huang. Using a constrained maximum likelihood method, Huang developed statistical procedures for estimating a large-scale demand system from time-series data. He then applied his procedures to an estimation of a domestic food demand system including forty food items and one non-food item. The food items, direct-price elasticities, and standard errors of the estimates are listed in Table 2.2. The estimated elasticities ranged from -0.0385 (cabbage) to -1.378 (grapes). Huang noted that an exact t-test for the statistical significance of the elasticity estimates is not applicable, given the assumptions of a maximum likelihood model. For the purposes of his analysis, Huang considered an estimate to be statistically significant if the estimated elasticity was larger than its standard error. While estimated elasticities with relatively large standard errors may imply that the estimates are not statistically precise, only four of the thirty-four commodity elasticity estimates used in this analysis had a standard error greater than the elasticity estimate (butter, other fresh fruits, carrots, and cabbage).

Huang also provided estimates of demand elasticities for the following aggregated food groups: meat, staples, fats, fruits, vegetables, processed fruits and vegetables, and desserts. The direct price elasticities he obtained were negative for all seven food categories, with magnitudes ranging from -0.08 to -0.34. For purposes of the discussion here, however, the individual food items must be reorganized to correspond to the crops included in the clusters.

Table 2.2

ESTIMATED DIRECT-PRICE ELASTICITIES

(USDA, 1985)

Commodity	Direct-Price Elasticity	Standard Error
Beef & veal	-0.6166	0.0483
Pork	-0.7297	0.0327
Other meats	-1.3712	0.2045
Chicken	-0.5308	0.0608
Turkey	-0.6797	0.1332
Eggs	-0.1452	0.0225
Cheese	-0.3319	0.1174
Fluid Milk	-0.2588	0.1205
Evaporated & Dry Milk	-0.8255	0.2642
Wheat Flour	-0.1092	0.1026
Rice	-0.1467	0.1438
Potatoes	-0.3688	0.0689
Butter	-0.167	0.1748
Apples	-0.2015	0.1469
Oranges	-0.9996	0.1465
Bananas	-0.4002	0.1334
Grapes	-1.3780	0.1829
Grapefruits	-0.2191	0.1067
Other Fresh Fruits	-0.2357	0.5471
Lettuce	-0.1371	0.0656
Tomatoes	-0.5584	0.0624
Celery	-0.2516	0.0636
Onions	-0.1964	0.0693
Carrots	-0.0388	0.1816
Cabbage	-0.0385	0.0405
Other Fresh Vegetables	-0.2102	0.1436
Fruit Juice	-0.5612	0.1006
Canned Tomatoes	-0.3811	0.1072
Canned peas	-0.6926	0.1746
Canned Fruit cocktail	-0.7323	0.3677
Dried beans, peas, & nuts	-0.1248	0.0313
Other processed Fruits & vegetable	-0.2089	0.0921
Sugar	-0.0521	0.0172
Ice Cream	-0.1212	0.0848

Source: U.S.D.A. (1985). U.S. Demand for Food: A Complete System of Price and Income Effects. By Kuo S. Huang. National Economics Division, Economic Research Service. Technical Bulletin No. 1714

To estimate an average elasticity for individual crops in a cluster, the elasticities of the included crops are weighted by the quantity of the relevant pesticide applied to that crop, as reported in Pimentel et al. (1991). This weighting factor incorporates the fact that pesticide use varies between crops; the elasticity of demand for a crop with heavy pesticide use will more greatly influence the elasticity of demand for the relevant cluster of pesticides than will the demand for a crop with low pesticide use. The resulting elasticity estimate is not a measure of the elasticity of the entire cluster of crops (unless the cluster consists of only one crop). Rather, it is a measure of the weighted average elasticity of the individual commodities in the cluster. The elasticity of the entire cluster will be lower than the average elasticity of the individual commodities due to the reduction in the number of substitutes. For example, people may easily substitute beef for pork and therefore these individual commodities may have relatively high elasticities. However, substitutes for all meats are less readily available and this category is likely to have a lower elasticity than the average elasticity of individual meats.

Since the elasticity of the demand for food commodities is assumed to represent the elasticity of demand for pesticides, this elasticity will also be overstated. The overestimation of the value of demand elasticity will likely result in an exaggerated estimate of the fraction of cost increases that is borne by the manufacturers. In the absence of more appropriate data, however, this value provides a reasonable best estimate of the demand elasticity for clusters of pesticides.

Table 2.3 displays the average elasticities for the clusters based on Huang's analysis. The elasticity estimates for the clusters represented range from -0.12 (herbicides on sugar beets, beans, and peas) to -1.38 (fungicides on grapes, herbicides on grapes, and insecticides on grapes). This range of values indicates that the demand for the food clusters varies from highly inelastic to somewhat elastic.

While the calculations for most of the clusters are straight-forward, the estimation of elasticity for the six clusters containing crops that serve as animal feed required an intermediate step. The elasticity of demand for corn, sorghum, soybeans, and alfalfa - all crops that are largely used for animal feed - was calculated from Huang's estimates of the elasticity of demand for animal food products.

An average elasticity for animal feed crops can be obtained by weighting the elasticity of each animal product by the amount of that product consumed. Huang provides "the retail weight equivalent of civilian food disappearance", a measure of consumption, for each food item. This weighting calculation yields an elasticity of demand for animal products of -0.55. However, for this weighting method to accurately reflect the elasticity of demand for feed crops, it must be true that a unit of feed yields equal units of all included animal products. This is not the case. The yield rates of dairy products and eggs are substantially higher

Table 2.3

Average Elasticities of Crops Within Clusters

Cluster	Crops	Own-Price Elasticity	Pesticide Use (millions of kgs/yr)	Percent of weight /15	Weighted Elasticity /16
fungicides on fruit & nut trees excluding oranges /1	apples	-0.20	3.50	0.27	-0.05
	grapefruit	-0.22	0.50	0.04	-0.01
	other fresh fruit	-0.24	9.14 /7	0.70	-0.16
	total		13.14	1.00	-0.23
fungicides on oranges	oranges	-1.00	1.50	1.00	-1.00
fungicides on grapes	grapes	-1.38	9.00	1.00	-1.38
fungicides on vegetables /2	lettuce	-0.14	0.04	0.01	-0.00
	tomatoes	-0.56	0.85 /8	0.15	-0.09
	canned tomatoes	-0.38	1.65 /8	0.30	-0.11
	onions	-0.20	0.20	0.04	-0.01
	carrots	-0.04	0.06	0.01	-0.00
	cabbage	-0.04	0.20	0.04	-0.00
	potatoes	-0.37	2.50	0.45	-0.17
	other fresh	-0.21	0.04 /9	0.01	-0.00
	total		5.54	1.00	-0.38
herbicides on sorghum, rice, small grains	rice	-0.15	6.00	0.46	-0.07
	sorghum	-0.69 /3	7.10	0.54	-0.37
	total		13.10 /1	1.00	-0.44

Table 2.3 (cont.)

Average Elasticities of Crops Within Clusters

Cluster	Crops	Own-Price Elasticity	Pesticide Use (millions of kgs/yr)	Percent of weight /15	Weighted Elasticity /16
herbicides on corn	corn	-0.69 /3	111.00	1.00	-0.69
herbicides on soybeans, cotton,	soybeans	-0.69 /3	58.00	0.96	-0.66
peanuts, and alfalfa	(dried beans, peas) & nut	-0.12 /4	2.50	0.04	-0.01
	alfalfa	-0.69 /3	0.10	0.00	-0.00
	total		60.60 /1	1.00	-0.67
herbicides on tree fruits	apples	-0.20	6.00	0.89	-0.18
(except oranges), nuts, & sugarcane /	grapefruit	-0.22	0.05	0.01	-0.00
	other fresh fruit	-0.24	0.51 /7	0.08	-0.02
	(dried beans, peas) & nut	-0.12 /4	0.20 /1	0.03	-0.00
	total		6.76	1.00	-0.20
herbicides on oranges	oranges	-1.00	1.70	1.00	-1.00
herbicides on grapes	grapes	-1.38	0.30	1.00	-1.38
herbicides on	canned peas	-0.69	0.05 /1	0.04	-0.03
sugar beets, beans, & peas	dried beans & peas (& nu	-0.12 /4	0.85 /1	0.65	-0.08
	sugar	-0.05 /5	0.40	0.31	-0.02
	total		1.30	1.00	-0.12

Table 2.3 (cont.)

Average Elasticities of Crops Within Clusters

Cluster	Crops	Own-Price Elasticity	Pesticide Use (millions of kgs/yr)	Percent of weight /15	Weighted Elasticity /16
herbicides on vegetables /2	lettuce	-0.14	0.06	0.04	-0.00
	tomatoes	-0.56	0.03 /8	0.02	-0.01
	canned tomatoes	-0.38	0.07 /8	0.04	-0.01
	onions	-0.20	0.40	0.23	-0.05
	carrots	-0.04	0.03	0.02	-0.00
	cabbage	-0.04	0.20	0.12	-0.00
	potatoes	-0.37	0.80	0.47	-0.17
	other fresh	-0.21	0.12 /9	0.07	-0.01
	total		1.71	1.00	-0.27
insecticides on vegetables /2	lettuce	-0.14	0.06	0.02	-0.00
	tomatoes	-0.56	0.27 /8	0.08	-0.04
	canned tomatoes	-0.38	0.53 /8	0.15	-0.06
	onions	-0.20	0.09	0.03	-0.01
	carrots	-0.04	0.02	0.01	-0.00
	cabbage	-0.04	0.40	0.12	-0.00
	potatoes	-0.37	2.00	0.59	-0.22
	other fresh	-0.21	0.04 /9	0.01	-0.00
	total		3.41	1.00	-0.33
insecticides on oranges	oranges	-1.00	8.50	1.00	-1.00
insecticides on grapes	grapes	-1.38	2.00	1.00	-1.38

Table 2.3 (cont.)

Average Elasticities of Crops Within Clusters

Cluster	Crops	Own-Price Elasticity	Pesticide Use (millions of kgs/yr)	Percent of weight /15	Weighted Elasticity /16
insecticides on soybeans, peanuts, wheat, & tobacco /17	wheat	-0.11 /6	1.00	0.15	-0.02
	(dried beans, peas) & nut	-0.12 /4	0.50	0.08	-0.01
	soybeans	-0.69 /3	5.00	0.77	-0.53
	total		6.50	1.00	-0.56
insecticides on fruit & nut trees excluding oranges & grapes /1	apples	-0.20	7.00	0.53	-0.11
	grapefruit	-0.22	3.00	0.23	-0.05
	other fresh fruit	-0.24	3.10 /7	0.24	-0.06
	(dried beans, peas, &) nu	-0.12 /4	0.02 /1	0.00	-0.00
	total		13.12	1.00	-0.21
insecticides on corn and alfalfa	corn	-0.69 /3	14.00	0.93	-0.64
	alfalfa	-0.69 /3	1.00	0.07	-0.05
	total		15.00	1.00	-0.69
insecticides on sorghum	sorghum	-0.69 /3	1.10	1.00	-0.69

Sources for Table 2.3:

Values for "own-price elasticity" were obtained from U.S.D.A. (1985).
Values for "pesticide Use" were obtained from Pimentel et al. (1991).

Notes to Table 2.3:

/1 The price elasticity of demand for bananas is not included since a separate estimate of the quantity of herbicides applied to bananas is not available. Also, fruit categories are only included if they can be assigned to a single cluster. For example, "fruit juice" is not included since it could include apple and orange juice, and therefore overlap two clusters.

/2 Vegetable categories are only included if they can be assigned to a single cluster. for example, "other processed fruits and vegetables" is not included since the category overlaps two clusters.

/3 Crop is assumed to be fed to animals. See text for explanation of elasticity estimate.

/4 The elasticity estimate is for dried beans, peas, and nuts. No separate elasticity estimates for these foods are available.

/5 The elasticity estimate for sugar does not distinguish between sugar beets and sugar cane.

/6 Elasticity estimate is for wheat flour.

/7 Includes lemons, cherries, peaches, plums, and "other fruit"

/8 According to the 1989 "Agricultural Statistics" published by the U.S. Department of Agriculture, 34 % of all tomato acreage is used to produce for the fresh market and 66% of the acreage is used to produce tomatoes for processing. Pesticide use is split between fresh and processed markets using these percentages. While this split will not be precise since production per acre and pesticide use may vary, it is used as a reasonable approximation.

/9 Includes cucumbers, peppers, sweet potatoes, and "other vegetables".

/10 The category "other grain" is excluded since elasticity estimates are not available. Use of herbicides on "other grains" is relatively minor, at 2.7 million kgs per year.

/11 Since estimates of the elasticity of cotton are not included in the U.S.D.A. report, cotton is not included in the elasticity estimate for the cluster. Herbicide use on cotton, estimate at 8.2 million kg/year, is small compared to herbicide use on soybeans. Therefore, the elasticity estimate for the cluster should not be substantially affected by the absence of an elasticity estimate for cotton.

/12 Includes pecans and "other nuts"

/13 The analysis assumes that half of herbicides used on peas are used on canned peas with the remainder used on dried peas.

/14 Includes all herbicides applied to beans and one-half of herbicides applied to peas.

/15 "Percent of Use" equals "Pesticide use on crop"/"Pesticide use on cluster"

/16 "Weighted Elasticity" equals summation of ("percent of use" multiplied by "own-price elasticity")

/17 Since estimate of the elasticity of demand for tobacco are not included in the U.S.D.A. report, tobacco is not included in the elasticity estimate for this cluster. However, since about 80 percent of the insecticides applied to crops in this cluster are applied to soybeans, peanuts, and wheat, the absence of an elasticity estimate for tobacco should not dramatically affect the elasticity estimate for the cluster.

than the yield rates of meats per unit of food. Therefore, a weighted average of the food elasticities based on consumption would be biased towards the elasticities of dairy products and eggs. That is, the elasticity values for dairy products and eggs would influence the resulting average elasticity more heavily than is appropriate.

As can be seen from Table 2.2, the elasticities of demand for dairy products and eggs are generally lower than the elasticity of demand for meats. Weighting the elasticities by consumption is therefore likely to understate the elasticity of demand for feed crops. To avoid this underestimation, the elasticity of demand for animal feed is calculated based only on the meat products. The resulting estimate of -0.69 is conservative in that it is likely to somewhat overstate the elasticity of demand for animal products, and therefore animal feed. This conservative value, however, still indicates that demand for feed crops is inelastic.

Huang's report analyzed demand elasticity for foods at the retail level. U.S.D.A. has also analyzed the elasticity of demand for farm products by modeling the quantity of the farm product as an input in food processing (U.S.D.A., 1989). The analysis considers eight commodities: beef and veal, pork, poultry, eggs, dairy, processed fruits and vegetables, fresh fruit, and fresh vegetables. U.S.D.A.'s results are consistent with previous findings, and show that all own-price elasticities are negative and less than 1 in absolute values. The authors found that, with the exception of poultry, farm-level demands are nearly as large as the corresponding retail elasticities or somewhat larger than the corresponding retail elasticities. Since specific commodity elasticities are not given and since the findings indicate that farm-level elasticities are similar to retail-level elasticities, this analysis uses the more detailed values for elasticities that are given in Huang's report.

2.4. Feasibility of Non-Chemical Substitution

In order to further delineate variations in the elasticities of demand exhibited by each cluster, one can examine the market characteristics that, according to microeconomic theory, influence the price elasticity of demand. These characteristics include the availability of substitutes for the product, the contribution of the product to the cost of production, and the productivity of expenditures for the product. This section discusses the availability of substitutes for clusters of pesticides. Section 2.5 considers the impact of pesticide contribution to the cost of production while Section 2.6 evaluates the productivity of expenditures for pesticides.

As discussed earlier, demand elasticity is, theoretically, a function of the availability of substitutes, among other factors. If a product has many close substitutes, it is likely to be characterized by an elastic demand. Substitutes for a pesticide active ingredient include an alternative active ingredient as well as non-chemical substitutes. In constructing pesticide clusters, U.S. EPA's Office of Pesticide Programs (OPP) grouped all active ingredients which are substitutes for each other. The active ingredients included in the clusters are both chemical and biological. Therefore, substitutes for a cluster include only cultural and environmental pest control technologies[1].

Achievable reduction in pesticide use for specific end-uses has been studied by Pimentel et al. (1991). Pimentel considered the costs and benefits of replacing chemical pest control methods with currently available biological, cultural, and environmental pest control technologies. Since both the pesticide clusters, as defined by EPA, include biological pest control methods, the biological alternatives listed by Pimentel are not alternatives to the clusters. However, Abt Associates knows of no analysis which considers only cultural and environmental pest control alternatives. Further, the biological pest control methods constitute only a small minority of the pesticides within the clusters. Pimentel et al.'s analysis is, therefore, used to measure the relative substitutability of the pesticide clusters.

In this report, Pimentel's study is used to develop a general rating of the degree to which pesticide substitution is feasible for each cluster. The greater the feasibility of substitution, the higher the expected elasticity of demand for pesticides in the cluster. The ratings are based on two criteria: (1) the percentage by which non-chemical alternatives can replace pesticides, and (2) the projected net cost of replacing pesticides with a non-chemical pest control method. Based on these criteria, the clusters are grouped into three categories as shown in Tables 2.4, 2.5, and 2.6. Clusters in the "high substitutability" category can, according to Pimentel et al., achieve at least a 40 percent reduction in pesticide use at an additional cost of less than one dollar per hectare. Clusters in the "moderate substitutability" category can achieve at least a 20 percent reduction in pesticide use at a cost no greater than five dollars per hectare. Clusters which do not qualify for either of these categories are listed under the heading "low substitutability".

The clusters defined by OPP often group several of the crops that are listed in Table 2.4, 2.5, and 2.6. To determine ratings for the clusters, the crop-specific ratings were weighted by the pounds of fungicide, herbicide, or insecticide applied to each crop, as was relevant for the cluster. The cluster ratings, as developed by Abt Associates based on Pimentel et al. are as follows:

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[1] Most of the pesticide clusters include at least two active ingredients, indicating that chemical substitutes exist for most active ingredients. The substitutability between active ingredients will vary by region and with meteorological conditions, as well as with specific crops. A comparison of the chemical substitutes available for particular active ingredients is not undertaken in this analysis.

Table 2.4
Non-chemical Substitutability for Pesticides by Cluster
Fungicides

High Substitutability	Moderate Substitutability	Low Substitutability
soybeans	rice	cotton
other vegetables	sugar beets	sweet corn
peaches	lettuce	tobacco
	carrots	peanuts
	potatoes	tomatoes
	onions	
	beans	
	cantaloupe	
	peppers	
	sweet potatoes	
	watermelons	
	apples	
	cherries	
	peas	
	pears	
	plums	
	grapes	
	oranges	
	grapefruit	
	lemons	
	"other" fruit	
	pecans	
	"other" nuts	
	cole	
	cucumbers	

Source: Abt Associates estimates based on Pimentel et al. (1991)

Table 2.5

Non-chemical Substitutability for Pesticides by Cluster

Herbicides

High Substitutability	Moderate Substitutability	Low Substitutability
tobacco	peanuts	corn
potatoes	sorghum	cotton
tomatoes	pasture	wheat
cucumbers	grapes	soybeans
apples	alfalfa	rice
plums	hay	sugar beets
oranges	beans	"other" grain
grapefruits	cherries	lettuce
lemons	peaches	cole
"other" nuts	pears	carrots
	"other" fruit	sweet corn
	pecans	onions
		cantaloupe
		peas
		peppers
		sweet potatoes
		watermelons
		"other" vegetables

Source: Abt Associates estimates based on Pimentel et al. (1991)

Table 2.6

Non-chemical Substitutability for Pesticides by Cluster

Insecticides

High Substitutability	Moderate Substitutability	Low Substitutability
sorghum	cotton	corn
hay	wheat	lettuce
tomatoes	carrots	cole
cherries	onions	potatoes
peaches	cucumbers	sweet corn
pears	beans	cantaloupe
plums	sugar beets	
grapes	peas	
"other" fruit	watermelons	
pecans	"other" vegetables	
"other" nuts	sweet potatoes	
oranges	peppers	
grapefruit	alfalfa	
lemons	soybeans	
	rice	
	tobacco	
	peanuts	
	"other" grains	

Source: Abt Associates estimates based on Pimentel et al. (1991)

Low Substitutability

fungicides for use on vegetables
herbicides for use on corn
herbicides for use on soybeans, cotton, peanuts, alfalfa
herbicides for use on sugar beets, beans, and peas
insecticides for use on corn and alfalfa
insecticides for use on vegetables

Moderate Substitutability

fungicide for use on fruit and nut trees, except oranges and grapes
fungicides for use on oranges
fungicides for use on grapes
herbicides for use on vegetables
herbicides for use on sorghum, rice, small grains
herbicides for use on grapes
insecticides for use on cotton
insecticides for use on soybeans, peanuts, wheat, and tobacco

High Substitutability

herbicides for use on tree fruits (except oranges), nuts, and sugarcane
herbicides for use on oranges
herbicides for use on tobacco
insecticides for use on grapes
insecticides for use on oranges
insecticides for use on fruit and nut trees excluding oranges and grapes
insecticides on sorghum

As discussed earlier, these data can be used to suggest pesticide clusters for which the demand elasticity differs substantially from the demand elasticity for the associated food commodities. Demand for the six pesticide clusters with low substitutability may be inelastic relative to the demand for the associated foods. In the seven cases of high substitutability, the demand for the pesticide cluster may be more elastic than the demand for the associated foods. The feasibility of substitution for pesticide clusters is considered in Section 2.7 in constructing estimates of the elasticity of demand for the pesticide clusters.

2.5. Contribution to the Variable Cost of Production

Economic theory predicts that a producer's sensitivity to price will increase with the percentage of production cost contributed by that input. To further distinguish between the elasticities of demand for the different clusters of pesticides, Abt Associates has considered the extent to which the pesticides in the clusters contribute to production costs.

The U.S.D.A. publishes cost-of-production data summarizing all operator and landlord costs and returns associated with the production of several individual commodities (U.S.D.A., 1989a). The cost estimates separate the cost of chemicals and can be used to determine chemical costs as a percentage of total variable costs of production. Cost of chemicals is included in two categories: "chemicals" and "custom application". Both custom operators and farmers apply pesticides. The category "chemicals" includes agricultural chemical use by farmers and does not include labor spent in chemical application. Many custom operators charge a flat rate and do not provide a cost breakdown between labor and materials. "Custom application" therefore includes operator-applied chemicals, operator labor, and farm operations other than chemical application. The category "custom application" was included in calculations of pesticide contribution to total cost in order to ensure that all chemical costs are included. The estimate of pesticide contribution to the cost of crop production will, however, be overstated. These data are presented in Table 2.7 for the commodities for which the information was available.

The pesticide clusters defined in this analysis separate agricultural chemicals into fungicides, insecticides, and herbicides. The U.S.D.A. report does not separate the costs of chemicals into these categories. In order to divide the cost of chemicals between each of these types of pesticides, Abt Associates estimated total expenditures for each pesticide type for the commodities considered in the U.S.D.A. report. Total expenditures were calculated by multiplying the pounds of fungicide, herbicide, or insecticide applied to a commodity (from Pimentel et al, 1991) by the average price of the relevant pesticide type i.e., fungicides, herbicides, and insecticides (as reported in Synthetic Organic Chemicals, 1988). The chemical contribution to variable cost was then divided between the three pesticide categories based on the percent of expenditures. The percentages of variable production costs for fungicides, herbicides, and insecticides by commodity are listed in Table 2.7.

The crop-specific estimates must be grouped into clusters for purposes of this analysis. An estimate of the contribution of pesticide to variable cost for a cluster is made only if such an estimate is available for individual crops contributing at least 50 percent of the pesticide use for the cluster (based on Pimentel et al., 1991). Eight clusters meet this qualification. These clusters are listed below in descending order of

Table 2.7

Fungicide, Herbicide, and Insecticide Contribution to Variable Costs of Production

Commodity	Chemical Costs as a Percent of Variable Costs[1]	Fungicide Costs as a Percent of Variable Costs[2]	Herbicide Costs as a Percent of Variable Costs[2]	Insecticide Costs as a Percent of Variable Costs[2]
soybeans[3]	37	0	35	3
peanuts[3]	31	12	17	3
cotton[3]	29	0	16	13
sugarbeets[3]	28	0	23	5
sorghum[3]	25	0	22	3
corn[3]	22	0	19	2
rice[3]	20	0	19	1
wheat[3]	18	0	16	2
potatoes[4]	16	7	3	6
barley[3]	16	0	16	0
tobacco[5]	10	0	3	7
oats[3]	9	0	9	0

[1]Equals ("chemicals" + "custom operations")/"total variable cash expenses"

[2]Estimate by Abt Associates using pesticide prices from Synthetic Organic Chemicals, 1988 and pounds applied from Pimentel, D. et al, (in press), "Environmental and Economic Impacts of Reducing U.S. Agricultural Pesticides Use", Pest Management in Agriculture, CRC Press.

[3]Source for percent of production costs - USDA, 1989. "Economics Indicators of the Farm Sector, Costs of Production, 1987". Economic Research Service. February.

[4]Source for percent of production cost- USDA, 1988. "1985 Potato Cost and Returns: Fall Production Areas". Potato facts special edition. Economic Research Service. September.

[5]Source for percent of production cost - USDA, 1989. "Tobacco: Situation and Outlook Report". Economic Research Service. September.

the percent of the pesticide contribution to cost. Based only on contribution to cost, the order also corresponds to expected decreasing price elasticity of demand. The clusters are:

1) Herbicide used on soybeans, cotton, peanuts, alfalfa (33 percent of variable cost)
2) Herbicides used on sorghum, rice, small grains (20%)
3) Herbicides used on corn (19%)
4) Insecticides used on cotton (13%)
5) Insecticides used on soybeans, peanuts, wheat, and tobacco (3%)
6) Herbicides used on tobacco (3%)
7) Insecticides used on sorghum (3%)
8) Insecticides used on corn and alfalfa (2%)

U.S.D.A. did not estimate the cost of production for specialty crops. These data are compiled at the county level and collected by individual states, but are not available on a national level. It is beyond the scope of this study to collect cost of production data from each county in each state for each crop. Abt Associates did, however, obtain cost of production reports for specialty crops of interest from the states that represented a large percentage of the planted acreage of each crop. From these reports it was evident that the pesticide contribution to cost varied significantly between regions. Therefore, it was decided that without a statistically valid national sampling, the county-level data could not accurately be used to represent national cost data. No estimates of the pesticide contribution to variable costs of producing specialty crops are included in this analysis.

The purpose of considering the pesticide contribution to variable cost is to determine whether the demand elasticity for clusters of pesticides is likely to differ substantially from the elasticity of demand for the associated food commodities (calculated is Section 2.3). In particular, for the four pesticide clusters where chemicals contribute over ten percent of total variable cash expenses, farmers may be relatively sensitive to pesticide price changes. Therefore, demand for these pesticide clusters may be more elastic than demand for the associated food commodities. This factor is considered in Section 2.7, along with the other available data, to estimate the elasticity of demand for each of the pesticide clusters.

2.6 Productivity of Expenditures for Pesticides

The productivity of an input refers to the marginal value product of expenditure for the input compared to the cost of the input. When the marginal value product exceeds the input cost, the input is said to be productive. If an input is highly productive, demand for the input is theoretically likely to be insensitive to small changes in price. Three studies which examined the productivity of expenditures for agricultural pesticides were located and are discussed below.

Headley (1968) estimated partial production elasticities for the following input variables using Cobb-Douglas functions: labor, land and buildings, machinery, fertilizer, pesticides, and "other". He then compared the marginal value production of expenditure for pesticides to the marginal factor cost of pesticides to determine the extent of disequilibrium in the use of pesticides by farmers. The results of Headley's study indicated that the marginal value of a one-dollar expenditure for chemical pesticides is approximately $4.00. Headley noted several limitations of his analysis, including that his conclusions are based on aggregative analysis and may not apply to local situations.

Campbell (1976) considered this same issue for a cross-sectional sample of tree-fruit farms in British Columbia. The statistical techniques used by Campbell include Ordinary Least Squares and Factor Analysis Regression. The data used in fitting Campbell's regression equation were as follows: the dependent variable was the value of output of fruit; the input variables were the values of services of land and buildings and capital equipment, and the values of inputs of irrigation water, labor, fertilizers, and pesticide sprays. Corresponding to Headley's findings, Campbell found that the value of a marginal dollar's worth of pesticides was significantly greater one dollar, indicating a relatively inelastic demand. However, as Headley did, Campbell suggested caution in the interpretation of this result. He noted that it is possible that his statistical procedure introduced an upward bias to the estimate since the sample data exhibited fairly high correlations among some of the independent variables, including pesticides.

According to Lichtenberg and Zilberman (1986), however, the studies of Headley and Campbell are methodologically flawed. Lichtenberg and Zilberman argue that econometric measurements of pesticide productivity that are derived from standard production theory models contain significant upward biases that result in the overestimation of pesticide productivity. The authors claim that the constant elasticity of the marginal effectiveness curve produced by a standard Cobb-Douglas specification will not match the actual behavior of the marginal effectiveness curve. The correct form of the marginal effectiveness curve, according to Lichtenberg and Zilberman, will show an increase in pesticide use in response to pest resistance and a decrease in use only when pest resistance is so widespread that alternative measures are most cost effective. The true marginal effectiveness curve will decline at an increasing rate in the economic region. Lichtenberg and Zilberman cast doubt on the high marginal productivity of pesticides estimated by Campbell and Headley.

Given that these studies do not provide definitive estimates of the productivity of pesticides and do not address the productivity of specific pesticide clusters, we develop simple original estimates of the productivity of pesticide clusters. In this analysis, the productivity of pesticides (specified as either fungicides, herbicides, or insecticides) on individual food commodities is calculated as follows:

$$P = \frac{V \times MP}{C}$$

where:

C = the cost of pesticide treatment for the food commodity (dollars per hectare),

MP = the marginal value product from the pesticide application (percent of total production value),

P = the productivity of the pesticide on the food commodity (dollars per hectare/dollars per hectare), and

V = the production value of the crop (dollars per hectare harvested).

The data sources for the three input parameters were as follows. The production value of the crops was obtained from U.S.D.A. (1989). The cost of pesticide treatment was taken from Pimentel et al. (1991). No source of specific estimates of the marginal value product associated with fungicides, herbicides, and insecticides on crops was located. The analysis therefore relied on the expertise of the U.S. EPA Office of Pesticide Programs (OPP) to estimate the value of this parameter. The OPP stated that it was reasonable to generalize that the marginal product associated with the use of fungicides, herbicides, or insecticides on a crop equaled ten percent of the production value of that crop (telephone communication, Dave Broussard, OPP, 2/91). Since no more precise estimates were available, the analysis adopted this value.

In reality, there will be some variation in the marginal value product of fungicides, herbicides, and insecticides on different crops. To the extent that the marginal value product for a pesticide type on a crop is greater than 10 percent, the analysis will understate productivity and therefore overstate the elasticity of demand. Similarly, if the marginal value product for a pesticide type on a crop is less than 10 percent, the productivity of the pesticide will be overstated and the elasticity of demand will be underestimated.

Weighted averages of the productivity measures for pesticides used on individual crops were calculated to obtain measures of productivity for pesticide clusters. The weighting factor was the quantity of pesticides included in the cluster applied to each crop, as determined by Pimentel et al. (1991). Table 2.8 displays the productivity measures for the pesticide clusters for which the information was available.

Table 2.8

Productivity of Pesticide Clusters

Cluster	Productivity (Dollars of Marginal Product per Dollars of Pesticide Expenditures)
Fungicides on:	
Fruit and nut trees, except oranges and grapes	$ 5.81
Grapes	$ 9.83
Vegetables	$12.37
Oranges	$12.54
Herbicides on:	
Sorghum, rice, small grains	$ 0.88
Corn	$ 1.11
Soybeans, cotton, peanuts, alfalfa	$ 2.68
Sugar beats, beans, peas	$ 2.72
Vegetables	$17.85
Oranges	$17.91
Tree fruits (except oranges), sugar cane, nuts	$19.29
Grapes	$61.43
Insecticides on:	
Cotton	$ 0.72
Sorghum	$ 1.24
Corn, alfalfa	$ 3.69
Vegetables	$ 7.92
Fruit and nut trees, except oranges and grapes	$ 8.51
Soybeans, peanuts, wheat, tobacco	$13.08
Oranges	$15.04
Grapes	$37.80

Note that there is great variation in the productivity estimates. The lowest productivity estimate is $0.72, for insecticides used on cotton; Herbicides used on grapes had the highest productivity, at $61.43. The wide range is due both to variability in the value of production of crops and variability in the cost of applying pesticides to the crop. For example, the value of production of cotton is $487 per hectare while the value of a hectare of grapes is $4,914 per hectare (U.S.D.A., 1989). In addition, the average cost of insecticide application to cotton is about $118 per hectare while the costs of applying herbicides to grapes is $8 per hectare (Pimentel et al., 1991). However, it must again be recognized that due to lack of data, the analysis assumes that the marginal value of production of insecticides on cotton and herbicides on grapes are identical.

The productivity of the clusters is considered in the next section, along with the factors previously discussed, in developing estimates of the elasticity of demand for each pesticide cluster. Demand for the pesticide clusters for which productivity is low can be expected to be elastic relative to the demand for the associated food commodities, ceteris paribus. Similarly, when a cluster of pesticides is highly productive, demand is likely to be inelastic compared with demand for the associated food commodities.

2.7. Conclusions - Agricultural Pesticides

Section 2 of this report estimates the price elasticity of demand for twenty-four pesticide clusters. Estimates of the elasticity of demand for clusters of pesticides are based on the price elasticity of demand for the associated food commodities. However, the elasticity of demand for an input is not solely a function of the demand for the end product (unless input ratios are assumed to be fixed). Therefore, the elasticity estimates are adjusted as warranted by consideration of three factors: (1) the feasibility of substituting non-chemical controls for the pesticide cluster, (2) the contribution of the pesticide cluster to the variable cost of crop production, and (3) the productivity of the pesticide cluster. In addition, the literature estimates of elasticity are considered when appropriate.

Since the effect of these factors is not easily quantified, we use this information to adjust the pesticide elasticities estimated from the demand for crops rather than to attempt to pinpoint the value of demand elasticity. Based on this information, we identify clusters for which the elasticity of the demand for the food commodity is likely to differ substantially from the elasticity of demand for the corresponding cluster of pesticides.

Note that the effect of the factors considered may cancel each other. For example, the feasibility of non-chemical substitution for a cluster of pesticides may be high, indicating that the elasticity of demand may be higher for the cluster of pesticides than for the associated crops. However, if the productivity of the pesticide cluster is also high, less elastic demand is indicated for the cluster of pesticides than for the associated foods. To decide whether an adjustment to the elasticity of demand for the food commodities is warranted, the net indication of the factors is considered. Factors that indicate relatively elastic demand and factors that indicate relatively inelastic demand cancel each other. If, on net, two factors indicate relatively elastic or inelastic demand, an adjustment to the elasticity estimate is made.

Table 2.9 summarizes the information from the five areas of research: literature estimates, demand elasticities of food commodities, feasibility of substitution, contribution of chemicals to production costs, and productivity estimates. The information is summarized for twenty-one sectors of agricultural pesticide use. Three additional clusters of pesticides are included in the following summary of elasticity of demand for agricultural pesticides: fungicides used on grain storage, fungicides used for seed treatment, and fungicides - post-harvest. Since these clusters differ from the other agricultural pesticide clusters in that the pesticides are not applied to crops in the field, they have not been included in the analysis to this point. However, since the pesticides in these clusters are used agriculturally, elasticity estimates are discussed in this section. The best estimate of elasticity for each of the twenty-four agricultural clusters is discussed below.

a. Fungicides used on vegetables

The elasticity estimate of -0.38 is taken directly from U.S.D.A.'s (1985) estimate of the demand elasticity for retail vegetables, weighted by the amount of fungicides applied to each type of vegetable. No adjustments are made since the substitutability for fungicides on vegetables is low and the marginal productivity of fungicides on vegetables is moderate.

b. Fungicides used on fruit and nuts except oranges

The elasticity of demand for food commodities in this cluster, based on a weighted-average of the elasticity values estimated by U.S.D.A. (1985), is -0.23. No adjustments are made to this value are made to arrive at the elasticity of demand for fungicides applied to these food commodities. No corrections were necessary since the substitutability for fungicides on fruit and nuts except citrus is moderate as is the marginal productivity of fungicides on fruit and nut trees, except oranges. The estimated elasticity of -0.23 indicates less elastic demand than does the analysis of Pingali and Carlson (1985). However, the elasticity estimate of Pingali and Carlson consider only apples and is therefore not directly comparable to the elasticity estimate for the cluster. Both the current estimate and the Pingali and Carlson estimate indicate that demand is inelastic.

Table 2.9
Summary of Elasticity Information

Cluster	Literature Estimates	Elasticity of Food Commodity	Feasibility of Substitution	Fraction of Contribution to Production Costs	Marginal Productivity
Fungicides on:					
vegetables	N.A.	-0.38	low	N.A.	$12.37
fruit & nut trees, except oranges	-0.92 (2)	-0.23	moderate	N.A.	$5.81
oranges	N.A.	-1.00	moderate	N.A.	$12.54
grapes	N.A.	-1.38	moderate	N.A.	$9.83
Herbicides on:					
sorghum, rice, small grains	N.A.	-0.44	moderate	0.20	$0.88
soybeans, cotton, peanuts, alfalfa	inelastic (5)	-0.67	low	0.33	$2.68
corn	0.03, -0.75 (3) -1.46 (4) inelastic (5)	-0.69	low	0.19	$1.11
oranges	N.A.	-1.00	high	N.A.	$17.91
tree fruits, nuts & sugar cane	N.A.	-0.20	high	N.A.	$19.29
grapes	N.A.	-1.38	moderate	N.A.	$61.43
vegetables	N.A.	-0.27	moderate	N.A.	$17.85
tobacco	N.A.	N.A.	high	0.03	$58.60
sugar beets, beans peas	N.A.	-0.12	low	N.A.	$2.72

(1) Burrows (1983), cotton only
(2) Pingali and Carlson (1985), apples only
(3) Miranowski (1980), corn only
(4) Huh (1978), corn insecticides and herbicides
(5) U.S. EPA (1974), corn or soybeans, only

Table 2.9 (cont.)
Summary of Elasticity Information

Cluster	Literature Estimates	Elasticity of Food Commodity	Feasibility of Substitution	Fraction of Contribution to Production Costs	Marginal Productivity
Insecticides on:					
vegetables	N.A.	-0.33	low	N.A.	$7.92
fruit & nut trees exc. oranges	-1.39 (2)	-0.21	high	N.A.	$8.51
oranges	N.A.	-1.00	high	N.A.	$15.04
grapes	N.A.	-1.38	high	N.A.	$37.80
corn, alfalfa	-0.78 (3) -1.46 (4) inelastic (5)	-0.69	low	0.02	$3.69
sorghum	N.A.	-0.69	high	0.03	$1.24
soybeans, peanuts, wheat, & tobacco	inelastic (5)	-0.56	moderate	0.03	$13.08
cotton	-0.9, -1.23 (1)	N.A.	moderate	0.13	$0.72

(1) Burrows (1983), cotton only
(2) Pingali and Carlson (1985), apples only
(3) Miranowski (1980), corn only
(4) Huh (1978), corn insecticides and herbicides
(5) U.S. EPA (1974), corn or soybeans, only

c. <u>Fungicides on oranges</u>

The elasticity estimate of -1.0 is taken directly from U.S.D.A.'s (1985) estimate of the demand for oranges. No adjustments are made since the substitutability for fungicides on citrus is moderate, as is the marginal productivity of fungicides on oranges.

d. <u>Fungicides on grapes</u>

The elasticity estimate of -1.38 is again taken directly from U.S.D.A.'s (1985) estimate of the demand for retail foods. Since the feasibility of substitution for fungicides in this cluster is moderate and the marginal productivity is moderate, no adjustments are made.

e. <u>Herbicides on sorghum, rice, and small grains</u>

The best estimate of the elasticity of this food cluster is based on the demand elasticity of rice, as reported by U.S.D.A. (1985) and on the demand elasticity of sorghum. As discussed above, the elasticity of demand for sorghum, generally an animal feed crop, was calculated based on the elasticity of demand for animal meats. To estimate an elasticity for the crops in this cluster, the two crop elasticities were weighted by the amount of herbicides applied to each crop (as reported in Pimentel et al., 1991). The resulting elasticity estimate is -0.44.

However, it is likely that the elasticity of demand for this cluster of herbicides will exceed the elasticity of demand for the associated crops. Although the feasibility of substitution for herbicides in this cluster is moderate, herbicides contributed a relatively high percentage to total variable costs, and the marginal productivity of the herbicides is very low. There is no precise method by which to translate these factors into an estimate of the elasticity of demand for herbicides on sorghum, rice, and small grains. However, to account for the low marginal productivity and high contribution to costs of herbicides on sorghum, rice, and small grains, demand on herbicides on this cluster is assumed to be more elastic than demand for crops in this cluster. The elasticity estimate is adjusted from -0.44 to -1.0.

f. <u>Herbicides on soybeans, cotton, peanuts, and alfalfa</u>

As discussed earlier in this report, assuming that soybeans and alfalfa are fed to animals, the price elasticity of demand for the crops in this cluster, excluding cotton, is -0.67. Since the quantity of herbicides applied to cotton is small in comparison to the quantity of herbicides applied to soybeans, peanuts, and alfalfa, the exclusion of cotton should not substantially affect the elasticity estimate[2].

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[2]According to Pimentel et al. (1991), 8.2 million kgs. per year of herbicides are applied to cotton and 60.6 million kgs. per year of herbicides are applied to soybeans, peanuts, and alfalfa combined.

Supporting the elasticity estimate of -0.67, U.S. EPA (1974) found the demand for herbicides on soybeans to be inelastic.

Three additional factors present information on the expected price elasticity of demand for this cluster of herbicides: the feasibility of substitution, the fraction of contribution to production costs, and the marginal productivity of the herbicides. The feasibility of substitution for this cluster of herbicides is low, influencing the demand for the herbicides to be inelastic. However, herbicides (including custom application) are estimated to contribute 33 percent of the total cost of production for this cluster. This high contribution to variable cost is likely to drive greater elasticity of demand. Also, the marginal productivity of herbicides in this cluster is estimated as $2.68. This return on herbicide use is fairly low, suggesting somewhat elastic demand.

Given the opposing factors that influence demand for herbicides in this cluster, it was judged that the estimated elasticity of demand for the crops, -0.67, serves well as an estimate of the elasticity of demand for the cluster of herbicides.

g. Herbicides on corn

The estimate of elasticity of demand for corn herbicides is -0.69. This value is based on the average elasticity of meats as listed in U.S.D.A. (1985), since the corn is assumed to be used as animal feed. Pesticides in this cluster contributed a relatively high percentage to total variable costs (19% including custom application) and the marginal productivity of these pesticides is low, at $1.11. Both of this factors indicate elastic demand. However, the feasibility of substitution for these pesticides is low, indicating inelastic demand. Therefore, it was judged that no additional adjustment to the elasticity estimate was warranted.

h. Herbicides on oranges

The estimate of the elasticity of demand for herbicides on oranges is -1.00, taken from U.S.D.A.'s estimate of the elasticity of demand for oranges. Although the feasibility of substitution for herbicides on oranges is high (indicating elastic demand), the marginal productivity of the herbicides is also fairly high (indicating inelastic demand). Therefore, no adjustment to the U.S.D.A. estimate of elasticity of demand for oranges is made.

i. Herbicides on tree fruits (except oranges), nuts, and sugarcane

The elasticity of demand for this cluster, based on the elasticity of demand for retail food, is estimated as -0.20. Pesticides in this cluster have a high feasibility of substitution with non-chemical pest control methods, indicating elastic demand. However, the marginal productivity of these pesticides is also moderately high, at $19.19, indicating inelastic demand. Therefore, no adjustments are made to the elasticity estimate for retail food.

j. Herbicides on grapes

The price elasticity of demand for herbicides on grapes is estimated based on the elasticity of demand for grapes at the retail level. The estimated elasticity is -1.38. Since the marginal productivity on grapes is extremely high, the elasticity of demand may be less than -1.38. However, the marginal productivity is the only factor indicating inelastic demand; the feasibility of substitution for herbicides on grapes is moderate. Further, the degree of adjustment to the elasticity estimate warranted by the high marginal productivity is unclear. For these two reasons, this analysis relies on the elasticity estimate for retail grapes. However, it should be noted that this value may overstate elasticity, and therefore overstate the impact of the effluent guidelines on pesticide manufacturers.

k. Herbicides on vegetables

The weighted-average estimate of demand for vegetables at the retail level is -0.27. Since the feasibility of substitution is moderate and the marginal productivity is moderately high for this cluster, the elasticity estimate for food is used to represent the elasticity of demand for herbicides used on these foods.

l. Herbicides used on tobacco

U.S.D.A. did not estimate the elasticity of demand for tobacco at the retail level. However, the addictive nature of cigarette smoking probably results in inelastic demand for tobacco. It seems reasonable to assume demand for tobacco is as inelastic as the least elastic demand for retail food, since people seldom develop addictions to specific foods. Since U.S.D.A. found that the elasticity of demand for numerous food commodities was lower in absolute value than -0.20, the elasticity of demand for tobacco is estimated as -0.20.

Since the feasibility of substituting a non-chemical alternative for herbicides on tobacco is high, demand for the herbicides used on tobacco may be more elastic than demand for the tobacco itself. However, the costs of applying herbicides comprise only 3 percent of the total variable costs of production. Further, the estimate of the marginal productivity of herbicides used on tobacco is extremely high. These two factors indicate that demand for herbicides used on tobacco will be inelastic. Given these opposing factors, this analysis assumes that the elasticity of demand for herbicides used on tobacco will match the elasticity of demand for tobacco. The elasticity estimate for this cluster is therefore -0.20.

m. Herbicides on sugar beets, beans, and peas

The estimate of the elasticity of demand for this cluster is calculated from a weighted average of U.S.D.A.'s (1985) estimate of demand for food at the retail level. The value is -0.12. No adjustments are made since the indications regarding elasticity of demand for the herbicides conflict. The substitutability for herbicides on sugar beets, beans, and peas is low, indicating relatively inelastic demand, while the marginal productivity of the herbicides is low, indicating relatively elastic demand.

n. Insecticides on vegetables

The elasticity for this cluster is estimated as -0.33, based on a weighted-average of the values estimated by U.S.D.A. (1985) as the elasticities of demand for vegetables. No adjustments are made to the elasticity estimate for vegetables. The marginal productivity of insecticides in this cluster is moderate, at $7.92. Although the substitutability for insecticides on vegetables is low, there is no quantitative measure of the extent to which the estimate should be altered. Further, this is the only factor indicating that demand is relatively inelastic. Therefore, the elasticity estimate of -0.33 is used in this analysis.

o. Insecticides on fruits and nuts except oranges

The estimate of elasticity of demand for the food commodities in this cluster, based on U.S.D.A.'s (1985) estimates of elasticity of demand for food at the retail level, is -0.21. This value differs notably from the elasticity estimate of Pingali and Carlson (1985) for insecticides applied to apple orchards. Pingali and Carlson estimated the elasticity of demand as -1.39. Since the authors considered only apple orchards, the estimates are not perfectly comparable. However, since apples receive over 50 percent of insecticides applied to crops in this cluster, the differences between the two estimates is notable.

The marginal productivity of these insecticides is moderate and does not suggest that an adjustment to the elasticity estimate for retail food is required. However, the feasibility of non-chemical substitution for these insecticides is high, indicating elastic demand. To account for the high feasibility of substitution and the elasticity estimate of Pingali and Carlson, the elasticity estimate for this cluster is adjusted from -0.21 to -1.00.

p. Insecticides on oranges

The U.S.D.A. estimate of the elasticity of demand for oranges at the retail level was -1.00. This value is also used to represent the elasticity of demand for insecticides applied to oranges. Although the feasibility of substitution of insecticides used on oranges is high (indicating relatively elastic demand), the marginal productivity of the insecticides is also fairly high (indicating relatively inelastic demand). Therefore, no adjustments are made.

q. Insecticides on grapes

The U.S.D.A. estimate of the elasticity of demand for grapes at the retail level was -1.38. This value is also used to represent the elasticity of demand for insecticides applied to grapes. Although the feasibility of substitution of insecticides used on grapes is high (indicating relatively elastic demand), the marginal productivity of the insecticides is also high, at $37.80 (indicating relatively inelastic demand). Therefore, no adjustments are made to the U.S.D.A. elasticity estimate for grapes.

r. Insecticides on corn and alfalfa

Since a large proportion of production of each of these crops serves mainly as animal feed, an elasticity estimate for the crops was developed based on the retail demand for meat. As discussed above, the elasticity for corn and alfalfa is estimated to be -0.69. This elasticity estimate is also used to represent the elasticity of demand for insecticides applied to these crops.

Three literature values describe the elasticity of demand for crops in this cluster. U.S. EPA (1974) found the demand for corn insecticides to be inelastic. Miranowski's (1980) statistically significant estimate of the elasticity of demand for corn insecticides was -0.78. Finally, Huh (1978) estimated the elasticity of demand for corn insecticides and herbicides as -1.46. Since these literature estimates conflict, they do not indicate that an adjustment to the elasticity estimate is needed.

The feasibility of substitution on these crops is low, indicating that demand is relatively inelastic. The low contribution of insecticides to the costs of production of these crops also indicates that demand for the insecticides will be relatively inelastic. However, the marginal productivity of insecticides on corn and alfalfa is fairly low, at $3.69. Low productivity is associated with elastic demand. Given the opposing factors, no adjustment is made to the estimate of the elasticity of demand for corn and alfalfa.

s. Insecticides on sorghum

As was the case for corn and alfalfa, the elasticity of demand for sorghum is calculated based on the elasticity of demand for meat, since sorghum is used mainly as a feed crop. The elasticity estimate for sorghum is -0.69. Although the marginal productivity of insecticides on sorghum is low (indicating relatively elastic demand) and the feasibility of substitution is high (also indicating elastic demand), insecticides contribute only two percent of production costs (indicating inelastic demand). Given these opposing factors, no adjustment to the sorghum elasticity estimate is made. The elasticity of insecticides used on sorghum is estimated as -0.69.

t. Insecticides on soybeans, peanuts, wheat, and tobacco

The estimate of the elasticity of demand for soybeans, peanuts, and wheat is -0.56. Although an estimate of the elasticity of demand for tobacco is not available, this omission should not substantially affect the estimate since 80 percent of insecticides used in this cluster are applied to soybeans, peanuts, or wheat. The feasibility of substitution, fraction of contribution to production costs, and marginal productivity for this cluster of pesticides do not suggest that an adjustment to the elasticity of demand for the food crops is required. The elasticity estimate for this pesticide cluster is therefore -0.56. This estimate is consistent with the finding by U.S. EPA (1974) that demand for soybeans is inelastic.

u. Insecticides on cotton

No estimate of the elasticity of demand for cotton was given by U.S.D.A. However, Burrows (1983) empirically estimated this elasticity. Using a single equation model, Burrows estimated the elasticity of demand for cotton to be -0.9; with a simultaneous equation model, Burrows estimated the elasticity as -1.23. The average of these two estimates is -1.06.

Since the marginal productivity of insecticides on cotton is extremely low, at $0.72, the demand for the insecticides is expected to be elastic. Further, the insecticides contribute a fairly high fraction, 13 percent, of the variable cash costs of producing cotton. The feasibility of substitution for these insecticides is moderate. Since these factors are consistent with the elasticity estimate from Burrows, the elasticity of demand for cotton insecticides is estimated to be -1.06.

v. Fungicides on grain storage

In the absence of more specific information, the elasticity of demand for fungicides on grain storage is assumed to equal the elasticity of demand for grains. Elasticity estimates are available from Huang (1985) for wheat and rice. Other stored grains may be fed to animals. As discussed above, an estimate for the elasticity of grains fed to animals was developed as part of this analysis. However, since information was not located on the quantity of fungicides applied to each grain and each end-use, correct weighting factors for the different elasticity estimates could not be developed to estimate an average elasticity for all grains treated with fungicides in storage. The elasticity for this cluster is therefore estimated as a straight average of the elasticity of wheat flour (-0.11), rice (-0.15), and animal feed grains (-0.69). The resulting elasticity estimate for fungicides used on grain in storage is -0.31.

w. Fungicides used for seed treatment

Since no specific information on the elasticity of fungicides used for seed treatment was located, the elasticity of demand for fungicides in this cluster is calculated based on the demand elasticity for the crops constituting the majority of seed plantings, and for which an elasticity estimate was available. These crops include corn (elasticity estimated as -0.69), wheat (-0.11), dried beans, peas, and nuts (-0.12), and rice (-0.15). Since no information was located on the quantity of fungicides applied to seeds of each crop, a straight average of the elasticities was used to estimate the demand elasticity for this cluster. The resulting estimate for this cluster is -0.27.

x. Fungicides - post-harvest

The elasticity of demand for fungicides applied post-harvest is based on a weighted average of the elasticities of demand for the crops to which fungicides are applied in the field. These crops are assumed to be vegetables, fruit and nut trees, and grapes, as these were the crops included in the four fungicide clusters for which the elasticity of fungicides used in field applications was calculated. Fungicides are assumed to be applied to the crops after harvest in the same ratios as they were applied to the crops in the field. These ratios are used to weight the demand elasticities for the individual crops. The resulting elasticity estimate is -0.65.

A complete list of Abt Associates' estimated price elasticities of demand for clusters defining agricultural end-uses is provided in Table 2.10.

Table 2.10
Estimates of Elasticity of Demand for Clusters in the Agricultural Sector

Cluster	Elasticity Estimate
Fungicides on:	
fruit and nut trees except oranges	-0.23
seed treatment	-0.27
grain storage	-0.31
vegetables	-0.38
post-harvest	-0.65
oranges	-1.00
grapes	-1.38
Herbicides on:	
sugar beets, beans, and peas	-0.12
tobacco	-0.20
tree fruits (except oranges, nuts, sugarcane)	-0.20
vegetables	-0.27
soybeans, cotton, peanuts, and alfalfa	-0.67
corn	-0.69
sorghum, rice, and small grains	-1.00
oranges	-1.00
grapes	-1.38
Insecticides on:	
vegetables	-0.33
soybeans, peanuts, wheat, and tobacco	-0.56
corn and alfalfa	-0.69
sorghum	-0.69
fruit and nut trees except oranges	-1.00
oranges	-1.00
cotton	-1.06
grapes	-1.38

Source: Abt Associates estimates based on Pimentel et al. (1991), USDA (1985), USDA (1989a), USDA (1989b), USDA (1989c), Burrows (1983), Pingali and Carlson (1985), Miranowski (1980), Huh(19878), U.S. EPA (1974)

3.0 PRICE ELASTICITY OF DEMAND FOR PESTICIDES USED NON-AGRICULTURALLY

Most of the pesticides included in this analysis are used in the agricultural sector; pesticides in non-agricultural clusters, as defined by OPP, constitute less than 30 percent of total pesticide use by weight (U.S. EPA, 1988). However, the non-agricultural pesticides are described by eighteen separate clusters. Unlike in the agricultural sector, these clusters represent eighteen distinct and generally unrelated end-uses, each with its own customers, competitors, and costs. The literature search described above yielded no studies of the price elasticity of demand for pesticides in the non-agricultural sector. Since the scope of this project does not allow for the gathering and examination of primary data on elasticities of demand for each of these eighteen markets and since non-agricultural pesticide use represents a relatively small percent of total pesticide use, the demand elasticities for the non-agricultural sector are developed based on a reasoned consideration of two factors. Consistent with the analysis of agricultural pesticide use, these factors are: (1) the availability of substitutes for a cluster of pesticides, and (2) the contribution of pesticides to the total production cost of the end-user.

Based on the above two factors, the eighteen non-agricultural clusters fit into two categories: (1) pesticides that contribute a small percentage to total cost but have substitutes, and (2) pesticides that contribute a small percentage of total production costs and for which there are limited substitutes. There were no cases in which it appeared that pesticides contributed a substantial percentage of total production costs. The two categories and the clusters described by them are listed below, along with a brief discussion of the reasoning behind the cluster categorization.

(1) <u>Pesticides contribute a small percentage of total cost but substitutes are available</u>

The two non-agricultural herbicide clusters are included in this category: (a) herbicides on ditches, rights of way, forestry, and ponds, and (b) herbicides on turf. The available substitute is labor, a viable alternative to chemical weed control. To determine the shift to manual/mechanical weed control given an increase in pesticides price, one would need to know: the cost of herbicide per unit of area, the effectiveness of herbicides, the labor cost of applying herbicides per unit of area, the labor cost of manual weed control per unit of area, and the effectiveness of manual weed control. Since these two clusters together constitute less than one percent of the pesticides of interest (by weight) it was decided not to invest resources in the gathering of these data.

Rather, Abt Associates considered the cost structure of the end-users of pesticides in these clusters. Herbicides used on ditches, rights of way, forestry, and ponds would generally be used by major industries such as railroads and utilities and by government agencies, such as state highway departments. The cost of herbicides would be an insignificant percentage of their total production costs. Demand for this cluster of herbicides is therefore likely to be inelastic. While herbicides used on turf may contribute a greater percentage to the total production costs (assuming that these pesticides are used, for example, on golf courses and turf farms) the costs should still be relatively small. In addition, fungicides are applied in conjunction with herbicides to turf. It is therefore likely that an application system would be in place for fungicides, making the incremental costs of herbicide application small.

Based on the above discussion, this analysis assumes that demand for the two non-agricultural herbicides clusters is inelastic. Although the level of detail of the available information does not result in a quantitative measure of the elasticity, such a measure is required. Since only one of the two factors considered above indicates inelasticity (percent of production costs), while the other is inconclusive (substitute availability), this analysis assumes that demand for these two clusters is only moderately inelastic, and assigns a price elasticity of -0.66. The sensitivity analysis will consider the impacts on active ingredient manufacturers if demand for pesticides in these clusters is perfectly elastic.

(2) Pesticides contribute a small percentage of total production costs, and there are limited substitutes

The remaining sixteen non-agricultural clusters are grouped in this category. For each cluster, the cost of pesticides appeared incidental to the total cost of production and no readily available, cost-effective alternatives to the pesticides were known. These two factors suggest inelastic demand. Further, only three of the sixteen clusters in this category constitute more than one percent (by weight) of the pesticides of interest in this analysis. Therefore, little additional information on the ultimate costs to manufacturers would result from an investigation of the remaining thirteen clusters. The three clusters which included at least one percent by weight of the total pesticides of concern are listed below with a brief discussion of their categorization:

Insecticide fumigants and nematicides

According to Encyclopedia Britannica, "Fumigation, which requires some technical skills and certain precautions in application, is mostly feasible for non-selective quick killing of vermin in large commercial operations. For the control of household pests it has been, to a considerable extent, supplanted by more convenient methods of extermination such as the application of powders and residual sprays". Fumigants are largely used for killing insect pests of stored products, for fumigating nursery stock, or for fumigating sod, principally for the control of plant parasitic nematodes. Given the application in large commercial operations, the contribution of fumigants and nematicides to production cost is likely to be small. Further, since the use of these products has become somewhat specialized, it is probable that few substitutes exist.

Insecticides for termite control

Domestic and commercial use of chemical termite controls seems unlikely to contribute substantially to total consumer or commercial business expenses. Also, while in the long-run, wood could be replaced to some extent as a building material, in the short-run alternative protection from and eradication of termites is not readily available. Further, the cost of termite control can be viewed as insurance against the much larger cost of destruction of a building, making the cost of control appear small. For the reasonably foreseeable future, the demand for chemical termite control is likely to be inelastic.

Wood preservatives - industrial, commercial, marine use

The wood preservative industry developed because of the need for prolonging the life of wood structures, particularly where the structures come in contact with ground. Examples of treated wood include railroad ties, telephone poles, and marine pilings. Wood may be chemically treated to protect against fungicides, insects, and fire. According to U.S. EPA (1982), expenditures on wood preservative account for "only a small part" of the annual billion dollar preserved wood market. Cost-effective alternatives to chemical wood preservation are not known. Demand for pesticides in this cluster is therefore assumed to be inelastic.

The remaining clusters grouped in this category are:

- Insect repellents at non-agricultural sites
- Domestic bug control and food processing plants
- Mosquito larvacides
- Fungicides on turf
- Industrial preservatives - plastics, paints, adhesives, textiles, paper
- Synergist - used as insecticide synergists, surfactants, cheleating poultry and livestock
- Plant regulators, defoliants, desiccants - for all uses
- Sanitizers - dairies, food processing, restaurants, air treatment
- Insecticides on livestock and domestic animals
- Fungicides - ornamentals
- Industrial microbiocides, cutting oils, and oil well additives
- Preservatives, disinfectants, and slimicides
- Slimicides - pulp and paper, cooling towers, sugar mills
- Fungicides - ornamentals
- Industrial microbiocides, cutting oils, and oil well additives
- Preservatives, disinfectants, and slimicides

Ideally, a quantitative measure of the price elasticity of demand could be developed for each of the pesticides clusters listed above. However, the available data does not permit this precision. Since clusters in this category have no known cost-effective substitutes and since the pesticides are generally an insignificant portion of total production costs, demand is expected to be moderately to highly inelastic. The clusters in this category are assigned a price elasticity of demand of -0.33. The sensitivity analysis will examine the impact on manufacturers in the demand is perfectly elastic.

Finally, two clusters remain without demand elasticity estimates: herbicides for broad spectrum use and fungicides for broad spectrum use. The cluster "herbicides for broad spectrum use" contains only one active ingredient, 2,4-D. The price elasticity of demand for 2,4-D was estimated by Lacewell and Masch (1972) and by Carlson (1977a,b). Lacewell and Masch estimated the elasticity as approximately -0.38. Carlson estimated a short-run elasticity of -0.19 and a long-run elasticity of -0.59. Averaging Carlson's long-run estimate and the estimate of Lacewell and Masch results in an estimate of elasticity of demand for 2,4-D of -0.48. We use this value as the price elasticity of demand for broad spectrum herbicides.

The elasticity estimate for broad spectrum fungicides is calculated simply by a weighted average of the elasticity estimates for all of the other fungicide clusters. The weighting is based on the quantity (by weight) of active ingredient applied for the end-uses described by each cluster. The resulting elasticity estimate is -0.40. This value is in good agreement with the elasticity of demand for fungicides estimated by U.S. EPA (1985) as -0.35.

4.0 CONCLUSIONS

The estimated elasticities for all 44 clusters are listed in Table 4.0, in order of increasing elasticity of demand. As can be seen from the table, the elasticity estimates range from -0.12 (herbicides on sugar beets, beans, and peas) to -1.38 (fungicides on grapes, herbicides on grapes, and insecticides on grapes). The elasticity estimates vary substantially within the fungicide, herbicide, and insecticide clusters; the type of pesticide is not predicted to have a strong influence on the elasticity of demand.

The demand for pesticides in all of the clusters except four is expected to have unit elasticity or to be inelastic. Demand is expected to be inelastic for the three clusters of pesticides applied to grapes and for insecticides applied to cotton. The main factor driving the high elasticity for the grape clusters is the high elasticity of demand for grapes at the retail level. Demand for insecticides on cotton is expected to be somewhat elastic based on literature estimates of the elasticity and on the low marginal productivity of insecticides applied to cotton.

As should be clear from sections 2 and 3, the methodology employed to estimate the elasticity of demand for the clusters yields reasonable best estimates of elasticities rather than certain quantifications. The estimates are likely to accurately depict whether demand for a certain cluster of pesticides is extremely or only moderately elastic or inelastic; the specific numeric value should not be viewed as definitive. However, no estimates of elasticity of demand for clusters of pesticides that are more reliable than those developed through this analysis are known. To address the uncertainty implicit in the estimates, a scenario in which the manufacturers bear the total costs of regulatory compliance will also be examined.

Table 4.0

SUMMARY OF ESTIMATES OF ELASTICITY OF DEMAND

Cluster	Elasticity Estimate
Herbicides on sugar beets, beans, peas	-0.12
Herbicides on tree fruits (except oranges), sugar cane, nuts	-0.20
Herbicides on tobacco	-0.20
Fungicides on fruit and nuts trees (except oranges)	-0.23
Fungicides for seed treatment	-0.27
Herbicides on vegetables	-0.27
Fungicides on grain in storage	-0.31
Insecticides on vegetables	-0.33
Slimicides	-0.33
Fumigants and nematicides	-0.33
Insecticides on termites	-0.33
Wood preservatives	-0.33
Insect repellents at non-agricultural sites	-0.33
Domestic bug control and food processing plants	-0.33
Mosquito larvacides	-0.33
Fungicides on turf	-0.33
Industrial preservatives	-0.33
Insecticide synergists and surfactants	-0.33
Plant regulators, defoliants, desiccants	-0.33
Sanitizers - dairies, food processing, restaurants, air treatment	-0.33
Insecticides on livestock and domestic animals	-0.33
Industrial microbiocides, cutting oils, oil well addivites	-0.33
Preservatives, disinfectants, and slimicides	-0.33
Fungicides - ornamentals	-0.33
Fungicides on vegetables	-0.38
Fungicides - broad spectrum	-0.40
Herbicides - broad spectrum	-0.48
Insecticides on soybeans, peanuts, wheat, tobacco	-0.56
Fungicides - post harvest	-0.65
Herbicides on rights of way, drainage ditches	-0.66
Herbicides on turf	-0.66
Herbicides on soybeans, cotton, peanuts, alfalfa	-0.67
Herbicides on corn	-0.69
Insecticides on corn, alfalfa	-0.69
Insecticides on sorghum	-0.69
Herbicides on sorghum rice, small grains	-1.00
Herbicides on oranges	-1.00
Fungicides on oranges	-1.00
Insecticides on fruit and nut trees, except oranges and grapes	-1.00
Insecticides on oranges	-1.00
Insecticides on cotton	-1.06
Fungicides on grapes	-1.38
Insecticides on grapes	-1.38
Herbicides on grapes	-1.38

Source: Abt Associates estimates

References

Burrows, T. (1983). Pesticide Demand and Integrated Pest Management: A Limited Dependent Variable Analysis, *American Journal of Agricultural Economics*, November.

Campbell, H. (1976). Estimating the Marginal Productivity of Agricultural Pesticides: The Case of Tree-Fruit Farms in the Okanagan Valley. *Canadian Journal of Agricultural Economics* 24(2), 1976.

Carlson, G. (1977). The Long Run Productivity of Insecticides, *American Journal of Agricultural Economics*, 59, pp. 543-548, August.

Carlson, G. (1977a). Economic Incentives for Pesticide Pollution Control in *The Practical Application of Economic Incentives to the Control of Pollution: The Case of British Columbia*. ed. J. Stephenson. Vancouver: University of British Columbia Press.

Hall, D.C., and L.J. Moffitt. (1983). Stochastically Efficient Economic Thresholds for Discrete Choices. USDA-ERS unpublished manuscript. Washington D.C.

Headley, J.C. (1968). Estimating the Productivity of Agricultural Pesticides, *American Journal of AGricultural Economics*, 50:13-23, February.

Huh, Shing Haeng (1978). The Preventive and Incidental Demand for Pesticides: An Economic Analysis of the Demand for Herbicides and Insecticides Used by Selected Corn Producers in Minnesota. Thesis submitted to the Graduate School of the University of Minnesota. June.

Lacewell, R. and W. Masch, (1972). Economic Incentives to Reduce the Quantity of Chemicals Used in Commercian Agriculture. *Southern Journal of Agricultural Economics*. July.

Lichtenberg, E. and D. Zilberman (1986). The Econometrics of Damage Control: Why Specification Matters. *American Journal of Agricultural Economics*. May.

Miranowski, J. (1980). Estimating the Relationship between Pest Management and Energy Prices, and the Implications for Environmental Damage. *American Journal of Agricultural Economics*. December.

Pimentel, D., et al. (1991). Environmental and Economic Impacts of Reducing U.S. Agricultural Pesticide Use, in ed. Pimentel, D., *Pest Management in Agriculture*. CRC press.

Pingali, P. and G. Carlson (1985). Human Capital, Adjustments in Subjective Probabilities, and the Demand for Pest Controls. *American Journal of Agricultural Economics*. November.

U.S.D.A. (1985). U.S. Demand for Food: A Complete System of Price and Income Effects. By Kuo S. Huang, National Economics Division, Economic Research Service. Technical Bulletin No. 1714.

U.S.D.A. (1988). 1985 Potato Cost and Returns: Fall Production Areas. Potato facts special edition. Economic Research Service. September.

U.S.D.A. (1989). Retail to Farm Linkage for a Complete Demand System of Food Commodities. By Michael K. Wohlgenant and Richard C. Haidacher. Commodity Economics Division, Economic Research Service. Technical Bulletin No. 1775.

U.S.D.A. (1989a). Economic Indicators of the Farm Sector: Costs of Production, 1987. ERS, USDA, ECIFS7-3. February.

U.S.D.A. (1989b). Tobacco: Situation and Outlook Report. Economic Research Service. September.

U.S.D.A. (1989c). Agricultural Statistics 1989. Washington.

U.S. EPA (1974). Farmers' Pesticide Use Decisions and Attitudes on Alternate Crop Protection Methods. Washington.

U.S. EPA (1982). Regulatory Impact Analysis Data Requirements for Registering Pesticides under the Federal Insecticides, Fungicides and Rodenticide Act. Office of Pesticide Programs. August.

U.S. EPA (1985). Economic Impact Analysis of Effluent Limitations Guidelines and Standards for the Pesticide Chemicals Industry. September.

U.S. EPA (1988). Pesticide Industry Sales and Usage: 1988 Market Estimates. Office of Pesticide and Toxic Substances. February.

APPENDIX D

SENSITIVITY ANALYSIS OF COST PASS-THROUGH ABILITY

Appendix D: SENSITIVITY ANALYSIS OF COST PASS-THROUGH ABILITY

This appendix describes a sensitivity analysis of the percentage of compliance costs that a manufacturer is able to pass through to consumers. The model, as described in Chapter 4, assumes that producers can pass on a portion of compliance costs to customers in the form of price increases, to the extent allowed by producer price competition and customer demand behavior. To test the sensitivity of the closure analysis results to this assumption, the worst-case assumption is made that facilities would bear the full costs of compliance (i.e. they could not pass on any of the compliance costs to customers as price increases). This corresponds to an assumption that all clusters have completely elastic demand elasticities, or that the percentage of total production subject to compliance costs is close to zero.

The results of this sensitivity analysis are presented below by regulatory option and subcategory. In comparison to the model used in the EIA, there are no changes under the proposed option (Treated Discharge Option). Minor changes in results occur under the Zero Discharge Option: one additional product line closure is predicted for direct dischargers, while one additional facility closure and two additional product line closures would be predicted for indirect dischargers (compare Table D.1 with Table 4.4).

Treated Discharge Option

Impacts of BAT regulations on direct dischargers

Organic Pesticide Manufacturing - (Subcategory A)

Under the no cost pass-through assumption, no facilities are projected to close due to compliance with BAT. Two facilities are expected to close a product line as a result of the regulation (see Table D.1).

Metallo-Organic Pesticide Manufacturing - (Subcategory B)

Direct dischargers of Subcategory B chemicals are limited to zero discharge of process wastewater pollutants under BPT. No additional options were considered and no new limitations are proposed for the metallo-organic pesticide chemicals manufacturing subcategory. There are therefore no associated costs or economic impacts, and sensitivity analysis need not be examined.

Impacts of PSES regulations on indirect dischargers

Organic Pesticide Manufacturing - (Subcategory A)

No facilities are expected to close under the no cost pass-through assumption due to compliance with PSES. One facility is projected to close a product line as a result of the regulation.

Metallo-Organic Pesticide Manufacturing - (Subcategory B)

Because no new limitations are proposed for the metallo-organic pesticide chemicals manufacturing subcategory, no facility or product closures would be projected under the no cost pass-through assumption due to compliance with PSES.

Zero Discharge Option

Impacts of BAT regulations on direct dischargers

Organic Pesticide Manufacturing - (Subcategory A)

Sixteen facilities would be projected to close due to compliance with BAT limitations under the no cost pass-through assumption. Four additional facilities would be expected to close a product line as a result of the regulation.

Metallo-Organic Pesticide Manufacturing - (Subcategory B)

As discussed under the Treated Discharge Option, Subcategory B direct dischargers are limited to zero discharge of process wastewater pollutants under BPT. No additional options were considered and no new limitations are proposed for the metallo-organic pesticide chemicals manufacturing subcategory. Therefore, there are no associated costs or economic impacts, and sensitivity analysis need not be examined.

Impacts of PSES regulations on indirect dischargers

Organic Pesticide Manufacturing - (Subcategory A)

Twelve facilities would be expected to close due to compliance with PSES under the assumption of no cost pass-through. Five additional facilities would be projected to close a product line as a result of this regulation.

Metallo-Organic Pesticide Manufacturing - (Subcategory B)

Under the no cost pass-through assumption, one facility would be projected to close due to compliance with the PSES regulation. An additional facility would be expected to close a product line.

Table D.1
Impacts of the Proposed Regulation on Facilities Under No Cost Pass-Through Assumption**

	Treated Discharge Option		Zero Discharge Option	
	Direct Dischargers**	Indirect Dischargers	Direct Dischargers**	Indirect Dischargers
Number of facilities with costs	32	30	35	33
Facility Closures	0	0	16	13
Subcategory A/Subcategory B*	0/0	0/0	16/0	12/1
Product Line Closures	2	1	4	6
Subcategory A/Subcategory B*	2/0	1/0	4/0	5/1

* Five facilities produce both Subcatgory A and B active ingredients. Two of these have costs for both Subcategories. Subcategory B costs will not be incurred since the proposed regulation does not apply to Subcategory B active ingredients.

** Zero discharges are included with direct dischargers.

APPENDIX E

DETAILS OF ANALYSIS OF IMPACTS ON SMALL BUSINESSES

Appendix E: DETAILS OF ANALYSIS OF IMPACTS ON SMALL BUSINESSES

The figures presented in this appendix illustrate the relationship between facility impacts and facility size that were examined in the second stage of the small business analysis. This relationship was first examined by plotting the two financial impacts considered in the analysis:

- facility closures
- product line closures

against five measures of facility size:

- firm revenues
- total facility revenues
- total facility employment
- pesticide-related facility revenues
- pesticide-related facility employment

The plotting exercise outlined above resulted in a total of 10 plots: two impacts by five measures of size. The two impacts vs. the five measures of size were plotted for three populations: facilities that were classified as direct dischargers, facilities that were classified as indirect dischargers, and all facilities. Plotting the 10 relationships for each of the three populations cited above resulted in a total of 30 plots.

The 30 plots that are included in this appendix are arranged as follows. Figures E.1 - E.10 exhibit the relationship between facility impacts and facility size for all dischargers. The relationship between impacts and size for facilities classified as direct and indirect dischargers are displayed in Figures E.11 - E.20, and Figures E.21 - E.30 respectively.

Following the plotting exercise, 10 regressions were performed to examine the probability that a facility/product line will remain open as a function of entity size. Similar to the plotting exercise, each regression used one of the five measures of entity size as the independent variable and one of the two impacts as the dependent variable. The 10 regressions were performed for three populations: facilities that were classified as direct dischargers, facilities that were classified as indirect dischargers, and all facilities, leading to a total of 30 regressions.

Appendix E contains the results of the regression analyses that were performed for all dischargers.

Results that were obtained when examining direct and indirect dischargers separately are presented and discussed in Chapter 8.

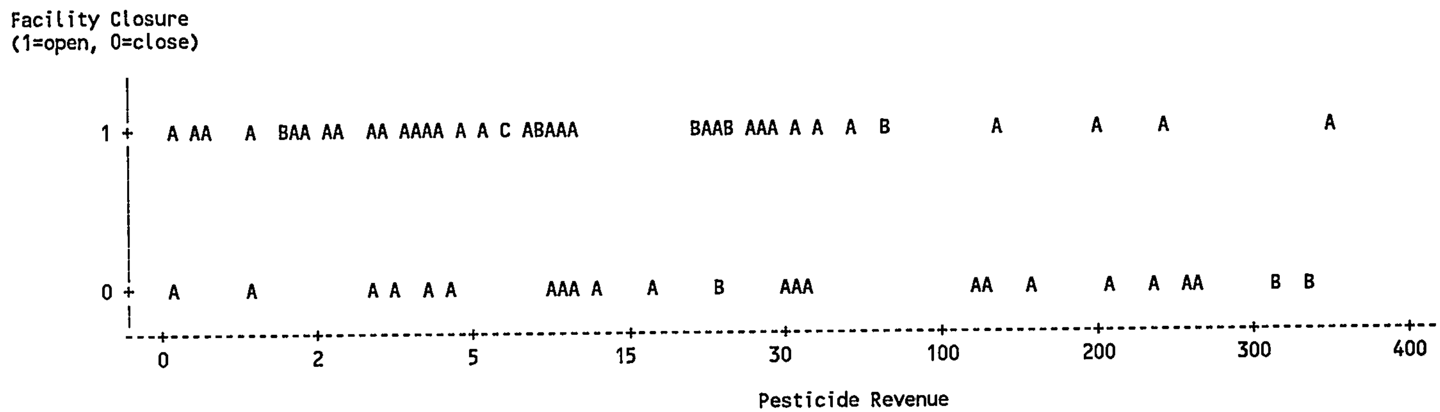
Table E.1
Logistic Regression Analysis
Zero Discharge Option: All Dischargers

Model #	# of Observations	Impact (y_i)	Measure of Entity Size (x_i)	Coefficient (β_i)	p value
1	72	Facility Closure	Pesticide Revenues	$-7.8E^{-9}$	.0064
2	72	Facility Closure	Facility Revenues	$-4.8E^{-9}$	.0184
3	70	Facility Closure	Firm Revenues	$-6.1E^{-11}$	.1077
4	73	Facility Closure	Pesticide Employment	$-4.4E^{-3}$	.0344
5	73	Facility Closure	Facility Employment	$-1.3E^{-3}$	.0658
6	32	Product Line Closure	Pesticide Revenues	$-1.3E^{-8}$	.0789
7	32	Product Line Closure	Facility Revenues	$-6.0E^{-9}$	.0995
8	31	Product Line Closure	Firm Revenues	$-1.1E^{-10}$	.1755
9	33	Product Line Closure	Pesticide Employment	$-9.9E^{-3}$	.1121
10	33	Product Line Closure	Facility Employment	$-1.2E^{-3}$	.3090

Note: At the 95 percent confidence level $p < .05$ indicates that the coefficient is significant, while $p < .10$ indicates significance at the 90 percent confidence level. Coefficients that are in shaded sections are significant to the 90 percent confidence interval.

FIGURE E.1

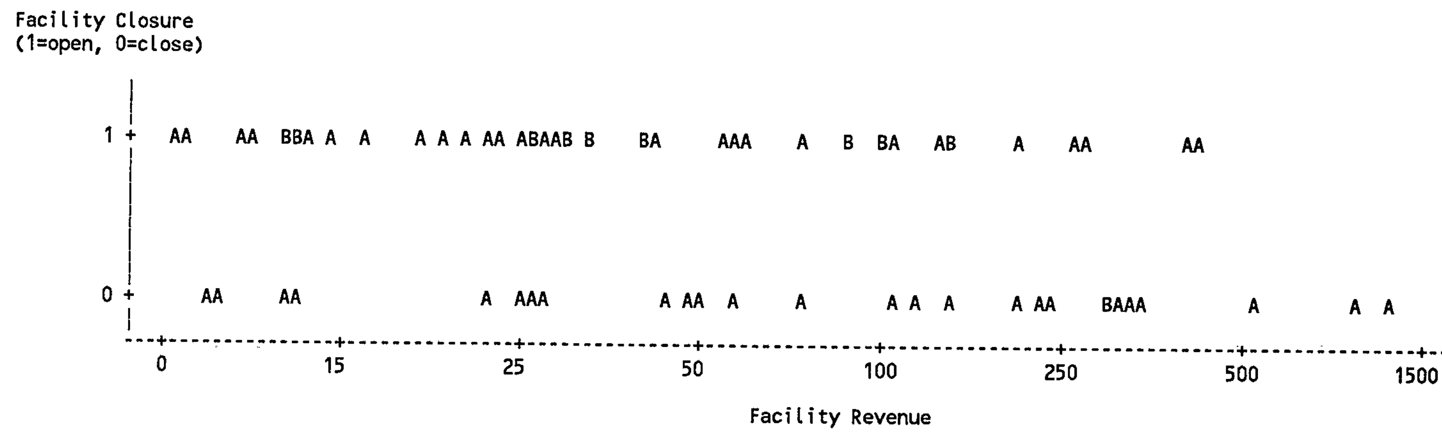
Zero Discharge Option, All Dischargers
Facility Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.2

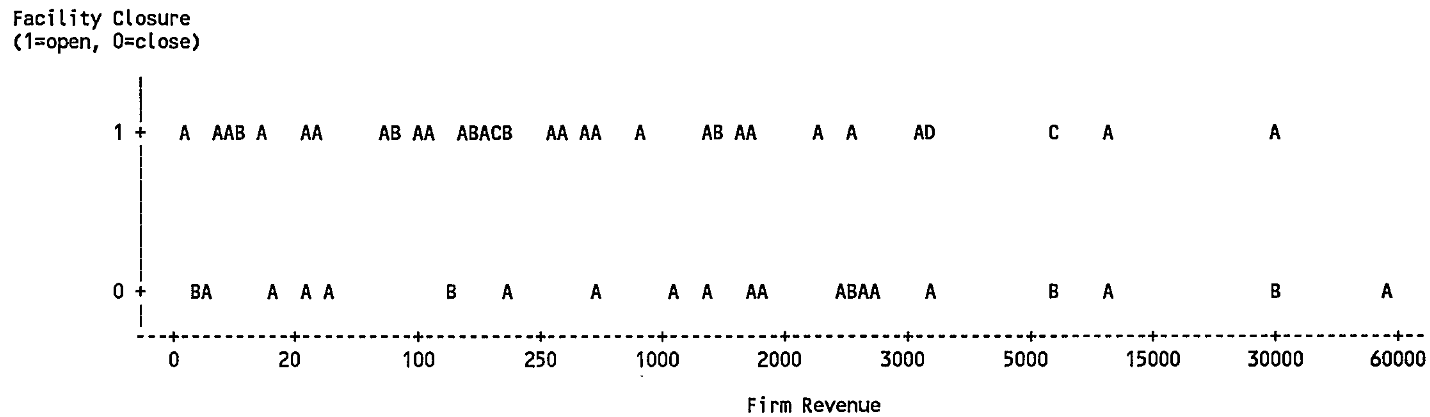
Zero Discharge Option, All Dischargers
Facility Closure vs.Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.3

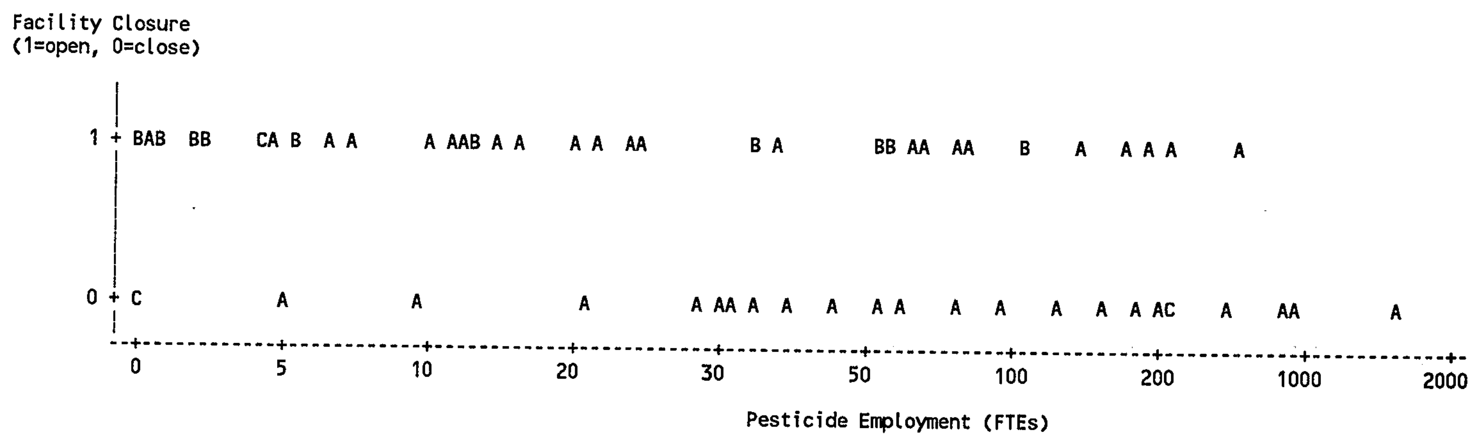
Zero Discharge Option, All Dischargers
Facility Closure vs. Firm Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.4

Zero Discharge Option, All Dischargers
Facility Closure vs. Pesticide Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.5

Zero Discharge Option, All Dischargers
Facility Closure vs. Facility Employment (FTEs)

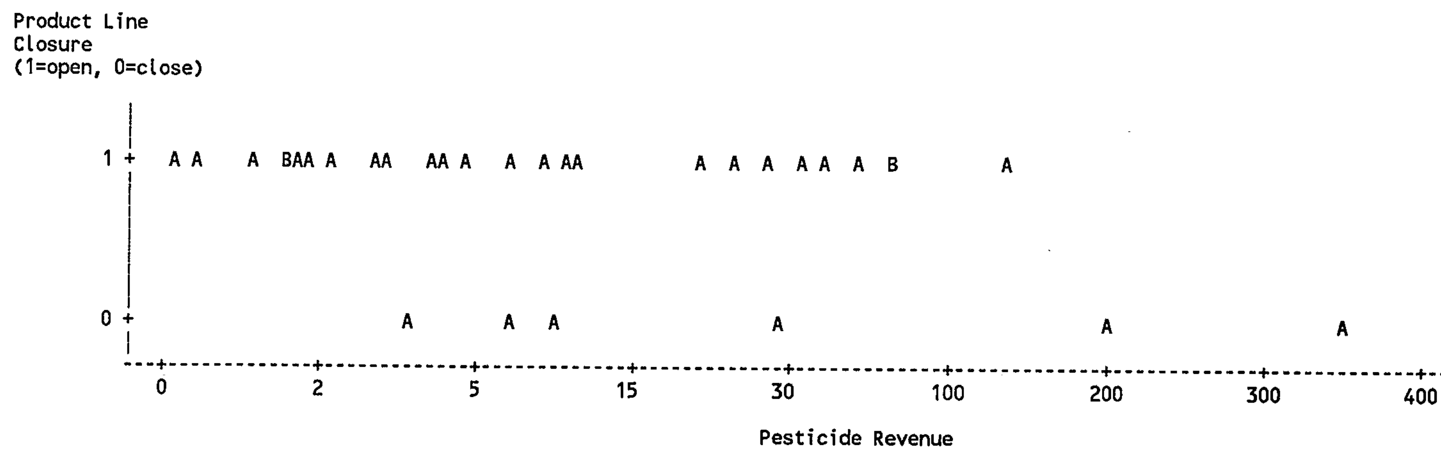
```
Facility Closure
(1=open, 0=close)
     |
     |
   1 + BB        A  B   A  BAAAA  B     AA    AA A A    AB B  C AAA    A      AB     A AAA A AA   A  A
     |
     |
     |
     |
     |
   0 + A          B          A    A     A A      A     AA AA     A A A   AA     A A    A  A BAA           A          A
     |
     --+----------+----------+----------+----------+----------+----------+----------+----------+----------+--
       0         10         40         60         100        200        400        1000       5000       11000

                                      Facility Employment (FTEs)
```

Legend: A=1 observation, B=2 observations, etc.

FIGURE E.6

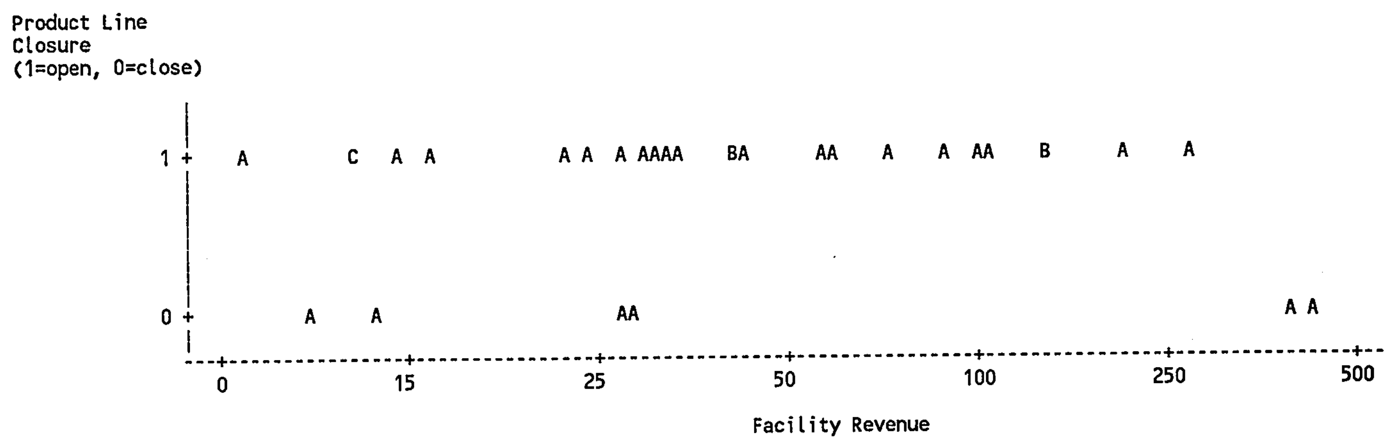
Zero Discharge Option, All Dischargers
Product Line Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.7

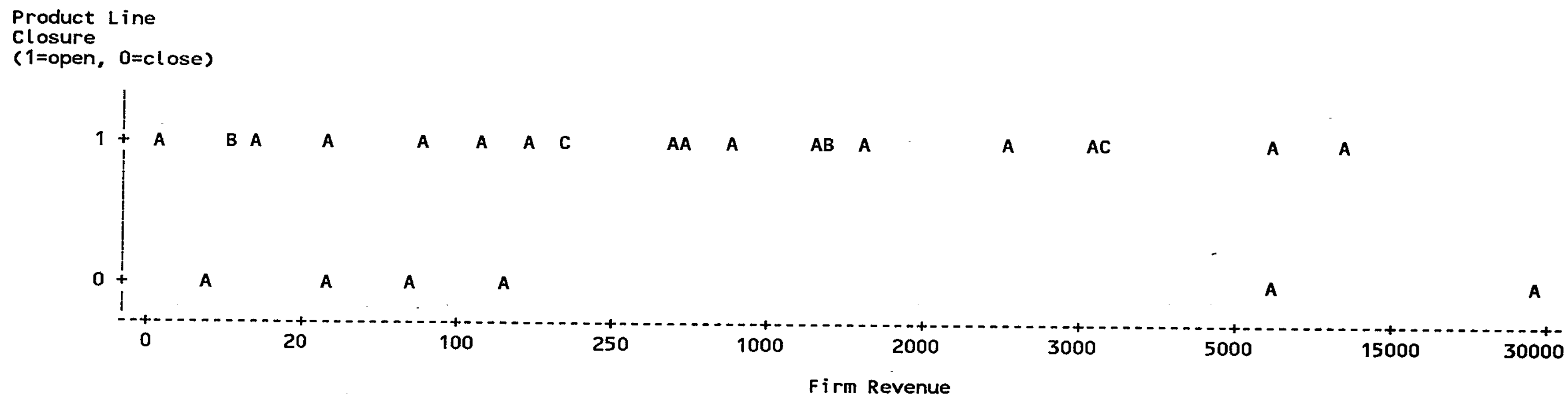
Zero Discharge Option, All Dischargers
Product Line Closure vs.Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.8

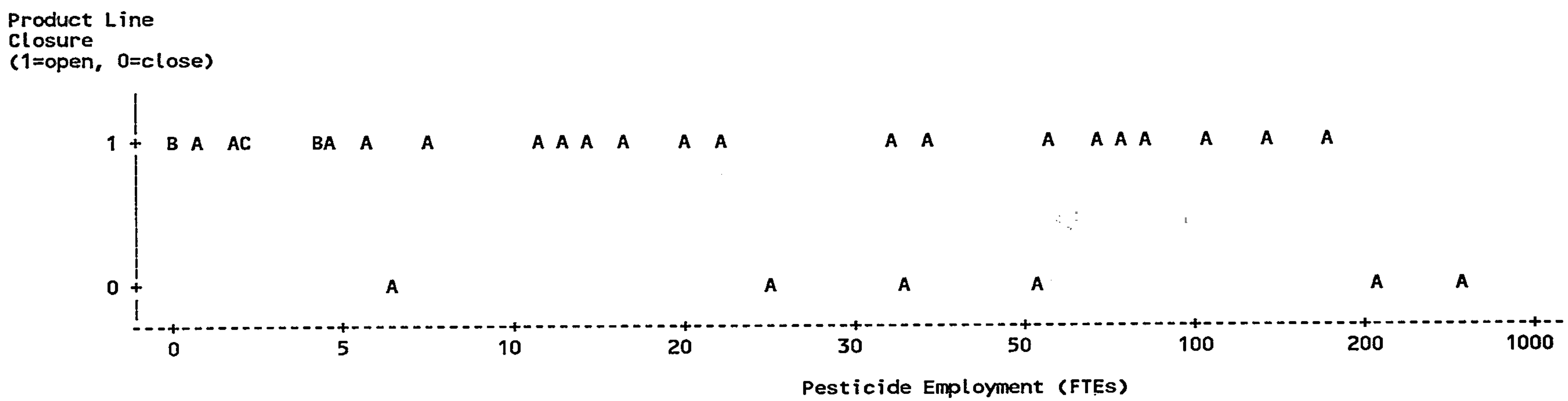
Zero Discharge Option, All Dischargers
Product Line Closure vs. Firm Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.9

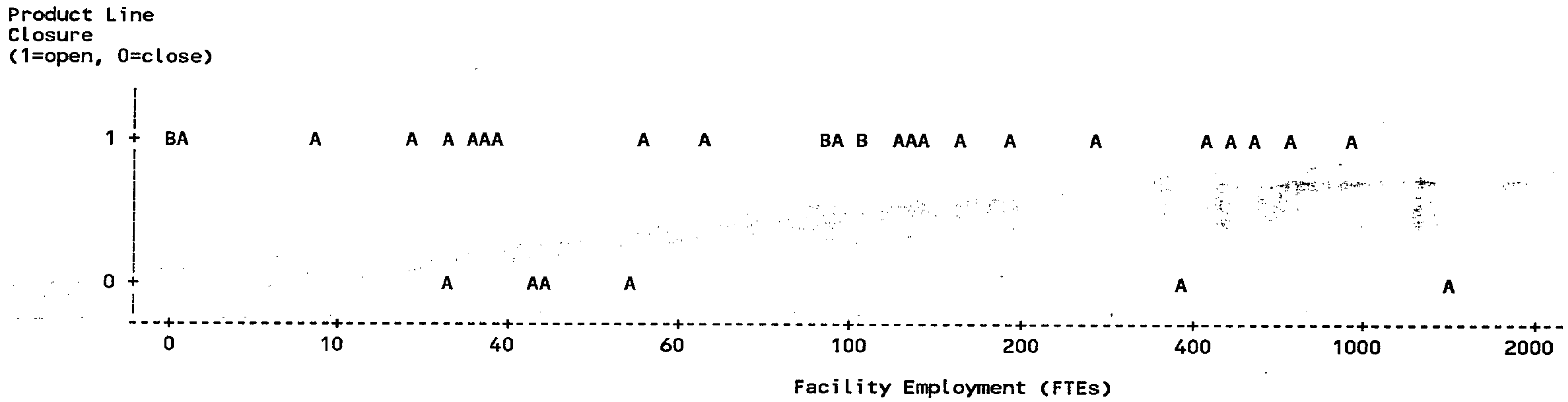
Zero Discharge Option, All Dischargers
Product Line Closure vs. Pesticide Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.10

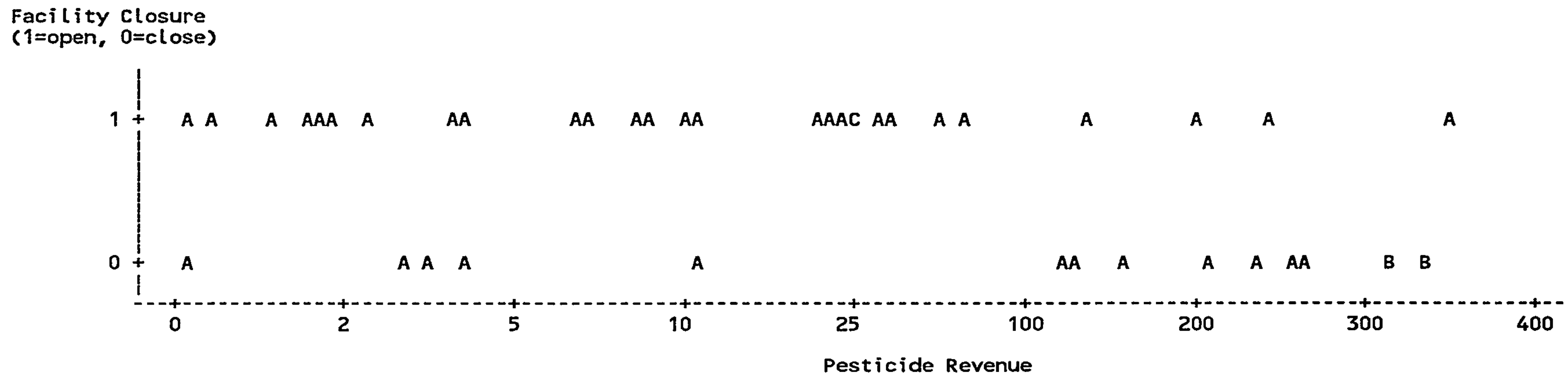
Zero Discharge Option, All Dischargers
Product Line Closure vs. Facility Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.11

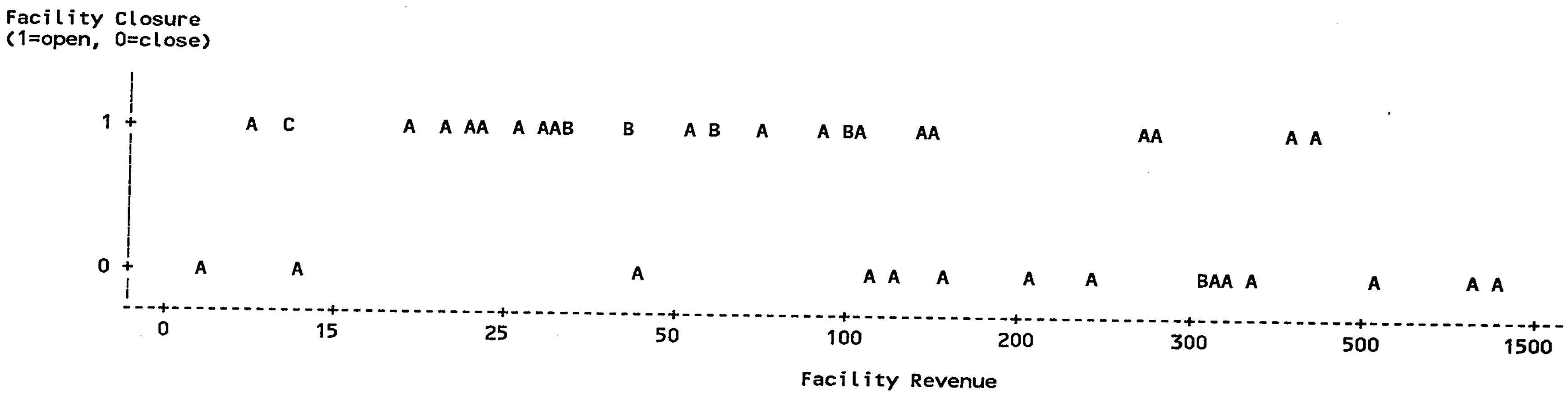
Zero Discharge Option, Direct Dischargers
Facility Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.12

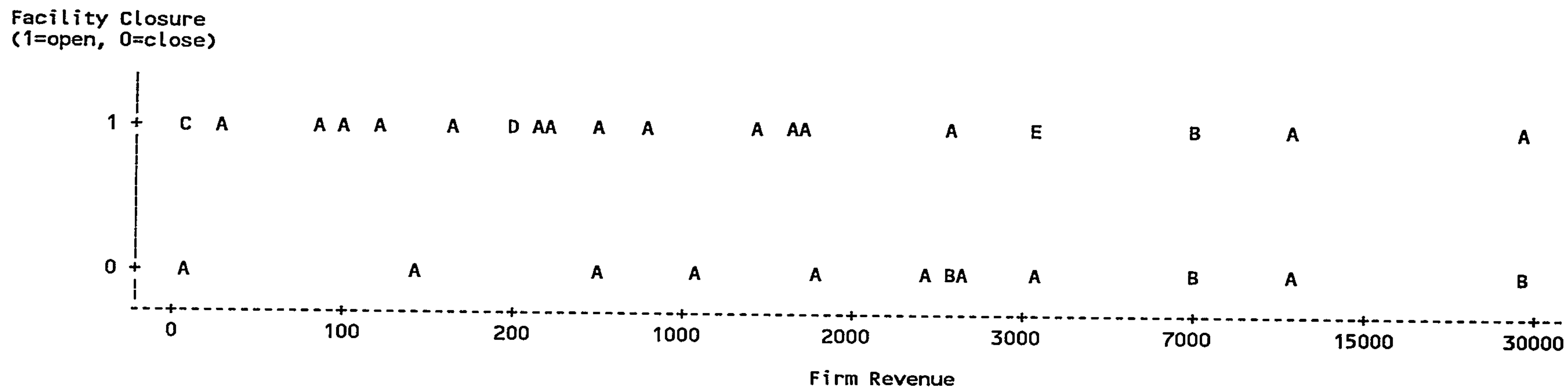
Zero Discharge Option, Direct Dischargers
Facility Closure vs. Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.13

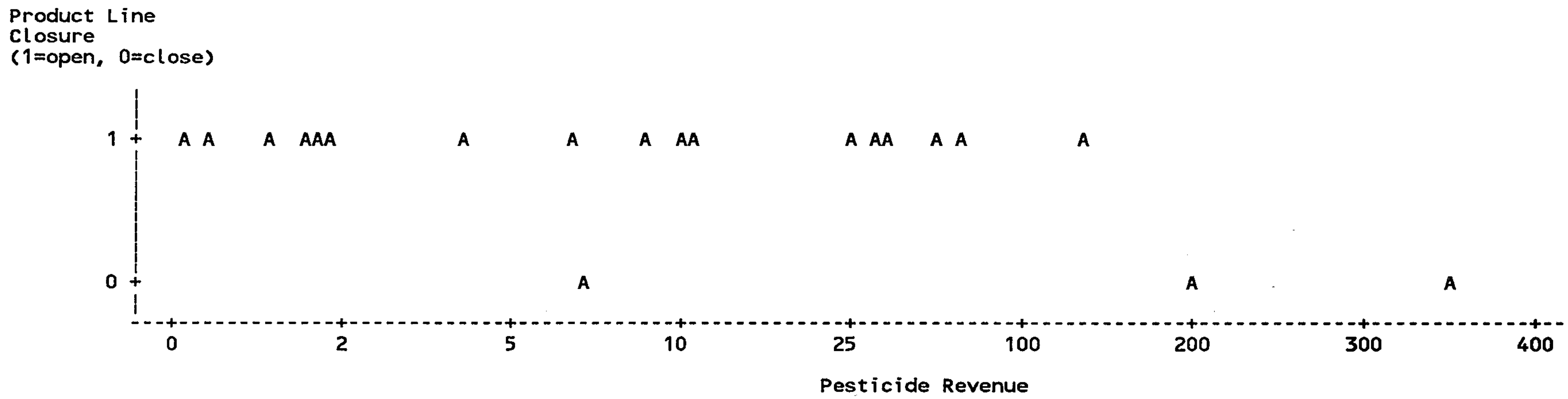
Zero Discharge Option, Direct Dischargers
Facility Closure vs. Firm Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.16

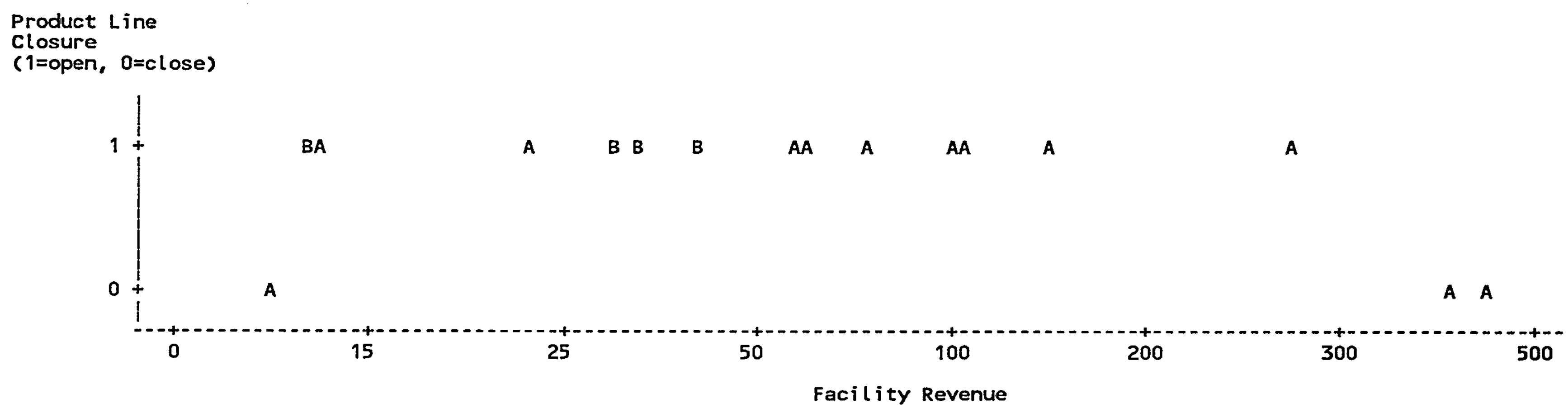
Zero Discharge Option, Direct Dischargers
Product Line Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.17

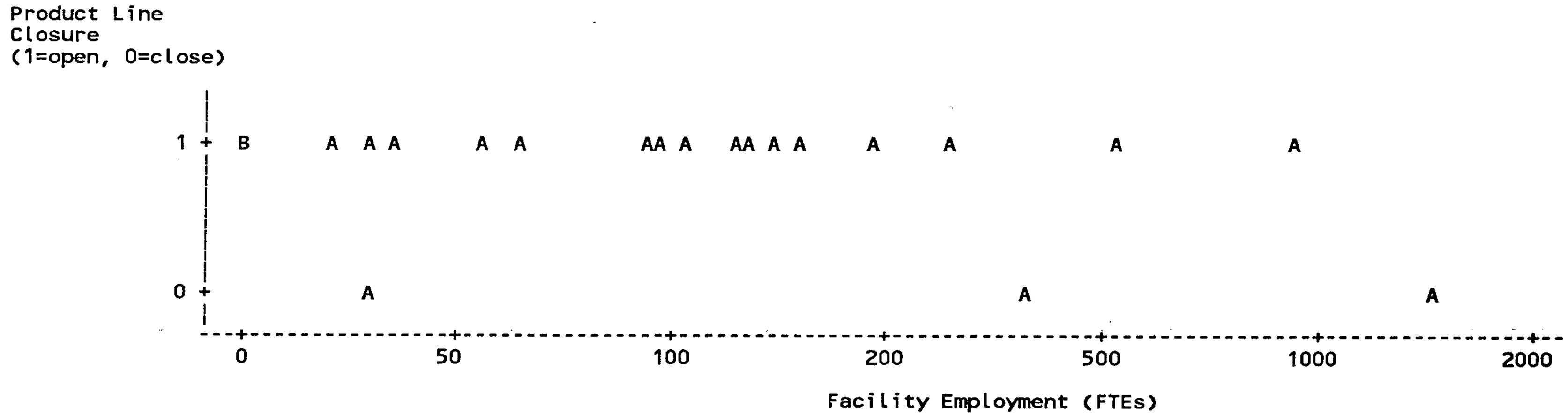
Zero Discharge Option, Direct Dischargers
Product Line Closure vs. Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.20

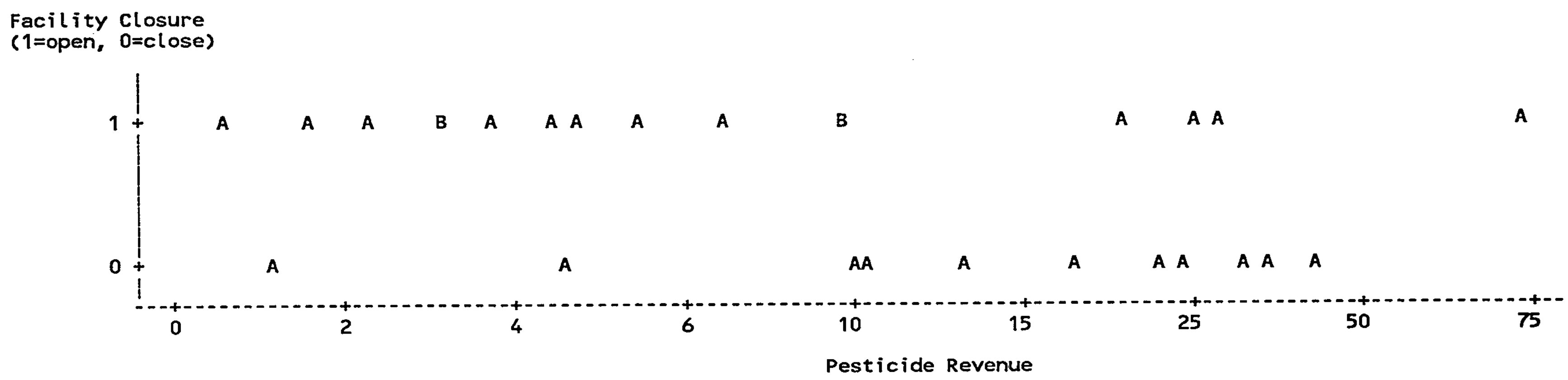
Zero Discharge Option, Direct Dischargers
Product Line Closure vs. Facility Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.21

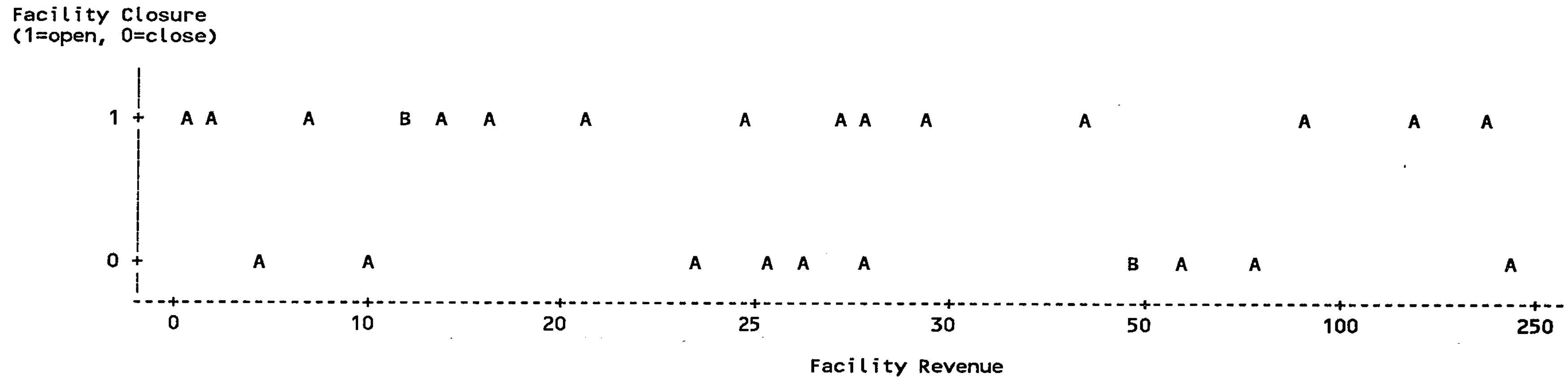
Zero Discharge Option, Indirect Dischargers
Facility Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.22

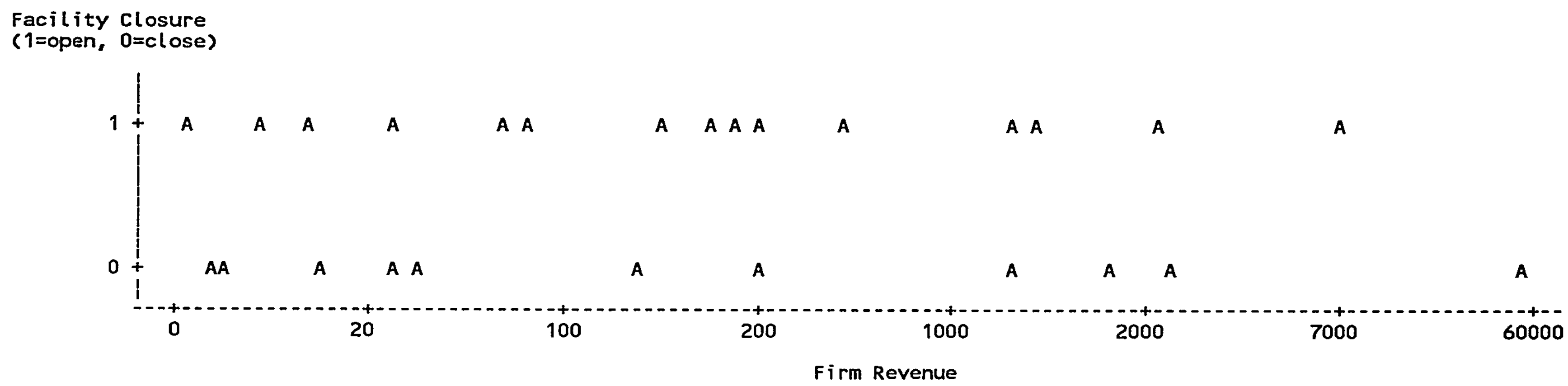
Zero Discharge Option, Indirect Dischargers
Facility Closure vs. Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.23

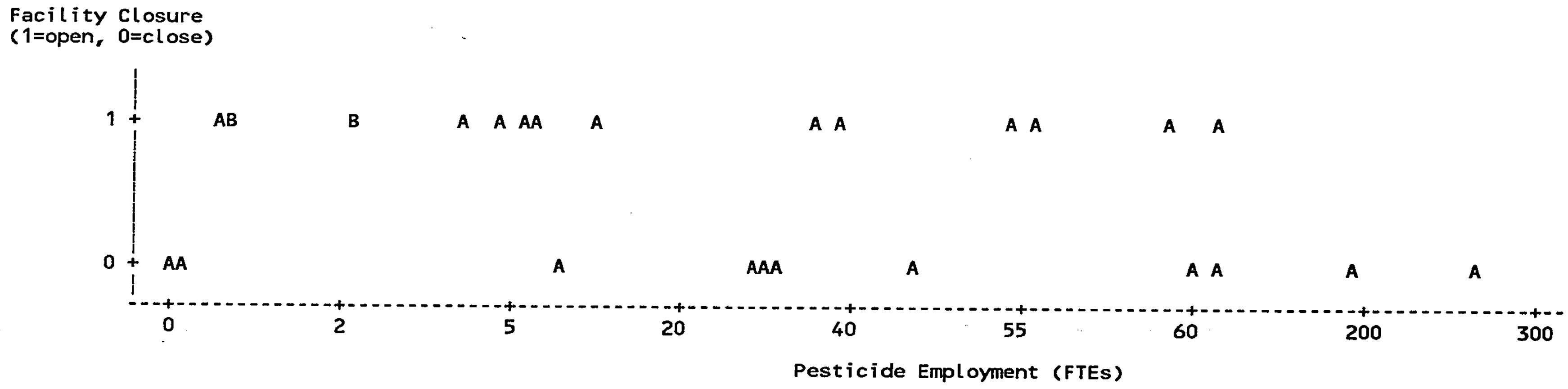
Zero Discharge Option, Indirect Dischargers
Facility Closure vs. Firm Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.24

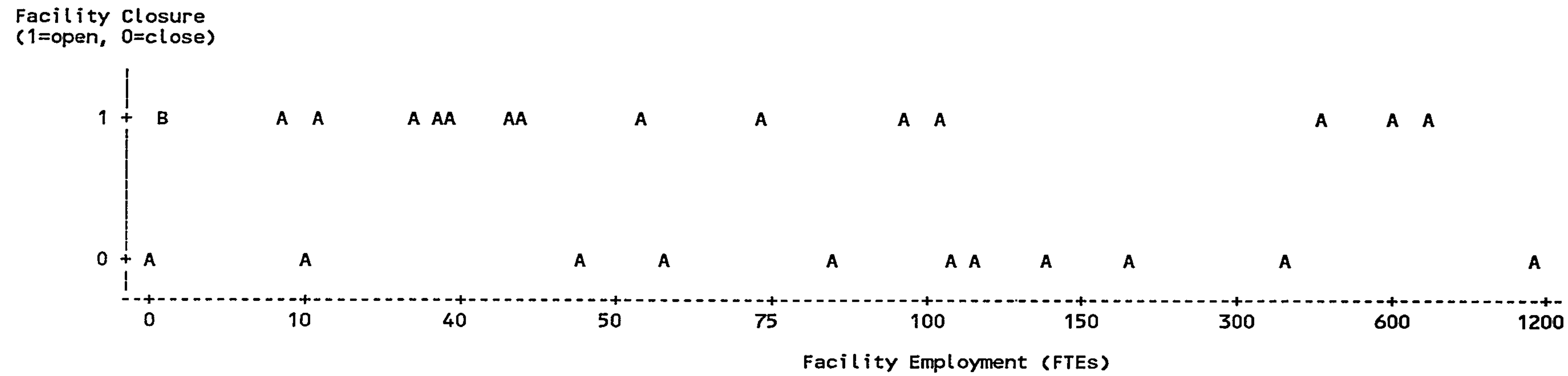
Zero Discharge Option, Indirect Dischargers
Facility Closure vs. Pesticide Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.25

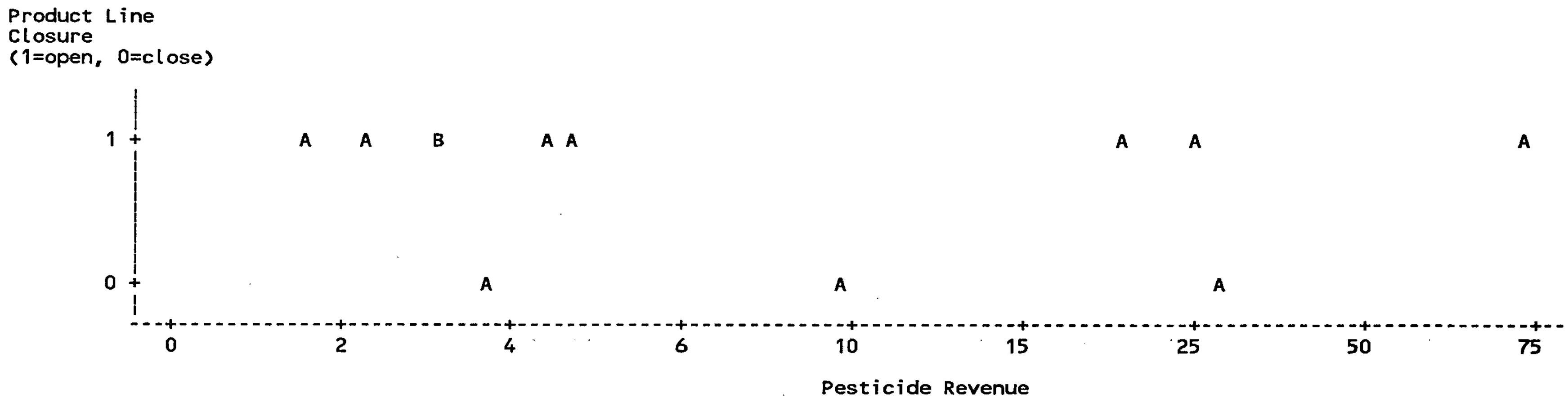
Zero Discharge Option, Indirect Dischargers
Facility Closure vs. Facility Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.26

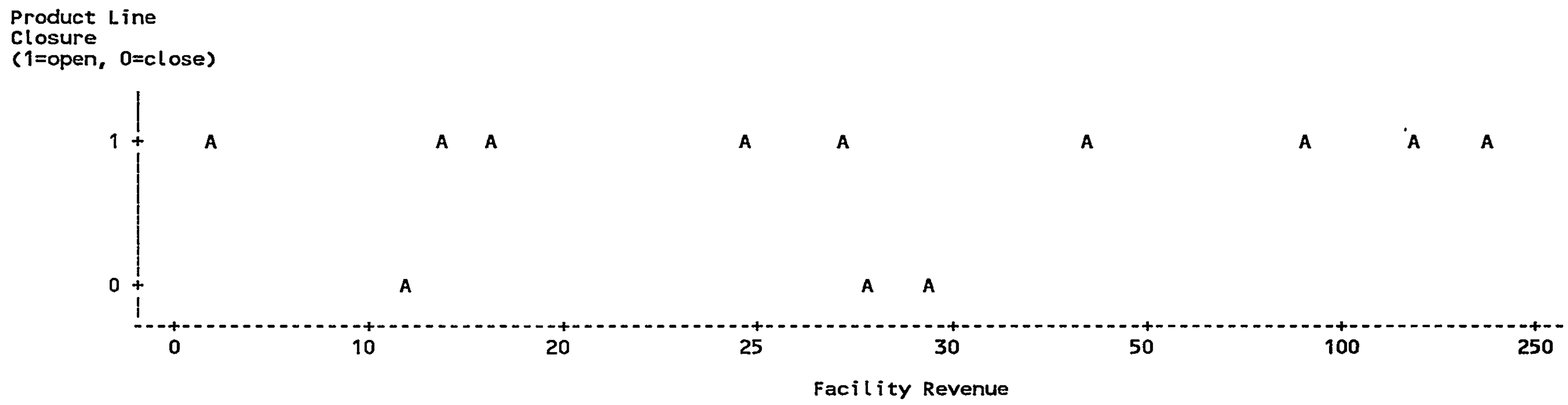
Zero Discharge Option, Indirect Dischargers
Product Line Closure vs. Pesticide Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.27

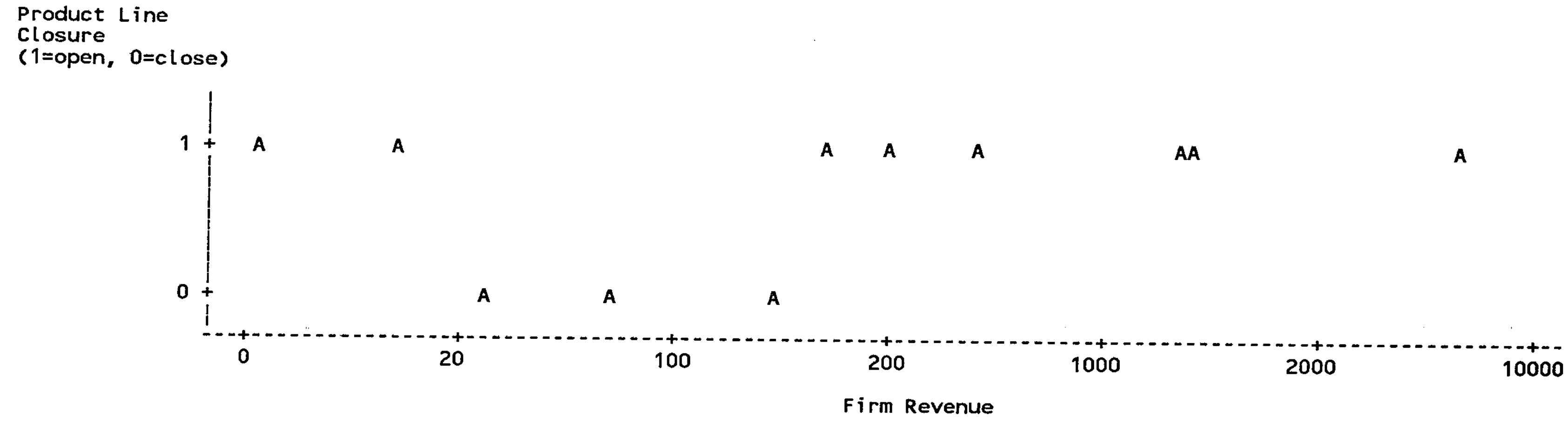
Zero Discharge Option, Indirect Dischargers
Product Line Closure vs. Facility Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.28

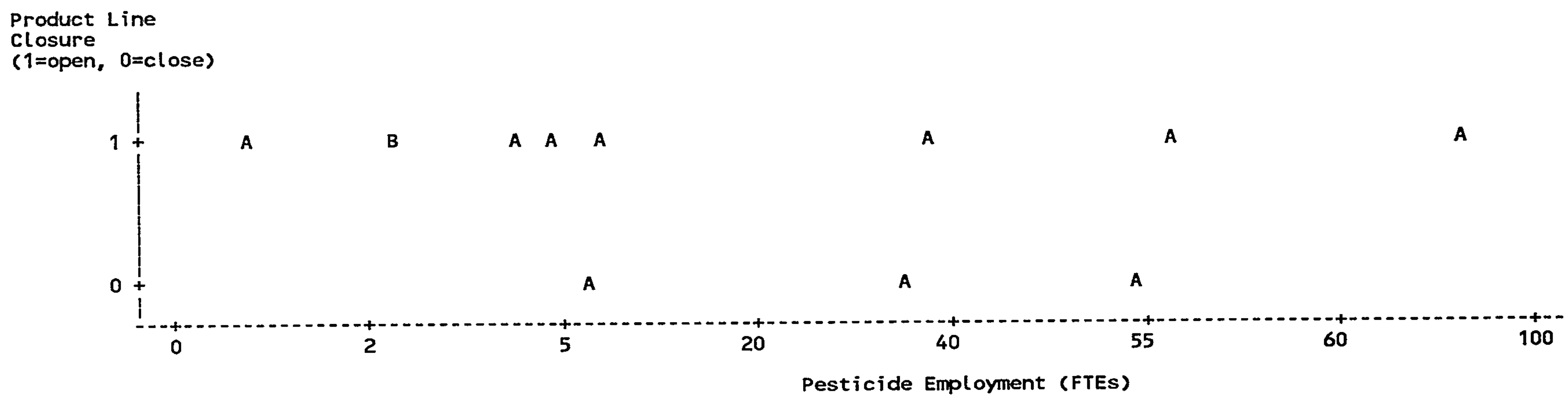
Zero Discharge Option, Indirect Dischargers
Product Line Closure vs. Firm Revenues ($millions)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.29

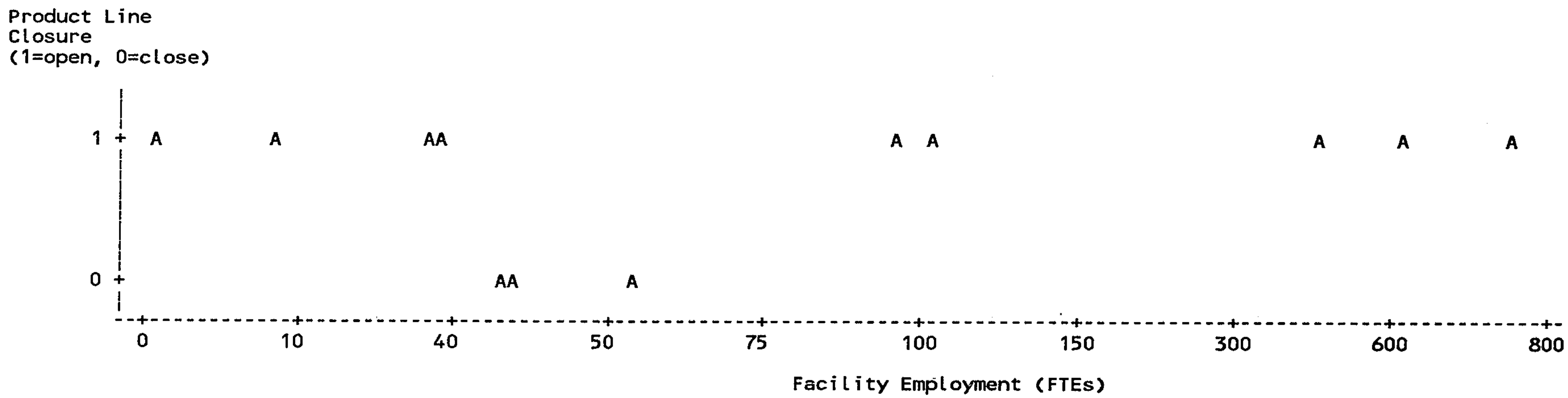
Zero Discharge Option, Indirect Dischargers
Product Line Closure vs. Pesticide Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.

FIGURE E.30

Zero Discharge Option, Indirect Dischargers
Product Line Closure vs. Facility Employment (FTEs)



Legend: A=1 observation, B=2 observations, etc.